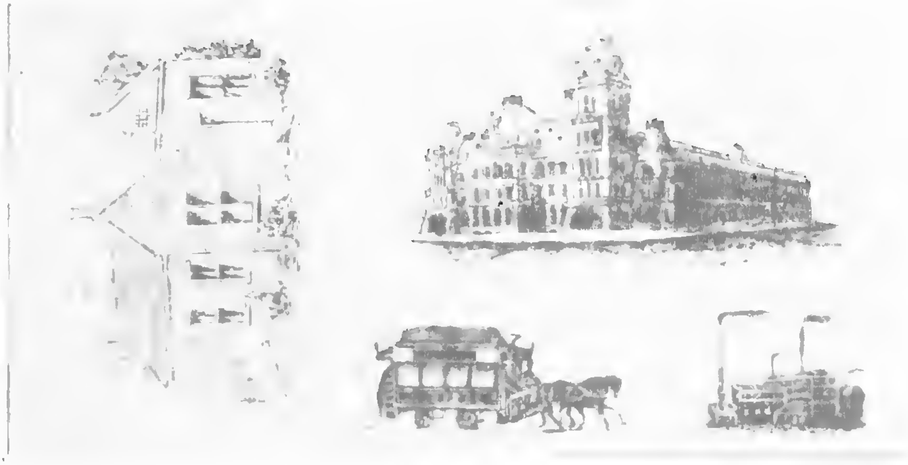
1

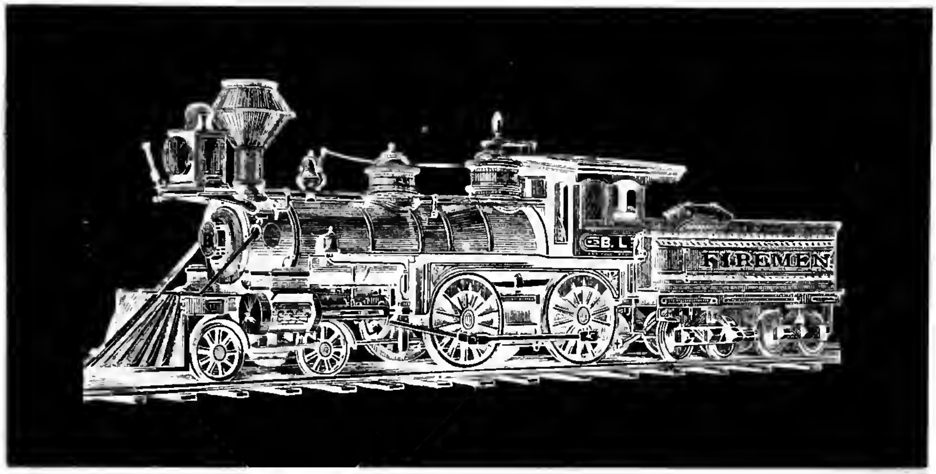
Silver Print on Citro-Chloride of Silver Paper.—Negative.

2



Silver Print on Citro-Chloride of Silver Paper.—Positive.

3



Ordinary Blue Print.—Negative.

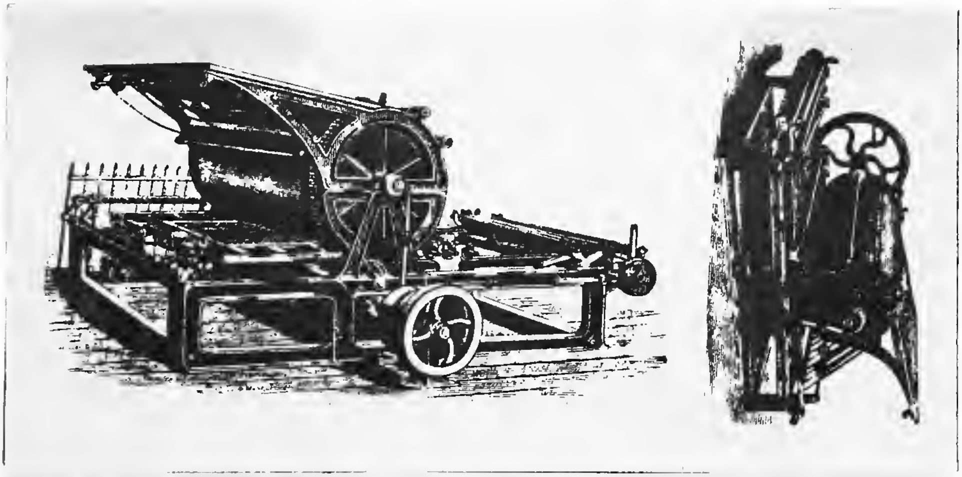
4

Ordinary Blue Print.—Positive.

