other of fourteen and a half. A steep stair leads through the vaulted gateway to a third entrance, defended by a portcullis and by machicolations, which opens into the guard-room, whence concealed wickets and narrow stairways led into the different parts of the abbey.

The principal of the conventual buildings is that called the Merveille, from its immense size, its walls measuring two hundred and forty-six feet in length and one hundred and eight feet in height. It has three stories of halls, with a cloister above and vast vaulted crypts beneath. Of the halls, that called the Salle des Chevaliers, where the knights of St. Michael held their chapters, is the finest. It is ninety-eight feet long by sixty-eight wide, and is divided into four naves by three rows of columns. Like the greater part of the superstructure of the Merveille, it dates from the twelfth century. Above it is the cloister, a gem of Gothic architecture, and by far the most beautiful part of the building. Its windows, which look out on the bay, are three hundred and thirty feet above the sea.

The church occupies the summit of the rock, and is in the form of a Latin cross. Its nave and transepts are in the massive style of the twelfth century, but the choir is of the fifteenth century, and one of the best examples of the flamboyant style extant. Beneath the latter is a curious crypt, in the middle of which is a circle of short thick pillars set close together around a central one. They support the entire apsis and the base of the great tower, which do not bear perpendicularly on the main platform of the rock. Under the north transept is the great cistern, excavated in the solid rock, from which the abbey was supplied with water.

Under the buildings upon the south and the west sides of the rock are the subterranean dungeons, of which there are several stories. Some of them are oubliettes, and many of them have fitting names, such as the Trap, the Devil's Dungeon, In Pace, etc. At the extremity of one of the larger caverns on the south side is shown the place where stood the cage in which prisoners of state were confined. It was here that Louis XV. shut up Dubourg, the Frankfort journalist, to be devoured by rats, because he had dared to lampoon Madame De Pompadour. The cage, which was built of heavy beams of wood placed three inches apart, was destroyed in 1777 by the sons of Philippe Égalité, Duke of Orleans, during a visit made by them to Mont St. Michel in company with their "governor," Madame De Genlis.

When Mont St. Michel became a house of correction, the church, the cloister, and other parts of the buildings were transformed into workshops, and the sound of hammer and file was heard where once echoed the clang of knightly arms and the voice of praise. But a few years ago the wooden platforms and partitions were destroyed by fire, and the place thus purified has not since been contaminated by the presence of criminals. Every lover of art will unite in the hope that this noble monument of a period which has left few other memorials comparable with it, this "grandest work of the Benedictines," as the Marquise de Créquy enthusiastically calls it in her *Souvenirs*, may receive henceforth the care commensurate with its historical and artistic value.

THE FIRST CENTURY OF THE REPUBLIC.

[Fifth Paper.]

MECHANICAL PROGRESS (*Concluded*).

PRINTING.

THE art of taking an impression from an inked stamp is of great antiquity, being found in the most ancient Egyptian and Assyrian remains. Of yore the rude king who smeared his hand with red ochre or the soot from a burning lamp, and then made the impression of his palm and digits beneath a grant of land, was a printer in his way in thus *putting his hand* to the document. Then came seals, engraved in *relief* or *intaglio*, and delivering an impression of the design upon bark, leaf, or skin, either white marks on a dark ground or dark on a light ground, according to the character of the engraving. Seals containing the pronomens of the Pharaohs, each in its cartouch, rewarded the early explorers in the valley of the Nile, and more lately the stamps and tablets of the recorders of the cities of Mesopotamia have been disinterred by thousands. The impressions, having been made in plastic clay, and then baked, have endured without injury a sepulture of twenty-five centuries. They exhibit the kindred arts of engraving and plastic moulding. It may be safely assumed that they were also used for giving printed impressions, but such memorials are, in the nature of the case, less permanent. Some of the ancient stamps in the British Museum are of bronze, and have reversed raised letters, evidently intended to print on bark, papyrus, linen, or parchment.

To this stage of progress various nations of the world had advanced, and yet it can hardly be said that printing, as we understand the word, had been thought of. This

EGYPTIAN AND CUNEIFORM, IDEOGRAPHIC AND SYLLABIC.

evidently originated in China, but it is not certain that Europe derived it from thence. The first notice that we find of printing is in the Chinese annals. Du Halde cites the following from the pen of the celebrated Emperor Van Vong, who flourished 1120 years before Christ. This was about the time of Samuel the prophet, and a little before Codrus, the last of the Athenian kings.

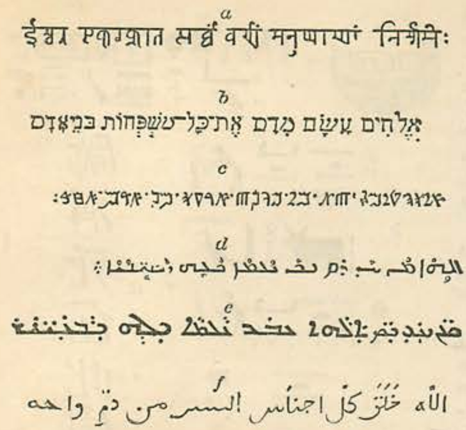
"As the stone 'Me' [ink, in Chinese], which is used to blacken the engraved characters, can never become white, so a heart blackened by vice will ever retain its blackness."

Other Catholic missionaries concur with Du Halde in supposing printing from blocks to have been invented at least as early as 930 to 950 B.C. The plan adopted was to take a block of pear-tree wood, squared to the dimensions of two pages of the work. On the smooth surface of the block the written pages are inverted, and the paper rubbed off, leaving the ink on the block, which is then delivered to the engraver, who cuts away all the parts not inked. No press is used, but the surface being inked by one brush, the paper is laid upon the block and dabbed down by a dry brush; the sheet is lifted, carrying the ink with it, and is folded with the blank sides in, one side only being printed; the folded edge being outward, the Chinese or Japanese book looks like one with uncut leaves. The first four books of Kung-fu-tze (Confucius) were thus printed between 890 and 925 A.D., and the description equally applies to the mode yet practiced.

The same system was used in Europe in the thirteenth century for printing playing cards and ornamenting fabrics; later, the works known as *block books*, each page being an engraved block like those of the Chinese. Such was the *Biblia Pauperum*, one of the earliest of European block books, compiled by Bonaventura, the chief of the Franciscans, in 1260. In manuscript form, as a book of forty or fifty pages of illustrated Bible scenes and passages, this Poor Man's Bible was a favorite for five centuries. It was printed as a block book about A.D. 1400. The *Speculum Humanæ Salvationis* of Koster, of Haarlem, to whom the credit of the invention of printing has been hence ascribed, was also a block book. Volumes by the score have been written on the rival claims of the cities of Mentz and Haarlem to the invention of printing. From a careful examination of the subject it would appear that Mentz has the prior right, and that the general verdict in favor of Gutenberg is correct.

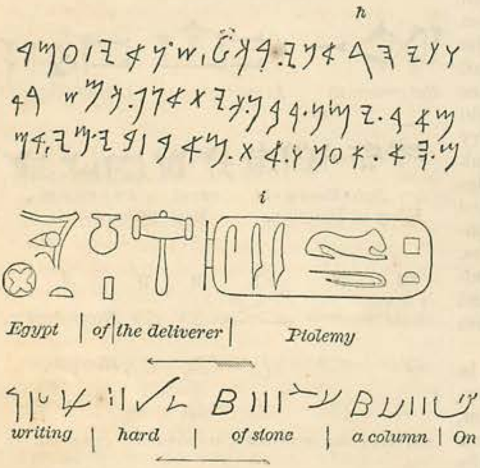
About the year 1041, a period when Edward the Confessor was King of England, another forward step was made in China. A blacksmith named Pi-Ching invented a mode of printing from plates formed from movable types, each of which represented a word. The types were about the thickness of a half dollar, each had a word on its face, and they were arranged in order on a backing plate, to which they were attached by mastic.

The Chinese have never advanced beyond *ideographs*, or *word signs*, in which arbitrary symbols (*d*) are made to represent things, qualities, or actions. The language has no elasticity, and, like the Egyptian hieroglyphics (*a b*), is incapable of fulfilling modern requirements. In this respect it is like the ancient Scythic cuneiform (*e*); but the genius of the Mesopotamian nations could not be thus cramped, and the language gradually took on the syllabic form: the cuneiform of the second period (shown in *f*) is a transition form. The Persian cuneiform was substantially syllabic. Other languages of Asia early assumed the phonetic form, in which signs stood for sounds, though it was many ages before the vowels were written definitely. The Phœnician (*h*), which is the



PHONETIC LANGUAGES OF ASIA.

a, Sanskrit. *b*, Hebrew. *c*, Samaritan. *d*, Syriac. *e*, Syrio-Chaldaic. *f*, Arabic.



PHŒNICIAN AND EGYPTIAN WRITING.

h, Moabite Stone. *i*, Rosetta Stone.

basis of all the principal alphabets of Europe, had its twenty-two letters 700 B.C., when the black basalt stone was used to celebrate the successes of the King of Moab. *i* is a portion of the inscription in hieroglyphic and demotic from the Rosetta Stone.

That which the Chinese were incapable of doing, from the nature of the case, was done by John Gutenberg, who was born in 1400, at Mentz. In company with Faust and others he printed several works with wooden types and wooden blocks: the *Alexandri Galli Doctrinale* and *Petri Hispani Tractatus* in 1442; and subsequently the *Tabula Alphabetica, Catholicon Donati Grammatica*, and the *Confessionalia*. In 1450 the Bible of 637 leaves was printed by Gutenberg and Faust with *cut* metallic types. Faust retired from partnership with Gutenberg in 1455 and became allied with Schoeffer, and they published in 1457 the *Codex Psalmorum* with cut metallic types; the *Durandi Rationale*, published by them in 1459, was the first work printed with cast metal types. Gutenberg took other partners, and published the *Catholicon Jo. de Janua* in 1460. He used none but wooden or cut metal types till the year 1462. Gutenberg died in high honor in the year 1468.

Peter Schoeffer, of Gernsheim, the partner of Faust and former workman of Gutenberg, was the inventor of *cast* types, the greatest invention of any of the series.

It may be mentioned that, in the early stages of the art, sheets were printed but on one side, and the backs of the pages pasted together. The pages were without running title, running folio, or direction word. The forms were usually folios, sometimes quartos. The character was a rude Gothic mixed with an engrossing character, and designed to imitate handwriting. Scarcely any division was made between words; the orthography was arbitrary and irregular; abbreviations, in imitation of cursive writing, were numerous; punctuation was confined to a double dot (:) or a single one (.), afterward a stroke (/), known as a *virgule*, was used for a slighter pause, and grew into a comma (,). Capitals were so sparingly employed that the beginning of sentences and proper names of men and places were not thus distinguished. This honor was reserved for paragraphs, and here the space was left vacant by the printer that the illuminated capitals might be put in by hand.

This was soon changed. The era of Leonardo da Vinci, Albert Dürer, Raphael, Michael Angelo, and Vandyck, of Benvenuto Cellini, Galileo, Kepler, Shakspeare, and Bacon, could not long endure mediocrity. The type-founders and printers were worthy of the occasion, and their work leaves little to be desired on the score of sharpness and color. The letters of their books have a vivid blackness that makes one who takes an occasional excursion into *black-letter* wonder where they obtained their ink. The *color* of our pages is gray and rusty in comparison.

In celebrating the achievements of the century we will not claim that we print better, but we do it more easily and much faster; while we handle with great appreciation and respect the works of our worthy, patient, and persevering predecessors, they would view with admiration mixed with awe the towering structure of Hoe, or the compact perfecting presses which print from a web of paper from one to three miles long, and deliver in piles at the rate of 12,000 per hour. They might think, as the doctors of Paris did of Faust, when they considered, from the cheapness of his books and the exact correspondence of their pages, that he was in league with the Evil One.

The art of printing was scattered over Europe when the city of Mentz was taken and plundered by Archbishop Adolphus, of Nassau, in 1462. Within the next decade the Caxton press was set up at Westminster, and that of Theobaldus Manutius at Venice. Æsop's Fables, by Caxton, is supposed to have been the first book with its leaves numbered.

Italic, Greek, Roman, and Hebrew fonts were cast, letters were pruned of their irregularities and excrescences, and order was gradually introduced and concurred in.

The *Aldine* classics are celebrated in prose and verse; in the latter by Alexander Pope among others. The Aldine "Livy" was perhaps the first perfect book, as a modern printer might say. This press was in the hands of the descendants of Aldus for nearly a century.

Catch-words at the foot of the page were first used in Venice by Vindeline di Spori. They have but lately been abolished. *Signatures* to sheets were used by Zorat at Milan in 1470.

A new light dawned upon the nations of Europe. The avidity with which the pages of the printer were seized and read shows that an unsuspected yearning for knowledge possessed the minds of the people. From this time the current was uncontrollable, and the refuges of lies being undermined, commenced to totter and fall, and some others are yet toppling and falling from time to time.

Germany had taken the lead in the invention of printing, as it did seventy-seven years afterward, when the deputies of thirteen imperial towns protested against the decree of the Diet of Spires. The previous attempts at reform in England and Bohemia were before the invention of printing, and, though not fruitless, were apparently quelled. Italy during the Renaissance, at the beginning of the sixteenth century, was the home of arts and letters. Of the various editions of books published in the sixteenth century one-half were Italian, and one-half of these Venetian. One-seventeenth were English.

