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GREAT AMERICAN INDUSTRIES.

VII.—A PRINTED BOOK.

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I.

THE world has many times come near to printing, and just missed it. The ancient Assyrians stamped their records deep in bricks or cylinders of clay, using a raised wood block, or possibly separate characters. A wooden hand-stamp discovered in a tomb at Thebes, left upon the Egyptian bricks for which it was used, in raised hieroglyphics, the name of Amenoph—possibly that very Pharaoh who was the taskmaster of the Israelites—which was cut into it. The Greeks not only cut exquisite seals, leaving raised impressions upon wax, but used also the contrary process of engraving maps upon smooth metal plates, from which they might have taken ink impressions "if they had only thought of it."

The Roman potter used, it would seem, movable types to stamp his vessels with the owner's name or a contents label; the private loaves of bread sent to the public oven were stamped with an owner's mark; cattle and slaves were "branded" by a heated stamp; the "signum of Cecilias Hermias" in raised brass, which saved that Roman citizen the trouble of writing his name or of learning how to write it, as well as several incised brass stamps which seem intended for use with ink, are in the British Museum. Quintilian suggested the use of a stencil to teach Roman school-boys to write, since by following its lines with their stylus they could trace the letters; Cicero and other Latin writers come very near the idea of printing-types when they speak of the absurdity of expecting an intelligible sentence from chance mixing of engraved letters; Pliny, indeed, speaks of "a certain invention" by which Marcus Varro proposed to insert in his books "the images of seven hundred illustrious persons," thus "saving their features from oblivion," and "making them known over the wide world," which sounds very like our wood-cut printing. Yet, so far as we know, all Roman books were made by slave copyists, so cheaply that Horace complains that his books were too common, while Martial's first book of epigrams could be bought for six sesterces (24 cents) in plain and five denarii (80 cents) in fine binding, and the daily newspaper of Cicero's Rome, the *Acta Diurna*, which contained local news and gossip of marriages and divorces as well as acts of the Senate, was probably made in like manner. The Emperor Justin, who could not write, used a stencil to sign his name, and merchants had trade-marks to the same purpose.

The Codex Argenteus, or Silver Book, at Upsala, Sweden, which dates from the sixth century or earlier, must have had its silver letters stamped on its purple vellum one by one, since some of the letters are upside down, and such engraved letters were in use by many calligraphers of the Middle Ages to outline initial letters for their illumination. Woven fabrics of silk and of linen were printed in colored inks from hand-stamps in Italy possibly as early as the twelfth century; indeed, Breitkopf holds that the Egyptians thus printed cloths, and the Mexicans and Polynesians had perhaps a like practice. The printing-press itself was rather an adaptation of the wine-press or cheese-press used in all countries than an invention, and the playing-cards and block-books of the Middle Ages, made from engraved wooden blocks, which preceded the use of movable types, were probably printed on it.

All these items show that every ele-

ment of type-printing—except the type-mould for casting types, in which De Vinne finds the true origin of modern typography—existed here or there at one time or another in the world long before the mystical or mythical Koster or the undoubted Gutenberg of the fifteenth century. It seems, indeed, a predestination that it was left to the glorious era of the Reformation to consummate this among its other wonderful achievements. The truth is, the world was not ready before; there was no soil for the seed. An earlier Gutenberg would have lived—perhaps did live—in vain. In Darwinian phrase, printing was an evolution requiring environment. The environment was the same which made possible the Reformation.

Of course the Chinese were ahead of Europe. Their chronicles record printing upon silk or cotton in the century before Christ, paper being attributed to the first century after Christ. It is certain that many hundred years ago they had begun to put writing on transfer-paper, lay this face downward on wood or stone, rub off the impression or paste on the transparent paper, cut away the wood or stone, and take an impression in ink which duplicated the original. First, probably, they cut the letters into the block, leaving white letters on black ground, which method, Didot thinks, was known to the Romans and was the process referred to by Pliny; afterward they cut away the block, leaving the letters raised, to print black on white. This last process is attributed to Foong-Taou, Chinese minister of state in the tenth century, who was driven to the invention by the necessity of getting exact copies of his official documents. Indeed, there is detailed tradition of a Chinese Gutenberg, one Pi-Ching, who in 1041 carved cubes of porcelain paste with Chinese characters, afterward baking them, and literally "setting" the porcelain types by help of parallel wires on a plate of iron in a bed of heated resinous cement. These types he hammered or planed even, and pressed close together, so that when the cement hardened they were practically a solid block, which could be taken to pieces again by melting the cement. But Pi-Ching was born out of time, in the wrong country, and to the wrong language. The Chinese word-alphabet contains at least 80,000, possibly 240,000, characters (the National Printing-office at Paris made types for 43,000), and for the lesser number the Chinese compositor would require a large room to himself, where he could wander among five hundred cases "looking for a sign," while Chinese wood-engravers will cut on pear-wood, or on the hard waxen composition used for that oldest of existing dailies, the Pekin *Gazette*, an octavo page of characters for forty or fifty cents—a hundredth part of the cost of coarse work, a thousandth of the cost of the finest work, here. The Chinese printer, without a press, but with a double brush like a canoe paddle, inking the block with one end, and pressing the paper laid on the block with the dry brush at the other end, prints two thousand sheets a day, on one side only, which are then bound into a book by making the fold at the front of the sheet, and stitching through the cut edges at the back. A fair-sized book is sold for eight or ten cents, and there is little inducement for improvement. Playing-cards, invented probably in Hindostan as a modification of chess, and then engraved on ivory, were made in China and in Hindostan centuries ago, and thence they seem to have made their way into Europe, probably through Saracens or Jews, before 1400.

The demand for playing-cards and for image prints caused the industry of wood-block or xylographic printing to attain great proportions early in the fifteenth century. The image prints were the religious chromos of the fourteenth and fifteenth centuries. They were rude outline drawings cut on wood, printed in an undetermined way, possibly on a press, and colored by hand, probably by use of a stencil. A St. Christopher, dated 1423, is the best known of these. Printed on paper, by this time in general use, cheap, widely distributed, they were of enormous educational service.

Meanwhile the business of book-making by copying had had a curious development in two directions. The industry so flourishing in Cicero's Rome had dwindled to nothing by the sixth century. The great libraries had been destroyed. Few could write their names; fewer could read. The Irish monks alone preserved the art of illuminating, and from the island of Iona shed such light as they could throughout Europe. Charlemagne himself could not write, but used a curious monogram to picture his name; he was the more ready, it may be, to permit his

English adviser, the monk Alcuin, to require that every monastery should maintain a scriptorium, and every convent or bishop should employ a permanent copyist, "using only Roman letters," for the making of books. The Church monopolized this art up to the twelfth century, when the ignorance of the inferior clergy, and later the influence of St. Francis d'Assisi, who forbade Bible, breviary, and psalter to his order, made way for the lay booksellers, who congregated about the great schools of theology like Padua and Paris. But the Church still arrogated superintendence and censorship; the University of Paris required "the stationers, vulgarly called booksellers"—the first name coming from their selling at a station or shop—"to tell the truth, without deceit or lying, touching the price of books," which was fixed by four master-booksellers appointed by the university, with four deniers profit when sold to teachers or scholars, or six deniers when sold to the public. Even then the bookseller might not buy a book for sale until it had been exposed five days in the hall of the university, and its purchase declined by teachers and scholars; and he was obliged to loan it for copying, at a small fixed price, to any student giving security. Consequently the university was, later on, compelled to fulminate against base booksellers who, naturally desiring to earn a living, did not uphold the dignity of their profession, but mixed it up with "vile trades," such as "fripperies and like haberdashery," as modern booksellers have also been compelled to do. Vellum became scarce, and the richer buyers disdained paper. This fact promoted the differentiation of book-making into two distinct divisions: on the one side the superb missals of the religious orders and the daintily written and bound troubadour books of the courts; on the other, a flood of alphabets, primers, creeds, prayer-books, and crude school-books, wonderfully cheap, from a groschen up, made by unprofessional copyists, demanded as the result of the Church schools, the work of such early reformers as Wycliffe and Huss, and the general awakening of Europe. The Fraternity of St. Luke, existing in Paris in 1391, the Company of Stationers, in London, 1405, and book-trade guilds in other cities, show the extent of the industry.

Yet the great body of the people, and many of the friars, could not write. For them pictures were necessary; hence the image prints. It was natural that these should presently be bound together into books; and wood-engraving was also called upon to reproduce the pictures of the *Biblia Pauperum*, or Bible of the Poor, the *Speculum Salutis*, and other early books of religious instruction, which had become very popular in manuscript, and which gave the ignorant friars material for their sermons. Thus the block-books came to be. There is a story, not fully accepted, of a "Heroic Actions of Alexander," pictures and legends cut in wood, made by a twin brother and sister, Cunio, when but sixteen years old, at Ravenna, Italy, in 1286; but the block-books known to us are chiefly German or Dutch, and a hundred years or more later. Some of them were without text, except for the legend engraved in the picture; others had text around the picture, or on an opposite page. At first, the edition being small—perhaps a hundred copies or so—this text was copied by hand after the pictures had been printed, for the engraving of letters was costly. When movable types were invented, the text also was printed, sometimes with the pictures, sometimes by a second impression and in different ink. Much of the confusion in the early history of printing is due to the multiplicity of editions—some of them printed from blocks imitating type letters after others had been printed from types—of popular books, such as the famous *Speculum*, whose "unknown printer" is a mysterious, shadowy figure in early typography, and as the *Donatus*, or Boy's Latin Grammar, the only block-book without pictures, *the* school-book of the Middle Ages, known, like Webster's Speller, from the name of the Roman grammarian of the fourth century, Ælius Donatus, from whose greater work it was abridged.

II.

