# MODERN

## REPRODUCTIVE

# GRAPHIC PROCESSES.


BY

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# PREFACE.

The following pages were prepared for the use of the Department of Drawing of the U. S. Military Academy, as a basis for elementary instruction in, and with a view to the imparting of some analytical knowledge of the means employed for the production of the many beautiful and useful prints, &c., that are constantly brought before the public, either in the publications of the day or in more artistic shapes. Each subject could be expanded into a separate volume. Those within the reach of amateurs, I have endeavored to explain at length. The others can be learned only in the school of long experience, and text books would be of little assistance. I am indebted to the courtesy of several publishing firms in New York, and to Lt. Lusk, in charge of the laboratory at

Willet's Point, for much valuable information, and to Messrs. Abney, Munckoven, Vidal, Vogel and Griffin for the use of their works on kindred subjects.

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# PROCESSES IN USE TO-DAY

FOR THE

# REPRODUCTION OF WORKS OF ART,

## Mechanical, Engineering and Map Drawings.

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Before entering into a detailed description of the various processes now in use in the reproduction of the many beautiful works of art, maps, mechanical drawings, illustrations, &c., it might be well to state that, due to the constantly increasing number of discoveries in the sciences of optics and chemistry, the great rivalry between large publishing houses, the diffusion of knowledge on art, and the increased appreciation of artistic things, many of the methods herein described are undergoing changes and improvements in the details, with increasing ranges in application. This is especially true of the various applications of photography. Good paintings, engravings and etchings, and fine photographs will always be appreciated by educated people. The various patented processes must fluctuate with a very uncertain popular taste.

I find the following to be the practical processes of the present day:

1. Sensitive paper processes.
2. Hektograph.
3. Engraving.
4. Electrotypy.
5. Lithography.
6. Photography.
7. Miscellaneous.

Mention must be made of the fact that many of the fine works of the old masters are frequently copied, not only by artists desirous of studying them, but by others for pecuniary purposes, and so skillfully is this done that the judgment of experts will sometimes fail to distinguish them from the originals, for which they are falsely sold.

Sensitive Papers.—The process in general use to-day in large manufacturing establishments, architects' offices, &c., is ordinarily known as the "blue paper" process, so-called because the sensitized surface turns from a dark grey to a blue color on exposure to the light and after washing. The drawing to be copied must be made on good, clear tracing paper, and with a very heavy opaque ink. It is then placed on a frame, on top of the sensitized paper, the frame having a heavy glass lid, which should press evenly on the surface of the drawing and hold it firmly down to the paper. It is then exposed to the light for fifteen or twenty minutes. After sufficient exposure the sensitive paper is washed in a clean water bath. The parts affected by the light have become insoluble, while the parts screened by the interposition of the lines wash out, leaving the clear white of the paper on a back-ground of blue.

The following formula is used in the laboratory at Willett's Point with most excellent results:

| | | |
|---|---|---|
| Double citrate of iron and ammonia | 1oz. | } |
| Water. | 4oz. | } |

| | | |
|---|---|---|
| Red prussiate of potassium | 1oz. | } |
| Water. | 4oz. | } |

For use, mix equal quantities and float paper for two minutes. The mixture is poured into a flat dish. The paper is then taken by diagonally opposite corners, giving it a convex surface. This convex surface is gently placed in contact with the surface of the liquid; the corners are then dropped and the paper floats on the surface. The corners must be carefully lifted in a few seconds, and the air bubbles on the surface of the paper must be removed with a brush. After floating, the paper is placed in a dark place to dry, and must be rolled up and kept from the light until ready for use.

The following process will give black lines on a white ground. The paper is coated with the sensitive solution by drawing it in continuous bands over a roller saturated with

| | |
|---|---|
| Sulphate of iron...... | 10 grammes. |
| Chlorate " " ...... | 20 c. c. |
| Gelatine............. | 10 grammes. |
| Tartaric acid......... | 10 " |
| Dist. water.......... | 300 " |

It must then be hung up to dry, protected from the light and air. The drawing is made on tracing paper with a deep black ink. The exposure is made as in the "blue" process, and must be continued until the ground is seen to turn white. It is then removed from the frame and immersed in the following solution:

| | | |
|---|---|---|
| 200 | grammes | gallic acid, |
| 20 | " | alcohol, |
| 1,000 | " | water. |

It is then washed in water and dried. It is much more difficult to handle, and more expensive than the blue process, and is seldom used.

I have been told the Major Jones, of the Corps of Engineers, obtained most excellent copies of the original drawing by using the following method. The drawing was first made on tracing paper with a mucilaginous ink. This was transferred by the above-mentioned process to a paper which was sensitized with the silver solution, giving the drawing in white lines on a black surface. This copy was in turn placed over the same kind of paper, and after exposure and washing he got excellent reproductions of the original—black lines on white paper. I have seen some maps and many machine drawings made by the "blue" process. They were very good, and suited to the purposes for which they were made. Of course this process would be too slow where a great number of copies is desired. Blue lines on a white ground give the most pleasing effect.

Hektograph, or Chromograph (French).—This is an exceedingly useful and a very simple little arrangement of gelatine for reproducing letters, manuscripts and small drawings which do not require great accuracy or much elegance. It is based on the discovery that gelatine forms an excellent body for receiving and holding certain aniline inks. The drawing is first made on paper with hektograph ink, and is transferred to the gelatine by simply pressing the drawing on the surface. If printed, while the ink is fresh, one good impression will admit of as high as fifty copies in fair condition. The violet ink seems to be the best and brightest. After the printing is completed the surface of the gelatine must be washed off with a sponge and clean water. This is quite troublesome. The gelatine solution can be poured into a glass jar. When ready to print put the jar into hot water, and allow it to stand until the gelatine will flow. Pour a film on a glass plate as a photographer pours collodion. Allow this to set, and it is ready for use as prescribed for the hektograph. When through, heat the plate and wipe off the gelatine.

Autocopiste Noir.—In order to avoid the use of aniline inks, which are very unstable, M. Lelm invented another process, called "autocopiste noir." It is very similar to Hektography in operation.

He makes use of a special ink, composed of a solution of the perchloride of iron and water, with coloring water added to enable the operator to see the lines he traces. The vehicle to which the transfer is made consists of gelatine, to which a little alum is added to harden the film. This is spread evenly on strong parchment paper. The drawing is placed face down on this, and is transferred to the gelatine by hand pressure, as in the Hextograph. After removing the original, a roller, covered with the prepared ink, which comes in tubes, is passed quickly over the film, as in lithography. The ink adheres only to the lines; press the paper which is to receive the copy, on the film, with the hand, and then remove it carefully; re-ink the film and another copy can be taken. The prepared parchment is placed in a case which keeps it stretched. Before applying the original drawing to the gelatine the roller full of ink must be passed from one end to the other of the parchment sheet. If it takes any of the ink the entire sheet must be wiped off with a damp sponge, and be thoroughly cleaned and dried. These prints have all the durability of prints with a carbon base. The prepared parchment is put in a stretching case, and can be purchased ready for use.

ENGRAVING.—To engrave has but one signification, viz., that of marking by incision. The rudest mark, if it is cut into the substance, is engraving. Some of the applications of photography, such as the Heliogravure and Photogravure, are engraving, for the surface of the plate is cut away by the action of acids. Etching is also included under the generic name of engraving, but has a technical signification of its own.

Engraving is older than printing, and dates from the first quarter of the 15th century. Wood engraving was learned from the Chinese. The process of printing from metal plates was not discovered until towards the close of the 15th century. Its history from that day to this is exceedingly interesting. It has always been subordinate to painting, but some original work has been executed by good engravers. The apprenticeship to the art is necessarily long and tedious.

The chased ornamentation of watches, silver-plate, &c., is engraving. I shall confine myself, however, to its technical signification as one of the fine arts. The following are the usual varieties of engraving:

1. Pure line engraving on metal plates, usually of copper or steel.

2. Mezzotint.

3. Wood-cuts: in which the lines that print black must be left in relief.

In chronological order the wood-cut comes first. The genius of steel engraving has not improved since the days of Dürer and Marcantonio notwithstanding the progress in means and materials. Wood engraving has, in the past thirty years, grown into a wonderful degree of excellence, and has widened into a range of application that covers almost all degrees of artistic reproduction. As a "process" it is not surpassed by any known invention, unless, perhaps, it be the Photogravure process, as executed by Messrs. Goupil & Co., in Paris. Some writers go so far as to claim that there is nothing artistic which can not be exactly reproduced on wood. The best of our wood engravers are, beyond dispute, the best in the world, and the beautiful prints published in our standard magazines have never been equaled in any country at any time. We may well feel proud of the progress of our countrymen in this art, and a little time will do much for us in the others. It is difficult to believe that the work done by Cole, Müller, Juengling and others can ever be excelled, and yet we cannot believe that perfection has been reached. The wood engraving of to-day has made no advance in *principle* over that of Dürer and Thomas Bewick. It fills a different sphere, and has been greatly assisted in the results of its practice to-day by the use of modern presses, paper, ink, photography, and electrotypy, though many of our best engravers prefer to work from a drawing on the block rather than from a photograh.

Photographs of paintings, engravings, &c., have frequently to be much reduced in size, and it is very difficult to work out an exact copy of the original. Again, red and yellow colors in a painting take dark, and blue and violet take white in a photograph, so that it is necessary for an engraver to have the original by him for reference in order to give expression to the true color value of the painting. The history of engraving is long, but exceedingly interesting, and I must refer the student to other works written on this subject alone, as it is scarcely within the province of this article to give more than a description of the mechanical and artistic means employed for the production of finished work.

We may divide the process into five distinct operations, viz. : 1. The drawing or photographing of the picture on the block ; 2, the engraving ; 3, the moulding in wax ; 4, the electrotyping of the mould; 5, the setting and printing. Each operation requires special care, and the fineness of the original is a little blunted by each operation. The artist's proofs, obtained by methods of his own, and with much time and care devoted to printing, are much superior to the copies obtained from a powerful and rapid press, printing hundreds of copies in one hour.

(1.) THE PREPARATION OF THE BLOCK. —A block of boxwood of unifrom thickness, and cut across the grain, is carefully polished and cleaned, and is covered with a light coating of Chinese white, giving a grey tint to the block. The drawing is made on this, either by the artist or by the engraver, or by the photographer, as the case may be. There are but few photographers competent to do this work without filling the block with silver, which interferes with the cutting. (2.) Engraving.—This, of course, is the main feature of the work, and to it the engraver must bring his artistic skill and genius, coupled with his own particular method of working. If he be a true engraver his endeavor will be to thoroughly translate the genius and ideas of the artist whose work he is endeavoring to place before the public. Herein lies the difficulty. The lights of the drawing must be cut out so as to leave the darks, from which the print is to be taken, in clear, distinct relief.

In this, wood engraving is more difficult than its more aristocratic counterpart, steel engraving. In the latter the cross hatchings can be readily made with the burin without any trouble as to what will be left in relief, but the wood engraver must cut out each little diamond-shaped space between the lines, and leave the edges clean and sharp. Again, if he desires to copy an engraving faithfully, the little dots often placed in the diamond-shaped spaces by engravers on metal must be cut around and left. Such skill, however, has been reached by our good engravers that they can faithfully represent crayon or pencil drawings, line engravings, etchings, and even the brush mark on paintings.