At Venice was printed the first newspaper, the *Gazette de Venise*, about 1563, during the war with the Turks; the *Gazette de France* appeared in April, 1631; the *London Gazette* in 1642; the Dublin *News-Letter*, 1685; the Boston *News-Letter*, 1704; the first German newspaper, 1715; the first in Philadelphia, 1719; in Holland, 1732. The growth, mission, and power of the press are to be considered elsewhere.

The first press in America was in Mexico. The *Manual for Adults* was printed on it about 1550, by Juan Cromberger, who was probably the first printer in America. The second press was at Lima, in 1586. The press at Cambridge, Massachusetts, was established in January, 1639, by Stephen Daye. The college was censor till 1662, when licensers were appointed. In 1755 the press was free. A psalter in the English and Indian languages was printed upon this, 1709. The press still prospers as the "University Press."

Printing-presses were established at New London, Connecticut, in 1709; Annapolis, Maryland, 1726; Williamsburg, Virginia, 1729; Charleston, South Carolina, 1730; Newport, Rhode Island, 1732; Halifax, Nova Scotia, 1751; Woodbridge, New Jersey, 1752; Newbern, North Carolina, 1755; Portsmouth, New Hampshire, 1756; Savannah, Georgia, 1763; Quebec, Canada, 1764. The first press west of the Alleghanies was at Cincinnati, 1793; west of the Mississippi, at St. Louis, 1808.

TYPE.

The fonts of the earlier printers, as we have said, had a quaint old Gothic character, with various curious tails and inflections, in imitation of the secretary hand of the period. Schoeffer took the best handwriting of his time for his model. The letters gradually became more formal and compact, with fewer exuberances of flourish and abbreviations. It was some time before Italian taste triumphed over German quaintness; but the change was made with more speed than one might suppose would have been the case, considering what a close corporation it was that owned the art of printing in the tight little city, with its tall houses, dark, narrow streets, and its strongly built bastioned walls frowning upon the River Rhine and the adjacent hill. When the archbishop with weapons of this world scattered the coterie of printers it was like the sending forth of the foxes and firebrands of Samson, which carried conflagration into the fields of the Philistines.

In 1465 Schweynheym and Pannartz, who printed first at Subiaco, and afterward at Rome, introduced a new type, very closely resembling Roman. It was professedly derived from the best handwriting of the age of Augustus; and in their *Commentary of De Lyra on the Bible*, 1471, are to be found the first Greek types worthy of the name. Subiaco was the first place in Italy where printing was practiced. In 1468 Ginther Zainer printed at Augsburg the first book in Germany with Roman type.

Roman letters were first used in England by Wynkyn de Worde, Caxton's foreman and successor. He employed them for distinguishing remarkable words or passages, as is now done with *Italic*.

Theobaldus Manutius (Aldus) introduced the *Italic* about 1476: this is believed to have been imitated from the handwriting of Petrarch. This type was first known as *Venetian;* by the Germans as *Cursive.* The first book printed in Italic was in 1501, with the title, *Virgilius; Venet; apud Aldum.*

In 1476 Aldus cast a Greek alphabet, and printed a Greek book. The Pentateuch was printed in Hebrew at Soncino, in the Duchy of Milan, 1482. Irish characters were introduced by Nicholas Walsh, chancellor of St. Patrick's, in 1571.

Aldus's Greek type and books were made by the assistance of Greek fugitives from Constantinople, which had been captured by Mohammed II. in 1453, since which the area of Turkish domination had been continually extending. Aldus finished the publication of his Latin classics in 1494. Some of his Greek works were interleaved with Latin translations.

In 1500 he printed the first part of his polyglot Bible, the Hebrew, Greek, and Latin being on the same page.

The first book printed in the English language was a translation of the *Recueil des Histoires de Troyes* of Le Fevre, by Margaret, sister of Edward IV. of England. When the princess married Charles the Bold, William Caxton was one of her household, and is understood to have assisted in the translation, as also in the setting up and printing, which were done at Cologne, 1471. Caxton moved a few years afterward to England, where, in 1474, he printed the *Game of Chesse,* the first book printed in England.

For some centuries each printer was a law unto himself as to forms and face sizes of letters, height of type, relation of face to body, and composition of type-metal. In course of time the most tasteful superseded those which had less excellence, and something like order was initiated. Without citing the successive changes and attempts at uniformity, it may be stated that the American and English practices approximate in the names of the various fonts and the sizes of body, from the small diamond, which has 205 ems to a foot, to canon, which has $18\frac{1}{3}$ ems in that length. The agreement is not absolute, nor do even the American type-foundries have precisely the same standard. The French standard was established in 1730. The height to paper of the *Bruce* type is $\frac{92}{100}$ of an inch; other foundries make the height $\frac{11}{12}$ of an inch.

The number of punches in the Imperial Printing-office at Paris was 361,000 in 1860. It has fonts of fifty-six Eastern languages, and sixteen European languages which do not use the Roman character.

The "Spécimen Album" of Monsieur C. Derriey, of Paris (1862), affords the most beautiful and graceful examples of the art of the type cutter, founder, and printer. It may fairly be said that the forms, disposition of parts, accuracy of apposition and register—the latter especially noticeable in the chromo printing—have never been excelled.

The scheme of a font is the proportion of the respective *sorts;* an approximate estimate may be given, but different kinds of work require different proportions; for instance, indexes, dictionaries, and directories are *hard on sorts,* as they require so unusually large a proportion of capitals and points.

In a font of 500 pounds:

Lower-case letters	264	pounds.
Points and references	20	"
Figures	14	"
Capitals	37	"
Small capitals	17	"
Braces, dashes, and fractions	13	"
Spaces and quadrats	98	"
Italic	37	"

For French or Italian the above would be deficient in accented letters. Fonts for special work also contain numerous sorts not in the above, such as superior and inferior letters in capitals and lower-case, superior figures in Arabic or Roman, prime letters, arbitrary signs used in arithmetical, astronomical, botanical, chemical, classic, commercial, mathematical, musical, and other works.

Almost every science has symbols of its own. Algebra has one set, chemistry another. For a dictionary which attempts to represent the minute shades of pronunciation a great number are required. Thus in Webster or Worcester, what with letters with dots above and dots below, lines above, below, and across, there are probably 100 additional characters. Some foreign languages have very complicated alphabets. The Greek, with its "accents" and "breathings," requires about 200. Formerly there were so many logotypes and abbreviations as to require 750 sorts. The Oriental alphabets are complex. The Hebrew, with the Masoretic points, requires about 300 sorts, many differing only by a point, stroke, or angle. The Arabic has quite as many. In Robinson's Hebrew lexicon eight or ten Oriental languages appear, and required 3000 sorts, distributed through at least forty cases.

After all, this is simple compared with the Chinese, which has no letters, as we understand the word, no sign which represents a mere sound, but has an arbitrary symbol for each word in the language.

The Chinese dictionary shows 43,496 words; of these 13,000 are irrelevant, and consist of signs which are ill formed and obsolete. For ordinary use 4000 signs suffice. Kung-fu-tze can be read with a knowledge of 2500. There are 214 root-signs, so to speak, which indicate the pronunciation and form *keys* or *radicals,* called by the Chinese *tribunals.* Each character is a word, and the actual number is vastly increased by tones which give quite a different value and meaning.

The number of letters in the following alphabets is thus given in Ballhorn's *Grammatography* (Trubner and Co., 1861):

Hebrew	22	Ethiopic	202
Chaldaic	22	Chinese	214
Syriac	22	Japanese	73
Samaritan	22	Dutch	26
Phœnician	22	Spanish	27
Armenian	38	Irish	18
Arabic	28	Anglo-Saxon	25
Persian	32	Danish	28
Turkish	33	Gothic	25
Georgian	38	French	28
Coptic	32	German	26
Greek	24	Welsh	40
Latin	25	Russian	35
Sanskrit	328		

TYPE-FOUNDING.

Type-founding is the invention of Peter Schoeffer, and no important improvement on his mode seems to have occurred to the printers for several centuries. In early times all the operations, from the engraving of the punches, striking the matrices, and casting the type, down to the binding of the book, were carried on within the same establishment. Caxton seems to have regarded himself as well supplied, having five fonts. Type-founding was a separate business in England in 1637.

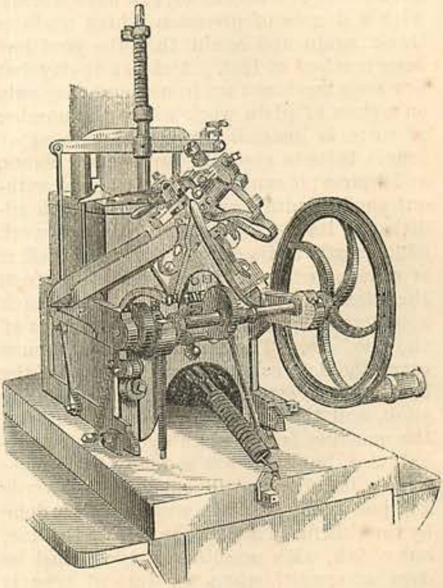
The "Caslon" type-foundry, established in London in 1716, is still known by that name.

The first type-founder in America was Christopher Saur, of Germantown, Pennsylvania, and the first font cast was of German type, about 1735. In 1768 a foundry was established in Boston, but did not succeed. Abel Buell, of Killingworth, Connecticut, succeeded so far as good work was concerned, but was prevented by a turbulent disposition and by the war of Independence, which supervened, and in which he took an active part, from pursuing the business to a successful issue. Just before the war of the Revolution he was one of the party who destroyed the leaden statue of George III. in the Bowling Green, New York, and was discovered at his house melting up the lead into type-metal, so as to put his Majesty to work disseminating information. A piece of the head of this statue, with some punches and matrices, was found many years afterward in the ammunition chest of an old field-piece to which Buell had been attached during the war.

The American provinces had a hard and generally unsuccessful struggle for independence in business before the idea of political independence seems to have occurred to them. No venture in type-founding was successful till about 1798, when Binney and Ronaldson established themselves by State aid in Philadelphia. The type-founding tools and materials imported by Dr. Benjamin Franklin from France for his own use fell into the hands of Mr. Binney and partner.

The old hand-mould and spoon reigned supreme till 1838, when the first successful type-casting machine was invented by David Bruce, Jun., of New York. Machines for casting a number of types simultaneously, projecting from a common sprue like the teeth of a comb, had been invented in America and in Europe, but no success attended them.

David Bruce's machine is the model of all American and many European type-casting machines. The great difficulty experienced in the development of the machine was in the fact that the resulting type was porous and about fifteen per cent. lighter than the hand-made, each of which was formed by a peculiar spasmodic jerk given by the founder to the mould as he poured in the metal. The effect of this was to condense the metal and expel air. In the Bruce machine the



BRUCE'S TYPE-CASTING MACHINE.

metal is kept fluid by a gas jet beneath, and is projected into the mould by a pump, the spout of which is in front of the metal pot. Each revolution of the crank brings the mould up to the spout, where it receives a charge of metal; it flies back with it; the top of the mould opens, and the type falls out. The matrix containing the letter is held by a spring against the mould opposite to the opening at which the metal is injected, and the rate of making is about 100 per minute for average-sized type.

After casting, the *jet* or surplus metal at the foot of the type, and which formed the ingate of the mould, is broken off, the sides of the type are rubbed on a grit-stone, they are set up regularly in sticks, corrected for inequalities, a groove planed in the middle of the base, forming what are known as *feet*. The proportion of each letter for a font of given weight is arranged in a galley six by four and a half inches, and forms what is known as a type-founder's page. This is papered and marked with the kind of letter contained.

Printing types were first electrotyped with copper in 1850, and have lately been nickel-plated.

TYPE SETTING AND DISTRIBUTING MACHINES.

It is now just about fifty years since the first type-setting apparatus was invented, and a thoroughly successful machine has not yet been introduced. Great hopes have been formed from time to time as one machine after another has been announced, and several of these have done very fair work. As mechanical contrivances they have been quite ingenious, and have worked with a degree of precision which made us think again and again that the goal had been reached at last. And yet to-day but few such machines are in use, and they only on a class of plain work where the number of sorts is limited. A machine must of course include capitals, lower-case, points, and figures; it can not be very efficient without small capitals and italics, but each addition to its capability for variety of work adds greatly to its complexity. After all, it is a race between fingers traveling from the stick to the boxes of the case and back again, and fingers beating upon the keys of the machine. The latter would of course carry the day, as the average travel of the hand after a letter is twelve inches from the stick, and the travel on the key-board of the machine is considerably less than one-half this, but there are so many little niceties to be observed in spacing the words and justifying the lines, work which is done by the skillful printer as he sets up the line, but which, with machine-set type, must be done afterward, when the line of type is broken into lengths for the measure of the work, and then justified by *spaces*. Type-setting machines have separate pockets or galleys for each *sort*, and the mechanical arrangement is such that on touching the key, arranged with others like the key-board of a piano or concertina, the end type of the row is displaced, and is conducted in a channel or by a tape to a composing-stick, where the types are arranged in regular order in a line of indefinite length, and from whence they are removed in successive portions to a justifying-stick, in which they are spaced out to the proper length of line required.

Three machines of this character were exhibited at the Paris Exposition in 1855.

Of the American machines that of Alden has perhaps excited most attention. The persistence of the inventor for seventeen years in the endeavor to perfect his invention, and his death, in 1859, when success appeared to be crowning his efforts, afford one more interesting item to the history of invention when it shall come to be written. His machine has types arranged around the circumference of a horizontal wheel, which rotates slowly, carrying with it fingers which pick up the proper types from their respective cells. The ordinary types are used, with the exception that each has its peculiar nick on one side, which will enable the fellow-machine to discriminate when *distributing* the type.