The world was now ready for printing. Before the middle of the fifteenth century Europe had a cheap material, paper; an oily ink, developed for block-book printing, in place of the fluid ink, which could be used only with the brush; probably the press itself; skilled artisans, trained in the block-book work; most important of all, the demand caused by education. It lacked movable types that could be fitted evenly and readily together, for nei-

ther the porcelain letters of Pi-Ching nor the individual stamps of the early copyists had developed to this point. "The invention of printing" in its modern sense consisted in the simple production of such types, or, as De Vinne puts it, of the type-mould which should produce such types. Fifteen cities claim to be the birthplace of printing, but the honor rests between Haarlem, Strasburg, and Mainz. The Dutch legend is that some time about or previous to 1440, one Laurent Janszoon Koster, custos or sexton of a church in Haarlem, while in the Hout, or Haarlem wood, cut letters on a beech-tree, which suggested to him wooden types, from which he afterward developed metal types; and that a man in his employ, escaping with the secret to Mainz, originated the art there. Haarlem contains many portrait-monuments of Koster, and belief in him is an article of the Dutch faith, but later investigators claim that he is altogether a myth, made up, with much imagination and some rascality, of two Haarlem citizens, neither of whom was a printer, and of the "unknown printer" of much later days.

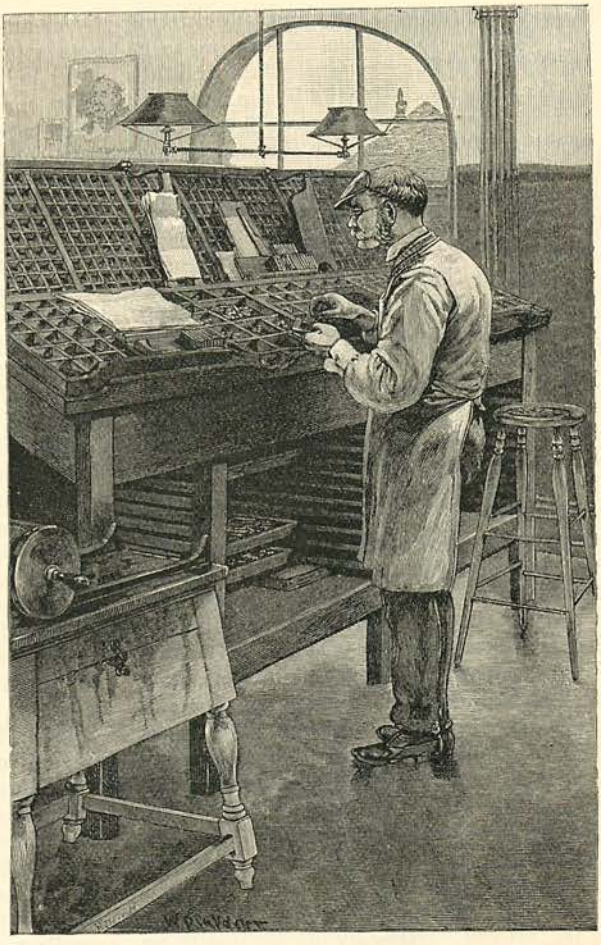
The German story centres in John Gutenberg, of the family called Gensfleisch—taking his mother's name in accordance with a German custom, because her family was dying out—as to whom there is a definite historical chain of evidence, including the records of two lawsuits. Nothing is certainly known of his first thirty years. He is supposed to have been born about 1399, at Mainz, whence his family were exiled, going to Strasburg. In 1439 he appears as a defendant in a lawsuit brought in Strasburg by an heir of one Andrew Dritzehen, to compel Gutenberg to admit him to the secret and benefit of an art into which the deceased had bought by payment to Gutenberg. This art seems to have been printing, and the evidence in the suit shows that Gutenberg sent his servant to Dritzehen's house, immediately on his death, to have a "form" of "four pieces," "lying in or about a press," separated "by turning two buttons," "so that no one might know what it is." We do not know, for Gutenberg won the suit and kept the secret. Different modern scholars construe "it" to be parts of the press, pages of type, matrices, or a four-part type-mould, such as is known to have been used by early printers. It is not definitely known whether Gutenberg printed any books in Strasburg (some fragments of a type *Donatus* being most plausibly connected with him there), which caused a German critic to declare that if Strasburg is the cradle of printing, "it is a cradle without a baby." By 1448 Gutenberg had removed to Mainz, for there is record of his hiring money, and in 1450 he made a contract with John Fust, a money-lender, to provide money for "paper, vellum, ink, wages, and the other materials required," on half-profits, which contract was the basis of the second suit. In this suit, brought in 1455, Fust, who has been sadly confused with that later Dr. Faust, of Wittenberg, from whose wicked learning grew the Faust legend, foreclosed his mortgage, got possession of part of Gutenberg's implements and stock, and by help of Gutenberg's apprentice, Peter Schoeffer, who afterward married Fust's daughter Christina, took up the business of printing. There is a legend that this Schoeffer, and not Gutenberg, invented the type-mould, but recent investigators show that this invention was peculiarly Gutenberg's.

Gutenberg, who started a new printing-office after the separation, by help of money from Conrad Humery, physician and town clerk, printed two editions of the Bible. He printed also an edition of the *Donatus*, several *Letters of Indulgence* (the earliest job-work), a broadside *Calendar* of 1457, a *Catholicon* of 1460, and many other things. He was alive in 1465, when Archbishop Adolph made him one of the gentlemen of his court, and was dead in 1468, for in that year Conrad Humery had succeeded to his effects.

III.

Gutenberg, Koster (if he ever lived), and most of the early printers made their own type, and this, indeed, is the germ and key of the whole industry. The making of the type is now a calling by itself—the trade of the type-founder—but it is most curious that up to the invention of the type-casting machine in 1838, by an American, David Bruce, Jun., of New York, there had been scarcely any improvements in the process since the early days. Then, as now, in all probability, the type-founder cut first his "counter-punch" of hard steel, which stamps into the end of a tiny bit of soft steel the interior part of the letter to be made. It is a patient man who must do this work, which is completed

by cutting away all the superfluous metal outside the letter, leaving in relief the letter A of the desired new pattern or new size. When a smoke-proof of his die shows the punch-cutter that his A is perfect, he hardens the bit of steel, and with successive blows of this die upon a bit of copper makes the *matrix* for any number of type. If it is a very large letter, the metal is poured into a mould, with these matrices at the bottom, by hand, in the old-fashioned way, and the letters sawn apart; but most types are now cast in the little casting machines, which will turn out a hundred or more type a minute. The type-metal has been fused in great melting-rooms, where the lead, antimony, and tin have been mixed in the crucibles in the proper proportions to form this alloy, which must be "hard, yet not brittle; ductile, yet tough; flowing freely, yet hardening quickly." It is kept fluid in a little furnace under the casting machine, whence, as the caster turns a crank, it is spurted by a pump in just the right quantity to fill a tiny mould which presents itself at the spout at just the right moment to receive it. The copper matrix forms the end of the mould, and as the latter jumps back with its quickly cooling charge of metal, the matrix frees itself from the mould, the upper half of the mould pops off, and the formed type is tossed out *instanter*. Thence the tiny bits go to the breakers, boys who break off the waste "jets" of metal; rubbers, with leather-protected fingers, sitting at large circular stones, rub down the rough edges; girls set the types up in long rows into a "dressing-block," in which they are held while the dresser, with a planing tool, grooves their understandings and shaves their sides perfectly true. After passing the inspection of his magnifying glass, the good letters go to a haven of rest to wait the printer's orders, while the bad are committed again to the flames.



THE COMPOSITOR AT WORK.

IV.

The compositor who "sets" the type is commonly spoken of as the printer, while his fellow who does the actual printing is called the pressman. The former stands, hour after hour, before his "case" of types, each kind in its own little box, and each box in its well-defined position in the case, so that the hand reaches for it by instinct, picking up and placing in the "composing-stick," which he holds in his left hand, type upon type, line upon line, the bits of metal of which there are in a page of the size and type before the reader about 6000 pieces. There are really two cases before him, the "lower case," nearly flat, containing in its fifty-four boxes the small

letters, figures, and common punctuation marks, the "upper case" containing in its ninety-eight boxes the capitals and less used characters. In the lower case, *e*, of which there are 60 to every 40 *a* and every 1 *z*, always occupies the centre, and the letters most in use are grouped nearest to it, so that the hand may travel no farther than need be. If he needs italics or other "sorts," the workman must step aside to another case, or if he is to change to matter of another size or style of type he takes off the cases on his "stand" and replaces them with others. When he has filled up one line in his composing-stick, which he has previously adjusted by a screw to the "measure" or width of his page or column, it will frequently happen that the word does not finish with the line. He must then break it properly, putting the hyphen at the end of the syllable, and "justify" his line by putting thicker or thinner "spaces" between the words of the line. After the compositor has set his stickful of type, he deftly shifts it off upon a "galley"—a movable brass trough usually the length of one or two pages or columns of the book. With the help of a "measuring stick" he counts up the number of "ems" he has set, *m* being a square letter which forms a convenient basis of measurement. English compositors reckon by "ens," the *n* being nearer the average letter.

As soon as a galley is filled with type it is "proved," either by inking it with an ink ball or roller as it stands on the "stone" or work-table, spreading over it a strip of wetted paper, and taking an impression by means of a flat block covered with cloth, struck by a hammer; or else by putting it upon a proof press of the old-fashioned hand pattern. The proof-reader now compares proof with the author's "copy," and sends the proof, with his mysterious signs upon it, back to the compositor for correction. This correction, as well as the "distribution" of the different letters into their proper boxes after the page is printed off or electrotyped, is paid for in the compositor's charge per thousand ems. The most valuable compositor is the one who makes the "cleanest" proof, for the time lost in careful work is saved in the time of proof-reading and correcting.

Either for taking proof or for printing, the types must be carefully locked up in their "chase" (another form of the word *case*)—a strong frame of metal or wood—by means of quoins, or wedges. For the rotary press this chase becomes a curved "turtle," so called from the resemblance of its curvature to a turtle's shell, and the rules between columns are thinner at the base than at the top, so that the square types may fit in and be properly "locked up" by screws which tighten them together. In the printing of a newspaper or a book each page of type must be so placed in the chase that when type and chase are locked up into a "form," as it is then called, the pages will back each other and fold together properly as the completed sheet comes off the press. This is called "imposition," and the printers' hand-books give diagrams to fit the different problems of the "stone-man" or "maker-up."