After the engraving is finished and the block cleaned, a proof is taken; if satisfactory a wax mould of the block is made. This is black-leaded, and electrotyped in copper, as will be described, and after being backed with type metal and "type high" wood, it is ready for the printer. The fine prints executed by the Century Co. and Harper Bros. are obtained with much labor and care. Cylinder presses with several inking rollers are used; but one side of the paper is printed at a time, and dry paper is used. A light pressure proof is taken first, and an examination of this shows whether any parts of the form are too high or too low. The low parts are raised up by underlaying the block with bits of paper until the desired height is obtained. As all printing machines are made to give an even impression on all parts of the "form," cuts with strong contrasts of light and shade must be so arranged as to receive different degrees of pressure, which should be very strong on the intense blacks, firm on the middle tints, and light on the others. This is obtained by the process of "overlaying." The pressman first prints a number of flat proofs on different thicknesses of paper. The "overlayer" cutter compares these with the artist's proofs, and decides how many overlays he will need to produce the work to advantage. If he decides to use three overlays he cuts out of the proofs, skeleton figures of the strong blacks, of the middle tints, and of the lightest tones. He puts these accurately on the cylinder so that the strong blacks shall have three, the middle tints two, and the light grays one thickness of paper to increase the pressure on the corresponding parts of the electrotype, and these overlays must be attached to the cylinder and to each other, so that they will cover *exactly* the corresponding lines on the electrotypes. This work is necessarily long and tedious, but the beauty of the results amply repays for the time and care expended.

Many prints are made directly from the wooden block, but only coarse blocks can be used for a large number of copies, as printing in the rapid and powerful steam presses of to-day would soon blunt the sharp lines of the drawing and make the block utterly useless. It is impossible to obtain the pure, clean lines of an engraving in metal, from a relief plate. In the latter, the prints are merely darkened surfaces, and the ink must of necessity spread a little, while from the former we get a black cast of the line, with sharp, clean edges. Large wood cuts are frequently divided into sections, and executed by separate engravers. The blocks are then joined together and electrotyped as described above. We can readily see that the engravers must work so as to give similar tones to the different parts. What the future of wood engraving will be can only be a matter of conjecture. It is at present passing through an era of favor and success

Line Engraving on Metal.—The manner of printing from an engraved metal plate is the converse of that used in obtaining a print from a wood cut. In the latter it is the raised parts, in the former it is the parts cut out which give the darks of the picture. The metal plate must be carefully made of a uniform thickness throughout, and the surface to be engraved must be carefully polished and cleaned. It must be free from blemishes of all kinds, as the slightest scratch on the metal will show on the print. The lines are cut with a little steel instrument called a burin, which is simply a small hand tool, with a (◊) diamond shaped edge, and which the engraver holds between the thumb and forefinger and *pushes* from him instead of drawing towards the body, as we would a pen or pencil. By varying the pressure the lines are made deeper or more shallow at the pleasure of the engraver, and the result depends solely upon his genius and skill. Much of the engraving of to-day is done with machinery. The broad surfaces of skies, foregrounds, etc., are readily and beautifully done in this way.

The plates are cut while soft, and are tempered before printing. The plate is covered with ink, either with a roller or a dabber. The surface is carefully wiped off, first lightly with a cloth, and then with the palm of the hand. The paper is slightly moistened, and the pressure of the press forces it into the incisions in the plate, from which it absorbs the ink.

The ink from the markings settles on the paper in strong, distinct lines, and the darks are much purer and stronger than in a wood cut. In block printing the line is only a blackened surface, in plate printing it is a *cast*. The line may be of exceeding fineness, it will print just the same. The art of line engraving seems to be doomed to extinction. There are still a few good engravers in the world, but engravings, if good, are expensive, and, worse than that, their place in public and popular estimation has been usurped by the cheaper productions of the etcher, and the many excellent patented processes based on photography.

Mezzotint.—For the Mezzotint the surface of the plate is first worked over in many directions with a small tool called a cradle, which is a chisel-shaped instrument with a circular edge, having many fine teeth. This gives the surface a fine grain, with many little projections. The parts are then cut away with a sharp instrument called a scraper, and at the pleasure of the engraver. The parts which are to print white are entirely cut away and the surface burnished. This process is better adapted to the expression of texture in garments, clouds, &c., than the pure line engraving, but the beautiful effects and expressions of the line are omitted. It is quite common to see the two combined in the same plate. The burin being used where it can be made most effective. Mezzotint plates are, unfortunately, not very durable, and after a few hundred copies have been taken, the little projections become blunted and the effects destroyed.

Etching.—Etching is a species of engraving in which the cutting is done by the action of an acid. *Pen* sketches are very frequently and *very improperly* called etchings. Etchings are very popular to-day, and are very handsomely executed. The process is substantially as follows: To prepare the plate, it must first be covered with an etching ground, a composition that will resist acid, and it must be so adhesive that it will not quit the metal when fine strips are left isolated between lines, and yet it must be easily removed by the etching point. The following mixture is found to give an excellent body: Melt two ounces of white wax, add one ounce of gum mastic in powder, a little at a time, stirring until they are well mingled, then add in the same manner an ounce of bitumen in powder. To apply the ground to the plate the composition is melted, and a little of the essential oil of lavender is added. When the mixture is cool it forms a thin paste, which is applied to the plate with a small hand roller. The surface is then smoked by holding the plate over the flame of a candle or tallow dip; the drawing is made on this, and the composition is removed from the parts to be etched, by means of an etcher's point; the acid is then applied, and the depth to which the eating is allowed to proceed is left to the skill and desire of the etcher, as the biting may be stopped out at any point very readily by removing the acid. After the biting in is finished and the composition removed the burin may be used in finishing up parts found to be insufficiently etched. The plate is printed from in the same manner as the engraved plate, and gives beautiful and very artistic results.

Copper is the best substance to etch and engrave upon; steel resists printing better, but is not nearly so agreeable to work upon, and does not yield such beautiful prints. Etching is the only form of engraving that has ever been practiced directly from nature. Etchers go out with their materials like painters or any other draughtsmen. *Dry point* is often used in connection with etching. The lines are scratched on the polished surface with a sharp steel point. Etching is extremely favorable to the imitation of textures such as the intricacy of lace work, the richness of velvet, the sheen of armour.

Electrotypy.—The ordinary form of a Daniell cell is a copper vessel containing a saturated solution of blue vitriol (sulphate of copper), inside of which is placed a porous jar containing dilute sulphuric acid. If a rod or strip of zinc be placed in the acid and be connected with the copper vessel by a wire, electrical action will immediately take place. The zinc plate will be gradually decomposed with a consequent formation of zinc sulphate in the porous cell, and pure copper will be disengaged from the sulphate, and will be found deposited on the surface of the copper vessel, the current passing from the positive generating zinc plate to the negative copper pole. By the use of a copper coin in some of the early experiments with electricity, it was discovered that a very perfect copy of the coin was formed, with the exception, of course, that the copy was in *intaglio;* a bit of varnish was accidentally dropped on the surface of the coin and no deposition of metal was found over the varnish, which was a non-conductor, and the operator saw that he had the power of directing the deposition at his pleasure The apparatus was for many years very rude. The strength of the copper solution had to be maintained by the addition of crystals of the salt, and the zinc plates, which were quickly eaten away, had to be renewed. For carrying on the operation extensively, a large number of cells was necessary, and this method was replaced by the use of dynamo electric, or magneto-machines. If a coil of copper wire be revolved between the poles of an electro-magnet, a current of electricity will be generated in the wire at each half revolution; in the next half revolution, a similar current will be generated, but in the opposite direction. By means of a little instrument called a commutator, these counter currents are converted into a constant stream of electricity, and this current is utilized in the electrolysis. Large and powerful machines are constructed, run by steam-power. It is said that there is one at Birmingham which will deposit 4½ cwt. of copper in 24 hours. Wood engravings may be electrotyped by coating the surface with a wash of black lead and then placing the block in the current by a connecting wire. The finest scratches and the smallest ridges are faithfully reproduced. To obtain an exact copy of the object, the matrix or first plate is in turn electrotyped. The surface to be electrotyped must be perfectly free from stains and grease spots. The electrotyping of objects of the most delicate nature, such as Daguerreotypes and negatives (which are metallic), is now done with perfect ease. Insects, flowers, etc., may be faithfully reproduced by first immersing them in a metallic solution.

The process of electrotyping is simple and moderately expensive. It is used extensively in the engraving department of the Coast Survey office, with apparatus that will cause the deposit of from two to three lbs. of copper per square foot in 24 hours. The copy, after removal from the mould, is strengthened by a backing of type metal, and is then ready for the press. It is admirably adapted to map work, which is generally pure line-work. It is also the final step in many of the processes based on photography, both for the production of engraved plates and plates in high relief. The copper is supplied by putting a plate of the *pure* metal in the current in front of, and parallel to, the surface to be electrotyped. Electroplating is similar to electrotyping, except, of course, the deposit remains on the metal, and forms an inseparable part of the object. Many small objects can be electrotyped or electroplated in the same bath at the same time by simply attaching them to the proper pole of battery. For depositing copper, a solution of the sulphate is used; for silver a solution of cyanide of silver, in cyanide of potassium; for gold, the double cyanide of gold and potassium. It must be borne in mind that the cyanide of potassium is a rank poison.

STEREOTYPING.—The process of stereotyping a valuable work, for the purpose of saving it for subsequent editions, is now a very simple proceeding. In its early stages of development a plaster cast of the type form was taken, and this was in turn put through a troublesome process in order to obtain a metallic mould of the plaster; defective parts had to be taken out and new letters or words set into the metal, and in addition to this the enormous quantity of metal necessary to stereotype a large work, made handling and storage quite important features. Electrotypy has completely changed this laborious process into one of easy manipulation, and certainly of good results. A sheet of wax, covered with a coating of graphite, is laid upon the type form, and is secured in a shallow pan called the moulding pan. Strong pressure forces the wax into all the interstices, and even into the lines of the wood cuts.

The moulding pan is then removed, and the impression is covered with a second coating of black lead, and is then placed in the electric circuit, and regularly electrotyped and backed. Mr. Silas P. Knight, of New York, pours a solution of the sulphate of copper over the graphite, and then dusts on this fine iron filings. Decomposition and recomposition take place immediately. The acid leaves the copper and unites with the iron, depositing a coating of pure copper on the mould, it is then placed on the circuit and kept there until the thickness of the deposition is about that of blotting-paper. It must now be backed with strong metal, as printing would crush the mold out of shape.

The shell is placed face down, and the back is washed with a solution of chloride of tin to make the metal adhere. A sheet of tin-foil is laid on this, and the pan is heated to about 460,° when the tin melts. Melted metal is now poured into the mould and a solid plate is formed. This plate is trimmed and made of the proper thickness, and is stowed away for future use. Electrotypy does not cost more than the stereotype, it will wear much longer, and gives far more perfect impressions, as electrotypes are practically as good as the original blocks from which they were taken

LITHOGRAPHY { Lithography,<br>Photo-Lithography,<br>Chromo-Lithography.

In lithography we have one of the simplest and yet the most useful and most extensive of the industrial arts. It is based on the antagonistic qualities of grease and water. The greasy lithographic ink is made to adhere to a polished surface of a peculiar kind of limestone obtained in Bavaria. The parts thus covered acquire the property of receiving printer's ink, which is prevented from adhering to the other parts by the interposition of the water.

The lithographic stone is a very fine-grained homogeneous limestone, and is imported free of duty. It is cut into blocks of from two to three inches in thickness. Before receiving the lithographic ink, the face is carefully and highly polished, and the stone made of *exactly* the same thickness throughout. Some stone is obtained in this country, but it is too coarse for fine work. Lithographic ink is composed of tallow, wax, soap and shellac, about equal weights, and *quantum sufficit* of fine Paris black. It may be purchased in almost any market.