In the distributing process the *dead matter* is placed on a bed to the right of the key cylinder, and is taken up line by line as each is exhausted. The types are taken up by distributing transits in the revolving wheel, selected by means of the nicks, and then transferred by way of the channels to the respective type pockets. Extra spaces, etc., are tipped out at the end of the channel. Unnicked type are thrown into a separate box, italics into another.

Another instance may be given: the Kastenbein composing machine, in which common types are used, each sort being arranged vertically in a series of tubes, like the pipes of an organ. As a letter key of the key-board is struck, the lever connecting with the particular letter tube opens the lower end of the tube, and allows the lowest type in the rank to fall into a groove which conducts it to the slide where the letters are assembled in a long line, and whence they are taken by the compositor's rule and justified.

The distributing machine reverses this method. The *dead matter* is placed on a bed, each line is cut off and the types raised *seriatim* so that they can be read by the observer. The corresponding key on the key-board being depressed, the type is pushed into its appropriate tube, ready for supplying the composing machine.

Printers have been wont to boast that a practical type composing and *justifying* machine presented a problem which even Yankee ingenuity and persistence could not solve; but in view of the progress made in this direction during the last decade, it can hardly be doubted that complete success will be achieved in the near future.

Still later machines for composing and distributing, the invention of Mr. Paige, are now exhibiting in New York, and work well. It remains, however, to be determined whether or not the capital invested in them and the casualties incident to complicated and delicate machinery will discourage their use in place of compositors, who own themselves, are always ready, and for whom substitutes can be found if one or another prove ailing or erratic.

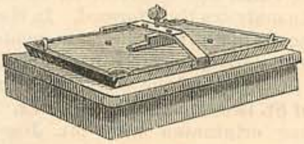
STEREOTYPING.

The art of casting solid metallic plates from type was invented by William Ged, a goldsmith of Edinburgh, in 1731. The plates ordered by the University of Oxford for an edition of the Bible were mutilated by jealous printers and thrown aside—the old tale of narrow-minded prejudice and ignorance. Ged's plan was the *plaster process*, but after its abandonment several other means were tried before the plaster was resumed.

Carez (France, 1793) had a plan of dashing down the inverted form upon a surface of hot lead just in the act of solidifying. The cast thus obtained was used in the same way to obtain a cameo impression for a printing surface. Didot's plan consisted in casting types of a hard alloy, and pressing them into a surface of pure lead. This was brought down upon a paper tray of molten type-metal just in the act of solidifying. The *English Monthly Magazine* of January, 1799, comments on this plan. Herham set up the form in copper matrices, and took a cast therefrom in type-metal. These three plans were French.

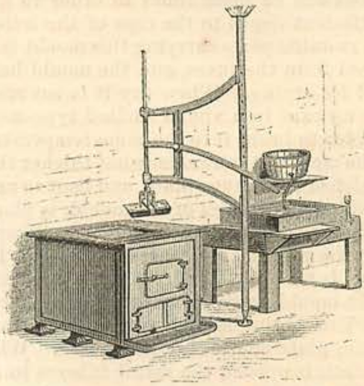
Stereotyping was introduced into the United States by David Bruce, of New York, in 1813. The first work cast in America was the New Testament, in bourgeois, in 1814.

In the *plaster process* of stereotyping the type is set up with spaces, quadrats, and leads which come up to the shoulders of the type. Guard-lines and bearers are placed at the top of the page and at intervals of the type lines to support the plate during finishing. The type is then oiled, and inclosed by a flask to hold within bounds the fluid plaster, which is poured upon the face of the form, and worked in between the letters by a roller covered with flannel and leather. The plaster soon sets, and the mould is carefully raised by screws which lift it vertically from the form. The stereotype plate is then cast from the plaster mould, which is done by inclosing the mould in a box and plunging it into the bath of molten metal. The casting pan is



CASTING PAN.

of iron, consisting of a tray and a lid, the latter having at its corners gaps for the metal to flow in. Each pan has an iron plate or floater three-eighths of an inch thick, which fits within it. Upon this plate the mould is laid face downward. The cover is chalked and secured by a yoke and screw. The pan is swung over the pot, and lowered on to the metal so as to become heated, then depressed so that the metal flows in at the corners and forces itself between the *floater* and *mould*. When the pan is filled it is submerged, and left till the bubbling has ceased. It is now swung over

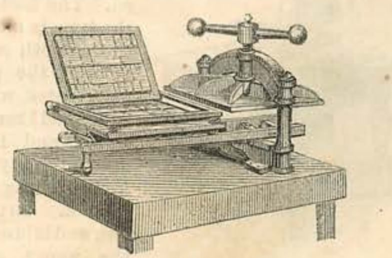


STEREOTYPE CASTING APPARATUS—PLASTER PROCESS.

the water-trough and cooled. The cast is knocked out of the pan, the surrounding metal broken off, and the stereotype freed from the plaster.

The plate is then finished by trimming the edges, laying it on its face, and shaving off the back to bring it to an even thickness. The bearers are cut away with a chisel and mallet, the heads trimmed, and the sides beveled with a plane upon the shooting-board. The plate is then carefully examined and faults repaired.

In the *clay process* a plastic composition of fine clay and plaster of Paris, with a small quantity of gum-arabic water, is spread with a trowel to the thickness of a quarter of an inch upon a plate which is secured to a frame shown in the drawing as hinged like a tympan to the press bed. The form is laid face upward on the bed, the face of the type is brushed over with benzine, covered with a cloth and paper, the tympan is turned down upon the form, the bed run under the platen, and an impression



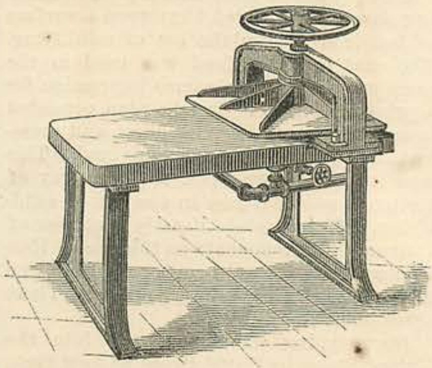
MOULDING PRESS—CLAY PROCESS.

taken sufficiently deep to cause the clay to flow into the blank spaces and give the general outlines of the type. The press is then opened, the cloth and paper removed, and also any superfluous material which has been thrown up by the first pressure, and would be likely to bind. The press is again closed, and a complete impression taken, imbedding the type in the plastic material to the desired extent. This process is usually repeated one or more times in order to give a sufficient depth to the *cups* of the letters. The metallic plate carrying this mould is removed from the press, and the mould hardened by drying. When dry it is set afloat face upward in a vat of melted type-metal in order to bring it to the same temperature as the metal. A wire somewhat thicker than a finished stereotype plate, and bent so as to surround three sides of the mould, is placed on the plate, and a second plate is clamped over the wire, as in a moulder's flask. The whole is then put in a trough, the open edge of the mould upward, and the metal poured in. The casting is cooled by pouring water on the plate containing the mould. When the flask is opened the metal adheres to the mould, which is removed by wetting and brushing. The plate is then planed, trimmed, and dressed up for use.

Curved plates for cylinders are made from a flat form by using a sheet of spring steel of the desired curvature for a mould plate, which is spread flat on the tympan, and the plastic material is applied upon what is to be the concave side. After the impression is taken the sheet is released, and resumes its normal curvature, bending the plastic mould with it. The face of the plate is, of course, somewhat distorted, the stereotype appearing as if taken from type a little more condensed one way than that actually employed in the form.

The *papier-maché* process is very expeditious, and is generally used on daily papers of large circulation. A paper matrix is formed by spreading paste over a sheet of moderately thick unsized paper and covering it with successive sheets of tissue-paper, each carefully patted down smooth; the pack is then dampened. The face of the type is oiled, the smooth surface of the paper treated with powdered French chalk, and laid upon the type. A linen rag is wetted, wrung out, and laid over the paper, and dabbed on the back with a beating brush so as to drive the soft paper into all the interstices between the letters of the form. Remove the cloth, lay a reinforce sheet of damp matrix paper upon the back of the matrix, and beat again to perfect the impression and unite the surfaces of the two. For large establishments a matrix rolling machine is used. A double thickness of blanket is placed upon the matrix, the form and matrix laid in a press, and screwed down tight. The lighted gas heats the press and the form, and dries the paper matrix. The press is unscrewed, the matrix removed, and it is warmed on the moulding press. The matrix is then placed in the previously heated iron casting mould, and a casting gauge to determine the thickness of the stereotype plate is placed upon it. This extends around three sides of the matrix, the other being left open to serve as a gate at which the molten metal is poured in. The cover is screwed tight, the mould tipped to bring the mouth up, and the metal poured. When the metal is *set* the mould is opened and the matrix removed. The plate is then trimmed and otherwise prepared in the usual manner.

BEATING-TABLE—PAPIER MACHÉ PROCESS.

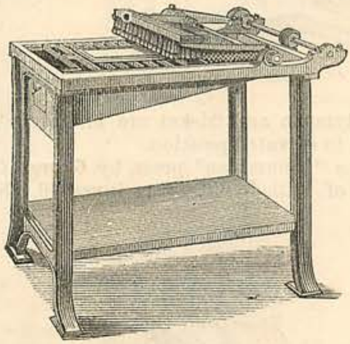


STEREOTYPE MOULD-DRYING PRESS—PAPER PROCESS.

ELECTROTYPING.

Electrotyping is an application of the art of electroplating, which originated with Volta, Cruikshank, and Wollaston about 1800–1. In 1838 Spencer, of London, made casts of coins and impressions in intaglio from the matrices thus formed. In the same year Jacobi, of Dorpat, in Russia, made casts by electro-deposition, which caused him to be put in charge of the work of gilding the dome of St. Isaac's at St. Petersburg. Electrotyping originated with Mr. Joseph A. Adams, a wood-engraver of New York, who made casts in 1839–41 from wood-cuts, some engravings being printed from electrotype plates in the latter year. Many improvements in detail have been added since to the process as well as the appliances. Murray introduced graphite as a coating for the forms and moulds.

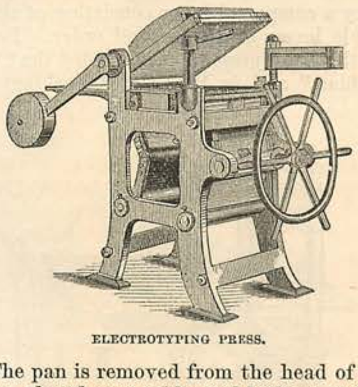
The process of electrotyping is as follows: The form is locked up very tight, and is then coated with a surface of graphite, commonly known as *black-lead;* but this is a misnomer. This is usually put on with a brush, and may be done very evenly and speedily by a machine in which the brush is reciprocated



BLACK-LEADING MACHINE.

over the type by a band wheel, crank, and pitman. A soft brush and very finely powdered graphite are used, the superfluous powder being removed, and the face of the type then cleaned by the palm of the hand. Knight's wet process of black-leading, as practiced at Harper and Brothers' establishment, is, however, much to be preferred, and will be described presently.

A shallow pan, known as a moulding pan, is then filled with melted yellow wax, making a smooth, even surface, which is black-leaded. The pan is then secured to the bed of the press, and the form placed on the bed, which is raised to deliver an impression of the type upon the wax.

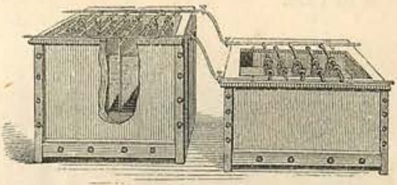


ELECTROTYPING PRESS.

The pan is removed from the head of the press, placed on a table, and *built up,* as it is termed. This consists in running wax upon the portions where large spaces occur between type, in order that the corresponding portions in the electrotype may not be touched by the inking-roller, or by the paper sagging down in printing.

The wax mould being *built,* is ready for black-leading, to give it a conducting surface upon which the metal may be deposited in the bath. The wax mould is laid face upward on the floor of an inclosed box, and a torrent of finely pulverized graphite suspended in water is poured upon it by means of a rotary pump, a hose, and a distributing nozzle, which dashes the liquid equally over the whole surface of the mould. Superfluous graphite is then removed by copious washing, an extremely fine film of graphite adhering to the wax. This is Silas P. Knight's process, and answers a triple purpose. It coats the mould with graphite, wets it ready for the bath, and expels air bubbles from the letters. This process prevents entirely the circulation of black-lead in the air, which has heretofore been so objectionable in the process of electrotyping. Black-lead being nearly pure carbon, is a poor conductor, and in the usual process a part of the metal of the pan is scraped clean to form a place for the commencement of the deposit, and the back of the moulding pan is waxed to prevent deposit of copper thereon. When the dry black-leading is used the face of the matrix is wetted to drive away all films or bubbles of air which may otherwise be attached to the black-leaded surface of the type.

The mould is then placed in the bath con-



ELECTROTYPING BATH AND BATTERY.

taining a solution of sulphate of copper, and is made part of an electric circuit, in which is also included the zinc element in the sulphuric acid solution in the other bath. A film of copper is deposited on the black-lead surface of the mould, and when this shell is sufficiently thick, it is taken from the bath, the wax removed, the shell trimmed, the back tinned, straightened, backed with an alloy of type-metal, then shaved to a proper thickness, and mounted on a block to make it type-high.