5

Red Prussiate of Potash Print.

6



Direct Cyanotype. (Pizzighellitype.)

7

Ink Picture.

8

Carbon Print.

9

Uranium Print, Developed with Nitrate of Silver.

10

Uranium Print, Developed with Red Prussiate of Potash.

MODERN
HELIOGRAPHIC PROCESSES:

A

MANUAL OF INSTRUCTION

IN

THE ART OF REPRODUCING DRAWINGS,
ENGRAVINGS, MANUSCRIPTS, ETC.,

BY THE

ACTION OF LIGHT;

FOR THE USE OF

ENGINEERS, ARCHITECTS, DRAUGHTSMEN, ARTISTS
AND SCIENTISTS.

With Thirty-two Illustrations on Wood
and Ten Specimen Heliograms.

BY

ERNST LIETZE,

MECHANICAL ENGINEER.

D. VAN NOSTRAND COMPANY,
Publishers,
NEW YORK.
1888.

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UNIVERSITY PRESS.

PREFACE.

THE present book had its origin in a lecture on "The Heliographic Methods of Reproducing Drawings, Manuscripts, Engravings, etc." read by the author, November 17, 1885, at the Ohio Mechanics' Institute. This lecture met with such favor and applause that it had to be repeated January 9, 1886. Thereupon the author was urgently requested by his friends to publish his paper in the form of a pamphlet, or little book. He, at length, determined to do this; but much had to be added — many recipes tried and experiments made — in order to give the work the value which the author wished it to have. He who knows how often an experimenter is deceived and disappointed, in trying recipes and processes, can easily imagine why the publication of the book was so long delayed.

An abundance of excellent and valuable works on photography already exist, but, as far as the author is aware, there is no book, in the English language, which is adapted to the special use of the Engineer, the Architect, and the Draughtsman, who may wish to employ the heavenly light as a copying clerk. All that has been written and printed for this purpose is scattered through the numerous scientific and technical periodicals.

It is true that the professional photographer and the photographing amateur use the same forces of nature — the same light and the same chemicals — as the draughtsman who copies his drawings by a heliographic process; but it is also true that the heliographic reproduction of large drawings, etc., differs as much from photographic printing as does the work of a carpenter from that of a cabinet-maker, or the art of engine-building from that of watch-making.

This book is not written or compiled by a photographer, nor is it intended for photographers; but it is gotten up by an engineer and draughtsman, for the use of his professional associates.

Parts of the following pages have been gathered from periodicals, portions are taken from standard works on photography, chemistry, and physics, and a great deal is selected and translated from German works on the subject.

The attentive reader will, nevertheless, observe that a great deal of the matter is original with the author. A large number of the formulas given have been tested by the writer, and many of the processes communicated have been practiced by him for years. Care has been taken to select such recipes and processes as may be useful to engineers, architects, draughtsmen, etc. Formulæ which are of no value to the writer, but which were given by reliable authorities, and which may prove useful to others, are also added.

Some of the processes described may appear, at first, to be imperfect, difficult to execute, or otherwise open to objection, but they may be developed and usefully applied in the hands of intelligent draughtsmen. In order to support this statement, the history of the "Blue Print Process," which is now so universally adopted, needs only to be mentioned. This process was invented by Sir John Herschel, in 1840; but how many years passed before it was esteemed and practically introduced!

The works and periodicals from which the writer obtained information, collated recipes, thoughts, and ideas, which were tested, compared, modified, and, together with his own experience, compiled into the present book, are the following:

Roscoe, Henry Enfield, and Schorlemmer, Charles: A Treatise on Chemistry.
Wood, George B., M.D., and Bache, Franklin, M.D.: The Dispensatory of the United States of America; Philadelphia, 1883, J. B. Lippencott & Co.
Fowler, T., M.D.: The Silver Sunbeam; New York, E. & H. T. Anthony & Co.
United States of America Patent Office Reports.
Abridgments of Specifications of English Patents.
Burton, W. K., C.E.: The A B C of Photography; London, 1882, Piper & Carter.
Pettit, Jas. S.: Modern Reproductive Graphic Processes; New York, 1884, D. Van Nostrand.
The Scientific American.
The Scientific American Supplement.
The American Machinist.
Heinlein, H.: Photographikon; Leipzig, 1864, Otto Spamer.
Haugk, Fritz: Die Modernen Lichtpaus-Verfahren; Duesseldorf, Ed. Liesegang.
Halleur, D. G. C. H.: Die Kunst der Photographie; Leipzig, 1853.
Eder, D. J. M.: Die Reactionen der Chromsaeure und der Chromate auf Gelatine, Gummi, etc.; Wien, 1878.
Husnick, J.: Das Gesammtgebiet des Lichtdrucks; Wien, 1880, A. Hartleben.
Pizzighelli, G.: Anthrakotypie und Cyanotypie; Wien, 1881.
Pizzighelli, J. und Huebl, A.: Die Platinotypie.
Vogel, Dr. H. W.: Die Chemischen Wirkungen des Lichtes; Leipzig.
Talbot, Romain: Die Benutzung der Photographie zu Wissenschaftlichen und Technischen Zwecken; Berlin, 1883.
Neueste Erfindungen und Erfahrungen.