The many efforts to make a steam man do the work of a human compositor have not been fully successful. There are many patterns of type-setting machines, but the essential principle of most of them is the delivery from horizontal channels centring at one point, or from upright pipes dropping the type to one spot, of the types called for on a key-board struck by the finger. The types are set in a continuous line, and must be "justified" to the proper measure and mistakes corrected by hand, since brains cannot be got rid of. For "distributing," each letter or sign has its individual set of nicks, like the wards of a key, and it is passed on by the distributing machine until it reaches a corresponding combination of metal fingers, which, so to speak, unlock its proper door and pass it into its particular home.

In England most books are printed from the actual types, which are reset for new editions. The cost of type-setting is so much higher here that publishers were early driven to the use of "plates," first stereotypes, afterward electrotypes, in the case of books of which more than one edition was likely to be required. Van der Mey, a Dutch printer, about 1698, soldered his types together into a solid block, much as the Chinaman Pi-Ching cemented his porcelain types, but it was not till 1725 that an Edinburgh printer, William Ged, hit upon the present method, by which the types were freed for further use. One of his plates is still preserved in the Advocates' Library in Edinburgh. The type, set with high "quads" and spaces, is hammered, or "planed," to an even surface, and is then coated with oil. Two pages or more at a time are locked in a moulding

TAKING PROOF OF ENGRAVED BLOCK.

frame, and either liquid gypsum is poured into the frame and allowed to set, or the form is pressed upon a soft clay or papier-maché bed, which makes the mould. These moulds are dried, enclosed in a "casting pan," and lowered into the "metal pot," where half a ton of molten type-metal is kept hot enough to set fire to paper. When the casting pan is filled, it is lifted out and taken to a cooling trough, and more metal is poured in to fill any interstices left by cooling. The mould is now peeled off, and the solid (stereo) block lifted out from the pan and sent to the planing and flanging machines—both American inventions—where the back is shaved to leave the blocks of a standard height. This process can be performed so quickly that the morning dailies perfect their plates within thirteen minutes from the receipt of the type.

Stereotyping produces, however, only a type-metal block, not finely accurate, and easily worn down by much use. About 1839, two Englishmen, a Russian, and an American seem to have been simultaneously at work in developing a galvanic process. The last, Joseph A. Adams, an engraver of New York, first did practical work, and he electrotyped the borders of the illustrations in the Harper Family Bible of 1842. In 1852, the process as developed by Mr. S. P. Knight was applied to entire pages of this Magazine, which then required from 36 to 48 hours per page. The form of type is prepared much as for stereotyping, but is coated with graphite carbon ("black-lead"). Upon this a plate of prepared wax, or similar yielding substance, is then pressed to make the mould. The wax is, however, a non-conductor, and must therefore be coated evenly and completely with black-lead. This was formerly brushed on, in fine powder, by hand or by a brushing machine—a dirty and not healthful process, requiring careful skill. The newer Knight method shuts the moulds in a tight box, within which a strong jet of water carrying the fine carbon is pumped against their face, leaving them perfectly and evenly coated. The deposit on this mould of a film of fine copper, precipitated from a solution of copper by reducing it with iron filings, is another improvement of the same inventor. The mould is now placed in the copper solution bath, attached to one electric pole, while a plate of copper is attached to the other. Electro-chemical action deposits infinitesimally fine particles of copper on the mould from the solution, while the copper at the other pole is giving up its substance

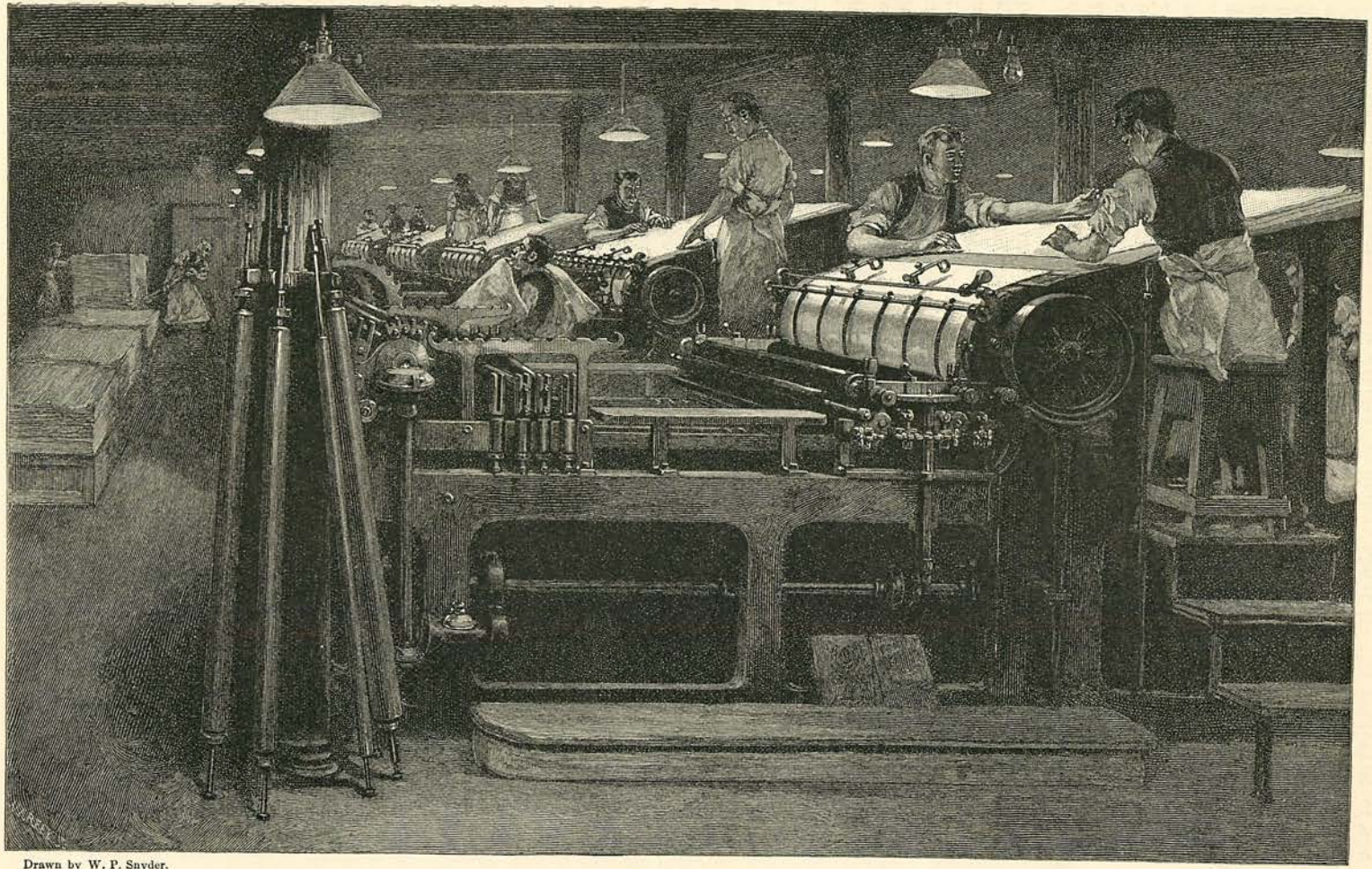
to the solution. Under the old processes, and when the galvanic battery supplied the current, twelve or fourteen hours were required to complete the shell; the newer processes, with the help of the dynamo machine, converting coal into heat, heat into power, and power into electricity, do the same work in from two to four hours. The shell is now removed from the mould, soft metal is poured into the under side, and the plate is planed down to standard height. We have now an accurate reproduction of the finest lines of the original, in hard copper, from which nearly half a million copies can be printed.

V.

Our type being now locked up, or our electros or stereos finished, we follow the "forms" to the press-room, where the actual printing, properly speaking, is done. The great room is filled with enormous machines, some noisily, some quietly, doing their work, evidently of most complicated mechanism. Their purpose and method become, however, quite simple to understand if we trace their development from its beginnings.

The development of the printing-press itself has indeed been most interesting. The early presses, as shown in old woodcuts, and as still existing in the Musée Plantin-Moretus at Antwerp, were very nearly the same as the press used by Benjamin Franklin, now in the United States Patent-office, and the hand-press used in many modern printing-offices for taking proofs and at the other extreme for fine hand-work. They were a simple adaptation of the cheese or wine press, with a carriage for running the type and paper under the plate or "platen," which lowered by a screw made the impression. The "form" of type, locked in its "chase," was laid face up on the bed of the press; ink was applied by hand from an ink pad or ball; the sheet of paper was carefully placed between the "tympan" and a "frisket" or frame to keep the sheet in place and prevent the soiling of that part of the paper not to be printed on, which together were folded down upon the form; all this was pushed, or in later days rolled by the "rounce," under the "platen"; pressure was applied by the screw, and when this was relieved, the carriage was brought back, the tympan lifted, and the printed sheet taken out. Blaew, of Amsterdam, about 1620, made some minor improvements in the travelling bed, the easier working of the screw, and a spring to throw back the platen after the impression, in his nine presses, which he named after the nine Muses; but so late as 1770 his press was still "new-fashioned" among English printers, many of whom yet held to the "old-fashioned" kind. Until the end of the last century the press still had a wooden frame, a plank of wood or slab of stone for its bed, and so small a platen that two "pulls" were required to print one side of a full sheet. Between 1790 and 1800, Didot, the French printer, devised a platen of iron large enough to print one side without moving along the bed, and Ramage, a Scotch American of Philadelphia, substituted an iron bed for the stone slab; and in 1798 Earl Stanhope, who revived the art of stereotyping, presented to the trade (waiving a patent) his famous press, a stout affair, all of iron, printing at a single pull, which was made much more easy by the action of levers on the screw. He was outdone by George Clymer, of Philadelphia, who early in the century (1817) completed the famous Columbian press, in which the screw was entirely replaced by a combination of powerful levers above the carefully counterpoised platen, by which the pressman was given delicate and indeed exact control of the pressure, so that he could almost "feel the type." The stout frame of the Stanhope and the lighter but serviceable model of the Columbian presented at that early day the contrast which has since been so often noted between English and American machine-building. Peter Smith, of New York, who was connected with the Hoe firm, in 1822 made a further improvement by simplifying the levers; and the Washington press, patented in 1829, constructed by Samuel Rust on this plan—including the "toggle" or elbow joint, with its enormous power, used by Otis Tuft in his press of 1813—displaced in great measure the Columbian, and is still made by the Hoes.