Knight's expeditious process consists in dusting fine iron filings upon the wet graphite surface of the wax mould, and then pouring upon it a solution of sulphate of copper. Stirring with a brush expedites the contact, and a decomposition takes place; the acid leaves the copper, and forms with the iron a sulphate solution, which floats off, while the copper is freed and deposited in a pure metallic form upon the graphite. The black surface takes on a ruddy tinge with marvelous rapidity. The film is afterward increased in the usual manner in the electro bath, but the deposit takes place immediately and regularly over the whole surface. The saving in time, acid, copper, and zinc is very great.

THE PRINTING-PRESS.

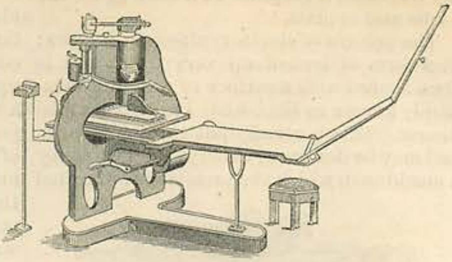
The *printing-press* in its earlier forms was but an adaptation of the ordinary screw-press. The form was locked up in a tray and placed on a platform, upon which the platen was brought down by a screw traveling in a cross-bar above. The screw was moved by a lever, which was shifted into holes in the boss of the screw.

The Blaew was the first patent press, 1620. The carriage was rounced in beneath the platen; the pressure was given by a handle attached to a screw hanging from the beam, and having a spring which caused the screw to fly back as soon as the impression was given. Blaew was a very ingenious and versatile man, and was for some time, in the earlier portion of his career, associated with Tycho Brahe, at the observatory of the latter in Denmark, in contriving instruments and reducing observations. Subsequently he was in Amsterdam, where he made globes and maps, and invented his improvements in printing-presses. He died there in 1638.

BENJAMIN FRANKLIN'S PRESS.

The Franklin press, one hundred years afterward in London, was a Blaew press with some minor improvements.

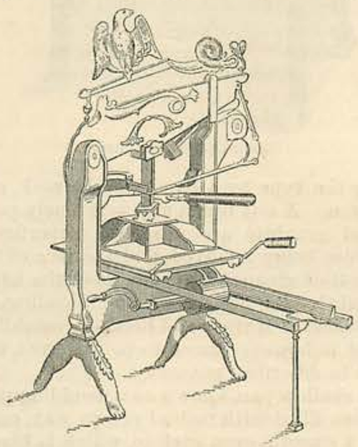
To this succeeded the Stanhope press, about the end of the eighteenth century. The oscillating handle operates a toggle to force down the platen upon the paper on the form. The bed travels on ways, and



LORD STANHOPE'S PRESS.

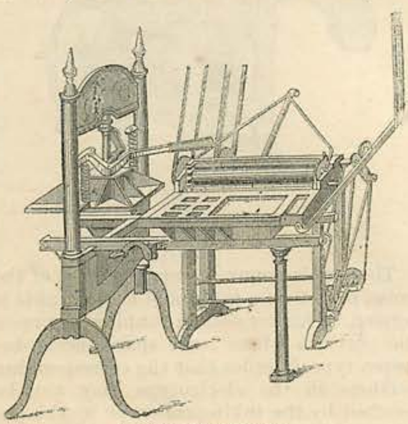
the tympan and frisket are hinged to lay back in elevated position.

The "Columbian" press, by George Clymer, of Philadelphia, was invented about



"COLUMBIAN" PRESS.

1817, and was perhaps the first important American contribution to the art of press-making. The power is applied to the platen by a compound lever consisting of three simple levers of the second order. Peter Smith's hand-press soon succeeded the "Columbian," and in 1829 the "Washington"



"WASHINGTON" PRESS.

was patented by Samuel Rust. The pressure in this is obtained by a compound lever applied to a toggle-joint, and the platen is lifted by springs on each side. The frame is made in sections, and the bed is run in and out by turning a crank which has a belt attached to its pulley or *rounce*. The tympan and frisket are held up by the nature of their hinges, which allow only a certain amount of swing.

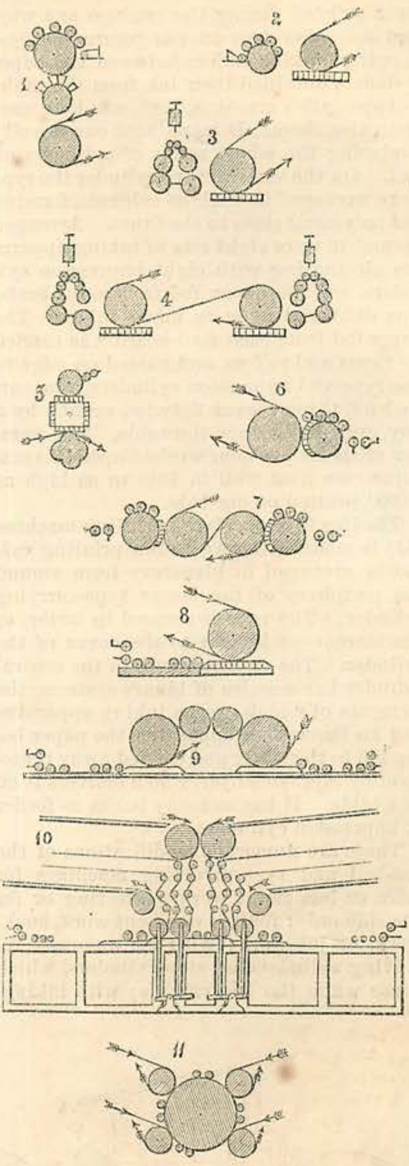
Power-presses or *printing-machines*, as they are indifferently called, belong exclusively to our century. Nicholson obtained a patent for a cylinder printing-machine (1) in 1790. It is not known that it was ever brought into use, but several of its features have survived in later and successful machines. The ink was applied by a roller; the types were made narrower toward the foot, so as to fit against each other snugly when attached to the exterior surface of a cylinder. The type cylinder revolved in gear with a leather-covered impression cylinder, and at another part of its rotation with an inking cylinder, to which inking apparatus was applied. The arrangement was modified (2) for a flat bed.

König, a German, constructed a printing-machine (3) for Mr. Walter, of the London *Times*, in 1814. The issue of the 28th of November of that year was the first newspaper printed by machinery driven by steam-power. It gave 1100 impressions per hour, and subsequently was worked up to 1800. The paper was held to its cylinder by tapes; the form was reciprocated beneath the inking apparatus and the paper cylinder alternately. To double the rate, a paper cylinder was to be placed on each side of the inking apparatus. The ink was placed in a trough, and ejected upon the upper of a series of rollers, passing downward in the series; and here first occurred the distributing roller with end motion.

König's press (4), which consisted of two single machines acting in concert and consecutively upon the two sides of the sheet, was perhaps the first attempt at a perfecting press. It was erected in 1818, but did not prove successful.

Donkin and Bacon's machine (5), 1813, was built for the University of Cambridge, England. Several forms were attached on the sides of a prism, and were presented consecutively to the inking cylinder and paper cylinder. In this machine were first used the composition inking-rollers, of glue and molasses.

In 1815 Cowper obtained a patent for curved stereotype plates, to be affixed to a cylinder (6). By duplication of parts the machine (7) was designed to become a perfecting press. The greater portion of the cylinder forms a distributing surface for the ink, the remainder is occupied by the stereotype plate.



PRINCIPLES OF ACTION OF POWER-PRESSES.

Applegath and Cowper's single machine (8) went back again to the flat reciprocating bed, the double machine (9) being a perfecting press. This machine was the first to have diagonal distributing rollers to spread the ink smoothly by sliding on the reciprocating inking-table.

Applegath and Cowper's four-cylinder machine (10), 1827, superseded König's in the *Times* office, and printed at the rate of 5000 per hour on one side. It had four printing cylinders, one form of type on a flat bed, and the paper cylinders were alternately raised and depressed, so that two were printed during the passage one way, and the other two on the return passage. A pair of inking-rollers between the paper cylinders obtained their ink from the table.

Applegath's machine, 1848, was long used upon the *Times*. It introduced one novelty—placing the whole series of cylinders on end. On the vertical type cylinder the type were arranged in upright columns, forming flat polygonal sides to the drum. Arranged around it were eight sets of inking apparatus alternating with eight impression cylinders, and the paper, fed from eight *banks*, was delivered upon as many tables. The paper fed from each feed-board was carried by tapes and rollers, and passed on edge to the type and impression cylinders, was carried off, thrown over flatwise, caught by a boy, and placed upon the table. The number of sheets per hour worked upon this machine rose from 8000 in 1848 to as high as 12,000, printed on one side.

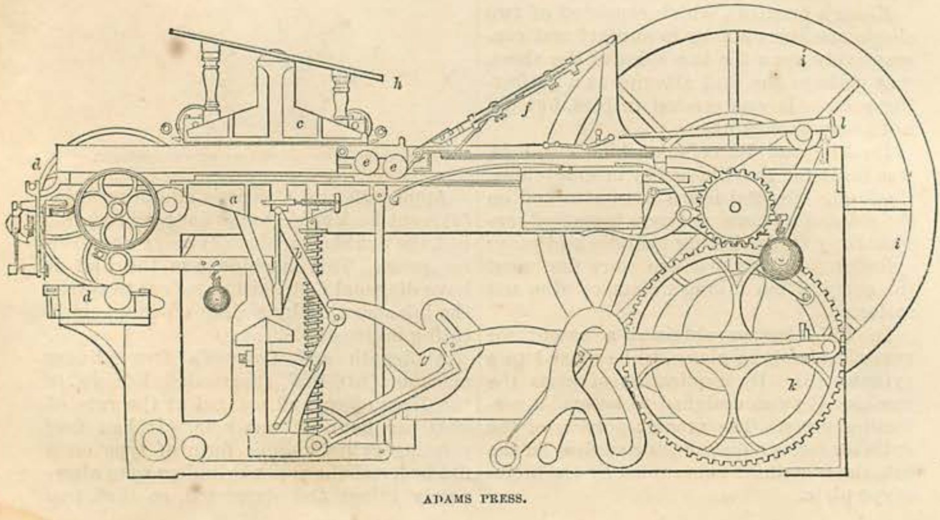
The Hoe type-revolving printing-machine (11) is made with two to ten printing cylinders arranged in planetary form around the periphery of the larger type-carrying cylinder. The type is secured in *turtles*, or the stereotype is bent to the curve of the cylinder. The circumference of the central cylinder has a series of binary systems, the elements of which are an inking apparatus and an impression apparatus, the paper being fed to the latter and carried away therefrom by tapes to a flyer, which delivers it on to a table. It has as many banks as feeder or impression cylinders.

There are numerous modifications of the flat-bed and type-revolving machines for more or less rapid work, perfecting or for one side only; for fine wood-cut work, book-work, or job-work; with continuously revolving cylinders or stop-cylinders, which pause while the bed returns; with inking-rollers varying in number with the kind of work required; and with many variations in size for posters, handbills, and cards.

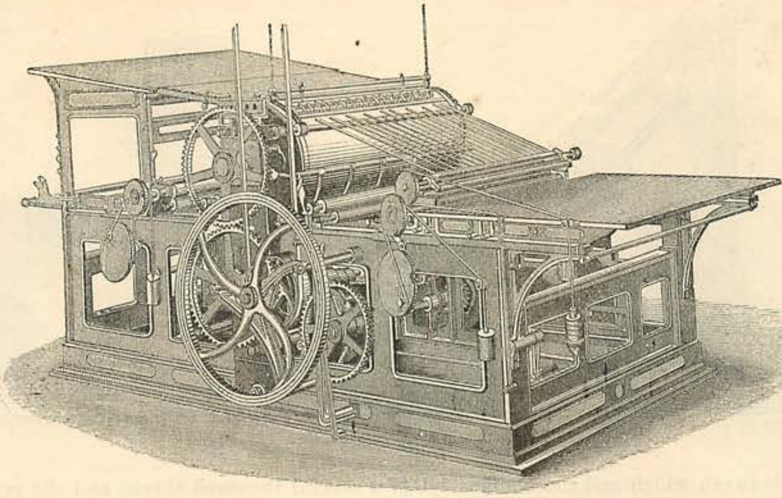
The first flat-surface printing-machine was made by Daniel Treadwell, of Boston, in 1822. His machines, first used in Boston, were afterward used by Daniel Fanshaw in New York in printing the Bibles and tracts for the "American Bible Society" and the "American Tract Society." The machines for the former society were driven by a steam-engine, and those for the latter by two mules in the upper story of the Tract-house building, using an endless-track power. In this press the platen comes down on the type. These were the first printing-machines in America driven by other than hand-power, and were long used by Gales and Seaton in Washington in printing the Congressional reports, etc.

Next was the Adams press, which was introduced in 1830, has been since much improved, and still has a high reputation. Its movement is based on that of the hand-press, and gives a perfectly flat impression by lifting the bed of the press and its form against a stationary platen. Sheets are fed to the press by hand, and taken away by tapes and a fly. One thousand sheets an hour is a full speed for a large Adams press on book forms. It is shown in the figure by a longitudinal vertical section: *a* is the bed, which is raised by straightening the toggles, *b b*; *c* is the platen, *d* the ink fountain and ink-distributing apparatus. The inking-rollers, *e e*, pass twice over the form, and are attached to the frame of the tympan, *f*. The segment *g* serves to straighten the toggles, and cause the impression; *h* is the feed-board, *i* the drive-pulley, and *k* a gear wheel, with a pitman rod to *g*; *l* is the fly.