The transfer paper is prepared by coating the surface with a composition of size or starch and glue, with a little gamboge. This forms an excellent body for the reception of the ink, preventing the paper from absorbing it, and allows it to be readily transferred to the stone. The drawing is made on this paper with the ordinary instruments, when completed it is placed on the prepared stone, face down, and is run through the press; the paper is then carefully pulled off, leaving the lithographic ink on the stone. The stone is then slightly etched by pouring on it a very dilute acid, giving the inked lines a little greater relief. The work is then proven. Alterations may be made by simply scratching off the ink with a penknife or common eraser. The surface is kept moistened with water throughout the printing, and thousands of copies may be struck off of the same stone without a renewal of the drawing. I saw some very fine specimens of map work being done by Messrs. Julius Bien & Co., for the Coast Survey office, and also for the Census Bureau.

There is but little difficulty in producing excellent prints of pure line work by any of the processes described. It is the shading—the fine gradations from light through half tints to the strong darks that call for the skill of the artist. It is quite common for lithographers to print from etched stones, especially in the copying of small detailed drawings. The surface of the stone is smoothed and polished as before described; it is then coated with a ground of Paris black. The drawing is then made with sharp steel needles fixed in cane handles, leaving clean white lines on the face of the stone; these lines are filled with the fatty ink; the surface of the stone is cleaned with water and a piece of coarse flannel, and is then ready for the operator, or the ground may be removed and the stone cleaned, and the lithographic ink be applied to the surface of the stone with a roller. The lines scratched in will receive no ink, and we obtain white lines on a black ground. Lithographic chalk is often used for shading of large surfaces, and is applied in the same manner that we apply pencil shading. Fine shading on small surfaces, such as the shadows and gradations on a face, is frequently stippled in with a lithographic pen, which is similar in shape to the ordinary writing pen, but is stronger, and is unsplit.

In searching for a process for the production of maps, of which a large number of copies may be desired, making economy necessary, I doubt if one better than lithography can be found, certainly not in our country. The most excellent maps of the Wheeler survey were made in Vienna by a secret process belonging to the Austrian Government. Lithography proved of great value to General Sherman's army on the march from Atlanta to the sea. A wagon was fitted up with a hand-press, half a dozen small lithographic stones and the necessary materials. An operator was found, who, in addition to being a good draughtsman, understood the method of printing. The reconnoisance sketches and reports made during the day were turned over to him in the evening, and, by the following morning, lithograph copies were in the possession of the officers entitled to them Many of the models now in the Academy bearing the names of Calamé, Harding, Julien are excellent examples of the beauty and finish of lithographic work of some twenty to thirty years ago.

General Abbott, in some notes submitted to the chief of engineers, speaks of some impressions obtained by treating a newspaper picture with acid and transferring the printer's ink to the stone. He says the effect was fine, resembling an old etching. I was told by a prominent lithographer that the process is known in this country, but is not considered to be of any value, as a wood-cut is a poor basis on which to form a high grade picture, much better results can be obtained by copying the wood-cut directly on to the stone.

PHOTOLITHOGRAPHY.—There are several photolithographic processes, similar in principle, but different in detail. Photography is brought into use as a valuable aid to lithography. There is nothing to prevent the direct formation of the image on the lithographic stone by exposure under the negative; but it would be difficult to handle stones of any considerable size. The result can be obtained in the following manner: A mixture of water, albumen (white of eggs), or of dry albumen, and bichromate of ammonia is passed over a lithographic stone, which has been thoroughly polished and cleaned. The excess of the sensitizing mixture is carefully rubbed off, and the surface of the stone dried, so as to remove all traces of humidity. It is then exposed under the negative. Wherever the light has penetrated to the bichromated albumen it has rendered it impermeable to water, while the other parts remain soluble. After sufficient exposure the stone is carried to the dark room, and the surface is uniformly covered with lithographic ink; it is then immersed in a basin of water and the soluble parts are washed out, leaving the image on the stone, which is then treated with the acid and gummed, and is printed from as in the ordinary lithographic process.

The difficulty of handling the stones has given rise to the use of a transitory support for the image and a transfer of this to the lithographic stone. From such transferred prints the original drawing is reproduced by ordinary surface printing.

The paper which is to receive the image should be unsized and be tough and not easily torn or stretched. It is sensitized by immersion for three or four minutes in the following solution:

| | | |
|---|---|---|
| Potassum di-chromate | | 44 grammes. |
| Gelatine | 44 to 60 | „ |
| Little Glycerine water...... | 1 litre, | |

and is then hung up to dry. As soon as it is dry it is exposed under the negative. After exposure the surface of the gelatine film is carefully covered with a coating of lithographic transfer ink, either with a roller, or by putting it face down on a lithographic stone, which has been coated with the ink, and subjecting it to light pressure. The picture is then developed by floating the print, back downwards, on a dish of water, at a temperature of about 50°c. As soon as the lines appear as depressions on the film it is immersed in a warm water bath, to which a little alum should be added. The soluble gelatine is carried away, together with the ink that covered it, and the image remains formed of ink lines in relief on a gelatine back. This is re-inked with the roller, and is transferred to the lithographic stone, as in ordinary lithography. This process lends itself most readily to the execution of line work.

The original drawing should admit of some reduction in size, as the lines are slightly increased in width by this process. Some very good results have been obtained by this process, in the reproduction of half tints.

It may be necessary to use a sponge and tepid water for arresting the development. Various modifications of this process have been tried, but without any particular increase of excellency in work.

The word lithography has long lost its etymological meaning. It is now applied indifferently to any impression made from an inkable surface by reason of the inverse affinities developed thereon for water and greasy ink.

Chromo-Lithography.—Chromo-lithography is simply lithography in colors, and differs in no wise from ordinary lithography. It is a much more laborious process, as a separate stone must be made for each color, and it is consequently more expensive and slower than lithography in black. No better specimens of chromo-lithographic work can be found than the many beautiful cards printed on paper and also on satin by Messrs. Prang & Co. It is the great commercial process of the day, and enormous quantities of this kind of work are required to meet the demands of industry and commerce. The difference between the show-bill and the satin card is not due to the process, but, as in everything else, to the quality of the materials used, and the skill and artistic taste and knowledge of the makers.

Great care is necessary in making the drawings on the different stones, so that the various colors shall fit accurately into their places in the drawing. A "keystone" is first executed and proved; marks or small needle-holes are made for "registering" particular points of the drawing. This "keystone" is only used for making as many impressions on the other stones as there are colors to be employed. I saw preparations for the printing of a card for which seventeen stones were to be used, and copies of this card could probably be bought for from 15 to 25 cents.

I have read a description of Mr. Eckstein's new method for reproducing maps and drawings, for which he claims the following advantages:

1st. A color is printed in all its shades by means of *one* stone.

2d. *All* colors are printed by means of but *three* stones.

It answers very well for map work, as all of the necessary colors can be readily obtained by the simple superposing of the primaries—blue, yellow and red; but for the reproduction of art works, in which great varieties of color and tone are necessary, I am told it does not answer so well as the ordinary chromo-lithographic process.

His process is substantially as follows:

A photographic negative of the object is taken, from which a positive image is formed on glass. This image is consecutively transferred to the three prepared stones. Each stone is then polished and lightly coated with a mixture of asphalt, white wax, stearine and a solution of soda; it is then exposed to the light, which makes the coating insoluble to a limited extent. It is then dried and placed under a line drawing machine, which covers the whole surface of the stone with fine parallel lines, by means of a blunt diamond, which takes away the coating without cutting the stone. The stone is then etched at the pleasure of the operator, as in ordinary etching, and on this depends the success of the operation; so that the skill of a practised etcher is necessary after the etching is finished. The surface of the stone is washed with turpentine, and the remnants of asphalt and ink removed. The color is then rubbed on, and the stone is ready for impression.

His process for printing all gradations of a single color works admirably in topographical maps; but for the reproduction of art works, his process is more artistic than mechanical, without corresponding results.

Oleography.—This is a name given to

a merely vulgar process, which is simply an attempt to adapt chromo-lithography to the purposes of imitating oil paintings. The print is mounted on canvas, sized and varnished, and is sold under the ordinary name of "Chromo."

ZINCOGRAPHY.—This process is simply lithography applied to zinc plates instead of to the stone. Zinc plates are cheaper, and more readily transported; but as the ink does not penetrate the zinc as it does the stone, the adhesion is not so strong, and accidents are liable to occur in the printing which would require the preparation of a new plate.

HOESCHOTYPE.—This is a new process of color printing in fac-simile, named after the German inventor. The following advantages are claimed for it over chromo-lithographic processes: More delicate gradations of tint and greater simplicity of processes, which requires only five printings, and its therefore immensely diminished cost; also the almost unlimited number of copies to be obtained from the plates. First comes the copy in photography and the transfer to the metallic plates, which are prepared with gelatine. Five such copies are treated successfully with the required proportions of yellow, red, blue, neutral and brown pigments, and the printings are taken off in the same manner. Under this process, by the adjustment of the relative proportions of the five combined colors, it professes to cover 1,620 different tints. The specimen prints show surprising delicacy and variety of tone.—*Portfolio.*

CEROGRAPHY—A cerograph, as the name implies, is a drawing in wax. The earliest development of cerography consisted in making a drawing in a wax coating on a metal plate. The lines were drawn with an ivory point, and were cut through the wax to the surface of the metal, a mould of the wax was then taken and stereotyped. Electrotypy has superseded the unsatisfactory stereotypic process; but otherwise the process of to-day is the same. Messrs. Struther, Servoss & Co., of New York, do a great deal of this kind of work, and furnish some very handsome prints. It is exceedingly well adapted to the reproduction of small maps, mechanical and engineering drawings, small landscapes and other illustrations without difficult gradations in light and shade.

A copper plate, about $\frac{1}{10}$ of an inch in thickness, is slightly oxydized on one face, and this face is covered with a coating of white wax, the composition of which is a secret. This coating is made of about the thickness of a sheet of blotting-paper, and is kept perfectly clean and smooth. The wax must be of such a nature that it will adhere firmly to the plate in the parts not cut away, and yet must be easily removed by the V shaped drawing instrument. The drawing is made on the wax, either by hand, or it is photographed directly from the original to the wax by a process not made public. The drawing completed, the lines are cut out of the wax, just to the surface of the copper. The lettering of maps is put in by simply pressing the type in the wax, so as to leave a clean sharp impression of it in the proper place. The drawing is then "built up" with beeswax, so as to give the electrotyped lines sufficient relief. After the "building up" is completed, the plate is electrotyped in the usual way.

They also do some very good work in colors, and use only the three primaries red, yellow and blue. They get a sufficient number of tints for map-work by superposing these colors, as in chromo-lithography. A separate relief block must be made for each of the primary colors. In preparing the plates for colored work, the waxed face is put under a line drawing machine, and is ruled in to the surface of copper. The electrotypes taken from these surfaces give beautiful prints in the ordinary rapid steam press. The work done by this process is certainly most excellent. It is reasonably cheap and rapid, and is only executed in two places in our country.

The process of M. Dulos is as follows:

A plate of copper is covered with the following mixture:

| | |
|---|---|
| Ordinary Benzine<br>Caoutchouc<br>Zinc, white | to saturation. |

This coating can be easily cut with steel or ivory points. The drawing finished, the plate is plunged into an iron bath, which deposits the iron only on the uncovered copper. If we desire to obtain an engraved plate, the varnish is removed and the plate is silvered. The silver is deposited on the copper, to the exclusion of the iron, by pouring a dilute solution of sulphuric acid on the plate. The iron is eaten out, and, by treating the plate with the ammoniacal sulphate of mercury, the relief of the silvered parts is slightly increased, and we have the lines in intaglio.

A relief plate may be obtained of the same drawing by depositing silver in place of the iron.