With the era of steam, the steam-press, of course, made its appearance. In 1790 a "literary feller," one William Nicholson, of London, editor of the *Philosophical Journal*, took out a patent for improvements in printing, which contained the three germs of the modern rotary press. The types, made narrower at the base than at the face, were to be fixed upon



Drawn by W. P. Snyder.

IN THE PRESS-ROOM

Engraved by Varley.

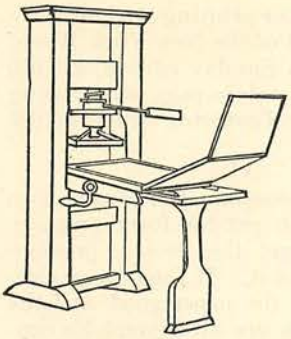
(1) a printing cylinder, to be inked by (2) an inking roller, against which (3) an impression cylinder of soft leather was to press the paper. Nicholson caught the true idea of fast printing in substituting rotary for reciprocating motion throughout his press. His printing cylinder required further development; but his impression cylinder, substituting for the great pressure required to cover the whole surface of a platen a contact with the type along a mere line of pressure, and his inking-roller, substituting for the ink-ball which jabbed ink on the form by hand a revolving cylinder which received from the ink-trough and gave off upon the form a continuous supply of ink, made further progress easily possible. The ink-roller was first made of leather; afterward cloth, felt, and silk were tried, and found unsatisfactory; finally a printer happened upon the dabber composition of the Staffordshire potteries, and this mixture of molasses and glue—a kind of solid jelly with a sticky surface—proved the one thing needed.

But it was one König, a Saxon clockmaker who came to London early in the century, who put power-printing to the actual test. After futile attempts to apply power-printing to the ordinary hand-press, he developed a machine on which in April, 1811, he printed an edition of a London weekly, and, backed by Bensley, the printer, and by Mr. Walter, he then constructed the famous press on which the London *Times* of November 28, 1814, was printed. This had a flat bed of type, inked by rollers, and passing to and fro under an impression cylinder; by using two forms of type and two impression cylinders, virtually two presses attached together, he presently succeeded in printing both sides of the paper on the same press.

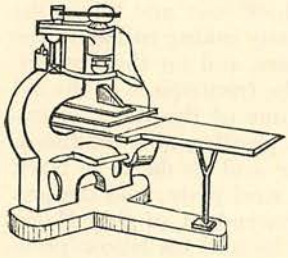
To understand fully the later development of steam-presses it must be noted that the printing form (type or stereotype) may be either flat, in which case it may be stationary, or may move up and down or to and fro; or curved, in which case it revolves. All the varieties of presses vary on these lines, or on combinations of them. The old hand-press used a flat stationary form, on which the platen descended. The first American power-press, that of Daniel Treadwell, of Boston, patented in 1826, was of the same type; it was first used by the American Bible Society and the American Tract Society, the latter working theirs by donkey-power, two mules being daily hoisted by tackle to the top story of their building. The Adams steam-press, invented by Isaac Adams, of Boston, 1830–36, and still much used for fine work, reversed this method, pressing the flat form of type, by an up-and-down motion, up against a fixed platen at the rate of about 800 impressions an hour, by help of a toggle or elbow-joint worked by an eccentric rod.

The "cylinder press," so called (a term confusing because it covers also the type-revolving presses) is virtually König's press, more or less modified, the flat form being inked by rollers and carried to and fro under an impression cylinder. König's own press had been much bettered by Applegath and Cowper, in whose machine an inking-table distributed the ink more evenly to the rollers, and two wooden drums, carrying the sheet accurately from one impression cylinder to the other, obtained an exact "registry" for the two sides; and in 1827 the *Times* adopted their press of four cylinders, raised and depressed in pairs, so that two printed while the bed went forward and two when it went back. In one or another shape the cylinder press still does the bulk of the world's printing. The ordinary newspaper presses have a small cylinder which rises to permit the form to run back for inking; job-presses have mostly a larger cylinder, revolving continuously, but with one portion of a smaller radius to permit the return of the form without printing; while the finest illustrated work, such as that of this Magazine, is mostly done with the "stop cylinder," which stands still while the type returns, having a flat side to avoid contact, printing 1000 or more impressions an hour.

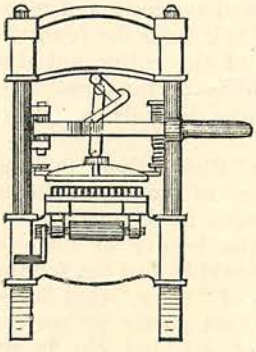
The evident advance from the flat-bed presses was to put the types themselves on a cylinder. Nicholson's idea had proved unworkable because of the awkwardness of his wedge-shaped types. In 1815 Cowper patented curved plates to be affixed to a cylinder, the rest of which was to be used as an inking surface, but stereotyping was then slow and costly. Napier, an English press-builder, devised in or before 1841 a press with an enormous printing cylinder, on whose periphery the ordinary types were to be held in place by rules larger at the top than at the bottom, with ten small impression cylinders about it—the prototype of the great Hoe rotary.



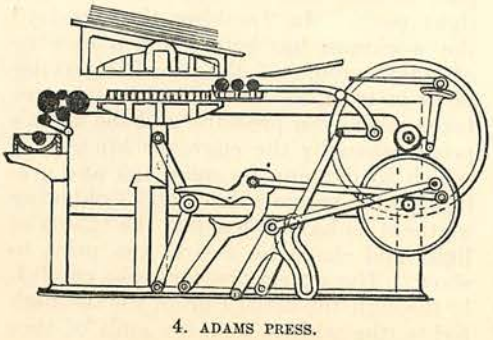
1. EARLY PRESS.



2. STANHOPE PRESS.

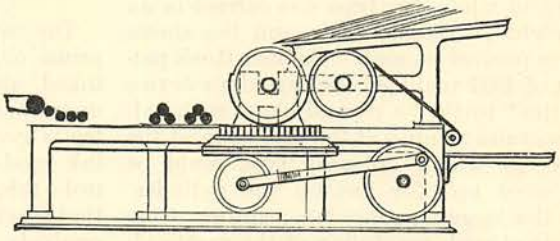


3. WASHINGTON PRESS.



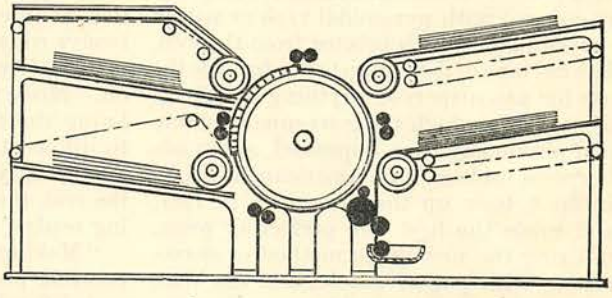
4. ADAMS PRESS.

But it was left to an American, Colonel Richard March Hoe, to bring together the *disjecta membra* of these various improvements into a press which has been pronounced "the greatest innovation on the routine of the printing craft since the days of Gutenberg." Yet



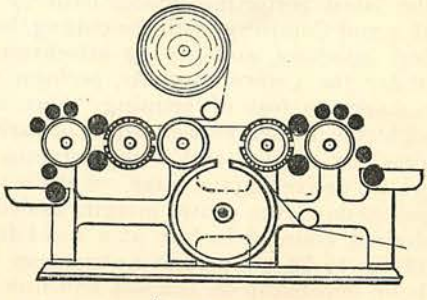
5. STOP-CYLINDER PRESS.

how closely this development of the printing-press has been a work of evolution has already been shown. His first claim, in the patent of 1842, was for a double-cylinder combination of Applegath and early Napier presses. In 1844 he patented what he called the Planetarium press, in which small cylinders were grouped around



6. THE HOE ROTARY PRESS.

a larger one, like planets around the sun. Out of this was developed the famous Hoe rotary or lightning press, in which the form was carried on a huge cylinder, the other three-fourths of which was used as an inking surface, about which the two, four, six, or eight



7. WEB PRESS.

impression cylinders and attendant inking rollers were grouped. This press, first used by the *Public Ledger* of Philadelphia, and in 1848 by *La Patrie*, Paris, finally superseded in the office of the London *Times* the curious Applegath press of 1848, in which the type was carried in an upright polygonal drum and the sheets were printed on end. Colonel Hoe's patent of 1847 included the ingenious device of the "turtle," a curved chase with column rules thinner at the base than at the face, in which ordinary type could be "locked up" for use on the cylinder. In the largest presses ten printings were made at each revolution of the great cylinder, five men feeding from each side, one above another, on this enormous five-story press, eighteen feet high, producing 20,000 impressions an hour.

One more advance remained to be made. It occurred to Rowland Hill, the father of cheap postage, that the continuous web of paper made by the Fourdrinier ought to be utilized, and in 1835 he actually constructed a press with a small cylinder, completely covered with pyramidal type or with a curved plate, which printed from the web. The red tape of the Stamp Office forbade the use for newspapers of anything but sheets of paper on which the government stamp had previously been impressed, and made his press useless. An American, William Bullock, took up the same idea in 1861, and made the first web perfecting press, utilizing the new quick method of stereotyping with *papier-maché*, and the Walter press was constructed later on the same principle. The Hoe rotary was limited only by the human limitations of the feeders; the web perfecting press, containing two printing cylinders, printing both sides of the paper, does away with feeders altogether. These compact machines, eight feet high, eight wide, and twenty long, are fast displacing the old rotaries; and the latest perfecting presses built by R. Hoe and Company, with the cutting, folding, inserting, and pasting attachments, under the Crowell patents, perform the remarkable feat of printing "four, six, eight, ten, or twelve page papers of various sizes, six, seven, and eight columns in width, delivering the same, cut at the top, pasted down the centre margin, folded as desired, counted in lots, at a speed from 12,000 to 72,000 perfect newspapers per hour, depending on the size and number of pages to be printed." The capabilities of modern newspaper printing are best illustrated in the feat of the New York *World* in printing, of a Sunday edition, 250,000 copies of a twenty-eight-page paper, using 98,000 pounds, and covering with print 600 miles, of paper.