Single-cylinder presses, such as Hoe's, Potter's, Campbell's, etc., have a flat bed, which



ADAMS PRESS.



CAMPBELL'S SINGLE-CYLINDER PRESS.

is geared to reciprocate at an even speed with a revolving cylinder. Sheets of paper are fed to the cylinder, which carries a prepared tympan. The inked form runs along with the sheet until it is printed, when the form is retracted and inked again. In some machines the cylinder stops after the impression is delivered.

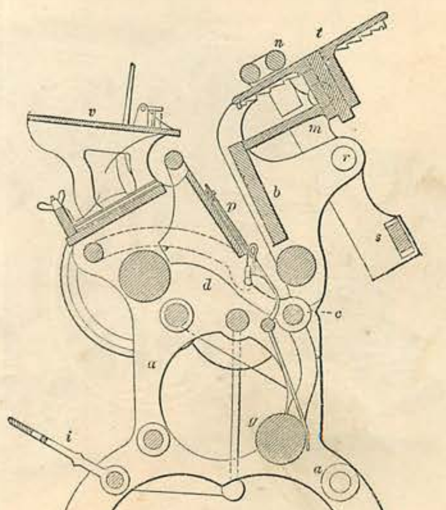
The Campbell press is remarkable for several fine points of adjustment. The operation is controlled by the sheet, which, when badly fed, is thrown out. The registering is operated by a small valve through the agency of points, making an electric circuit through point-holes in the sheet. When the press *fails to point*, the exhaust apparatus is brought into action, operating a bolt attached to a diaphragm, which locks up the impression. It has other peculiar features well worth mentioning if space permitted.

America produces a remarkable variety of handy job presses, known by the name of the makers, as the "Gordon," or by names which constitute trade-marks, as the "Globe," "Liberty," "Universal," etc. —a favorite device both with books in the early days of the art and with presses for a hundred years past; witness the "Columbian" and "Washington" hand-presses. One instance may be given.

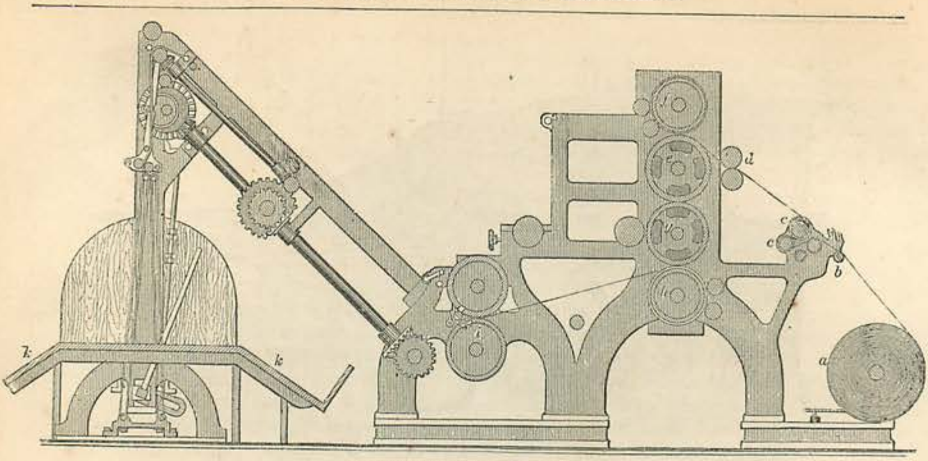
The form in the "Gordon" press is secured in a chase, which is clamped to the bed, *b*, of the press. This bed rocks on a pivot at *c*, and comes into parallelism with the platen, *p*, when the impression is about to be given. The platen rocks on the main shaft, *d*, which is propelled by pitman and intermediate gearing from the treadle, *i*. The arm, *m s*, is the roller-carrier, which swings on a pivot, *r*, and carries the rollers, *n n*, alternately over the form and the revolving disk, *t*, which distributes the ink: *g* is a counter-weight to balance the swinging bed and attachments, and operate the movable fingers by a spring bar, *a* : *v* is the feed-board.

The *web press* is a later thought, and bids fair to supersede all others for large editions and long numbers, where great nicety is not required. It is not yet expected that for fine work and cuts it will supersede the flat-surface and reciprocating-bed presses.

The "Walter" press prints the London *Times* and the New York *Times*. A roll of paper, *a*, three miles long, reels off over the pulley, *b*, which serves to keep it taut. It then passes by the wetting rollers, *c c*, and over the cylinder *d* to the first type cylin-



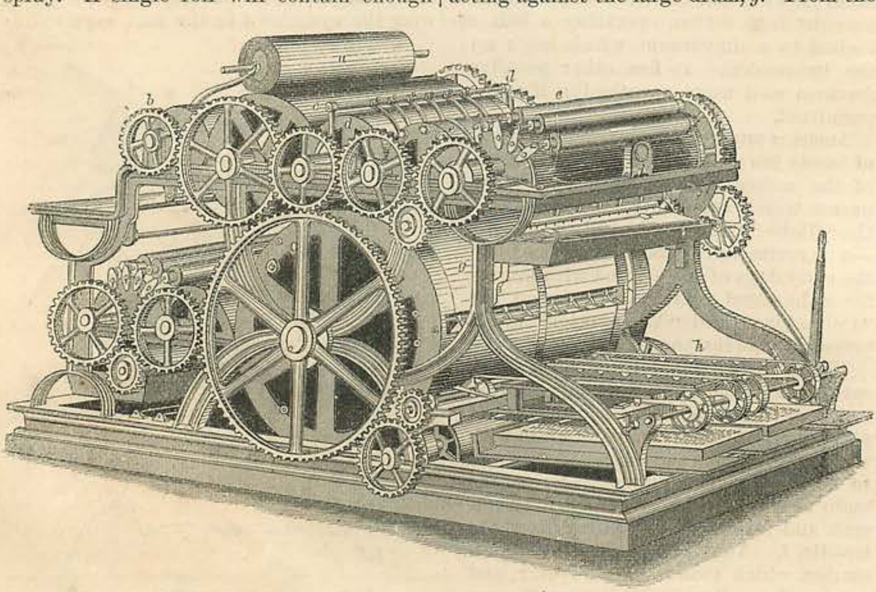
GORDON JOB PRESS.



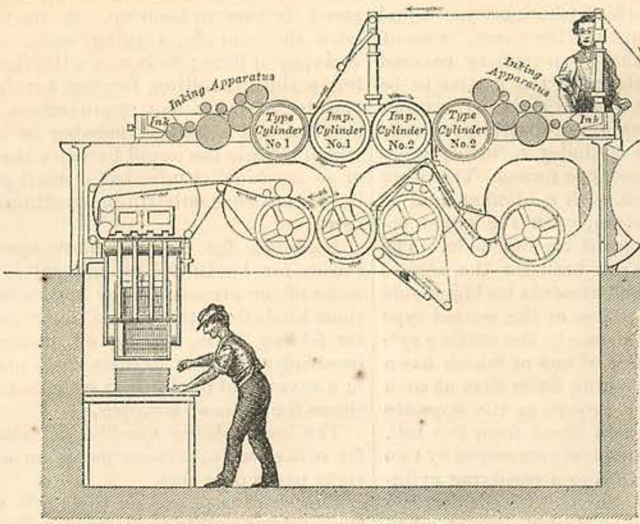
WALTER'S PERFECTING PRESS.

der, *e*, between which and the blanket cylinder, *f*, it receives its first impression. Following the direction of the type cylinder, it passes between two blotting cylinders, and is then delivered to the second printing cylinder, *g*, receiving the impression at *h*. It is then cut by a knife on the cylinder *i*. The sheets are finally piled by two persons on the paper-boards, *k k*. The speed of the Walter press is 11,000 printed sheets per hour.

The "Bullock" press, so named from the inventor, the late William Bullock, of Philadelphia, carries the forms upon two cylinders, requires no attendants to feed it, and delivers the sheets printed on both sides. The paper, in the form of an endless roll, is moistened by passing through a shower of spray. A single roll will contain enough for several thousand sheets, and the printing operation, including the cutting of the paper into proper lengths, proceeds uninterruptedly until the roll is exhausted. The roll of paper having been mounted in its place, the machinery is started, unwinds the paper, cuts off the required size, prints it on both sides at one operation, counts the number of sheets, and deposits them on the delivery board at the rate of 6000 to 8000 per hour. The roll of paper, *a*, is cut into sheets by a knife on roller *b* acting against the cylinder *c*. The sheets are seized by grippers, carried between the impression cylinder, *g*, and the form, *e*, receiving the first impression. The printed sheet then follows the large cylinder, *g*, to the second form, receiving its second impression from this form acting against the large drum, *g*. From the



BULLOCK PERFECTING PRESS.



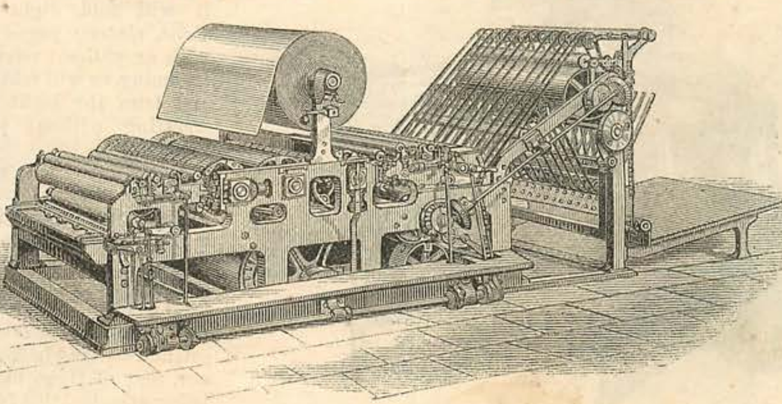
"VICTORY" PERFECTING PRESS AND FOLDING MACHINE.

large cylinder the sheets are automatically delivered to the receiving board: *i* is a counting device or arithmometer. The inking-rollers are shown above the inking cylinders, beneath which are the ink-troughs. The starting lever is shown on the right.

The "Victory," like those just described, receives its paper from a roll. The names on the parts will obviate the necessity of specific description. The paper is led over two wetting boxes, and then over two hot copper cylinders, and entered between the first type and impression cylinders. Here one side is printed, and it thence goes to the second type and impression cylinder, where it is backed. It then travels on tapes to the cutting and folding cylinders. Here it receives a transverse fold, and the doubled paper is passed to a serrated knife, which cuts the first printed sheet from the web. A second blunt knife again folds the double sheet, which is carried by grippers to a vibratory frame, entering each alternate sheet to the respective pairs of cross-folding rollers, which deliver the sheets to tapes, which carry them to a swinging delivery frame, by which they are deposited in a pile on the table.

This machine will damp, print, cut, fold, and deliver 6000 to 8000 per hour of an eight-page newspaper of fifty inches square; or it will damp, print, cut, fold, and paste at the back a twenty-four page paper at the speed of 7000 per hour.

The "Hoe" web perfecting press is one of the lately established and successful candidates for public favor. The paper is printed from a roll containing a length of over four miles and a half, equal to 10,000 papers. The machine has three pairs of cylinders geared together. A roll, having been previously damped, is lifted into place by a small crane, and the paper from it passes between the first pair of cylinders, the cir-



"HOE" WEB PERFECTING PRESS.

cumferences of each of which are just equal to the required length of the sheet. One of these cylinders has its periphery covered with stereotype plates of the matter to be printed, and is supplied in the usual manner with an ink fountain and distributing rollers, which, as the cylinder revolves, apply the ink to the stereotype forms. The other cylinder is covered with a blanket, and as they revolve together, with the paper between them, they print its first side. The paper then passes on between the second pair of cylinders, and presents its blank side to the stereotype plates of the second type cylinder. It next passes to the cutting cylinders, the periphery of one of which has a vibrating and projecting knife that at each revolution enters a groove in the opposite cylinder and severs a sheet from the roll. The sheets are successively conveyed by two series of endless tapes to a revolving cylinder, which retains them until six (or any desired number) are collected upon it, when they are delivered in a body to the sheet flyer. A circular cutter cuts the double sheets into single copies.

A counter is attached which shows the number of sheets printed. The machine occupies a space of about twenty feet long, six feet wide, and seven feet high, and delivers 12,000 to 15,000 perfected sheets per hour.

These machines have a reputation on both sides of the Atlantic, being used by the London *Lloyds' News*, *Standard*, and *Telegraph*, while five of them are now building for offices in the United States and two for Australia.

FOLDING MACHINES.

As an improvement occurs in one of the machines of a series, every other one has to mend its pace to keep up. So we found it with the ginning, carding, spinning, and weaving of fibre; so it was with the smelting, puddling, rolling, forging, turning, and planing of iron: one improvement begets another, and a halting member of a series which retards the speed becomes the object of so much solicitude that it shall go hard but he ere long outstrip his brethren in the race.

Machines for folding newspapers and sheets for books follow naturally in the wake of the presses. They are made of various kinds for octavo, 16mo, and 32mo; also for folding 12mo, cutting off, pasting, and inserting the inset; in some cases placing it in a cover, and doubling it up into compact shape for the mail wrapper.