The process of M. Comte, for producing a typographic plate, is somewhat similar to that of M. Dulos. He used the following solution:

| | |
|---|---|
| Gum Arabic<br>Zinc, white<br>Avignon, yellow | Mixed to a convenient consistency. |

This solution is placed on a zinc plate, which has been carefully prepared. The lines are removed with a quill or an ivory point, leaving the naked metal. Lithographic ink is daubed into the lines, and the plate is cleaned with benzine, so as to remove all of the varnish, after which the plate is dampened and inked anew. The ink is received only by the lines which have previously been in con-contact with the greasy ink. A resinous powder is now carefully sprinkled on the greasy ink, and the plate is subjected to the action of dilute acid, until the desired relief is obtained. The greasy resinous varnish protects the lines of the drawing from the action of the acid. These processes are not, as will be readily seen, *purely* cerographic, but are allied to it.

For industrial uses, electrotypy answers much better than the purely chemical processes, based on the use of the salts of mercury. By making a good drawing in the wax, applying a coating of black lead and electrotyping, an excellent plate can be obtained, having the additional essentials of cheapness and rapidity of execution. The wax must have similar properties to that used in etching. The following formulas give satisfactory results:

| | | |
|---|---|---|
| A. | Pure wax (white) | 75 grammes. |
| | Burgundy Pitch | 90 " |
| | Resin | 15 " |
| | Asphalt | 60 " |
| | Turpentine | a few drops. |
| B. | White wax | 60 grammes. |
| | Asphalt | 60 " |
| | Black Pitch | 30 " |
| | Burgundy Pitch | 15 " |

PHOTOGRAPHY.—It will not be possible, within the necessary limits of this article, to give more than a general outline of the principal operations in photography. It is a science of optics and chemistry combined. Its rapid progress, and the wonderful developments in its various applications in the past twenty years have spread it over almost every branch of human effort and knowledge. In astronomy, geography, lithography in artistic reproductions of valuable works, and in the departments of justice, its value cannot be overestimated. Its utility in time of war, and its value to the military man, was clearly shown in the war of 1870–'71, and its range has manifestly widened since that time. In some foreign schools of technology it is carefully taught. It will reproduce in minutes, work which required weeks and months of hard and careful work, and with far greater accuracy than could be obtained by any other method. It takes long practice and some natural ability to make a good draughtsman. A few months of careful instruction in photography is sufficient. Good apparatus can now be bought at very low rates. It gives ample returns in instruction and amusement for all of the time spent in studying its various applications.

Before describing the various detailed operations, it will be necessary to briefly give the principles which make photography possible

Various substances, such as the salts of silver, some of the salts of iron, uranium and chromium, potassium dichromate, and a certain kind of asphaltum or bitumen found in Judea, when exposed to action of the actinic or chemical rays of light undergo peculiar chemical changes, and if in the presence of some organic substance, such as collodion, gelatine, etc., they form new compounds with peculiar properties as to solubility. The parts acted upon by the light, become nearly insoluble in water, turpentine, etc., while the parts screened from the light remain soluble and are easily washed out. This action is so perfect that it extends admirably through the half tones and delicate gradations, enabling us to get a complete detailed picture. The extent of the action depends upon the intensity of the light and the time of exposure of the sensitive plate. The actinic rays are found in the green, blue, blue violet and violet rays of the spectrum, and are very weak in the yellow and red rays; so that the colors which appear brightest on the retina have the least effect on the negative plate. This explains why yellow and red objects print dark on the picture, and blue and violet print white. The process of taking a picture by photography may be divided into the following distinct operations:

(1.) The Formation of the Sensitive Plate.—Glass is found to be the most satisfactory material to form the negative on; where but a single copy is desired it may be taken on paper, wood, or other substance. The glass should be clear and must be thoroughly cleaned just before the sensitive solution is placed on it, as any specks of dust or grease spots on its face will injure the negative. It should be immersed in a bath of nitric acid and then thoroughly dried and rubbed with a dry cloth. It is then ready for the collodion, which is almost universally used for a body, as it is particularly suitable for holding the precipitable salts of silver, and is, for ordinary purposes, totally unacted upon by the sensitising solution. The plate is held by one corner. and a circular mass of the thick fluid, to which a metallic iodide and a bromide, as of potassium, have been added, is poured upon the center and allowed to flow to each of the four corners by a gentle inclination of the plate, about half of the fluid remains and adheres to the plate, the remainder is poured off at a corner. As soon as the collodion stiffens, the plate is immersed in the nitrate of silver bath. This is accompanied by a chemical change. The iodine and bromine salts change properties with the nitrate of silver, and give birth to the iodide and the bromide of silver and nitric acid salts. All of these details having been carefully conducted in a dark room, or in a room to which light is admitted through a yellow or ruby colored glass, the plate is placed in the cassette or dark slide, and is ready for the camera, and the second stage of the operation, or

(2). THE DEVELOPMENT OF THE IMAGES.—The object is carefully placed in the focus; the cassette is put in the camera: the slide is drawn out, and the light is allowed to fall on the sensitive plate. This is a very important operation. If the time of exposure is too short, the picture will be weak, if it be exposed for too long a time the bright lights will appear as great white blotches. The time must be regulated by the nature and intensity of the light, and is different for differently sensitized plates. It can be learned only by experience. The chemical strength of the blue sky light varies greatly with the latitude of the place, the season of the year, and the time of day—southern latitudes. The summer season and mid-day give the most favorable opportunities. Electric calcium and magnesium lights are actinic; moonlight, lamp and gas light, but very slightly so. After sufficient exposure, the slide is replaced and the plate removed to the dark room. The image is as yet invisible, and must be brought out and developed by some chemical agent. The light has peculiarly affected the iodide of silver, the principal constituent of the plate, changing it from the iodide $Ag_2I_2$ into the subiodide $Ag_2I$, leaving but one atom of silver saturated and the other free to combine with any substance for which it may have an affinity. A solution of green vitriol (Ferrous sulphate) is gently poured on the plate. The silver is precipitated on the plate, and the picture slowly makes its appearance; first the lightest parts, such as the shirt and the face, then the darkest. The picture may not be strong enough yet, and must now be put through the operations of

(3). Intensifying and Fixing.—After the development the plate is washed with clean water, and the picture is intensified by repeating the process of development. A mixture of green vitriol and a solution of silver is poured upon the plate and more silver is thus precipitated. After the image has been sufficiently intensified, in the judgment of the operator, it is fixed by pouring on the plate a solution of the hypo-sulphite of sodium, or the cyanide of potassium. This dissolves out the surplus salts of silver, leaving the image intact in metallic silver. The plate is now washed and dried and covered with a varnish for protection, and is ready for the

(4). PRINTING.—The negative shows everything reversed—the white face is black and the black coat is white, hence a *positive* must be obtained from this. It is also evident that the relations of light and shade are not correct; all defects in the original are faithfully reproduced in the negative; and, indeed, so sensitive is the plate, that many marks on the object, not visible to the eye, show plainly as spots on the negative. Vogel relates an incident in the taking of a portrait of a lady, on which many dark spots were found on the negative of the face. As the lady had a fairly good complexion, these spots excited the curiosity of the photographer, and he learned that three days afterwards she was taken ill with the small pox. The negative had forestalled the eye in its detection of the disease.

These defects were formerly marked out of the pictures as they were printed, but now they are changed on the negative, which is carefully retouched with a camel's hair brush and India ink or vermilion. A piece of paper, coated with the white of egg, and moistened with a solution of kitchen salt, is laid in a dish containing a solution of nitrate of silver. Chloride of silver is formed on the surface of the paper through the action of the salt (chloride of sodium). The white of egg takes the place of the collodion used on the negative. The paper is now dried in the dark and becomes fully sensitized. It is then placed in the printing frame, under the negative, and is exposed to the light. A faithful positive is formed on the paper. It is then removed to the dark room, and the superfluous salts washed out, as described, for the negative. It is then immersed in the hypo-sulphate of sodium solution, from which it unfortunately suffers a disagreeable change of color, and must be toned down; this is effected by immersing it in a dilute solution of chloride of gold. It is then fixed with the hypo-sulphite and thoroughly washed, after which it is dried out into regular shape, mounted on cardboard, touched up, and rendered glossy by two smooth steel rollers. Such is substantially the *wet-plate* process of photography.

The dry-plate process is much more convenient for amateurs, as the plates can be purchased ready for use, and will remain good for long periods if kept in a dark and dry place.

These plates are prepared in the same manner as the wet plates, except that the addition of some organic substance, such as tannin, morphine, caffeine, having chemical relation with iodine, is necessary, as it allows the coating to become dry without injury. After being dried, the plates are given a light coating of varnish for protection. Pyrogallic acid and a solution of silver is used in the development and intensifying. Potassium oxalate and ferrous sulphate may be used in the development. The negative is fixed with the hyposulphite of sodium.

Instantaneous Photography.—This is an important feature in the study and practice of the science of photography. It is particularly valuable to the military profession. It enables us to obtain beautiful and accurate representations of the effects of torpedo explosions, the explosion of mines, the firing of heavy guns at experimental targets, movements of troops on the field at any particular moment, etc. One of the various emulsion processes is generally used, preferably the gelatino-bromide process; it gives very sensitive plates. The medium used for holding the sensitive salts in solution is gelatine, which gives valuable qualities to the image. They are prepared with an excess of the sensitive salt, preferably the bromide of silver.

The gelatine is soaked in water and heated, while the solution is hot, potass-bromide is added and then the silver nitrate, with constant stirring,; the emulsion is then poured into a dish and allowed to set; after setting it is cut into strips and washed for several hours, with constant changes of water. It is then dried, and is warmed and poured on the plate. The operations of developing, intensifying and printing are the same as described for the ordinary negative; greater time is necessary in developing and intensifying. Pyrogallic acid pot-bromide, a little ammonia and distilled water may be used in developing and intensifying, and the hypo-sulphite for fixing. * * * *

The science of photographing colors is not yet fully developed; enough has been accomplished to show the possibility of it; and we may expect the discovery of the secret at no very distant day. In fact a German photographer has succeeded in taking some good color work, but it fades out very quickly. With the development of this branch of photography its range will be vastly increased. Pictures of nature, copies of the many beautiful works of the old and of the modern masters, true in all of the details of color and light and shade will, we trust, soon supersede the many poor and false pigment prints now forced on the public.

In connection with the discussion of photography in colors, it may be interesting to learn something of the work already accomplished.

We know that the solar spectrum is composed of seven distinct colors—violet, indigo, blue, green, yellow, orange and red. These colors are indecomposable, however. If we project red on blue we get the violet, yellow and blue give green, and yellow and red give orange rays. We have then

Violet = red + blue.
Indigo = violet + blue.
Green = blue + yellow.
Orange = yellow + red.

If we combine the common factors, we

get violet + indigo + green + orange = red + yellow + blue. That is to say, with combinations of red, yellow and blue we can reproduce all of the colors of the spectrum. If, then, we look at an object through a green glass, the rays which pass through the glass and reach our eyes are found in the blue and yellow regions of the spectrum, the red rays being stopped out by the green glass. With an orange glass the blue rays are arrested, and with a violet glass the yellow rays are stopped. We come now to the following synopsis:

| | | | |
|---|---|---|---|
| Green glass | yellow<br>blue | red | isolated. |
| Orange " | red<br>yellow | blue | " |
| Violet " | blue<br>red | yellow | " |

If, then, we make three negatives, interposing between the sensitive plate and the object; first a green glass, then an orange, then a violet one, we will get plates upon which for the first, the red rays will have had the least effect, for the second the blue, and for the third the yellow rays. The process then as used by M. Gros and M. Ducos, du Hauron, consists in the production of three negative plates, as described above, preserving the same dimensions in each. The negative obtained with the green glass serves for the printing of the red monochrome, the second for the blue, and the third for the yellow. Then following the idea of the inventors, the superposing of these three monochromes should result in a reproduction of the colors of the natural objects. But when we think of the complications and difficulties attending the production of these three separate negatives with the varying times of exposure, made necessary by the different actinic properties of the glass plates, and added to these the complications of light and shade, we cannot make any serious comparison between the results and the originals. As I stated in the article on photography, the red rays of the spectrum are practically non-actinic, as the orange and the violet plates contain red, the production of the negatives from those colors is attended with increased difficulties.