VI.

The careful pressman has always two prime objects—to get his form properly inked, and to get the proper pressure upon each part of it. If the type or electro is good, and the paper good, and the ink good—which are all beyond his control—this makes good printing. He finds that several light coats of ink applied successively give a much better "distribution" than one thick coat, and this is the reason for the many inking rollers in the best modern presses, and for the stop-cylinder device. The frontispiece of the old Harper Bible is one of the finest examples of wood-cut printing ever produced, its lights as clear and its darks as black as prints from a steel plate; and the present press-superintendent of this Magazine recalls how he and his fellow-'prentice counted aloud one, two, three to twelve rolls of the inker on the old hand-press before each sheet of paper was laid on. Modern presses have means of regulating the flow of ink from the fountain to different parts of the roller, but this applies only lengthwise on the form. For the rest, the pressman depends on "making ready."

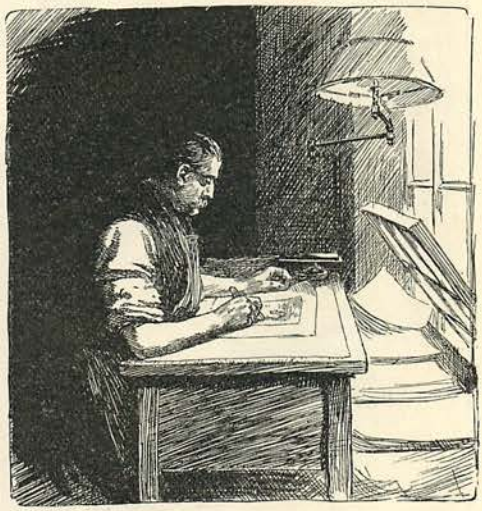
"Making ready" illustrations for the printing-press is one of the most delicate and difficult processes in the mechanical arts. Much of the beauty of modern wood-engraving would be lost but for the careful regulation of "color," that is, degree of blackness, got partly by regulating the supply of ink, but chiefly by the "overlay," the purpose of which is to increase the pressure on the dark part of cuts and to diminish it on the light parts. In "making the overlay" the workman has before him a number of "flat" proofs of the wood-engraving he is to treat, so called because they are taken with even pressure, and the artist's proof, taken by the engraver himself, in which by dabbing on more ink and giving harder pressure here and lightening up there he has shown just the effects of light and shade he desires the print to show. The overlay cutter looks carefully through the artist's proof for the high lights (the whites) and the ends of thin

lines which should fade off into nothing. These portions he carefully cuts out of one of his flat proofs with keen knife, deft hand, and accurate eye, and then makes his "first overlay." He then looks for the absolute blacks, and cuts out from another flat proof all *but* these. He then judges how many intermediate shades should be brought out in the print, and cuts one, two, three, or four more overlays, as he thinks best, retaining in each

Sometimes it happens that there is a depression in the block or electrotype, or the block rocks by reason of being thicker on one side, in which case a layer of paper pasted *under* part of the block forces the face up, and this is called "underlaying."

The pressman must also get exact "registry"; that is, the paper must take its exact place on the press to give even margins, or in color printing to bring each

THE OVERLAY.



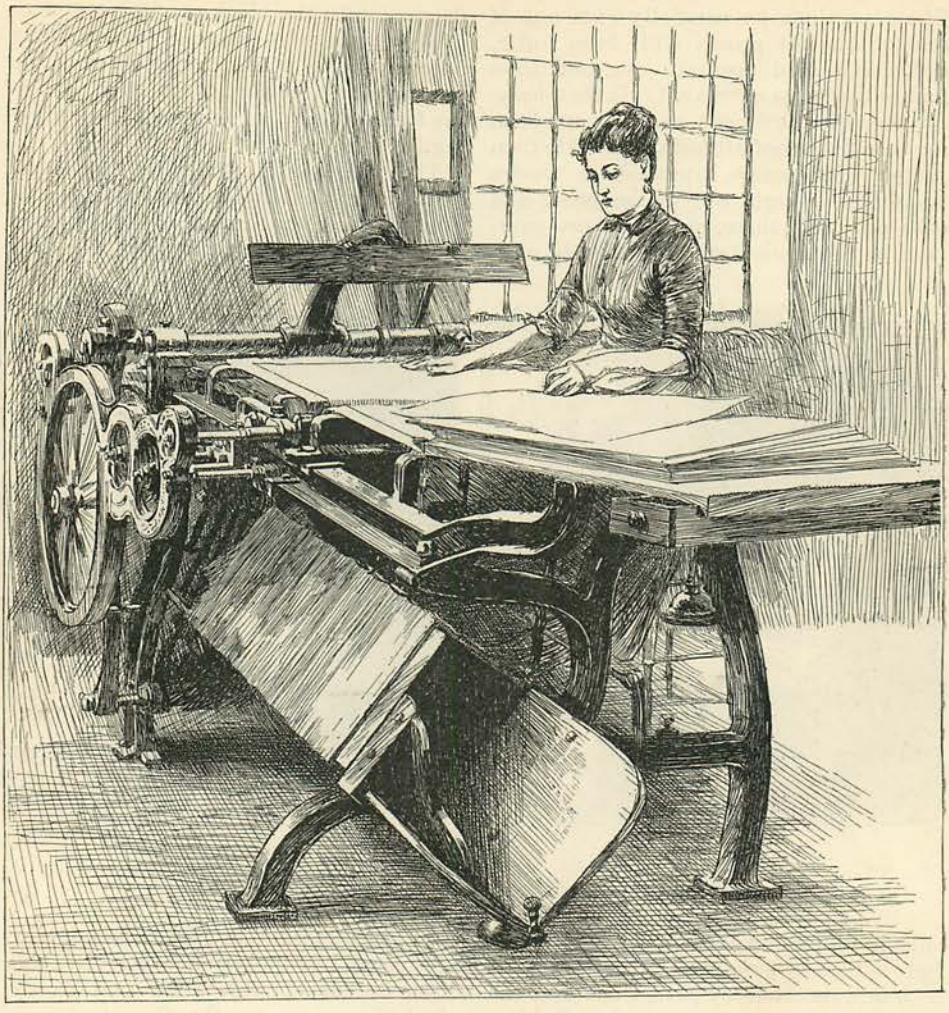
MAKING AN OVERLAY
(Showing print from overlaid block.)

only those parts where he wishes to bring forth effect by pressure. These are now with minute accuracy pasted, one over the other, exactly together, for the slightest error would compel all the work to be done over again. He has now a completed overlay, say of four layers, as in the cut here printed. The black part is four papers thick, the half black three, the middle two, the gray one, while the white is represented by holes. When the form containing this engraving is ready for the press, a light impression is printed on the paper sheet covering the tympan or cylinder, and by this guide the overlay is fitted on the pressing surface so that at every impression it will exactly correspond with the lines of the block. Where the overlay is thick the heavy pressure will load the ink heavily upon the printed sheet; where it is thin the pressure is relieved, and the lines get the merest film of ink.

color in exact relation to the others. This is effected by "pointing"—bringing the sheet in exact range with two points, which in one press, the Campbell, connect by electricity, so that the sheet regulates the entire process, and cannot be printed unless it is exactly in place.

VII.

Binding is a very simple art, which the division of labor has caused to seem very complex. Its beginning is so natural that it can scarcely be said to have been invented. The Egyptian *glutinator*, as the Romans translated his name, glued together his pieces of papyrus into the *volumen*, or long roll, which was the first volume. When printed sheets came into being it was natural enough that they should be folded for easier handling, that several sheets so folded should be fastened together, and that they should be protected by a stout cover, which should carry



FOLDING MACHINE.

the title of the book and such ornamentation as seemed desirable. It is this simple work which has developed into the seeming complexity of the modern bookbindery, of which the census of 1880 recorded (blank-book making included) 588 establishments, with $5,798,671 capital, producing from $5,195,771 worth of material, $11,976,764 product, and distributing $3,927,349 wages among 10,612 employés, half of them women—an average of $370 yearly.

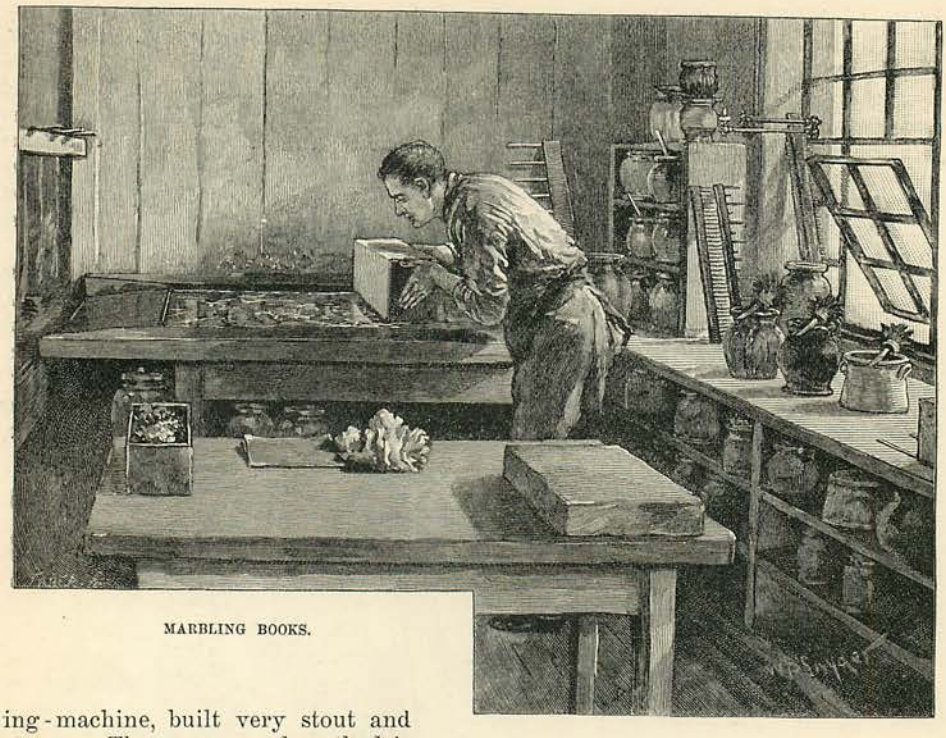
First of all, the printed sheet must be folded. This is done by hand, with no tool except a folder, like a paper-knife, to do the creasing, or by an ingenious machine, the principle of which was patented about 1853 by David A. Wells, who was apprenticed a paper-maker, though since known to the public rather as a paper-user. The sheet is laid on a flat table, across the centre of which is a slit, into which a thin bar of metal forces the middle of the sheet. Below this slit two rollers, working slowly together, clutch the sheet and carry it down folded, delivering it on a second table below for a repetition of the process, and so on as many times as the sheet is to be folded. A folder, human, will do about 500 octavo sheets (of three folds) per hour; a folding machine, about three times as many. A newer

method of folding, used mostly in machine folders dealing with a web of paper, creases the sheet by drawing it over a tapering cone, whence two rollers seize it and complete the fold.