The patented processes, described here, are inserted only to give a complete view of the subject treated; as, of course, they can not be used, except by permission of the patentees.

The SPECIMENS, which accompany the first thousand copies, are not at all intended to be artistic, but merely to show that the heliographic processes may be employed for reproducing any kind of drawing, print, or manuscript. The originals were partly *tracings*, and partly *woodcuts* printed on tracing paper.

I hope the contents of this book may prove as useful to those for whom it was written, as they have been to me.

ERNST LIETZE.

CINCINNATI, O., 1888.

CONTENTS.

MODERN HELIOGRAPHIC PROCESSES.

INTRODUCTION.

Heliography, or Solar Printing, includes all those processes by means of which drawings, manuscripts, copper-plate and other engravings, all products of the graphic arts, pattern devices and designs, such as lace, leaves and flowers of plants, and photographic negatives and positives, which allow light to pass through them unequally in different places, may be reproduced or copied, in the same size as the original, by the direct action of light.

When the number of copies required is not too large, the Heliographic or Sunlight Printing Process is the cheapest method of reproduction. For large editions, however, the photo-mechanical printing processes, photo-lithography, photo-zincography, artotypy (Lichtdruck), phototypy, photo-engraving, etc., as also the purely mechanical means of anastatic printing, authography and zinc-etching are decidedly cheaper.* These last-named processes, however, require practical knowledge and experience of the art, and, besides these, machinery and other costly appliances, while Sunlight Printing can be performed by any one, in almost any room or office, without very expensive apparatus and machines.

Heliography is a branch of the photographic art, and is based upon the chemical action of light on certain bodies. Heliography and photography are similar expressions. The former signifies sun-drawing or sun-writing, and the latter light-writing or light-drawing. Actinic impressions can be obtained by artificial light, by the rays emanating from other fixed stars than our sun, as also by the electric spark; but for our purpose we mainly apply light that comes directly or indirectly from the sun.

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*The Eastman Dry Plate & Film Co., Rochester, N. Y., print book illustrations, etc., on Bromide Paper with their Photographic Web Printing Press, and state that Bromide Prints, in editions not exceeding two or three thousand, compete in price with those made by the best photo-mechanical processes, and surpass such work in sharpness, graduation of tone and uniformity; being made from the original negative, nothing is lost by reproduction.

I.

CHEMICAL AND PHYSICAL ACTION OF LIGHT.

There are but very few substances which are not affected by light. Almost daily, opportunities present themselves for observing the great influence of light on the animal and vegetable kingdoms; how, at times, it produces color, and how, at other times, it bleaches and destroys color.

It would seem that the influence of light on organic bodies is a phenomenon which must have attracted the attention of the first inhabitants of the earth. Could they fail to mark that the side of an apple which had been turned toward the sun was of a beautiful, bright red, while the other side, which had not received the direct rays of the sun, was but of a pale green or yellow? The brilliant and rich coloration of a tropical vegetation, and the gradual change of this to green, as latitude increases, must evidently show the influence of light. The changing of the green leaves and sprouts of plants to white, when supplied with air and moisture, but not with light, is a still stronger proof of the influence of light on vegetables.

The influence of light upon mankind may be observed in the blooming cheeks and healthy features of a maiden from the pastoral lands of the sunny Tyrolese Alps, as contrasted with the pale and colorless facial expressions of miners, who are always in the dark, or with the inhabitants of crowded cities, who spend the greater part of their lives in dark homes or offices.