M. Guntrel conceived the idea of adding to the three plates already described, a fourth plate in black from which the shadows were to be obtained. This process is interesting as showing what can be done in the development of artistic fancy and genius, but is, I should say, more properly a method of polychrome printing, than of photographing colors. There exists in nature a multitude of colors, grays, browns, neutral tints, and all gradations of violet, green, orange, &c. We can scarcely expect to reproduce these accurately in pigment by the superposition of the three primary colors, red, yellow and blue.

The gelatino-bromide of silver process is destined to take the lead in photography, because of its extreme simplicity, its great rapidity, and the facilities it offers for dry plates. The amateur can procure the plates already prepared, and by studying for a few days, the manipulations in the development of the image can obtain results which were, until very recently, in the exclusive domain of the specialist. The image may be developed either by using the Pyrogallic acid bath or a solution of iron. The latter seems to be preferred by prominent photographers.

Dr. Munckhoven used the following bath:

In one-half liter of boiling water, dissolve 100 grammes of the neutral oxalate of potassium, and 50 grammes of ferrous lactate in powder, stirring the mixture. Filter as soon as cold, and add a small quantity of the following solution:

Water.......... 1,000 cent. cubes.
Br. of ammonia. 100 grammes.

The Bromide solution slightly retards the development of the image, but decreases the liability of fogged plates.

Dr. Eder, of Vienna, prescribes the following formula:

A. In a liter of dist. water dissolve 300 grammes of pure sulphate of iron, add 3 drops of sulphuric acid, then filter. The solution should have a pale emerald green color.

B. In one liter of dist. water dissolve 300 grammes of the neutral oxalate of potassium, then filter.

C. Dissolve 10 grammes of bromide of ammonia in 100 grammes of dist. water.

To prepare the bath for use, take 3 parts of B, to which add 1 part of A, a little at a time with constant stirring. This bath will remain good for about two days. The quantity of C to be added depends upon the emulsion employed, and the effects desired without the chromide. The negatives are very soft but are easily fogged.

To 400 cubic-cent. of the developer, 2, 4, 6′ or 8 cubic-cent. of the bromide may be added.

Use the hypo-sulphate for fixing.

The following "General Purpose Developer" is given by Lt. Griffin:

| | | |
|---|---|---|
| Ferrous sulphate.... | 100 | parts |
| White rock candy..... | 25 | " |
| Glacial acetic acid.... | 32 | " |
| Alcohol............. | 32 | " |
| Water............... | 1000 | " |

This may be strengthened or weakened by the addition or subtraction of the sulphate.

For intensifying (Capt. Abney).

| | | |
|---|---|---|
| No 1. | Pyrogallic acid. | 4 grammes. |
| | Citric acid.... | 4 to 8 " |
| | Water........ | 1 liter. |
| No. 2. | Ferrous sulph. | 10 grammes. |
| | Citric acid.... | 20 " |
| | Water........ | 1 liter. |

To each of the above a few drops of the following solution must be added immediately before application to the film.

| | |
|---|---|
| Silver nitrate. | 20 grammes. |
| Water....... | 500 cubic-cent. |

For fixing (Munckhoven),

| | | |
|---|---|---|
| (1) | Cyanide of potassium. | 20 grammes. |
| | Dist. water......... | 1 liter. |
| (2) | Hypo-sulphate of sodium.............. | 100 grams. |
| | Dist. water........... | 1 liter. |

For silver nitrate bath,

(Wet process.) Dist. water. 1 liter.
Nitrate of silver........ 80 grammes.
Iodide of potassium..... ½ "
Nitric acid............... 2 drops.

The cyanide is poisonous and should be used very carefully.

1 liter = 1.05 quarts.
1 gramme = 15.432 grains.

A few drops of the bromide of potassium added to the iron solution will retard a too rapid development of the image.

The following defects in negatives must be carefully guarded against and steps taken to remedy them.

"Fog," on the negative, this may be due, 1st. To a dirty plate. 2d. To improper exposure to the actinic rays either in the dark room, or in the camera. With the dry plates; storage in a damp place will injure the plates and give clouded results. 3rd. To want of acid in the developer. 4th. To the presence of vapors in the developing room.

A weak image may be due to unsuitable collodion, dull or cloudy weather, organic matter in the bath, or an over-strong developer.

Pin holes may be caused by the presence of dust in the plate, or the bath being over-iodized. Black specks are usually due to dirt on the camera, or on the lens, or on the collodion.

A want of sharpness is often caused by improper focusing, or by an accidental shaking of the camera during the exposure, or by slight unsteadiness of the object. For most of these defects the remedies are apparent, and practice will soon enable the amateur to judge of the various causes of the defects in his negative. Order and cleanliness and purity of chemicals are necessary aids to good work.

### APPLICATIONS OF PHOTOGRAPHY.

The processes of reproduction based on photography are numerous and some of them very detailed in operation. So much depends upon the skill of the operator that it is scarcely possible for an amateur to obtain more than fair results. It is difficult to tell how much of the beautiful work produced is due to skill in handling, and how much to the properties inherent to the process. Most of these processes are patented, and some of the most important details are carefully guarded secrets. Enough is known, however, to enable us to describe the methods of applying them to the reproduction of line work.

The photogravure, carbon prints, and heliotypes seem to occupy prominent places in public estimation. The first, as produced by the Paris firm of Messrs. Goupil & Co., have no superiors in the line of artistic reproductions. In the reproduction of paintings by these proccesses much is gained by photographing the picture, if possible, in the same light as that in which it was originally produced. This enables the operator to get a correct negative so far as the light and shade of the drawing or painting is concerned.

It is quite difficult to make an exact

classification of the various processes employed. A very general classification might be made on the following scheme:

1. Collotype printing, or those processes on which the print is taken directly from the gelatine film. To this class belong the autotype, albertype, autoglyph, or indo-tint, and the phototype.

2. Those on which the film is transferred to a provisional backing as a means of support, as the heliotype.

3. Those on which the film is used as a basis, from which plates either in high or in low relief may be obtained, either by etching or by building up parts of the metal. To this class the heliogravure, some varieties of photozincography, photogravure, and the various processes based on the use of the salts of mercury or copper, &c., belong

4. Those in which the film is used for obtaining a mould of the image in soft metal, as lead, tin, or pewter, from which the impressions may be taken. In this class we have the Woodburytype or

photoglyph, and the photogravure process of M. Rousselon.

5. A miscellaneous class, which comprises many methods, and great variety in treatment.

As the dichromates of potassium and of ammonia, and the sensitive bitumen of Judea, are the sensitizing agents in general use in the processes about to be described, it may not be amiss to go a little into the general chemistry of the operations.

In the presence of organic matter, the bichromates just mentioned become rather unstable compounds, and if subjected to the action of the light, decomposition and recomposition begin immediately. The dichromate of potassium ($k_2 cr_2 o_7$) readily parts with its oxygen and potassium, giving, with the aid of the organic matter, a chromium oxide, a potassium salt, and a slight change in the molecular construction of the organic matter with a probable loss of hydrogen.

The image would then remain as a chromium salt insoluble in water, while the potassium salt, readily soluble, is easily washed out, giving us the utmost simplicity in the process of development. The ammonia salts are very analogous in action to the salts of potassium. The bitumen of Judea is a very important agent in many of the processes now in use, being especially valuable on account of its great resistance to the action of the acids used in the production of engraved plates. It is readily soluble in benzole, turpentine and chloroform. After exposure to the light it loses excessive solubility, and it is quite practicable to dissolve away from a thin layer of it, all of those portions which have not been acted upon by the light. It seems that during exposure it becomes oxidized to a certain extent.

Collotype printing is made possible for half tints by the peculiar property generated in the chromatized gelatine for receiving printer's ink in direct proportions to the action of the actinic rays through the negative plate, and it is also absorptive or repellent of water in a similar degree, so that when a roller, charged with greasy printer's ink, is passed over the surface of the film after the application of a wet sponge the ink adheres copiously to the parts corresponding to the deepest shadows, and in a lesser degree to those corresponding to the half tints, the pure whites being dissolved out with water.

In the autotype and albertype processes a smooth or a ground plate glass acts as a support for the gelatine film during development and printing.

In the autoglyph or indo-tint a copper plate polished and slightly mulled with emery powder forms the backing. In the heliotype the gelatine film is transferred as a pellicle to a thin zinc plate, and then printed from. None of these processes leave a plate mark in the print, and after printing the prints are generally trimmed, mounted and glazed.

In the autotype and the autoglyph or indo-tint processes, the sensitive compound consists of a from 6 to 7 per cent. solution of gelatine in about equal parts of alcohol and water, which after perfect dissolution is sensitized by the addition of 1 or 1½ per cent. of ammonium bichromate. Fish glue, glycerine, soluble glass and chrome alum are sometimes added according to requirements. Both plate and solution having been warmed to about 100° F., a rather strong and very even coating is applied, and the plate placed on a level shelf in the drying box, where it is left in a temperature of from 120° to 130° F. until thoroughly desicated, a second coating of the same mixture is then applied, which is generally made a little thinner than the first by allowing more of the excess of the solution to run off the edges of the plate, the latter is restored to the drying closet, dried, cooled, and is then ready for printing under the negative.

In using this gelatine film the progress of the printing cannot be examined as such a print on paper, and recourse must be had to a photometer as with the negative process, the time of exposure depends entirely on the strength of the light and the quality of the negative.

Heliotype.—In the heliotype process both the sensitive compound, and the manipulations in the preparation of the film are somewhat different from those just described. Eight parts of gelatine are dissolved in 100 parts of water, and four parts of potassium bichromate are added, together with a small amount of chloride of silver. The addition of 1½ per cent. of glycerine and the same amount of chrome alum is recommended. The chrome alum slightly hardens the film. The solution being prepared and filtered, plates of ground glass are rubbed with a thin solution of beeswax or benzine, and leveled accurately on a table by means of wooden wedges or screw eyes. The necessary quantity of the gelatinous mixture is then poured upon the center of the plate, 1 oz. to every 34 square inches, and spread with the finger to within ½ inch of the edges. This may be done in day light, as bichromated gelatine is altogether insensitive when wet. As soon as the gelatine has set, the plates are removed to the drying room, where they are placed on shelves in a sloping position, and left to dry for 48 hours in a current of air, the temperature averaging 80° F. When dry. a wet sponge is passed over the edges of the film, a knife inserted under one corner, and the pellicle, resembiing a thick sheet of oiled paper, is pulled from the plate. In order to lessen the relief characteristic of gelatine treated with water after exposure under a negative, the film is placed face—that is, ground glass side—down upon boards covered with black velvet, and their backs are then exposed to diffused light for about twenty-five minutes, the proper duration of this sunning being governed by an actinometer. After this they are placed in a printing frame and exposed under a negative.

After exposure the pellicle is ready to be transferred to its final support, which is done by floating it in a tank of clean water on a zinc plate coated with a solution of rubber or benzine. A squeegee is then passed two or three times over its surface, and the plate is, without washing, transferred to the printing press. The composition of the inks, and their application to the cliché are identical in all of the processes. Two inks are used, of which one is rather stiff and black, and is intended for the shadows only, while the other is rather thin, and generally toned by the addition of a little carmine, rose madder and cobalt, and is applied to the rendering of the half tones and subdued lights of the picture. The first ink is applied under rather a strong pressure with a leather roller, the second by a light sweep of a composition roller. The processes described above are in use at the laboratory at Willett's Point, and excellent results are obtained under the skillful management of Sergeant Von Sothen of the U. S. Corps of Engineers.