The folded sheets must next be gathered and collated. Each sheet when folded bears at the bottom of its first page the "signature," the number or letter showing its place in the book, whence the folded sheet itself is often called a signature. Beginning with signature "1," or "a," or with any title or other extra signature which may precede "1," the piles of folded sheets are laid in their proper order on a long table, alongside which a quick-handed girl passes, taking one of each sheet after another until she holds a complete book. In some binderies a revolving round table takes the place of the long one, and the gatherer sits or stands in one place, and while the table is swung round by machinery, completes one book at each revolution. If "inserts" or "plates" of single sheets are to form part of the book, these are usually pasted or "whip-stitched" by hand upon or within the folded sheet before gathering. The book is then "collated"; that is, a careful eye runs over each gathered set of sheets to see that all sheets are there, that each sheet is in its proper order, and that inserts are in their right place.

The gathered and collated sheets are now to be "sewed" or "stitched" together. Sewing and stitching are, in binders' parlance, two very different methods of accomplishing the same end. "Stitching" or "stabbing" is the simpler and cheaper process of driving a thread or a wire, by the help of machine-power, straight through all the sheets of a book, which are first stacked evenly together, or "jogged up" by the back and top. For thin pamphlets, a line of stitching is sometimes run across the back by an ordinary sew-

STITCHING MACHINE.



MARBLING BOOKS.

ing-machine, built very stout and strong. The more usual method is to carry the thread through two or three holes by a stout needle, and tie it by hand. Wiring is the most modern method, by which tinned wire is fed from a spool, cut into a staple, driven through the book by the machine, and clinched on the other side, two or three such clamps completing the book.

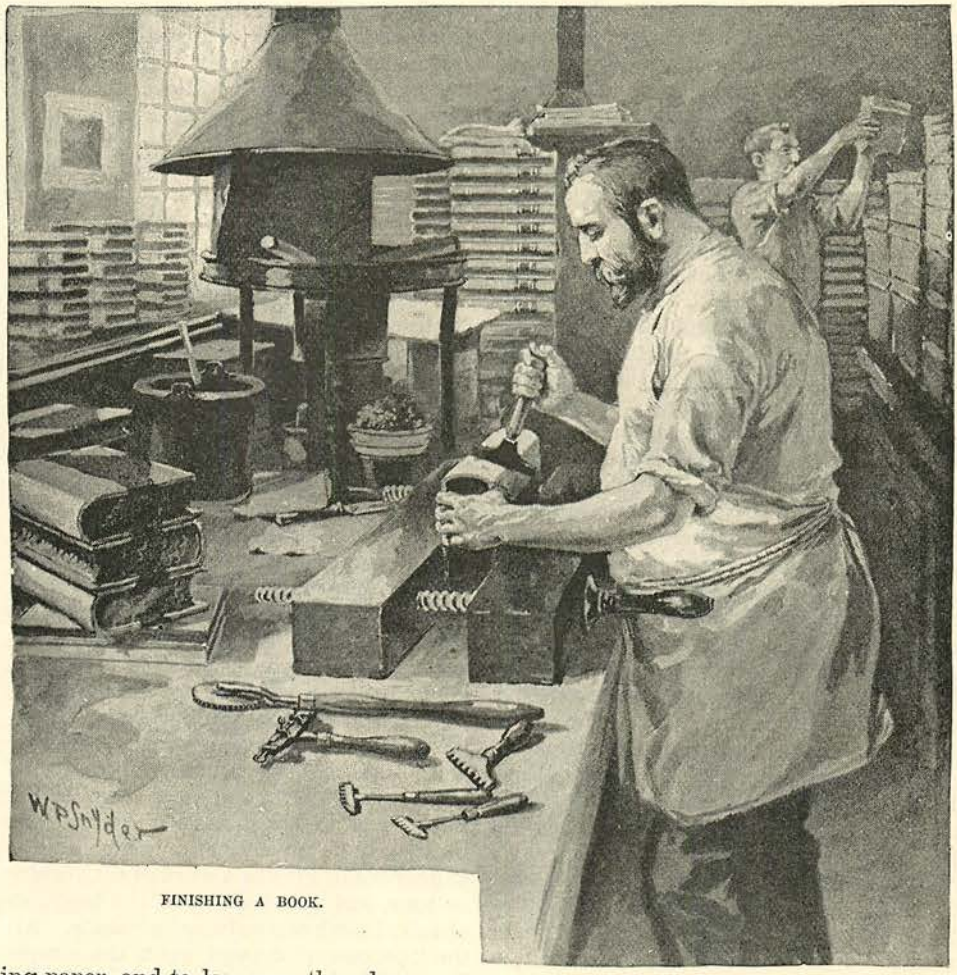
In sewing, which is both the older and the better way, the set of sheets is placed in a press or treated by the "smasher," which at a quick blow presses them firmly together between two plates of metal, and is thence taken to the "sawing machine," where a circular-saw cuts four or more furrows across the back to receive the threads. Several sets of sheets are pressed and sawn in a single stack, which is then taken to the sewing bench, an upright frame in which bands of twine are threaded perpendicularly, so that they fit into the furrows made by sawing. Here a girl sits, who sews and ties each sheet separately through its fold upon these bands. When she has finished "a bench of books," as a frameful is called, it goes to the "preparer," who "draws off" each set of sheets separately, fastens the bands, and pastes in the end or lining papers.

The books thus "prepared" are now trimmed at the edges by the "guillotine" or other cutting machine; "uncut" books of course escape this barbarity. If books are to be gilt-edged, red-edged, sprinkled, or marbled, these processes are next in order. The gold is applied in leaf, and burnished on. Red edges are made with the brush, and gilding is sometimes afterward added, producing a very beautiful effect. For sprinkled edges the color is literally sprinkled on from a brush. Marbled edges are produced by dipping the book edges in a marbling trough, just as marbled paper is produced.

The back of the book is now covered with glue, and presently "rounded" by pounding with a hammer till it takes the desired curve. It is next "backed" by placing it edge down between two clamps and working over it a heavy roller, which causes the back to spread slightly over the clamp, so that a ridge is formed along its edge, into which the cover board may fit. The head-band and backing of cloth are glued on, and the book is now ready for its "case."

For cloth-bound books, in considerable editions, covers are made in quantities separately from the book. The basis is

the two pieces of "binder's-board," a stiff pasteboard, made usually of manila, cut to the size of the cover, and perhaps bevelled at the edges. The piece of cloth or book-muslin has been cut large enough to allow for the back width of the book, where it is stiffened with a strip of stiffening paper, and to lap over the edges of the boards, and this is glued upon the two sides and folded over. For the lettering and ornamentation, brass dies have been cut or stamps electrotyped from type, and the blank stamping, colored ink, or gold-leaf is stamped on with the power of the embossing press.



FINISHING A BOOK.

The book is finished by "casing-up," which consists simply in pasting the set of sheets into the case by means of the outer flap of the lining papers.

In "fine bindings," where each book is separately covered, the bands are fastened to the boards through holes before the cloth, leather, or paper is pasted upon the sides, and the lettering and "tooling" which ornament edges, backs, or sides are put on with individual tools by the finisher.

VIII.

The engraver is a modern magician who has caused art to blossom in every corner of the land. If we put side by side an old block-book, one of Bewick's cuts, an English magazine wood-cut of twenty years ago, and one of the fine American tone engravings of to-day, we shall get a pictorial history of the progress of wood-engraving. The early engravers cut in bold outline, as if for filling in with

colors, black lines on white ground, using the fibrous side of pear or apple wood blocks. There was also the so-called "dot manner," perhaps suggested by goldsmiths' work, in which figures were produced by white dots on a black ground. The engravers of Dürer's and Holbein's day attempted finer work, introducing the cross-hatching, an imitation of brush shadings, and bolder black, with which was sometimes combined the stipple developed from the "dot manner," and later a style of white line on black ground. These proved too much for the ordinary press of that day, especially in connection with type-work, and wood-engraving, shunned by typographers, fell from its high estate to debased styles, and gave place, for book illustration, to copperplate printing. It was Thomas Bewick, of Newcastle, England, who revived the art in his books of *Fables*, *Quadrupeds*, and *British Birds*, published between 1779 and 1804. To him are attributed the use of wood cut across the grain, overlaying, and the counter process of slightly lowering surface portions of engraved blocks; but it is probable that he revived and combined rather than originated these. He was apprenticed to a metal engraver, but his art instincts led his graver to wood; his pictures of birds and animals are the perfection of simple vigor, avoiding the methods of copperplate, striking out for clean lines and masses in strong contrast, using both the black and the white line, never wasting two lines when one would tell the story. With his pupils and imitators, wood-engraving came into high fashion in England. Large blocks were attempted, but again presses proved inadequate; even the Stanhope press was unequal to Harvey's "Dentatus," a block 15 by 11½ inches, and it broke under the pressure of the Columbian press. These difficulties were ultimately to be avoided by the machine presses and the help of electrotyping, but meanwhile there was another reaction. Charles Knight's popular illustrated books and the illustrated papers and magazines which started a generation ago, again revived wood-cut work, and in the last twenty years there has been a surprising growth.