Upon *inorganic bodies* light has quite a similar effect. Sunlight sometimes combines chemicals to form one compound, and at other times it separates a compound into its constituents. Glass, even, is affected by light. The celebrated physicist, Faraday, made the observation that glass colored by manganese, and conspicuous for a peculiar flesh tint, rapidly became brown in the light. Prof. Vogel has observed and recorded a very interesting example of this kind. A handsome plate of glass was exhibited in a mirror store in Berlin. It bore the inscription, "Manufacturer of Mirrors," in brass letters, cemented to the glass. After having been exhibited for years, the business failing, the plate of glass, on account of its beauty, was taken away by the proprietor. The brass letters were removed, and the plate was cleaned. To the surprise of the proprietor, the letters remained plainly visible on the glass, notwithstanding all attempts made to remove them. The surface was abraded, even, but this did not produce any effect on the letters. It was found that the glass was traversed by yellow marks, and that it was white only in those places where the opaque letters had kept off the light. The plate of glass was afterward cut into two pieces; one, with the word "Mirrors," still remains, in the Philosophical Collection of the University of Berlin.

These changes, or chemical processes, evidently take place most rapidly in direct sunlight; less so in diffused light, and very slowly—or not at all—in artificial light. The latter is partly due to the insufficient power of such a source of light, and partly to the small chemical action of certain rays of light. Thus, the effect will by no means be the same, whether bodies are exposed to yellow or to blue light. The latter acts very powerfully, the former only conditionally.

In order that we may represent to ourselves a perfect picture of the chemical and physical action of the different rays of light, it will be necessary for us to dwell a little on the decomposition of light.

As is well known, a ray, or a pencil of rays, of solar light (or white light from any other source) can be decomposed into several colored rays. If a ray, or a pencil of rays, of solar light be admitted into a darkened room, through a small aperture (Fig. 1), and a triangular prism of flint glass or quartz be placed in the path of the pencil, near the aperture, the rays will be unequally refracted, and will form, on a screen, an elongated colored image, which is called the solar spectrum. Newton distinguished seven of the colors of the solar spectrum as primary. These are, in order, beginning with the least refracted, red, orange, yellow, green, blue, indigo and violet. Newton considered all the prismatic colors as simple, because they can not be further decomposed. If any colored ray of the spectrum be transmitted through a small aperture in the screen, and another prism be placed in the path of such a ray, it will again be refracted, but will undergo no further change in color.

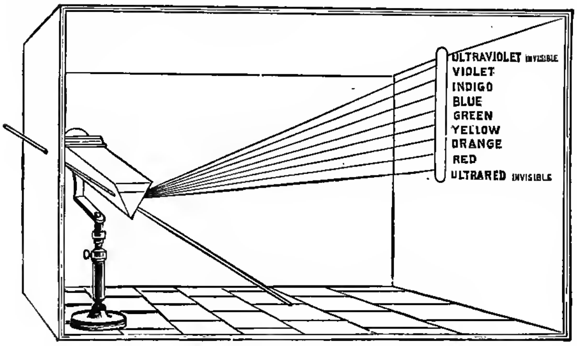


Fig. 1.

Physicists now consider only red, yellow and blue to be primary colors, and all the others to be compounds. Thus, green is a compound color; if blue and yellow rays are combined by means of convex lenses, the resulting color will be green. If certain two colored rays are collected—for example, if green and red rays are collected—colorless, or white light, as it is called, will be produced. Any two colors, which, combined, produce white light, are called *complementary colors.* Hence, orange and blue, violet and yellowish-green, indigo and orange-yellow are complementary colors.

Of the three primary colors of which a sunbeam is composed, each is a representative of one of the three distinct functions of light: 1st, to illuminate; 2d, to heat, and 3d, to produce chemical changes. The illuminating power exists mainly in the yellow rays; the heating property in the red, and the chemical power in the blue rays. Definitely speaking, then, it is not light, the illuminating agency, which is the cause of photographic action, but an active principle associated with it, and which is connected chiefly with the weakest illuminating and even with invisible rays. This active power of nature, that produces the photographic image and which is associated with light, but which is not the illuminating principle called light, is termed actinism.

Beside the seven visible rainbow colors, there are others—so-called invisible rays—at both sides of the visible solar spectrum (Fig. 1). Those beyond the red make known their presence by their heating power; those beyond the violet, by their chemical action. If we pass a thermometer over the solar spectrum slowly, from the violet to the red, we will notice a gradual increase in temperature. The point of maximum intensity varies with the material of the prism. By using a prism of rock-salt, which absorbs but little heat, the point of greatest heating power is found to be beyond the red rays, at the invisible ultra-red.

The relative chemical effect of the different rays has been determined by placing in the spectrum a slip of paper covered with a film of a substance very sensitive to actinism. Quartz prisms have been used for these experiments, as they are better adapted to this purpose than glass ones, because glass absorbs a large portion of the chemical rays. The chemical effect is scarcely perceptible in the red and yellow rays; it is decidedly apparent in the blue, and attains its maximum in the violet. The action extends beyond the violet, which proves that the spectrum contains rays more refrangible than the violet, but invisible. If these invisible ultra-violet rays be concentrated by a quartz lens, they will form a faint beam of lavender colored light. These rays also become visible when they fall on paper moistened by a solution of quinine, or by a decoction of chestnut shells, or if they fall on glass colored by the uranium.