Albertype.—This process, invented by M. Albert, of Munich, is very similar to the one just described. M. Albert has brought his process to a high degree of excellence, and furnishes prints in all sizes, from card size up to sheets 20×30 inches in size, and has taken as high as 200 prints from a single film in a day.

A thick glass, finely polished, is placed polished face up, and covered with the following solution:

| | | |
|---|---|---|
| 6 | grammes | gelatine, |
| 300 | " | dist. water, |
| 5 to 6 | " | bichromate of ammonia. |

The gelatine is first placed for half an hour in cold water; it is then warmed to about 40° C., and the bichromate is added little at a time. To this liquid is added 100 cubic centimeters of albumen; when the mixture has cooled to about 25 or 30° C. it is beaten rapidly and then filtered in warm place, and is then poured on the glass and placed in a box to dry. The interior of the box being kept at a temperature of about 30° C. After the gelatine is set the plate is put in a black cloth, the gelatine next to the cloth, and the glass side is exposed to the light for 5 or 10 minutes. The gelatine next to the plate becomes insoluble, and adheres to the plate, which is now ready for the second coating. The plate is now plunged for half an hour in cold water, and is then dried in a vertical position. The second phase of the proceeding consists in covering the first coating of gelatine with a second, composed as follows:

(*a*) 20 grammes of gelatine softened in cold water.
125 grammes of dist. water, cold.

(*b*) 4 grammes of fish glue, finely divided and softened in
60 grammes of cold water.

(*c*) albumen beaten white and allowed to settle, and filtered through a cloth.

(*d*) 10 grammes of bichromate of potassium dissolved in 60 grammes of dist. water; filter.

(*e*) 5 grammes lupuline, } are stirred 12 h'rs in
3 grammes benzine,
2 grammes Tolu balsam,
100 grammes aqueous alcohol (at 8° Gay Lussac).

(*f*) 1 gramme nitrate of silver,
30 grammes dist. water.

(*g*) 2 grammes bromide cadmium,
2 grammes iodide of cadmium,
30 grammes water.

Of these different solutions mix first (*a*) and (*b*), when the liquid has reached about 35° C. add

| | | | |
|---|---|---|---|
| of (*c*) | about | 6 | grammes. |
| " (*d*) | " | 36 | " |
| " (*e*) | " | 4 | " |
| " (*f*) | " | 1½ | " |
| " (*g*) | " | 45 | " |

This will produce a precipitate in the mixture, which must be shaken and filtered into a flask and maintained at 35° C. in temperature. The gelatine-covered glass is immersed in tepid water 40° C. until the water will flow in a continuous sheet over its surface. It is then dried for half an hour in a vertical position, and is then covered with the prepared mixture and is placed in a horizontal position to dry. Very thin films are good for the reproduction of line drawings; thicker ones are better for the half tints. The dried film is placed on the printing frame under the negative, and exposed to the light until the shades of the image are visible through the glass. After sufficient exposure the plate is plunged in cold water, and the superfluous potassium and chromium salts are washed out. The plate is then dried in a vertical position. Before submitting the film to the printing it is immersed for 4 or 5 minutes in cold water, to which a little glycerine has been added. It is wiped off with a dampened sponge, and then rubbed with a flannel cloth and a little oil. The inking can then be proceeded with as described above. The film should not be allowed to become completely dry during the printing. It should be wiped first with a damp sponge, and then with a sponge moistened with water and sulphuric ether. A solution of *fresh* fish glue, bichromate of potassium and albumen will suffice instead of the above complicated formula as used by M. Albert. The best quality of gelatine should be selected. The proofs obtained by M.

Albert resemble the most beautiful silver print photographs, and leave nothing to be desired in the way of fineness and half tints. Of course extreme care is necessary for the reproduction of first-class work. The glass plate must be thoroughly cleaned with acid and dry cloths, and must be entirely removed from the presence of dust and the action of the light in the dark room.

PHOTOTYPE.—The processes just described are phototypic.

M. Vidal's phototypic process differs from that of M. Albert in some of the details. The liquid containing the sensitive matter is formed of

| | | |
|---|---|---|
| Gelatine.............. | 90 | grammes |
| Water................. | 720 | " |
| Isinglass.............. | 30 | " |
| Water................. | 360 | " |
| Bichromate of potassium | 15 | " |
| " " ammonia. | 15 | " |
| Water................. | 360 | " |

This is applied as a second coating after the first, composed of

| | | |
|---|---|---|
| Albumen............. | 180 | grammes, |
| Water................ | 150 | " |
| Ammonia............. | 100 | " |
| Bichromate of potassium | 5 | " |

has been applied, and the plate treated as in the process of M. Albert. After exposure and development he plunges the plate in a bath of

| | | |
|---|---|---|
| Water......... | 180 | grammes, |
| Alum.......... | 2 | " |

and allowing it to remain for from 5 to 10 minutes. It is then placed vertically to dry. The plates are dampened before the inking by immersing them in a bath of

| | |
|---|---|
| Water........ | 100 cu. cent. |
| Glycerine..... | 40 grammes |

The glass plate is then placed on the bed of the press on top of a white blotting paper which has been immersed in a solution of

| | |
|---|---|
| Benzine..... | 100 cu. cent. |
| Caoutchouc .. | 10 grammes. |

Different kinds of cylinder presses can be used for taking phototypic impressions, that is, such as might be employed in printing from an engraved plate. A thin sheet of caoutchouc should be placed between the back of the paper and the cylinder. The presses generally used for phototype printing are similar to lithographic presses. The inking is done mechanically, and from a good plate from 1,000 to 1,500 prints can be taken per day. I have gone considerably into the details of these processes, as they are probably the most important ones within the possibilities of amateurs. In phototypic printing with a strong press a hard film is necessary, else it will soon be destroyed. The process of M. Obernetter, of Munich, seems to be the most satisfactory one in use to-day. The mounting, varnishing and satining of phototypic proofs is readily acquired with a little practice. If printed on sized paper the varnishing can be proceeded with as soon as the printing is dry; if the paper is unsized the print must be gelatined before varnishing. Dissolve 100 grammes of white gelatine in 1,000 grammes of water, and apply it to the print with a brush. There is no process which lends itself so readily to all kinds of work as this. It is very usefully employed in the illustration of *editions de luxe*, and, thanks to mechanical appliances for printing, good prints are produced very cheaply.

Phototype-process of M. Obernetter, of Munich:

There are many varieties of phototypic processes, differing in minor operations only. The autotype, albertype, and heliotype processes are phototypic, and have been given different names to cover patents on details. The process as carried on by M. Obernetter gives most excellent results, and is very simple in theory, and the half tints are obtained from the model to such a degree of perfection as to have the appearance of albumen proofs. The surface of a plate, either of glass or of metal, is covered with a film composed of 7 parts of albumen, 3 parts of silicate of soda, and 8 parts of water. This film is dried either in the air or by artificial heat. When dry it is washed for about 5 minutes in clean water, and is again placed on a shelf to dry. When dry it is placed on a warm stove, and when it has arrived at a temperature of 100° it is covered with a second coating, composed of 50 grammes gelatine, 50 grammes isinglass, and 15 grammes bichromate of ammonia in a litre of water. As soon as this solution is equally spread over the surface of the plate it is placed in a stove to dry. When dry it is exposed under a negative for a very short time, and is then washed in water for 10 or 15 minutes until the superfluous salts of chromium and ammonia are washed out. As soon as dry it is ready for the press, and ordinary lithographic ink can be used. It is a cheap and rapid process, and gives very fine and very durable prints.

Photo-Zincography.—This process in its simplest form is as follows: A zinc plate of uniform thickness is carefully polished and cleaned. The face is then coated with a dilute solution of bitumen in benzole, and is allowed to dry. It is then exposed under a negative. After sufficient exposure the soluble parts are washed out with turpentine, leaving the bare metal on the lines not acted on by the light. The plate is then slightly etched, to give the bitumen film a little greater relief; it is then printed from, as in lithography. Major de La Noïé made the following alterations in the process: The plate is coated as described above, but is exposed under a drawing made on tracing paper. A longer time is necessary in the exposure, as the paper slightly impedes the passage of the actinic rays. After exposure the picture is developed with turpentine, as above, and the plate is etched with a 5 per cent. solution of nitric acid for from ½ to ¾ of a minute. It is then washed with water and the remainder of the bitumen is washed off with benzole, and the plate is thoroughly cleaned. It is again coated with the bitumen solution, and the entire face exposed to the light. The etched portions become filled with the insoluble solution, and the other portions must be removed. This is done mechanically by scouring the plate with a stick of hardwood charcoal, ground to a beveled edge and moistened with oil. The etched parts still retain the bitumen, and the plate can be printed from as in lithography.

The chemical process is as follows: The second coating of bitumen is worked with a roller, and exposed to the light. After exposure the soluble parts, viz., those that have taken the ink, are washed out with turpentine; the etched parts, being lower than the others, have received no ink. The plate is washed and printed from as before described.

Carbon Prints.—The carbon process is an important one, and is extensively used, and I will go somewhat into details in describing it. A sheet of paper covered with a gelatine "couche" and coloring matter (generally India ink, from which the process derives its name) constitutes carbon paper. It is sensitized by immersion in a solution of bichromate of potassium, and is suspended in a dark and well-aired chamber to dry. It is then exposed under the negative. As the progress of the image is not visible a photometer must be used to regulate the time of exposure.

Two ways now present themselves for obtaining the image.

1st. By simple transfer, a process of wonderful simplicity, but which gives the image reversed, as regards right and left.

2d. Double transfer, which gives the image in a correct form, but which is more complicated in operation.

Sensitizing of the Paper.—This operation is very simple, but of great importance, and the success of the subsequent operations depends upon its regularity. The sensitizing should be done in a dark room, with yellow or red lights; the cuvette, or dish containing the mixture should be of wood lined with glass, as the bichromate readily attacks wood or gutta-percha. Mix the following solution:

| | | |
|---|---|---|
| Water .................. | 10 | liters, |
| Bichromate of potassium. | 200 | grammes, |
| Carbonate of ammonia. . | 10 | " |

The ordinary commercial bichromate may be used, but it should be finely pulverized. The mixture is poured into a flask, thoroughly shaken until the bichromate is dissolved; it is then filtered and poured into the cuvette. One bath of bichromate should not be used for sensitizing too many sheets of the paper, as it is poor economy to compromise the results in order to save so cheap a mixture. Before immersing the paper in the bath dust it carefully. Submerge the paper in the mixture, couche uppermost, and keep the liquid moving by rocking the cuvette. Keep the paper immersed for about 3 minutes, then remove it and re-immerse it for about one minute, the couche down, to work the adhering bubbles from the back. After withdrawing, place it face down on an inclined glass plate, and with a scraper work on the back, from the center towards the edges, until all of the excess of liquid is forced out; then detach the sheet from the glass and suspend it to dry. The bath should be kept at a temperature of about 15° C. Rubber gloves should be used while working with the bichromate, as it is a poison which acts by absorption, and should be handled very carefully. If we wish to produce vigorous images with light negatives, the paper must be used the next morning after drying; but if the negatives are strong it is better to wait 48 hours after the sensitizing before using it. Negatives for carbon prints ought to be a little more intense than for albumen paper. The edges of the negative must be covered with yellow paper, so as to limit the cliche to the part to be reproduced, and the carbon paper must be cut so that its edges shall not pass the edges of the yellow paper which protects the edges of the cliche; it is then placed in the printing frame and exposed, and the time regulated by a photometer. The impression on carbon paper continues even after the action of the light has ceased; this is an important point to remember. We now come to the development and the simple transfer. Simple transfer paper is prepared in rolls exactly like carbon paper. It is covered with a couche of gelatine and chrome alum. Before using this paper it is well to mark the reverse side of it with a crayon, so it will be easily recognized in the subsequent operations.