The engraver has upon his table a smooth block of boxwood, upon whose surface appears, reversed, the drawing or a photograph from the picture which he is to reproduce. Modern photography has been able to coat the wood with a sensitive film which takes an exact photograph, reversed, of a picture to be copied, leaving the picture itself as a guide to the engraver. This is a double gain, and most artists now draw directly on paper in wash or body color, in preference to drawing backward on the wood itself a design which the graver's tool must destroy as he interprets it. The block is placed upon a cushion on the engraver's table, and between the block and his eye is a magnifying-glass, supported from a frame, through which the eye directs and follows the hand. Thus equipped, the engraver uses otherwise only the simplest tools—gravers of well-tempered steel, sharpened occasionally on a whetstone near at hand, and sometimes the multiple graver or "tint tool," which has a cutting series like a comb, and cuts parallel furrows. This last is seldom used by the best men. Line by line, with exquisite patience, the engraver pursues his wonderful work, in whose highest reach there is no secret beyond the eye careful to see, the hand deft to cut, the artistic judgment which dictates the right kind, direction, and width of line to interpret the artist's feeling. The graver cuts away the furrows in the wood, leaving ridges which are to be the lines of the print, so that a magnified wood block is simply a carefully ploughed field.

Nature and science have of late years been set to vie with the work of the engraver, and it is now possible to copy a landscape or a work of art for reproduction by the printing-press without the intervention of the human hand. "Process work" makes a more exact fac-simile of pen drawings than the most accurate engraver can do, but it finds its limitations in the artistic interpretation which a great engraver can give to a work of art in color or tone, and to which even the best mechanical work can only approximate. All the "processes" depend upon the simple fact that bichromatized gelatine (or a similar material), when exposed to light, is rendered insoluble, while parts not so exposed can be dissolved away, leaving the other portions in sharp line, or swelled by water, producing a hill and valley surface. There are in the multiplicity of "processes" three general kinds, the simplest being the reproduction of line-work in absolute fac-simile, by making an ordinary photographic picture of the pen drawing on the prepared gelatine, and dissolving away the white spaces. The

Drawn by W. P. Snyder. Engraved by Tinkey

ENGRAVER AT WORK.

gelatine relief which remains serves in one variety of this kind of "process" to make a plaster cast, from which a stereotype can be taken, or it is directly electrotyped; or the gelatine itself in one method is so hardened that it can be printed from to the extent of tens of thousands of impressions without the use of metal. The cut on page 178 is an example. By using paper prepared with a surface in grain or line relief, soft-pencil drawings not in distinct line may be adapted to this process.

The second kind of "process" is the "half-tone," by which a picture not drawn in lines or points, but in tones or brush-work, like a wash-drawing or oil-painting, is divided into tiny lines or blocks in the process of photographing, and thus becomes a relief plate, closely imitating the effects of the brush. The

most successful method is that patented by Mr. F. E. Ives, an American, in 1881, in which the gelatine picture is swelled till the light parts of a picture stand out in hilly contour, like a relief map of the White Mountains, while the black parts remain as valleys. By taking a plaster cast from this the dark parts become the hills and the light parts the valleys. The ingenious part of the Ives process, most difficult to describe, is the inking method, for which the elastic "composition" of glue and molasses used in inking-rollers is made in flat sheets, furrowed by V-shaped ditches, which are crossed by other lines of ditches not quite so deeply furrowed. This leaves the inking surface a series of tiny pyramids close together, and the ink is pressed on so that it not only inks the tops of the pyramids, but their sides and the ditches between. This inked surface is now turned on its face and pressed upon the white plaster cast. Where this cast is high (the darks of the original picture), the inked pyramids are flattened out against it by the pressure, and leave a broad square of ink; where it is low (the lights of the original picture), only the tiny tops of the pyramids touch the cast, and the merest point of ink is left. The absolute blacks in the original picture are so high that even the furrows of the inking surface are pressed against the cast, obliterating the spaces between the blocks, and giving an absolute mass of black; *per contra*, the absolute whites of the original picture are so low in the cast that even the tops of the pyramids do not touch them, and they are not inked at all. When the inking surface is removed, the eye sees on the plaster almost an exact reproduction of the original picture, in little blocks instead of in continuous tone. This is taken off the plaster by a collodion film or photographed directly, and the picture being now practically in line or point, a relief plate is easily made, like that on page 181. Another method of "half-tone" work, made public by Meissenbach, a German photographer, consists in photographing the original picture as seen through a so-called "grating" made by coating glass with an opaque film, through which transparent lines are cut. By placing this "grating" a little distance in front of the picture a curious optical effect of translating the darker portions of the picture into thicker lines is produced. From this line effect a relief plate is produced.

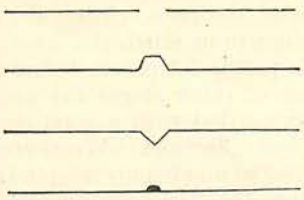
The third kind of "process" includes the photolithograph and the photogravure, which present themselves under any number of names and patents. Neither of these produces a relief plate which can be used on the ordinary printing-press. The photolithograph is made, after slightly wetting the gelatine, by inking it with lithographic transfer ink, which is of course rejected by that part which has accepted water, and so transferring the picture to the stone for ordinary lithographic printing. The photogravure is kindred to copperplate printing, a plate being made in metal in the hills and valleys before described, in which the blacks of the picture are represented by the depressions in the plate, which are deepened by a peculiar use of emery powder sprinkled on the mould, by which the granulated surface disclosed by a careful examination of photogravures is produced. This metal plate is inked as a steel or copper plate would be, the ink being left in the depressions and cleaned off the high lights, and the impression is taken by pressure on a copperplate press.

Photographic progress has now reached that point where it is possible to photograph colored objects, and reproduce them either in the equivalent light and shade, or, by the combination of several relief plates, in approximation to their actual colors, though this last has not been applied to any practical extent. In ordinary photography blue and purple turn out white, and strong red becomes black. By the use of plates prepared with a solution of chlorophyl (the remarkable natural substance which is the coloring matter of leaves) Mr. Ives in 1879 produced a true "isochromatic" photograph, and he contests the claim of priority of a German scientist, Dr. Vogel, who uses eosine to accomplish a like result. By using properly sensitized plates, the blues, the yellows, and the reds of natural objects may be eliminated, and a relief plate made for each, which, used in succession with the proper inks, would achieve a nature-colored press print.

IX.

Type or xylographic (wood-cut) printing is but one of four general methods of impressing a print upon the surface of paper, which are illustrated in the diagram (page 185), showing the four ways of printing a black line. The first is the old-fashioned method of the stencil, in

which the line is cut *through* thin metal or paper, and the ink is brushed on. This



METHODS OF PRINTING BLACK LINE.

is still somewhat used for coloring picture-books, and has had a curious modern revival in the devices for multiplying handwriting: by the electric pen, in which a fine needle, worked by electricity, makes minute holes in a paper stencil; the cyclostyle, which does the same thing by a tiny wheel or ball covered with sharp points; and a still later contrivance, in which a metal stylus presses prepared paper against sharp ridges of a metal surface underneath, and cuts a very similar stencil. Through any of the stencils thus prepared a brush or roller or pad makes an inked print. The second method is the raised line of type-work, wood-engraving, stereotype or electrotype, or "process" relief plate, worked on the printing-press as already described. The third method is the incised or cut-in line of the engraver on steel or copper, or the etcher in line or point, each of whom cuts his lines below the surface, rubs the ink into these lines, cleans off the surface of his plate before each printing, and removes the ink from the graved lines to the paper by applying the latter under enormous pressure. The fourth method uses no cut or raised lines, but transfers ink from a surface of stone or gelatine to a surface of paper as a result of chemical affinities; it is the method of lithography, and of such multiplying processes as the papyrograph and hektograph. These latter, however, have the peculiarity of printing from the original inking, giving off more and more faintly with each copy a portion of the aniline ink in which the original is written.

About 1440, Tommaso Finiguerra, an Italian artist in *niello* (black) work, or the art of cutting ornamentation upon metalwork and filling in the lines with a black composition, hit upon a process of taking proofs of his work by rubbing lampblack and oil into the lines, and pressing paper upon the metal. This is said to have been the beginning of plate engraving, though a German origin is also claimed for it. It is the most difficult of all the processes of illustration, whether on the softer copperplate or on hard steel, which latter may, however, be tempered soft for the engraver and again hardened. The plate engraver's tools are a burin or graver, foursquare but sharpened diagonally, to cut clean, strong lines; the dry-point, or needle, to scratch fine lines; the scraper, to scrape down the bur left by the dry-point; the burnisher, to polish the surface for high

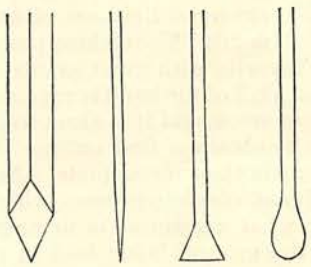


PLATE-ENGRAVERS' TOOLS.

lights, and to erase errors, when the plate is beaten up from the back to get a new surface; and the rubber, a roll of cloth dipped in oil, to finish the surface. He cuts his lines always from him, with strong, firm, delicate hand, and must reverse the picture as he works. Stipple—a kind of engraving using dots instead of lines—was formerly much in vogue for portraits, but is now chiefly used in combination with line. Mezzotint is a kind of engraving said to have been suggested to Prince Rupert by the sight of a soldier polishing his rusty blade. The metal plate is roughened all over so as to hold ink, by "rocking" with a grounding tool or cradle—a sort of graver with toothed edge—lengthwise, crosswise, and criss-cross, and the ground thus produced, which prints the dark "middle tint" from which the process takes its name, is scraped and burnished to produce the half lights and high lights.