Accordingly, we may divide the rays of the spectrum into three classes:

1. The rays of heat: Ultra-red, red, orange.
2. The rays of light: Orange, yellow, green.
3. The actinic rays: Blue, indigo, violet and ultra-violet.

Yellow, which offers the most intensive illuminating power, is, chemically, nearly inactive on most of those substances which are very sensitive to sunlight.

The sources of artificial light radiate mainly yellow rays, and this is partly the reason why gas and lamp-light have but little influence upon most substances which are sensitive to sunlight. Bromide of silver, in a gelatine emulsion, the most sensitive substance known, is, nevertheless, considerably affected by yellow gas or lamplight. In handling this substance, plates or paper coated with it, very weak, ruby-red light, which has the least effect upon it, must be used.

The property of quinine, to lower the tone of violet, ultra-violet and blue rays—that is, to convert them into rays of less refraction—is used in what is called "The Photography of the Invisible." If a writing or drawing is made, on paper, with a concentrated solution of sulphate of quinine, the result will scarcely be visible, but if this is then photographed, it will appear black and plainly visible in the picture.

The fact that colors exist which we can not see, but which possess actinic power, and that certain colored rays of light, which possess a great illuminating power, produce but little chemical action, is one reason why photography represents many objects with a wrong distribution of light and shade.

The intensity of moonlight is but the two-hundred-thousandth part of that of the sun, and although the human eye can easily perceive objects by moonlight, yet a photographic plate, exposed to a lunar landscape, will scarcely produce a picture at all. The photographic lunar landscapes, sometimes offered for sale, are taken by daylight, but very darkly copied, so as to resemble the effect of moonlight. The comparatively small susceptibility of the photographic plate to feeble light explains the reason why shadows, in photography, are generally too dark.

II.

CLASSIFICATION OF HELIOGRAPHIC PROCESSES.

The printing processes which make use of the actinic power of light are very numerous. They may be classified, with reference to the sensitive substances used, as follows:

1. Processes with salts of silver.
2. Processes with iron salts.
3. Processes with salts of chromium.
4. Processes with salts of uranium.

The processes with ferric and chromic salts may be divided into direct and indirect processes. The former furnish positives from positives; the latter, negatives, in regard to light and shade, from positive originals. All processes with silver and uranium salts are indirect.

The heliographic processes for copying drawings, etc., in which silver salts are employed, are identical with the photographic processes now universally used. The photographer, however, generally prints from a glass negative, while the draughtsman reproduces his tracings or drawings. Silver prints are somewhat more expensive than iron prints; but the former have this advantage over the latter, that any drawing or print may be copied with fair results. The processes with ferric and chromic salts, especially those by which dark lines are produced on a white or very light surface, require originals drawn with intense black ink on very thin and translucent paper. Silver prints of small, fine drawings present a much better appearance than iron prints. One of the processes with iron salts, known as the Herschel Process, and which furnishes the so-called "Blue-prints" (white lines on a blue ground), is most extensively used on account of its simplicity, and because it requires the least skill and experience. It, however, has the disadvantage of being easily destroyed, as all alkalies will decompose the color. The direct processes, with iron salts, demand more practice for their execution than the common blue-print process or the processes with silver salts, but they furnish beautiful prints. Ink-pictures are as durable as pen-drawings made with common writing-ink. Chromium prints are as cheap as iron prints, and some of the processes with chromium salts furnish very fine reproductions (*e. g.*, carbon prints and nigrographic prints), but they demand some skill on the part of the operator, or he will be successful occasionally only. Such iron and chromium prints as require for their development silver or platinum salts, cost as much, and sometimes more, than silver prints. Uranium prints are easily made. They are very durable, and by chemical means almost indestructible. They will even withstand the action of a boiling solution of cyanide of potassium.

III.

PAPER.

The paper used for heliographic printing should have a smooth, hard surface and a fine, uniform texture. There are in the market certain kinds of paper specially made for heliographic purposes. The materials used in the sizing and bleaching of the paper have much to do with its qualification for this purpose. Several manufacturers of paper advertise chemically pure paper, by which they mean that no substances have been used in sizing and bleaching which would have any undesirable effect on the chemicals used in Sun Printing.

Several kinds of writing and drawing-paper may also be used for heliographic copying. One kind may be suitable for a certain process, another kind for a different process.