TRANSFER.—The transfer paper having been cut to dimensions a little greater than the proof it is immersed for two or three minutes in cold water; it is then placed on a flat glass, or on a marble block, face up. The carbon proof is then immersed in cold water, back up, rubbing it with the hand so as to force out air bubbles. It is then placed on top of the transfer paper, face down, and the back is rubbed quickly and strongly with a scraper until the surfaces unite and the air bubbles and excess of water are forced out; a dry sponge is also passed over the back and the edges of the paper.

DEVELOPMENT.—One ought never to

proceed to the development before the bichromate has taken hold of the transfer paper, which ought to become yellow in its texture, and which can be observed by looking at the underside. The development can be made in full light, indeed it ought to be done in the light, as it is necessary to judge of the condition of the image at all stages of development. The transfer paper, supporting the carbon paper, is now put into water at about 30° C., the cuvette being constantly shaken to favor the absorption of the warm water. After a few minutes dark-colored veins are seen on the edges of the proof, and soon the edges show a tendency to separate. Take the carbon paper by a corner and slowly and carefully detach it from the transfer paper. The image will be seen transferred to the paper, which must be left in the warm water until the surplus coloring matter is washed out. The temperature of the water should be raised to about 40° C. by the addition of hot water. The image is formed by the gelatine in relief, and is very fragile; it should be immersed for 10 minutes in the following solution:

| | |
|---|---|
| Water ............. | 5 liters, |
| Pulverized alum..... | 250 grammes. |

This bath should be freshly made and filtered. The proofs are then immersed in water for an hour and are hung up to dry. After drying the proof is retouched, mounted, put through the satin press, and varnished. Once dry, the image is of extreme solidity and durability.

Double Transfer.—A flexible support is especially prepared with the aid of simple transfer paper, which is covered with a varnish of (wax, 1 part; warm benzine, 5 parts). The paper appears brilliant on the side which is to receive the transfer provisionally.

The operations for the first transfer are in every way identical with those just described. When the image is raised from the water, after the development, it is placed on a thick glass, face up, and the operator immediately proceeds to the second transfer. The double transfer paper is covered with a couche of gelatine, rendered half insoluble by chrome alum. The paper is cut of a little larger dimension than the image, and is immersed in water at a temperature of 40° C.. When the gelatine is a little softened remove the paper from the water, and place it carefully on top of the carbon image; cover the back with a sheet of caoutchouc, and with a scraper work out the air bubbles and superfluous moisture, and continue the operation until the two papers form a homogeneous sheet. Suspend this to dry in a chamber well aired and lightly warmed; when dry insert a knife edge between the two papers, and detach them from one another, which is easily done. The image will be found on the paper which is to receive the final transfer; it is mounted, retouched and varnished.

Double Transfer with the aid of Glass.—Polished glass of from 4 to 5 millimeters in thickness is generally used for this purpose, and has this advantage: The condition of the image and the state of the development can be observed through the glass. The glass is first thoroughly cleaned, and is coated with

Yellow wax...... 1 gramme,
Good benzine... 150 cub. cent.,

which is rubbed on the glass with a flannel rag and allowed to dry. After drying, the surface may be polished by rubbing it lightly with a dry flannel cloth. The coating of collodion, made as follows:

Ether ........... $\frac{1}{2}$ liter,
Alcohol .......... $\frac{1}{2}$ "
Pyroxyline ....... 5 grammes,

is then poured on the glass as prescribed in photography. The glass is dried, is well washed, and placed flat on a table, and the first transfer is made as described for the transfer paper. A sheet of caoutchouc should be interposed between the scraper and the carbon paper. In about 10 minutes after the transfer, one can proceed to the development. After the development the glass is placed for about five minutes in the alum bath.

which hardens the couche. After it has dried make a mixture of

| | | |
|---|---|---|
| Alcohol........... | 1 liter, | and |
| Water............ | ½ " | |

immerse the proof in it for 3 or 4 minutes. The alcohol takes the water from the gelatine and lowers the relief. Then apply the double transfer paper, and proceed as prescribed for the double transfer with the aid of paper. The retouching can be done on the glass before the second transfer, if desired, and should be done with a mixture of red and black oil (tube) colors. If certain parts are wanting they can be put in with a stumpf and a rather dry mixture of lamp black and madder lake; the satin finish is added as prescribed for albumen prints. Carbon prints are very durable, and can be made so as to stand comparison with the best silver prints. It is best for beginners to work with the single transfer until some of the difficulties of the process are thoroughly mastered. The rough prints obtained by this process have much the appearance of phototypes. Beautiful transparencies are also made on glass by this process.

Woodburytype, or Photoglyph.—This is an exceedingly ingenious process of obtaining a metallic mould from a gelatine film, from which any number of copies may be printed. Potassium bichromate is mixed with gelatine, giving a highly sensitive mixture. A thick film of this, resting on collodion, is exposed under a negative to a strong light, the collodion side being placed next to the negative; the usual action takes place; the parts remaining soluble are washed out with warm water, leaving the darks of the picture wonderfully strong and hard. A sheet of soft metal, generally lead, is placed on this film and subjected to very strong pressure. On removal, a beautiful mould of the picture is found in the lead, the dark parts in intaglio, the lights in relief. A peculiar kind of gelatinous ink, to which permanent dye or fine pigment may be added, is now poured on the mould, and the paper on which the picture is to be printed is placed on it, and strong pressure is brought to bear over the entire surface. This forces the gelatinous ink out of the lights which are in relief, and gives the half tones and darks by the varying thicknesses of the gelatinous ink. The pressure must be maintained for a few minutes, to allow the ink to set on the paper; the paper is then immersed in a solution of alum, which renders the picture insoluble. The pictures made by this process are good, and wonderfully cheap. It can work with any color.

The stannotype is the name given to the improved process of M. Woodbury. He makes use of a thin plate, tin, for the formation of the mould. His first improvement was the substitution of a fine tin plate for the leaden mould. The plate was fixed on the film and the back was strengthened by electrotypy. The prints were taken from the mould in ink composed of

Gelatine ........ 1 part,
Water ........... 5 or 6 parts,

Dark color...... at pleasure,
A little red...... to give tone.

He has endeavored, however, to still further simplify his process by using a positive, from which a negative relief is formed. The fine tin is forced on this, and is made to adhere to the film by first giving it a light coating with caoutchouc. It is then only necessary to put the mould directly under the press and print from it without any further treatment. For fixing he uses the following solution:

Alum........... 1 part,
Water.......... 50 parts.

Photogravure.—The novelty and the secret of the photogravure consists in the particular means adopted for obtaining immediately in the gelatine the grain necessary to an engraving. To accomplish this M. Rousselon (for some time connected with the house of Goupil and Co.) incorporated in the gelatine a substance which produced this grain under the influence of the light, and in proportion to the strength and duration of the light. By the Woodbury process this grain is reproduced in a leaden mould, and by the use of electrotypy a plate is obtained which is printed from as a copper plate engraving. A great deal depends on the skill of the manipulator, and with the assistance of the burin in touching up weak parts beautiful plates are produced. The process as now applied by M. Rousselon is very analogous to that used by M. Placet in the preparation of plates for heliogravures. The light is made to act through a negative on a bichromated gelatine film; the film is then immersed in water or in some liquid containing a contracting substance. The insoluble portions, viz., those acted upon by the light, cannot, like those surrounding them, absorb water, and remain united; they are raised up by the action of the water on the adjacent susceptible parts; these swell out, and there results from this a contraction more or less strong accurately following the action of the light. There results from this a roughened surface, which, absent in the lights, extends gradually through all the tones up to the strong darks. This film is dried and separated from its provisional backing. It is submitted to strong pressure againt a thin sheet of tin or pewter, from which an electrotype is taken ; this is touched up by skilled hands, and magnificent prints are obtained from it.

Another process, never made public, is believed to consist substantially of the following operations: A phototypic proof is transferred to a copper plate with sized India paper. It is then sprinkled with bitumen powder, so as to well cover the ink of the transfer ; it is then etched with the per-chloride of iron. and gives an engraved copper plate with all of the reliefs and depressions of the original.

This last is pure chemical engraving, and as such is more subject to accidents than the mere mechanical one of M. Rousselon. This latter is the prince of "processes," and the artistic reproductions exhibited by Messrs. Goupil & Co. have, to say the least, never been surpassed. Some chemical substance is added to the bichromated gelatine which gives to it, after exposure, development and drying, a grain more or less marked following the strength of the shades in the picture. The remainder of the process is purely mechanical and is thoroughly understood, and success is assured. After electrotyping, the plate is thoroughly cleaned and proven, and retouched with the burin, and the result is a finely-grained engraved plate, from which beautiful impressions are obtained, and which give even the details of the brush marks of the artist. The photogravure process of Major Waterhouse arrives at similar results. While the image formed by the gelatine is still moist he covers the surface with finely-divided sand, which has been covered with wax to prevent it from being retained by the gelatine after the development. The granulations produced by the sand are more or less deep, following the relief of the image. After the gelatine is dry the image is carefully cleaned with a brush, and all the sand removed, leaving the grain marks in the gelatine. A mould of the surface is then taken, and this is electrotyped and retouched.

PHOTOGRAVURE GARNIER, another process, the details of which have not been given to the public, has been invented by M. Garnier, and is believed to be as follows: A copper plate is covered with a film formed by dissolving sugar, gum, albumen in water. This is sensitized by the addition of the following solution:

| | | |
|---|---|---|
| Sugar............... | 2 | grammes, |
| Bichromate of ammonia | 1 | " |
| Water .............. | 14 | " |

This is exposed to the light under a positive. The hygroscopic properties of the parts not acted upon by the light permit the adherence of finely-powdered bitumen, which is sprinkled over the surface. The plate is then placed on a grating and heated until a faint iridescence is visible on the upper edge of the plate; the plate is then etched with the perchloride of iron, which eats out only the parts not protected by the powdered bitumen. For delicately graded half tints he repeats the process three times, using carefully-prepared reference points, stopping out the biting at pleasure. No retouching is necessary, according to the inventor, but an intelligent touch is always of value.

HELIOGRAPHIE AND THE HELIOGRAVURE.—The bitumen of Judea is generally used as the sensitive agent in heliographic processes. It should be of an especial quality. There are different substances of this nature, but the following solution is found to give the greatest resistance to the biting acid:

| | |
|---|---|
| Bitumen.......... | 3 to 5 grammes, |
| Anhydrous benzine. | 100 " |
| Essence of lemon.. | 2 to 5 drops. |

This mixture is poured on the metal as collodion is poured on glass. It is allowed to dry and is then exposed under the negative. The exposure completed, the insoluble parts are washed out with essence of lavender or essence of turpentine, and the plate is subjected to the action of the acid. the naked parts, or the bare metal corresponding to the lights of the drawing, are "bitten" at the pleasure of the operator, and upon this the beauty of the work largely depends. After the first biting, which is continued until the engraved parts are appreciable to the touch, the plate is placed on a lithographic press and coated with an inking of grey varnish, which naturally adheres only to the parts covered with the bitumen and already in relief. The plate is then warmed, and the varnish flows to the edges of the relief and gives an additional protection against the acid. A new biting takes place, and these same operations are continued until the operator judges the biting completed. the bitumen is removed, the plate cleaned, the lines touched up with the burin, and the plate is ready for the press. During the successive operations the grey varnish, if placed artistically will stop out the action of the acid so as to give an exact reproduction of the original. The operations are difficult, but do not compare with the difficulty of producing an engraved plate with the burin. By electrotyping, the converse of the plate may be obtained, making the process available for the production of plates either in high or in low relief.