Etching is a variety of engraving of uncertain origin, in use soon after 1500, in which the metal (or glass) plate is covered with a waxen composition, upon whose surface a design may be transferred, or which may present a clean ground for the free-hand artist. The artist with a sharp etching-needle draws through this composition, exposing the surface of the

metal; a wall of wax and pitch is then formed around the plate; acid is poured upon it, which bites lines into the exposed metal, leaving the protected parts untouched. This is quickly run off, and the plate rinsed with lukewarm water. The lines which are bitten in sufficiently deep are then stopped up with a mixture of lampblack and turpentine applied with a camel's-hair brush, and those which are to be deepened are again subjected to acid till the strongest lines are of sufficient depth. The etching process has been a favorite with great artists, as less technical skill of the hand is required than for graver work, and it is also used by engravers to obtain a first outline of their subject upon their metal plate. Aquatint is an almost obsolete process, which is to etching what mezzotint is to engraving proper, the ground being laid in pulverized resin dissolved in spirits of wine, which granulates in drying, permitting the acid to reach the plate in the interstices, and giving when printed an effect like a wash of India-ink.

ROCKING TOOL.

All these methods give a reversed picture in incised or cut-in lines, and their printing is the reverse of typographic or wood-cut printing. The plate is covered with ink, which is well rubbed or rolled into the lines, and the ink must then be rubbed clean off the rest of the surface, so that perhaps not a hundredth part is used. A dampened plate-paper is then laid upon the plate, and great pressure is required to transfer the ink from out the lines upon the surface of the paper. The plate press is practically the "rolling-mill" of the iron-foundery, two metal rollers in a stout iron frame, between which the plate and paper pass under heavy pressure, the upper roller being blanketed to press the yielding paper into the engraved lines, and worked by long arms like a ship's wheel. This press is also used to make transfer plates, soft steel being pressed against the hard steel engraving till it takes the lines in relief, and this plate being hardened so as to incise its relief lines into a third steel plate, closely duplicating the first. The process of plate-printing is necessarily slow, three hundred impressions of a large plate being a fair day's work; a steam plate press has been invented, but has been only moderately successful. The wear on a copperplate by the polishing first with a rubber and then with the hand, and by the strong pressure of the press, causes the earliest impressions to be much the finer, so that "artist's proofs," "proofs before letter," and those of other stages are usually of higher price; but with a good steel plate there is less difference. Wood-engraving has proved so much more adapted to book illustration that the number of plate-engravers is very much reduced; few are apprenticed, except by the bank-note companies, and steel-engraving is becoming almost a lost art.

In 1796 a musician of Munich, one Aloysius Senefelder, who had used bits of limestone for jotting down his musical notes before he put them on paper, happened to drop a piece of this stone, with a memorandum of some clothes the washerwoman was taking away, into the slop-bucket. On snatching it out, he noticed that grease adhered to the pencil marks, but not to the rest of the stone. This set him a-thinking, and for four years he studied drawing, tried crayons and inks and acids, and worked at devising a press, until in 1800 his new art of lithography was achieved, and he obtained the exclusive privilege of its exercise. From all over Europe came offers that would have made him rich, but choosing to have all or nothing, he got nothing. The secret leaked out, he could not protect his privilege, and in a few years several printers were using lithography, though Napoleon is said to have refused permission to practise the art in Paris because it offered a premium to counterfeiting.

The key to the process is simply the mortal antipathy of grease and water. A fine calcareous stone is used, found at its best near Munich, but also in the United States and elsewhere. It must be so porous as to absorb the lithographic ink or crayon (which is made chiefly of pure wax, white Castile soap, and mutton suet, with enough lampblack to make it distinct), yet so close-grained as to prevent the grease from getting much below the surface. The stone is "grained" by rubbing two stones together, if it is to be drawn on with crayon, or polished if for line-drawing or for transfer from paper. If the drawing is made upon paper, with a like greasy ink, it is direct; if upon the stone, it must, of course, be reversed. After the design is put upon the stone, a thin wash of gum

and acid penetrates between the grains of the parts not drawn upon, etching the surface slightly; and a wash of turpentine, which in turn affects only the drawing, takes out the lampblack, and leaves the colorless grease—to the sad astonishment of the novice in lithography, who sees his careful drawing vanish into naught. When the print is to be made, the stone is first dampened, the drawing repelling the water, and the rest of the stone taking it, and then inked with a roller, when the drawing takes the ink, and the rest of the stone repels it. The paper is now placed on the stone, and both together are run under a scraper, or roller, under severe pressure, whereupon the ink leaves the stone and remains upon the paper. The stone is now ready for another dampening, another inking, another impression; or it may be put away, with a coating of gum, for future printings; or it may be rubbed down to a new surface below the drawing, and used afresh for a new work. Zinc may be used much like the lithographic stone, producing a zincograph.

Chromo-lithography, starting from the so-called lithochromy of Lacroix, in Paris, in 1826, has developed to extraordinary results, twenty or more stones, carrying as many tints, being now used to reproduce, by as many successive printings, the gamut of the artist's palette. The color lithographer produces first an outline or ground impression from a key-stone, giving the general features of his picture. Prints from this stone are transferred in red chalk to other stones, on each of which, with the guidance of the outlines, the artist draws that part of his picture which is to have the color this stone will carry. Two points or cross lines, which appear on every stone, form a guide to give each color its exact "registry" with other parts of the picture in the printing, the sheet of paper being laid on the press by the help of these guides with absolute exactness. The skilled chromo-lithographer, in his choice of colors, seeks to produce the maximum of tones with the smallest possible number of printings, and the results achieved in the rapid work of such papers as *Puck* are often as surprising in their way as the triumphs of the Prang "chromos" in another direction.

The hand lithographic presses are always of the style devised by Senefelder himself, a scraper pressing the paper upon the stone as it rolls by under severe pressure. The steam lithographic press, invented in Paris by M. Eugues, 1850, is on the same principle, the stone moving under a roller to and fro, with attachments for alternately dampening and inking; it can print over a thousand copies an hour. One of the advantages of the lithographic process is that a drawing may be printed simultaneously on any number of presses by a simple process of taking an impression from the first stone in transfer ink, which sets off under pressure upon a clean stone, that can be at once made ready to print.

X.

The printer's trade can show one of the best organized labor unions of the country, or of any country, in the International Typographical Union, with its 159 associated local unions of compositors in as many places in the United States, Canada, and the Sandwich Islands (the Blue Grass, Kentucky; Tombstone, Arizona; Seattle, Washington Territory; and Victoria, British Columbia, being among the more recent), and sixteen pressmen's unions in the chief cities. The number of unions which have lapsed is, however, considerable, and a few "Printers' Protective Unions" of employers and employed oppose "free labor" to "organized labor." The membership, which reached 9800 in 1874, fell in 1878 to 4200; was in the census year 6600, and in 1885 reached 18,000. Each union printer in good standing has a travelling card, which is his passport to union offices, and which he deposits with the local union under whose jurisdiction he is at work. Union men taking work below the union scale become "rats," and a "Black Book" of such is kept. Each union makes its local scale of prices, and these vary extraordinarily, according to the reports of each to the International Union, having been within the past two or three years as high as 38 to 40 cents per thousand ems for day and 46 cents for night work in New York, and 50 cents for either in San Francisco, in both of which places weekly hands are at $18 per week, while in Leadville they reach $26; and as low as 20 cents per thousand ems for day and 25 cents for night work in Lawrence, Kansas, while weekly rates run as low as $9 to $12 in the smaller cities. Prices in non-union towns have "varied as much as fifty per cent. within a radius of fifty miles." Each union also

decides what proportion of apprentices to journeymen it shall permit. Strikes are deprecated in these General Laws, and can be ordered only by a three-fourth vote of a union; but provision is made for a strike fund, started at twenty-five cents per head, from which an Executive Council of the International Union may appropriate strike benefits of $7 per week per man to support strikes which it deems to be necessary; and rigid discipline is provided against union men who take or keep work in strikes, and in case of "the wilful violation of boycotts." The unions are judges of the qualifications of their own members, but are prohibited from admitting any one who has not served an apprenticeship of five years. They are prohibited from making any distinction on account of sex, and nearly two hundred women are members. Besides this organization, the men in each printing-office are usually organized as a chapel—a name originating, it is said, from the fact that Caxton's printing-office was a chapel in or near Westminster Abbey.

The betterment of wages is strikingly shown in the printing trades. Half a century ago American compositors were paid 25 cents or less per thousand ems on work which during the war reached 55 cents (currency), and is now at 40 cents—an advance of nearly double, considering the prices of the necessaries of life. English compositors in 1785 received but 3¼ pence (6½ cents) per thousand ens (a measure one-half our ems), and now receive 6*d.* to 9*d.* (12 to 18 cents) per thousand ems, and 8*d.* to 11*d.* (16 to 22 cents) per hour for corrections. Previous to 1850 American compositors averaged from $1 13 to $1 38; by 1860 they had reached $1 75, and during the height of the war earned $3 (currency) and upward; since 1872 the average has been from $2 25 to $2.

The product of the modern press almost defies estimate. In 1886 4676 books were recorded by the cataloguers as issued in the United States, 5210 in Great Britain, 16,253 in Germany, all of them probably below actual figures, since the Library of Congress acknowledges 8352 deposits scheduled as books. There are 15,000 periodicals in our own country alone. Truly, "of the making of books," and of the writing about them, "there is no end."

The following table shows the development of the printing industry in the United States according to census returns:

	1850.	1860.	1870.	1880.
Number of establishments	673	1,666	2,159	3,467
Number of hands	8268	20,159	30,743	58,478
Capital	$5,862,715	$19,622,318	$39,924,227	$62,983,704
Value of material	$4,964,225	$12,844,288	$24,600,245	$32,460,395
Wages	$2,737,308	$7,588,096	$18,795,356	$30,531,657
Product	$11,586,549	$31,063,898	$66,469,000	$90,780,341
Wages per person	$331	$376	$611*	$520

* Currency = $489 gold.

PHILLADA.

OH! what a pain is love!
How shall I bear it?
She will unconstant prove;
I greatly fear it.
She so torments my mind
That my strength faileth,
And wavers with the wind
As a ship saileth.
Please her the best I may,
She loves still to gainsay:
Alack and well-a-day!
Phillada flouts me.