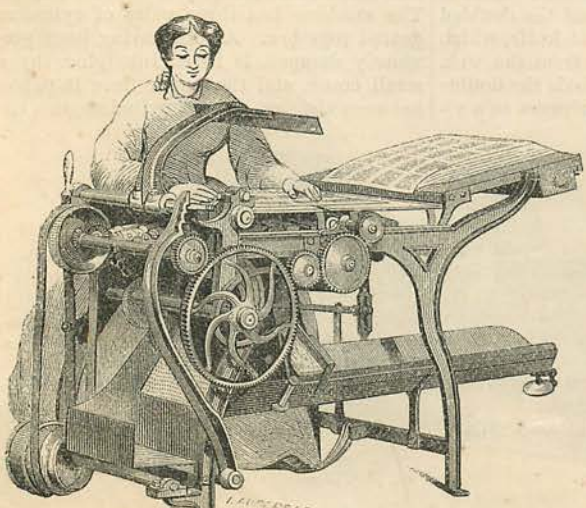
The book-folding machine illustrated is for octavo work, sixteen pages on a sheet, eight pages on a side.

The sheet is placed on the table so that two register points pass through two holes in the sheet previously made on the printing-press. The folder comes down upon the folding edge, the pins give way, and the sheet passes, doubled edge first, between a pair of rollers, which compress it; tapes deliver it to a second table beneath, where a second and a third folder act upon it in turn, and it is delivered into a trough at the rate of 1500 per hour.

With 12mo work imposed in two parts of sixteen and eight pages respectively, the machine cuts them apart, and folds the larger part like an octavo; the smaller folds but once, and is then "inset" into the octavo portion, which forms the "outset."

The two-sheet folder and paster, for large twenty-four-page periodicals, folds one sheet of sixteen pages, 30½ by 45½ inches, insetting the eight pages within the sixteen, and pasting and trimming all, delivering a complete copy of twenty-four pages ready to read at the rate of 1200 per hour. It will fold eight pages alone, sixteen pages alone, with or without pasting or trimming, or will fold, paste, and trim the eight pages, insetting without pasting them in.

Machines of this general character are also made for folding, pasting, and trimming, or for folding, pasting, trimming all around, and putting on a cover of different-colored paper. The *Christian Union* is folded, inset, and covered in this manner, four of these machines being attached to a four-cylinder "Hoe" press.



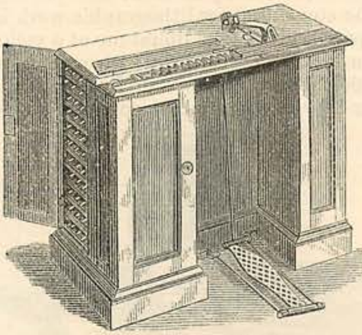
CHAMBERS'S FOLDING MACHINE.

ADDRESSING MACHINES.

Addressing machines are of two general kinds; one cuts the addresses from printed and gummed strips and attaches them to the paper. The Dick machine works in this way.

The other mode is to set up the addresses in a galley, and bring them successively to a spot at which the enveloped papers are consecutively presented.

The machine illustrated is one of many of the latter class. It prints with ink on the papers or wrappers at the rate of 3000 per hour. The names are set up in long narrow



ADDRESSING MACHINE.

galleys holding fifty or seventy-five each, and after inking with a hand-roller, these are placed successively in the channel of the table, and are pushed along by the apparatus till each name in turn has come under the impression lever, which is worked by the treadle. The motion of the galley is automatic, and the machine indicates a change of post-office by the stroke of a bell, so that the papers may be thrown into separate piles to be bundled for mailing.

The "Forsaith" addressing machine also operates in a very satisfactory manner.

PRINTING FOR THE BLIND.

The art of printing in raised letters which may be distinguished by the touch originated and has been developed within the century. The first successful efforts in this direction were made at Paris in 1784 by the Abbé Valentin Haüy, who in the same year founded "L'Institution Royale des Jeunes Aveugles," the first institution ever established for the instruction of the blind.

Various systems of forming the embossed characters have since been introduced, which may be divided into two classes—the *arbitrary*, arranged exclusively with reference to the supposed greater facility with which their forms may be distinguished by the touch, no attempt being made to imitate ordinary printing; and the *alphabetical*, in which the letters resemble those ordinarily employed.

Prominent among the first are those of Lucas, Frère, Moon, Braille, and Carton. Lucas's system is composed of a series of dots, curves, and straight lines, each of which represents a letter, distinguishable by its form or the position in which it is set. Many contractions and abbreviations are employed, and though it is claimed to be easily read by the touch, its bulk and the frequent ambiguities arising from the peculiar system of abbreviations are objectionable. Thirty-six volumes are required to contain the Scriptures, which in the American lower-case alphabet are comprised in eight.

Frère's system is phonetic, thirty-six characters being employed, each representing a simple sound.

Moon, himself a blind man, represents the letters of the ordinary alphabet by characters, each composed of but one or two lines. The printing is read alternately from left to right and from right to left.

Braille's system is that generally employed in France: the letters are formed by combinations of dots varying in number from one to six.

Carton's system also employs dots, but arranged to more nearly resemble the letters of the Roman alphabet.

Among those known as alphabetical are—

The French, a combination of lower-case and capitals.

Alston's, English, has modified Roman capitals.

Friedlander's, American, Roman capitals of the kind known as block letters.

That of Dr. S. G. Howe, principal of the Institution for the Blind at Boston, Massachusetts, employs an angular form of lower-case for all the letters except G and J, which are capitals. This character is used at most of the institutions in the United States, and many valuable works have been printed in it.

Mr. N. B. Kneass, of Philadelphia, himself a blind man and a publisher of works for the blind, employs lower-case like that of Dr. Howe and block capitals, under the title of "Kneass's improved combined letter."

ENGRAVING.

The early history of engraving concerns the inscriptions on stones; the "iron pen," and inlaid "leaden letters" in the rock, referred to by Job, if that be a fair understanding of the passage. Contemporary with this are the carved and lettered obelisks of Egypt, the tablets of Assyria and Etruria, the engraved gems in the breastplate of Aaron, perhaps the leaden *plates* inscribed with Hesiod's "works and days," which were so long preserved at the fountain of Helicon, in Bœotia, as recorded by Pausanias.

From inscriptions the Greeks proceeded to engraving maps on metallic plates; and the brass plates containing the Roman laws were complete enough for printing, but it does not seem to have been thought of. The history of engraving is the history of printing; but we must not repeat it here.

The art of engraving is naturally divisible into three orders—metal, wood, stone; the latter better known as lithography, and considered separately.

Engraving on metallic plates originated with chasers and inlayers. It can not but be that such artists took proof in dirty oil on rag or leather, but no impression of intrinsic value was had until the time of Finiguerra, a Florentine artist, in 1440. Euclid was printed with diagrams on copper in 1482. The copper-plate press was invented in 1545. Etching on copper by means of aquafortis was invented by F. Mazzuoli, or Palmegiani, in 1532; mezzotint engraving by Von Siegen in 1643; improved by Prince Rupert, 1648, and by Sir Christopher Wren in 1662.

Stipple engraving—also called "chalk engraving," from the resemblance of the work to crayon drawing—was invented by Jacob Baylaert in London in 1769; engraving on steel as a substitute for copper, by Jacob Perkins, of Philadelphia, in 1819.

The present century has not devised much that is new except the ruling machine by Wilson Lowry.

Plate engraving flourished in England from 1800 to 1850, but photography and lithography have gradually pushed it aside, since which the skill has decayed and the demand fallen off. Until this decadence persons of average taste would claim that though our predecessors excelled in rude vigor, our execution was as good as that of the earlier masters, and our effects better, the connoisseurs in the antique to the contrary notwithstanding. Nor will it avail for such to quote Gifford's sarcasm,

> "We want their strength: agreed; but we atone
> For that and more by sweetness all our own."

Wood-engraving originated in China, as we have had occasion to observe before; its first uses in Europe were in ornamenting paper and fabrics, afterward for making playing-cards.

The earliest known wood-cut with a date—the St. Christopher of 1423—is in the Althorpe Library, England, which, it may be stated in passing, contains the most valuable single volume in the world, an edition of Boccaccio printed at Venice by Valdarfer in 1474, of which no other perfect copy is known. It sold at the Duke of Roxburgh's sale in 1812 for £1260. The art of wood-engraving was much improved by Dürer, 1471–1528; by Bewick, 1789. It has gone on improving ever since, by fits and starts, but always onward. The great use made of it by the *Illustrated London News* is an era; its advance over the *Penny Encyclopedia* affords a good means of judging the rate of progress. The American *Aldine* and *Picturesque America* are triumphs of the art.

LITHOGRAPHY.

The art of engraving or drawing on stone, so that printed copies may be obtained therefrom in the press, originated with Alois Senefelder, of Munich, 1796–1800. The invention was not a mere accident, as recounted in the common myth of an absent-minded man, a piece of limestone, and a waiting washer-woman, but was the result of earnest, persistent, and intelligent work directed to an object kept steadily in view.

The stone used for lithographic work is a compact sedimentary limestone of a yellowish or bluish-gray color, which comes from the Solenhofen quarries in Bavaria. It is ground by moving one stone upon another

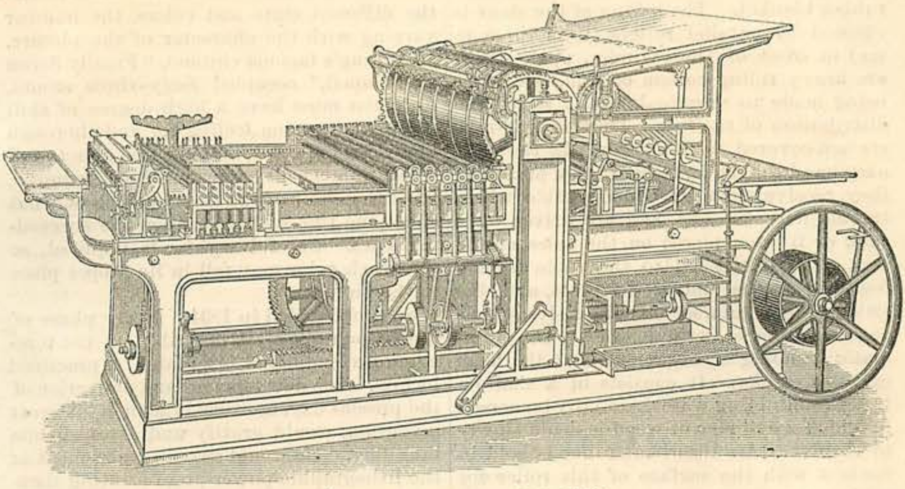
LITHOGRAPHIC HAND-PRESS.

with sand between them, and then polished with pumice-stone.

Upon the stone thus prepared the design may be produced in four ways:

1. It may be done with a fluid, watery ink.
2. With a solid crayon.
3. By a transfer from an inky design on paper.
4. By engraving with an etching point.

1. The *ink* is essentially a soluble soap colored with lamp-black, applied with a pen or hair-pencil. The stone is then *etched* with a weak acidulous solution, decomposing the soap, combining with its alkali, and setting free the fatty acid in contact with the particles of carbonate of lime of which the stone consists, forming an insoluble lime soap which no washing or rubbing can remove and no fatty matter can penetrate. The stone is then flooded with gum-arabic water to incapacitate the clear parts from receiving ink when wetted. The stone is now placed in the press and made ready.



HOE'S LITHOGRAPHIC PRINTING-MACHINE.

With a sponge and abundance of water excess of gum is washed off, and, while still wet, the drawing is *washed out* with turpentine applied with a rag. This appears to obliterate every thing, but a close inspection shows the work as a pale white design on the face of the stone. The stone is now *rolled up* by passing a roller charged with printing-ink over its face, which is still damp; the greasy ink adheres to the white design, while the clear gummed damp face takes no ink. A sheet of paper is laid upon it, the tympan closed, and the stone pulled through. The operations of damping, inking, and printing are then repeated in succession.

2. The work by *lithographic crayon* is upon a *grained* stone, the surface of which is evenly roughened by grinding with very sharp and even sand of a grade according to the fineness of grain required. The crayon is of soap, wax, and tallow, and it is used on the stone as a drawing chalk is upon rough Whatman paper. The subsequent processes in preparing the stone are the same as those before described. The process gives opportunity for much artistic taste and display, the broken surface of the stone preventing the continuity of the lines, whose depth of color will depend upon the pressure of the crayon upon the rasping surface.

3. The *transfer method* consists in placing the design on paper and then transferring it to the stone. The writing, for instance, is done on ordinary sized paper, but preferably on paper prepared with a coating of gelatine, which may be colored with gamboge. The written sheet is damped, laid face down on the stone, and pulled through. The ink adheres to the stone, which is treated as before.

4. The *engraving method* differs from the preceding. The surface of the stone is treated with gum-arabic water, which, when dry, is colored to allow the succeeding work to show. The design is then scratched in with needles or diamond points, and the face of the stone flooded with oil, which is absorbed by the stone where the etching points have laid it bare. The coloring matter and excess of gum are washed off, and the lines are filled with ink, the gum protecting the clean surface. The paper is laid on, and the stone pulled through the press, the sheet lifting the ink out of the lines. It is not usual to print from the engraved stone, but to transfer an impression therefrom to another one and print in the usual way.

There are many modifications of the art: a tint is rubbed on dry, and distributed or rubbed off according to the lights and shades of the design; by another mode the surface is covered with a solution of asphalt and crayon, and scraped off for the lights. The list might be much extended.