The bichromated gelatine film is used in a similar manner. After exposure the film is immersed in cold water, which causes the soluble portions of the gelatine to swell out and form an image in relief; a plaster cast of this is taken, and this is in turn electrotyped. The results of this process are not particularly good; it is available for line work only, and the swelling of the gelatine cannot be relied upon for uniformity in relief.

The invention and perfection of the processes for the production of heliographic plates is due to Scamoni, of St. Petersburg. With the assistance of electrotypy he produced excellent plates in high relief, a manifest advantage in the industrial arts, as engraved plates require a special paper, strong pressure, and more time for each impression, whereas, plates in relief can be printed from in the rapid steam press used in typographic printing, and a much cheaper paper can be used. Of course this necessitates the sacrifice of a little of the fineness of the work to rapidity and economy. The plates are covered either with the mixture of gelatine and potass-dichromate or with the sensitive bitumen of Judea; they are exposed under a positive; they are then etched, which gives an engraved plate, and by electrotyping this we get a plate in relief which can be printed from on an ordinary press. This was the process as invented by the Austrian, Pretsch, some years ago. Scamoni made the following changes: He observed that an ordinary photographic negative appears in relief, the transparent places—shadows—being in *basso,* and the lights in *alto relievo*; this relief is very faint. He increased it by treating the freshly developed image with pyrogallic acid and a solution of silver, and augmented it by a further treatment with chloride of mercury and iodide of potassium. A relief was thus ultimately obtained equal to the depth of the incisions in an engraved copper plate; by treating a positive in this manner all the means are at hand for obtaining an engraved plate. The relief-like photographic image is electrotyped, which gives low relief where the positive is in high relief, viz., in the darks of the original drawing, and we have an engraved copper plate. Most excellent maps can be produced by this process, with the original either enlarged or diminished.

Scamoni reduced a page of an illustrated journal to a square inch, and the words could be plainly distinguished with the aid of a microscope. It is very probable that the beautiful maps of the Wheeler Survey were made by some modification of this process, which the Austrian Government declines to make public.

Aquatinte.—This is a species of engraving with a peculiarly-prepared grain A plate of copper is first covered with a special gray varnish; the drawing is made on this in outline, and, as in etching, the bare parts of the metal are "bitten in" with acid. The varnish is then removed, the plate is cleaned and is placed in the graining box, which consists of a case in which, by mechanical means, a cloud of resinous powder can be raised. The powder is put in motion, and at an opportune moment the plate is placed in the box. A grain is thus deposited on the surface of the plate, and this grain can be regulated by the time the plate is allowed to remain in the box. The operation can be renewed until the grain is more or less thick. The plate is then submitted to gentle warmth, which softens the resin and makes it adhere to the plate. When the desired "grainage" has been obtained the parts to remain white are covered with the gray varnish, and the biting acid is poured on the plate. It attacks only the places not covered with the resin nor with the varnish. By successive "bitings" and coatings with varnish, the plate may be etched at the pleasure of the engraver, and the results are more or less beautiful, depending upon his skill.

A number of different processes have been invented by French scientists, based upon metallic precipitates and on the affinities of acids for different metals. For example, a drawing made on zinc, with an ink formed of a salt of copper, permits the formation of a plate in relief by the action of azotic acid, the copper, in this case, playing the role of a protecting varnish; or, we might use a salt of mercury for copper, a salt of gold for silver, &c., and engrave with an appropriate acid.

The following process has also been used: A plate of copper is silver plated; the drawing is made on the silvered surface, or, better, is transferred to it, as, for instance, a drawing in ordinary lithographic ink. With the assistance of an electric battery a light coating of iron is formed on the surface of the plate, the deposit occurring only on the parts not covered with the ink. The ink is washed off with turpentine or benzine. The whites of the drawing are now represented by the iron, and the darks by the pure silver. The ammoniacal sulphate of mercury is poured on the plate, and after the excess of the salt is brushed off the metal is seen in relief in all the parts previously covered with the lithographic ink. It is electrotyped, and we have an engraved copper plate. These processes are of doubtful value now, but they serve to illustrate the many resources that have been discovered and utilized by scientific men in the reproductions of drawings of various kinds. The ones just described were invented in 1864, and are quite modern.

To sum up, it is well known that an amalgam of mercury with another metal repulses the greasy ink when the roller is passed over it, and the black ink adheres only to the naked metal. If then, we trace on, or transfer, a drawing in mercuric ink to a zinc plate well polished, it will appear in brilliant white lines on the gray back ground of the zinc. To obtain a plate in high relief it is only necessary to plunge the plate, without the application of varnish or any stop, into the acid bath composed of 100 parts water to 2 parts of nitric acid. The biting takes place very rapidly, and the lines traced with the mercury soon stand out in relief, and can be printed from in a lithographic press. If, instead of plunging tho plate into a nitric acid bath, we use a dilute solution of hydrochloric acid, the reverse obtains, the lines arc eaten away and we obtain an engraved plate in low relief. So far we have included only line drawings. To produce half tints the drawing is made on a very dense paper, and is transferred to the zinc plate by strong pressure for about two hours. By pulling off the paper the drawing will be seen in clean, white amalgam on the gray surface, and may be treated as before. An ink, containing sugar, gum, &c., in solution, may be used on the drawing; on powdering this with a fine mercurial powder the same effects may be obtained; the biiodide of mercury is the salt generally used. It is thought that these processes are destined to become of great value in the graphic arts. The salts of mercury are violent poisons, and must be handled carefully: white of egg, sulphur-water and milk are antidotes.

SIMILIGRAVURE.—M. C. Petit has invented a process of engraving, having for its object the changing of the half tints of a photographic proof into line prints for the production of typographic blocks. The negative is placed over a bichromated gelatine film, and the image is developed as in the autotype. A plastic material, such as hardened white wax, is pressed on the film, giving a counter proof of the gelatine; this is placed under a line-drawing machine with a V-shaped cutting edge, and the wax is ruled with parallel lines, the depth being regulated by the operator. The surface of the wax having been covered with plumbago just after its removal from the gelatine, we now have white lines on a black background, the darks having been engraved more or less in proportion to the relief. From this wax mould a photographic cliché is formed, and from this we get a typographic cliché, as explained for other processes.

GILLOTAGE.—M. Gillot has invented a process for obtaining a line negative, from which excellent typographic blocks can be produced. He takes a strong paper and covers it with a white glazing; then, with a prepared plate, he prints a series of parallel dark lines on the glazed paper, giving about three lines to the millimeter. A steel plate is then put under a line-engraving machine, and a series of parallel lines, corresponding to those on the paper, are cut into the plate to the depth of about $\frac{1}{4}$ of a millimeter. The paper is then pressed on this plate so as to give two series of lines at right angles with each other, one series being the dark lines drawn on the paper, the other, the fine creases formed by the relief parts of the plate. The paper is now ready for the drawing; the pure whites are smoothed down with a scraper, so as to make the creases disappear, and the dark lines are erased; for the half tints he relies on the handling of the crayon, for the full darks the creases are filled with India ink; a negative is taken from this. A zinc plate is covered with a thin coating of the sensitive bitumen, and from this especially prepared negative, a relief plate is obtained, with the half tones excellently well rendered, as the negative gives them in series of lines, which are much more readily handled and transferred than the ordinary dotted half tints.

Luxotype.—This process aims at the production of "grained" negatives by a treatment with powdered glass or other finely divided material. It is very new, and is not made public. Its inventors claim that it is phototypographic, and that they can produce blocks very cheaply, from which good impressions can be taken in the ordinary printing press working with great rapidity. I saw several prints in a journal of photography. They were printed on text-paper, and had the appearance of very delicately executed wood cuts.

Reproduction of Polychromes.—We have thus far been interested only in processes for the reproduction of monochromes. The great and constantly increasing demand for copies of the many beautiful paintings old and new, true in color and in chiaro-oscuro; the still greater demands of the industrial arts for high grade work in colors are stimulating invention and taxing the abilities of men engaged in this work. The chromo-lithographic processes have attained a high degree of perfection, and the beautiful prints of Messrs. Prang & Co. on satin and on paper have never been surpassed in tone or finish. A skillful artist can paint on stone as he would on canvas, but with this difference, in working on stone he sees the results only in his imagination and must wait for a proof. In canvas the immediate results are incessantly under his eye. The discovery of a means of photographing color has been announced at stated intervals, but investigation has revealed the fact that the color has been introduced in the printing, and was not found in the negative. Many years have been devoted to efforts to obtain a plate from which a number of colors can be printed by a single pressure. The process of stenochromie promises a great deal, but for some unknown reason it has not entirely succeeded. It is briefly as follows: Pieces of color for each tint on the drawing are carefully adjusted to their places on paper, so as to constitute a mosaic tracing in paint on the paper. The unsized paper which is to receive the print is impregnated with the essence of turpentine; it is then pressed on the colors, and a superficial dissolution of them takes place, and the paper is removed carrying an imprint of the colors which constituted the stenochromic block. It is thought that the expense attending it has prevented its adoption.

The Bonnaudtype process for coloring photographs is used in New York to some extent, and is as follows: A feeble proof of the negative is taken, so as to have an indication of the various places occupied by the colors. When the colors have been applied a very light impression is taken on sensitized paper, a very light image is developed on this, and is fixed and washed as usual, and after drying it is immersed for 2 or 3 seconds in rectified alcohol. When this liquid has evaporated the proof is run through the press for polishing. It is then colored with a brush, using vegetable colors. After the coloring is terminated it is again passed through the polishing press; it is then immersed in rectified alcohol, and lastly the surface is albuminized.

An inking apparatus has been invented by J. L. F. Rice, of Cambridge, Mass., which can be attached to our ordinary printing press, and any desired number of colors can be printed at one impression, but only in bands or stripes.

Conclusion.—I have endeavored to give brief outlines of the various processes of reproduction in use to-day. It will be readily seen that constant study by a large number of inventors and scientific men has resulted in a series of processes and patents so numerous, and so closely allied, that it is difficult to classify them. Many of the patents have fallen into the public domain, and have been rendered of practical use in industry. The details of others are strictly guarded secrets. They are all beyond the reach of amateurs, and require much skill and knowledge in the operations. Advantages are claimed for each process, and excellent specimens of each can be shown. We are principally interested in the reproduction of maps and of mechanical and architectural drawings; sensitive papers, the hextograph and photography are within our reach. Experiments with any of the other processes would result in many signal failures. For contract work, requiring rapidity, economy and excellence, we have nothing better than the various processes of lithography. We have many good lithographing establishments. Prices are moderate, and the work excellent. Combined with chromo-lithography and photo-lithography it is very wide in range. Thousands of copies can be obtained from one lithographic transfer. One establishment at Berlin produced 500,000 maps during war of 1870–71.

For the selection of a method for the reproduction of any work, we must be guided by three things, viz., the cost, the rapidity with which the work can be executed, and its durability. The processes are sufficiently numerous, and are rich enough in results to meet any desired requirements. They are daily reaching higher grades of development, and beautiful pictures are being brought within the reach of all classes. The tendency of the day is undoubtedly towards the invention and perfection of typographic processes, but I think that I am safe in saying that a typographic block can never be made to give the beauty and brilliancy and the pureness of line obtained from engraved plates. This is clearly illustrated in the two processes for the production of heliogravures. Many skilled men are engaged in the reproduction of artistic works, and it is to their genius and artistic taste that we owe our homage for the many beautiful things brought within our reach and made available for home decorations, for by delicacy of handling, and quick appreciation of the possibilities in chemistry, light and mechanics, they have made the latter subservient to the artistic tastes of mankind.