For fine, artistic chloride of silver prints, it is, however, preferable to use the prepared albumen or arrow-root paper. This paper is coated with a thin film of albumen or arrow-root, which film closes all the pores, thus keeping the picture on the surface. Albumen paper, which can be obtained in any photographers' supply store, is bright and glossy, and the most brilliant and powerful pictures can be produced upon it. Photographers use it almost exclusively; for certain specialties they must use plain paper. Arrow-root paper is dull, and not as much used as albumen paper. The prints produced upon it are not as brilliant, but by no means inferior to those on albumen paper. Silver prints, on plain, uncoated paper, never present as dark or powerful a picture as when on albumen or arrow-root paper, but they do very well for machine, architectural and other technical drawings.

For iron, chromium and uranium prints, many different kinds of paper are suitable, but not all. It is always best to try a small sheet before sensitizing a large quantity of a new kind of paper.

IV.

VARIOUS METHODS OF SENSITIZING.

In order to render paper sensitive to the action of light, it is coated or saturated with a solution, or a mixture, of certain chemicals. These chemicals differ according to the process. The consistency of the sensitizing substance also differs; at times it is liquid, like water, at other times stiff, like a thick solution of gum arabic. Two or more operations are sometimes necessary for sensitizing the paper.

Paper may be sensitized by floating it upon the solution, by immersing it, or by coating it with the sensitizing substance by means of a brush, sponge, felt or india rubber roller, by hand or by machine. For solutions which are liquid, like water, a sponge or a soft camel's-hair brush is the most suitable appliance when sensitizing by hand. If the sensitizing material has a sirupy or still stiffer consistency, a hard bristle brush will be preferable. Some manufacturers of sensitized paper use a machine for preparing endless or roll-paper for certain purposes. We will mention, in describing the various processes, which method of sensitizing is thought to be the best in each special case. In this division we intend to give but general methods.

If the paper be floated upon, or immersed in, the solution, it is very important that the paper be uniformly moistened. Air-bubbles must at once be removed.

If the sensitive material is to be applied by means of a sponge or brush, pains must be taken to coat the paper as uniformly as possible. It is well to go over the paper in parallel strokes, taking care to leave no part of it untouched, using plenty of the solution and operating so quickly that no part will be dry before the whole is coated. The brush or sponge should then be pressed out, and, nearly dry, applied in parallel strokes, in a direction at right angles to the first. If the sheet be so large that one person can not go over it with sufficient rapidity and before parts of it become dry, two men must be engaged in the work, and commence either at opposite ends or in the middle of the sheet. A table covered with oil-cloth is a very suitable arrangement upon which to place the paper while sensitizing in this manner.

In most cases, floating the paper will distribute the liquid more uniformly than any other method. When large sheets are to be prepared, *floating* becomes impracticable on account of the large dishes and the large quantity of sensitizing solution required to sufficiently cover the bottom of the dish. Moreover, it is difficult to handle large sheets for this method.

The best way to prevent air-bubbles from forming under the paper, in floating, is to hold it at two diagonally opposite corners, bend the sheet, and then allow the other diagonal of the sheet to touch the liquid first. The two corners held in the hands should then be dropped, first one and then the other. This may sound rather elaborate to some, but in practice it is very simple, and, if skillfully executed, there should be no air-bubbles formed. Nevertheless, it is always best to lift the paper out of the liquid, after a short time, in order to be sure that none have been formed. If any should happen to have been formed, they may easily be broken by moving the paper, while half of it is held out of the solution. After one or two minutes, the paper should be removed from the bath, by drawing its surface over one edge, so as to drain off the surplus of the solution. It should then, if the sheet is not too large, be hung up by one corner to dry. Large sheets, however, will become distorted if hung up by one corner; they must be held by two corners or by three or more places, according to size, along one edge. This must be done loosely; that is, so as to form waves in the paper, in order that the sheet, while drying, may contract at the upper edge just as in other parts. A thin, but wide, strip of wood, running across the room, and supplied with spring clothes-pins, serves very well for hanging up the paper.

When the author wishes to sensitize or coat paper on one side only, by immersion, he pastes two sheets together by their edges, or folds one sheet in the middle, and trims three edges of one half a little smaller (about ¼ inch) than the other. He then bends the three edges of the larger part over the smaller part, and pastes the edges together. As a paste, he uses shellac varnish, which does not expand the paper or dissolve in the solutions. After the paper has been immersed and dried, the edges which were pasted together by the varnish are trimmed off.

V.

DISHES OR TRAYS, DEVICES AND MACHINES USED FOR SENSITIZING.