Until a comparatively recent period all lithographic printing has been upon hand-presses, but lately a successful lithographic printing-machine has been made. Hoe's machine is a stop-cylinder press, that is, one in which the cylinder comes to a stop pending the adjustment of the sheet. The paper is fed to grippers on the cylinder from the inclined table above. The traveling bed on which the stone rests is drawn under the cylinder by a crank and connecting rod from the end of the frame below, and the cylinder, after being thrown into gear, is rotated at the same time (carrying the sheet with it) by a rack attached to the side of the bed. At the end of the stroke the cylinder goes out of gear, and remains stationary and locked during the return of the bed and stone, the latter passing under a cut-away part of the cylinder, so as not to come in contact with it. In place of a tympan the cylinder is covered with a thin rubber blanket. The inking of the stone is effected by parallel rollers (from three to six) in front of the cylinder, upon which are heavy riding rollers of iron, the latter being made to vibrate laterally to aid the distribution of the ink. These inking-rollers are covered with leather, like the ordinary hand-rollers for lithographic printing; they receive their ink from a table which travels with the bed, and are driven by a rack or friction pieces on the sides of the bed. The ink is fed to the table from a fountain at the end of the press, and distributed by a number of oblique-lying rollers, also covered with leather. The automatic damping arrangement is at the back of the cylinder. It consists of a shallow trough containing water, partially immersed in which a cylinder of wood is made slowly to revolve. An absorbent roller is held in contact with the surface of this roller for a longer or shorter time, according to the amount of water required upon the stone, after which it carries its increase of moisture over to a heavy riding roller, which again gives it up to two damping rollers covered with linen, which traverse the stone as it passes beneath them, just before it meets the inking-rollers near the cylinder; the feed of water admits of adjustment as to quantity while the press is in motion.

The pressure in this press is adjusted by means of butting screws, which lift or lower the bed in the traveling carriage; these screws are turned by a key from above. When the sheet is printed it is conveyed by an intermediate cylinder provided with grippers to the fly at the end of the press, and there deposited, face up, on the pile of printed work.

This press, though by no means identical with European machines of the same class, may be regarded as furnishing an illustration of the essential features of them all.

The introduction of the lithographic power-press has totally remodeled the lithographic trade throughout the world within the short period of six years (1868–74), increasing the possible production about tenfold. It has lowered the cost of, and in fact rendered possible, large editions from stone which in former times found their way to the type press, with very inferior results. By this change the general public have profited largely.

Chromo-lithography, the highest development of the lithographic art, differs only from the ordinary processes in the imposition of a number of impressions in different colors from as many different stones upon a sheet of paper, the combination of colors making a finished picture. An outline drawing is transferred to each stone required to complete the picture, so as to secure exactness in the co-relation of all parts on each stone. Upon these stones the artist draws the different tints and colors, the number varying with the character of the picture. Mr. Prang's famous chromo, "Family Scene in Pompeii," occupied forty-three stones. An artist must have a high degree of skill in drawing, a fine feeling for and thorough knowledge of color, and must be able to tell what number of stones will be required, what the order of the tints and colors, what effect one tint will have upon the succeeding ones. Careful *register* is required, so that each color may fall in its proper place in the picture.

Senefelder died in 1834. Every phase of the lithographic art described in the foregoing was indicated, originated, or practiced by him. The development and perfection of the present day, in every branch of his great invention, would gratify and astonish him infinitely. He would gaze in amazement at the lithographic power-press printing thousands of sheets daily, and would be lost in admiration at the sight of a chromo which he would confound with the original painting, and which his art has placed within the reach of every one. All this he would readily comprehend; *photo*lithography alone would be to him a mystery and a revelation.

PHOTOGRAPHY.

The art of photography is entirely embraced within the century. The solitary fact bearing upon the subject, and known to the world previous to 1776, was that *horn-silver* (fused chloride of silver) is blackened by exposure to the sun's rays. It is now known that many bodies are photo-chemically sensitive in a greater or less degree, but some of the salts of silver and chromic acid in conjunction with organic matter are pre-eminently so, and are used practically to the exclusion of all others.

Scheele in 1777 drew attention to the activity of the *violet* and *blue* rays as compared with the rest of the spectrum; and Ritter in 1801 proved the existence of *dark rays* beyond the violet end of the visible spectrum by the power they possessed of blackening chloride of silver. Wollaston experimented upon gum-guaiacum. Wedgwood, previous to 1802, was the first to produce a photograph, in the technical sense of the word; this was a negative of an engraving which was laid over a sheet of paper moistened with a solution of nitrate of silver. Such a picture had to be carefully preserved from daylight, or the whole surface would blacken. Neither Wedgwood, nor Davy, who accompanied with observations the memorandum submitted by Wedgwood to the Royal Society, devised any mode of fixing the image.

From 1814 to 1827 Joseph Nicéphore Niepce, of Chalons on the Saône, experimented on the subject. In the latter year he communicated his process. He coated a plate of metal or glass with a varnish of asphaltum dissolved in oil of lavender, and exposed it under an engraving or in a camera; the sunlight so affected the bitumen that the parts corresponding to the white portions of the picture or image remained upon the plate when those not exposed to light were subsequently dissolved by oil of bitumen and washed away. This was a permanent negative picture. In 1829 Niepce associated himself with Daguerre.

In 1834 Fox Talbot commenced his investigations, and in January, 1839, announced his *calotype* process. He prepared a sheet of paper with *iodide of silver*, dried it, and just before use covered the surface with a solution of *nitrate of silver* and *gallic acid*, and dried it again. Exposure in the camera produced no visible effect, but the latent image was *developed* by a re-application of the gallo-nitrate, and finally *fixed* by *bromide of potassium*, washed and dried. A negative so obtained was laid over a sensitized paper, and thus a *positive print* was obtained. This was a wonderful advance.

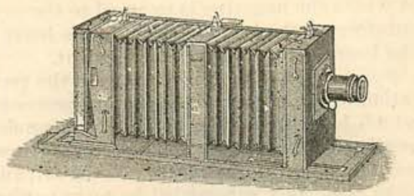
In the same month, January, 1839, Daguerre's invention was announced, but was not described till July of that year. In the *daguerreotype*, which has made the name of the inventor a household word, and furnished a test of skill in all the spelling schools of the United States, polished silver-surfaced plates are coated with iodide of silver by exposure to the fumes of dry iodine, then exposed in the camera, and the latent image developed by *mercurial fumes*, which attach themselves to the iodide of silver in quantities proportional to the actinic action. The picture is fixed by *hyposulphite of soda*, which prevents farther change by light.

Goddard in 1839 introduced the use of *bromine* vapor conjointly with that of iodine in sensitizing the silver surface.

The addition of chlorine was by Claudet in 1840. M. Fizeau applied the *solution of gold*, which combined with the finely divided mercury, and in part replaced it.

In 1848 M. Niepce de St. Victor coated glass with *albumen*, and treated it with nitrate of silver to sensitize and coagulate it. The film hardened in drying, and furnished a negative from which pictures might be printed by light.

The *collodion process*, by Scott Archer, of London, was one of the most remarkable inventions of the series, and has made photography the most important art industry of the world. A plate of glass is cleaned, floated with collodion, sensitized with iodides and bromides, usually of potassium. It is then plunged in a solution of nitrate of silver. Metallic silver takes the place of the potassium, and forms insoluble iodide and bromide of silver in the film,

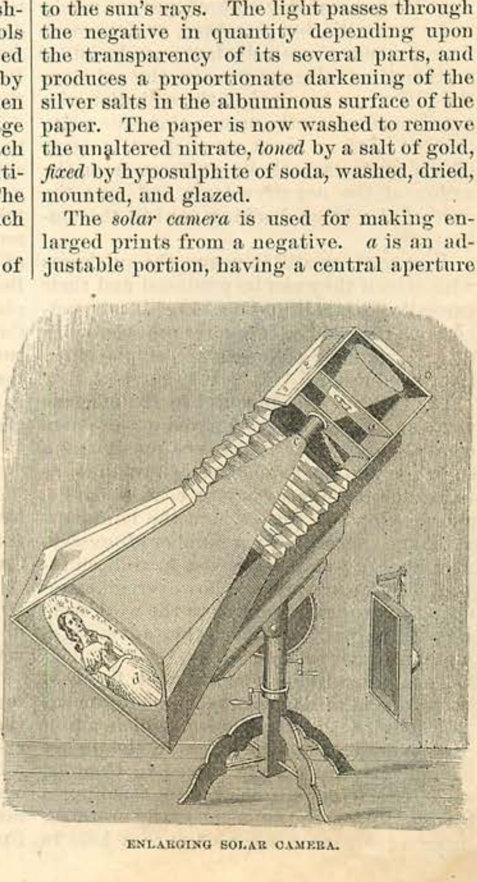


BELLOWS CAMERA.

which assumes a milky appearance. The plate is exposed in the camera, and the latent image developed by an aqueous solution of protosulphate of iron, the picture gradually emerging by a dark deposit forming upon those places where the light has acted, the density of this deposit being directly proportional to the energy of the chemical rays. When sufficiently developed, the plate is washed with water, and fixed by washing away the free silver salt by a solvent, such as the cyanide of potassium or hyposulphite of soda. This removes the milky character of the film, and leaves the picture apparently resting on bare glass.

To produce *positive photographic prints* from such a negative a sensitized sheet of paper is placed beneath the negative, and exposed to the sun's rays. The light passes through the negative in quantity depending upon the transparency of its several parts, and produces a proportionate darkening of the silver salts in the albuminous surface of the paper. The paper is now washed to remove the unaltered nitrate, *toned* by a salt of gold, *fixed* by hyposulphite of soda, washed, dried, mounted, and glazed.

The *solar camera* is used for making enlarged prints from a negative. *a* is an adjustable portion, having a central aperture



ENLARGING SOLAR CAMERA.

at which the negative is exposed to the rays entering at the window, *b*; *c* is the lens; *d* the board for the paper enlargement.

Space can not be spared for even the recitation of the names of the various processes which have from time to time been prominently before the public. Some of these were invented in the infancy of the art, and have been long superseded by more perfect methods; others yet survive for certain purposes.

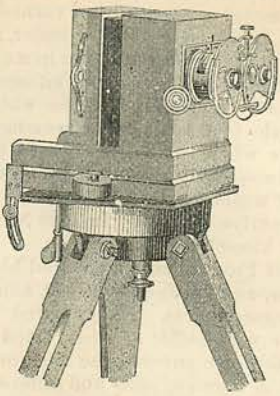
The *ambrotype* is a thin collodion negative on glass made by a short exposure, and developed so as to produce as white a deposit as possible on the lights. Such a picture is not looked at by transmitted light, nor is it valuable as a negative; it is to be backed up with a black surface, generally a black varnish, and regarded by reflected light only. Under these circumstances it appears as a positive, the deposit reflecting and the black backing absorbing the light. Pictures of this kind are rapidly made, and finished direct from the camera, as is the case with the daguerreotype, while the cost is very much less. They are, however, very inferior to good positives on paper, and had to make way for the latter as the negative process improved.

At the present day ambrotypes are rarely to be met with, but *ferrotypes*, or *tintypes*, as they are sometimes called, are produced by a perfectly analogous process, the substantial difference being that the collodion picture is made directly upon a thin iron plate covered with a black enamel or lacquer, which protects both its surfaces from the action of the negative bath, and acts the part of the black backing used in the ambrotype.

Ferrotypes are still in vogue, the quickness with which they can be produced and their exceedingly small cost making them popular with the public. Cameras provided with a large number of lenses are employed in their production.

The trouble and difficulty in the efficient working of collodion negatives out-of-doors created a desire for a means of preserving a collodion plate in a sensitive condition, so as to render it unnecessary to coat, sensitize, and develop the plate where the landscape is taken. Accordingly a number of preservative and dry-plate processes have been invented. No dry process, however, gives results fully equal in quality to the work from wet plates, but they offer other advantages which can not be ignored.

The stereoscopic camera used for field work has an arrangement for instantaneous exposure of the two lenses, which admit pencils of beams to the plates in the binary chamber. Shutters are placed in front of each tube, so arranged that by touching a spring they are simultaneously rotated, bringing for an instant of time a hole in each shutter in correspondence with the tube, admitting rays of light from the object to the sensitized surfaces in the interior.



STEREOSCOPIC CAMERA.

The first daguerreotype portrait from life was taken by Professor John W. Draper, of New York, in 1839. An announcement of it was made in the *London and Edinburgh Philosophical Magazine* in March, 1840. A full account of the operation was subsequently published in the same journal. He also took the first daguerreotype view in America, a view of the Church of the Messiah, from a window of the New York University. In his laboratory Professor Morse learned the art.

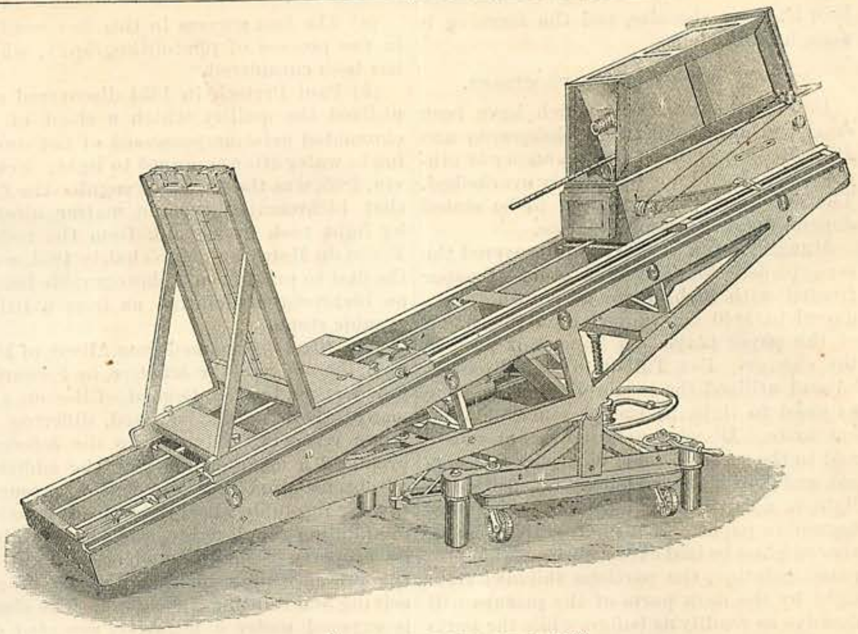
Daguerre made an unsuccessful attempt to photograph the moon. Dr. J. W. Draper succeeded in 1840 in obtaining a photograph of the moon on a silver plate with a telescope of five inches aperture. He presented specimens to the New York Lyceum of Natural History in 1840. Professor G. P. Bond, of Cambridge, Massachusetts, made photographs of the moon in 1850 with the Cambridge refractor of fifteen inches aperture. Many others followed. Mr. Rutherford's photographs of the moon are most excellent. Mr. Delarue, in England, must also be mentioned.

PHOTOLITHOGRAPHY.

Photolithography is a mode of producing by photographic means designs on stone from which impressions may be obtained in the ordinary lithographic press.

The first attempts in this line were by Dixon, of Jersey City, and Lewis, of Dublin, in 1841; they were followed by several inventors in Paris, Vienna, and Rome.

Their experiments were with resins directly upon stone. Joseph Dixon, 1854, was the first to use organic matter and bichromate of potash upon stone to produce a photolithograph. Poitevin was the first to recognize the fact that bichromated organic matter altered by light took the greasy ink from the roller. No great measure of suc-



OSBORNE'S COPYING CAMERA AND TABLE.*

cess was attained by operations with resins and directly upon stone. The various gelatine processes have been more successful.

J. W. Osborne patented in Australia September 1, 1859, and in the United States June 25, 1861, a transfer process, in which he prepares a sheet of paper by coating one side with a mixture of albumen, gelatine, and bichromate of potash, and dries it in the dark. This is exposed under a negative, whereby a visible change is produced, the brilliant yellow of the sheet, due to the salt of chromium, being changed to a chestnut-brown. In addition to this visible change, the organic matter becomes insoluble. A coating of transfer-ink is now applied to the whole exposed surface by passing the sheet through the press, face down, upon an inked stone. When the sheet is removed the photographic picture is almost invisible. The sheet is then floated, ink side upward, upon hot water, the action of which is to coagulate the albumen, rendering it insoluble, and to swell and soften the gelatine, causing the part affected by light to appear depressed by contrast. The sheet of paper so floated is next placed upon a slab, and the superfluous ink rubbed off by a wet sponge. This operation develops the picture. The sheet is then washed, dried, and transferred to the stone in the usual way. The coagulated albumen forms over the whole surface of the paper a continuous film, which adheres strongly to the stone during the transfer process, preventing any shifting and consequent doubling of the lines. This is, for all practical purposes, the first successful photo-lithographic process, and has been used in the Crown Lands Survey Office of Victoria since September, 1859, in the publication of maps. Substantially the same process is used in the Ordnance Survey Office of England. The duplication and copying of drawings for the United States Patent-office has been for some years performed by this process, which, in accuracy and speed, leaves nothing to be desired.

The copying camera employed in making negatives from drawings is shown in the figure. The camera (containing the negative plate) and the plan-board, on which is tacked the drawing to be copied, are adjustable on a table, which is tilted on its truck to give the drawing a good presentation to the light. The focusing is done by a thin metallic belt, giving a rapid and positive movement on either side of the problematical focus. The table is always brought into a horizontal position in focusing, the end of the camera box being covered by a hood, under which the operator stands. So placed, he controls the positions both of the plan-board and the lens, and has the ground glass always at a convenient distance from him. In copying at or near full scale the position of the lens affects the size of the picture, making little change in the sharpness of the focus, which latter operation is then done with the plan-board. When a large reduction is required, the position of the plan-

* The majority of the illustrations for this article are borrowed from *Knight's Mechanical Dictionary*, published by J. B. Ford and Co., New York.

board affects the size, and the focusing is done with the lens.

MISCELLANEOUS PHOTO PROCESSES.

Besides the processes which have been described under the titles *Photography* and *Photolithography*, there are a number of others which should not be entirely overlooked. The processes yet remaining to be stated depend upon the use of gelatine.

Mungo Ponton in 1839 first discovered the sensitiveness to light of a sheet of paper treated with bichromate of potash. Becquerel in 1840 determined that the sizing of the paper played an important part in the change. Fox Talbot in 1853 discovered and utilized the insolubility of gelatine exposed to light in the presence of a bichromate. Dissolve gelatine in hot water, add to the solution some bichromate of potash and dry it; the compound is sensitive to light in a way different from ordinary photographic paper. If a photographic negative on glass be laid over a sheet of this prepared gelatine, the portions shielded from light by the dark parts of the picture will dissolve as readily as before, while the parts acted on by light will form a tough tawny substance unaffected by hot water.

From this point the gelatine processes naturally divide into two groups.

1. The first group includes *carbon printing*. Poitevin, in 1855, was the first to use carbon combined with gelatine as a vehicle, availing himself of its insoluble character after exposure. This process is as follows: Paper is coated with a compound of bichromate of potash, gelatine, and lamp-black dissolved in cold water. This paper is dried in a dark room, exposed beneath a negative, and the parts not affected by the actinic action of the light dissolved off by hot water. The resulting picture is a positive print in black and white, of which the shades are produced by the carbon of the lamp-black, blackest where the light acted most freely, and with all the various shades according to the relative translucency of the different portions of the negative. Poitevin subsequently introduced a process for carbon printing under a positive. The process was materially improved by Swann about 1861. He transferred the film, after exposure, to another surface with the face downward, so that the dissolving was effected from its back, after which it was retransferred to the paper, on which it remained.

2. The picture is produced by the action of light on bichromated gelatine, and is made (*a*) to produce a print capable of being transferred; or (*b*) to serve as a printing matrix, from which impressions may be taken by the ordinary lithographic means; or (*c*) to obtain an impression in relief which may be printed from in the ordinary printing-press.

(*a*) The first success in this line resulted in the process of photolithography, which has been considered.

(*b*) Paul Pretsch in 1854 discovered and utilized the quality which a sheet of bichromated gelatine possessed of not swelling in water after exposure to light. Poitevin, 1855, was the first to recognize the fact that bichromated organic matter altered by light took greasy ink from the roller. Tessié du Motay and Maréchal, in 1864, were the first to print from a photographic image on bichromated gelatine as from a lithographic stone.

The *Albert-type*, named from Albert, of Munich, the *autotype*, the *heliotype*, by Edwards, now worked by J. R. Osgood, of Boston, and many others might be cited, differing in minor respects. Edwards, in the *heliotype*, produced a movable film; by the addition of chrome-alum to the gelatine a tough, tawny, insoluble sheet is formed, capable of standing rough usage, and yet retaining its property of being acted on by light in the presence of a bichromate, and of receiving and refusing greasy ink. The sheet is exposed under a negative, mounted on a metallic plate, the superfluous chemicals washed out, and then printed from with lithographic ink on an ordinary platen printing-press, being damped between each impression, as in ordinary lithographic printing.

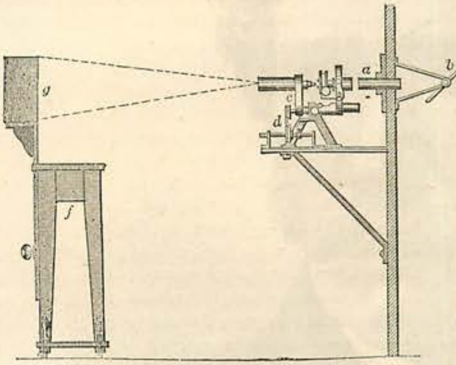
(*c*) *Relief-work* is produced in several different ways, but can not here be described. Niepce de St. Victor in 1827 led the way by an asphaltum and etching process.

The *photoglyptic* process of Fox Talbot, 1852, was another etching process. The *photogalvanograph* of Pretsch, 1854, depended upon the swelling of the gelatine after exposure; a matrix was taken in gutta-percha, and from this a cameo plate was obtained by electro-deposit. The *phototype* belongs to this sub-class. Poitevin in 1855 had a process somewhat resembling this, in which he obtained a cast by the use of plaster hardened with protosulphate of iron. Osborne in 1860 transferred the inked gelatine sheet to zinc, and etched to make a relief.

In the *Woodbury process*, from which such excellent results have been obtained for illustrating the *Medical and Surgical History of the War*, the gelatine picture in relief, obtained by light, is placed in contact with a sheet of soft metal, and subjected to heavy hydraulic pressure. This gives a picture in reversed relief and depression. Such a mould is deeper in the places answering to the shades in the original picture, and conversely, shallower in the lights. It is filled with a solution of colored gelatine in hot water; a piece of paper is placed on top and pressed down with a level lid, so as to squeeze out the superfluous gelatine. The paper is then lifted, bringing with it the colored gelatine, which forms the picture.

PHOTO-MICROGRAPHY.

The co-application of the microscope and photographic process has led to wonderful results, which we may briefly illustrate by an example. Merely referring to the early attempts of Donné, and the experiments of Gerlach, Albert, and Maddox in Europe, and of Rood and Rutherford in America, we may describe the plan adopted by Colonel J. J. Woodward, M. D., of the United States Army



WOODWARD'S MICRO-PHOTOGRAPHIC APPARATUS (WITH SOLAR LIGHT).

Medical Museum in Washington. He dispenses with a camera and ground glass. The operating-room has two windows, through one of which sufficient yellow light is admitted to enable the operator to work; the lower part of the other window is provided with a shutter fourteen inches high, the upper part being blackened. In the shutter is a hole in which is inserted a tube, *a*, through which the solar light reflected from a plane mirror, *b*, or, preferably, a heliostat, is thrown upon the achromatic condenser of the microscope, *c*, which is placed on a shelf at the window of the dark room. The light reflected through the tube, which is provided with an achromatic lens of about ten inches focal length, is thrown upon the achromatic condenser. *d* is the focusing device; *g f*, the negative holder and its stand.

For powers from 200 to 500, a $\frac{1}{8}$-inch objective without an eye-piece is used, the power being varied by increasing or diminishing the distance of the sensitized plate from the instrument. A cell filled with ammonio-sulphate of copper, which absorbs the non-actinic rays, is interposed between the large lens and the condenser, and a hood is drawn around the instrument to prevent any loss of light.

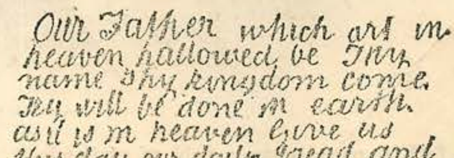
For objects magnified less than 500 diameters the time of exposure, being less than a second, is regulated by a sliding shutter placed before a slit in front of the microscope, the width of the slit being adjusted to correspond with the required length of exposure. For powers between 500 and 1500 a $\frac{1}{16}$-inch objective is employed, dispensing in general with an eye-piece or amplifier, and placing the sensitized plate at a distance not exceeding three to four feet from the microscope. In the case of objects having very minute details, however, it is frequently advantageous to employ an eye-piece or amplifier rather than enlarge a negative taken with a smaller power.

Though natural sunlight is to be preferred, it may be sometimes necessary, when this is wanting, to employ artificial illumination. For this purpose the electric, the magnesium, and the oxy-calcium lights have been used with success. Of these the electric light is the best, and for its production Dr. Woodward employs a Duboscq lamp, operated by a battery of fifty small Grove elements, ten in a cell.

The accompanying figure is a fac-simile of a photograph obtained by the instrument just described. It is an enlargement on a scale of 617 diameters from a writing on glass by Webb, of London, for the United States Army Medical Museum. The writing was executed with a diamond point by an instrument of Mr. Webb's invention, and known as a micro-pantograph.

The glass slip also contains the following inscription in a larger writing: "Webb's Test. The Lord's Prayer. 227 letters in the $\frac{1}{294}\times\frac{1}{441}$ of an inch, or the $\frac{1}{129654}$ of a square inch, and at the rate of 29,431,458 letters to an inch, which is more than 8 Bibles, the Bible containing 3,566,480 letters."

The area within which the prayer was written was micrometrically verified by Dr. Woodward, who found that it and the


Our Father which art in heaven hallowed be Thy name Thy kingdom come Thy will be done in earth as it is in heaven Give us this day our daily bread and forgive us our trespasses as we forgive them that trespass against us and lead us not into temptation, but deliver us from evil. Amen.

THE LORD'S PRAYER.

above inscription were contained within a space $\frac{1}{75}$ of an inch square.

According to a statement made in 1862 by Mr. Farrants, president of the Microscopical Society of London, Mr. Peters has succeeded in writing the Lord's Prayer so as to be distinctly legible, with sufficient magnifying power, within the space of $\frac{1}{356000}$ of a square inch.

WASHINGTON, D. C. EDWARD H. KNIGHT.