For the preparation of paper by floating or immersing, as also for the manipulations of fixing, washing, etc., flat dishes or trays are required. They must be water-proof, and the material of which they are made, or the protecting covering or lining of the same, must be inert to the solutions which they are to hold.

Glass Dishes are excellent, but the largest size made is only 16"× 20".

Porcelain Trays can be had as large as 19"× 24", which size costs about $12.00 apiece.

Earthenware Dishes (called Acid dishes) are made to order, up to 22"× 26", and cost as much as porcelain dishes. Glass and porcelain dishes break very easily, and should be protected by wooden frames.

Trays of Hard Rubber or Ebonite have the advantage of not breaking as easily as those of glass or porcelain, but they are made only of sizes as photographers require them for the development of dry plates. The largest commercial size of hard rubber trays is 21"× 26" (price, $8.75 to $12.00, according to depth); larger sizes must be made to order in an india rubber factory.

Enameled Sheet Iron and Cast Iron Dishes are very durable, but those which are manufactured are not of sufficient size. They must be specially made for the purpose, and sent to the enameling works to be glazed. Small sizes, up to 19"× 24" (price, $15.00), are in the market under the name of "Agate Ware Pans."

Japanned Sheet Iron Trays are also used for developing, and are a great deal cheaper than those just named; the largest size to be had is 20"× 24" (price, $2.50).

A Combination Pan for sensitizing large sheets of paper can be made of a strong plate of glass and four strips of wood, about 4 inches wide and 1 inch thick. Fig. 2 represents such a tray. Across the middle of one of the sides of each of the four strips of wood, a groove is planed, about $\frac{3}{16}''$ or $\frac{1}{4}''$ deep, and as wide as the glass plate is thick. The grooves are filled with putty, and the glass inserted. The frame is then screwed together with wood-screws. Before tightening the screws, some putty should be placed at the joints, and, finally, the wood should be varnished with shellac

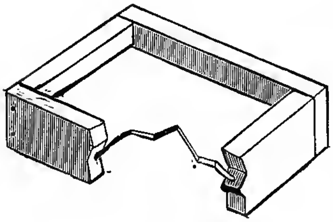


Fig. 2.

close to the glass. One side of this pan can be used for sensitizing, and the other for washing, silver prints after having been taken out of the copying frame. For sheets of small size, the writer uses—especially while experimenting—Temporary Dishes Made of a Piece of Paper by bending or folding, as shown in Fig. 3. According to the chemicals to be used in them, the paper is left as it is, varnished with shellac, or saturated with parafine.

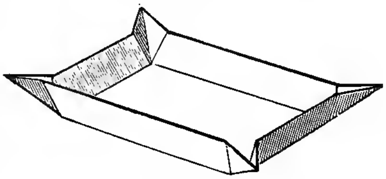


Fig. 3.

Trays Made of Wood or of Pasteboard and Lined with India Rubber Cloth are very practicable, light, cheap and easily made. For immersing large sheets of plain, salted paper in the silver salt solution, the author uses a light, wooden tray, lined temporarily with a piece of india rubber cloth, which is bent in a manner similar to that of the paper dish illustrated in Fig. 3. The rubber cloth is taken sufficiently large so as to project over the sides of the tray and permit bending to the outside, where it is fastened by means of thumb-tacks.

Fig. 4 is a perspective view, and Fig. 5 a cross-section, of a tray of a different form, for drawing sheets of paper through a liquid. This tray has the advantage over others of requiring but a small amount of liquid. The inside is to be well coated with a suitable varnish, or lined with india rubber or acid-proof cloth. A glass tube, T, closed at the ends by india rubber stoppers, or by corks impregnated with parafine, is clamped between the ends of the box. In Fig. 5, Q represents the sheet of paper to be sensitized. At the corners of the sheet, loops of threads are attached, through which thin, wooden sticks are slipped, so that the paper can be held by the sticks, and can be moved back and forth to the extreme ends, in the liquid, without dipping the fingers therein.

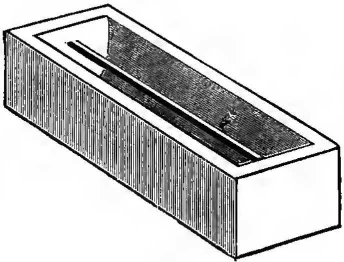


Fig. 4.

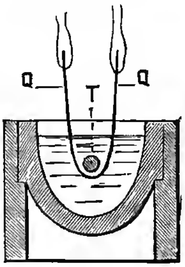


Fig. 5.

Figs. 6 and 7 illustrate a Device, suggested by the writer, for Sensitizing Large Sheets or Small Rolls of Paper by Means of Rollers. Two brackets, as A, and two other brackets, as B, are bolted to a wall or to posts; the first pair near the floor, and the other pair near the ceiling of the room. The lower brackets, A, are provided with journal-boxes for the iron shaft of the wooden roller, C, to rotate in. The upper brackets, B, are fitted with stems, which have, at their upper ends, forks, in which the iron shaft of the upper wooden roller, E, is journaled. The paper to be sensitized or coated is pasted together (preferably with shellac varnish) to form an endless band, and is placed over the rollers C and E. The stems, G, are pressed upward by springs (invisible in the sketch). The nuts, H, serve to adjust the distance between the rollers C and E, and to regulate the tension of the paper band. The brackets, B, may also be so arranged that they can be made to slide up and down on the wall or posts, and fastened at any desired height. Marks may be made on the wall or posts to indicate the position which the brackets must occupy for certain lengths of paper. The roller, D, is covered with india rubber, and revolves in the sensitizing (or other) liquid contained in the trough or fountain, F. The latter (shown in the sketch partly in section) is hinged to the brackets, A, and provided with the eyebolts and nuts, S, for bringing the fountain roller, D, in contact with the paper around the roller C. The scrapers, N, N, reach very close to the roller D, and prevent a too large amount of solution from clinging to the roller. The caps of the journal-boxes of the roller C are so arranged that they can be readily opened when the roller is to be taken out. In order to place the paper, which has been previously pasted together, in the apparatus, the nuts of eyebolts S are first turned back so that the fountain F hangs down, and the roller C does not touch the fountain roller D. The nuts H are then loosened so that the stems G rise up by virtue of the springs; the journal-boxes of the roller C are opened, and the rollers C and E taken out. Then the paper is placed on the roller E, the roller put back in its place, the roller C slipped in the endless paper band and let down easily, so that the paper will be tensioned by the weight of roller C. Then the nuts H are screwed up until both journals of the roller C just touch the bottom of their bearing-boxes; the journal-boxes are closed, and the paper moved in such a position that the lap of the same is directly above the roller D; then

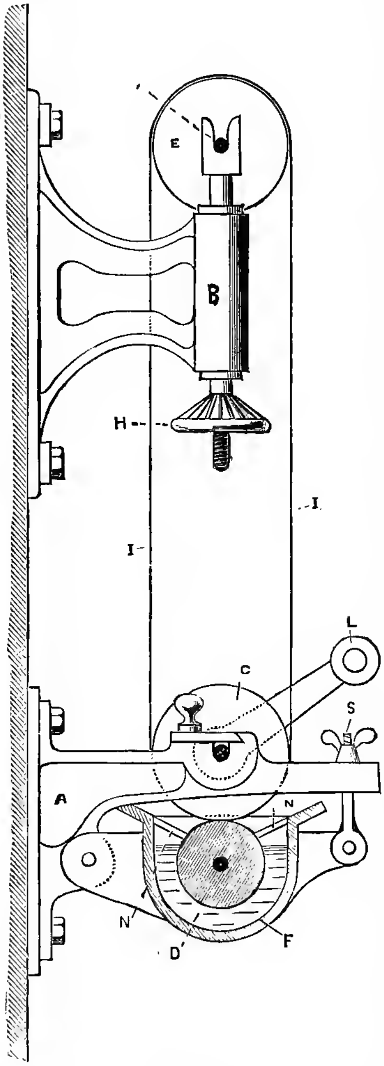


Fig. 6.

the nuts of bolts S are turned on, until the roller D touches the roller C. Finally, the hand-crank L is put on the projecting end of roller C, and, by means of it, the roller C is turned—at first a little backward and forward, and then uniformly in one direction—until the lap, in the paper band, again comes to the line of contact of the two rollers D and C. While turning the crank backward and forward, the paper must be observed, in order to see whether the solution is being equally applied at either side. If this should not be the case, one or the other of the nuts of the screws S must be tightened or loosened, in order to cause the roller D to press uniformly upon the roller C, and with as much pressure as necessary to apply the required amount of solution to the paper. When paper of various widths is intended to be coated in this apparatus, it is best to arrange the lower part so that a roller, O, can be placed between the rollers D' and C, as indicated in Fig. 7. The length of the rollers O and C should correspond with the width of the paper to be coated, while D and E may have a length equal to the width of the widest paper.

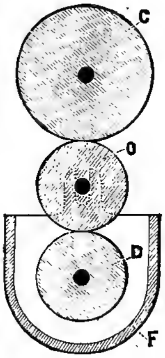


FIG. 7.

For the preparation of very large sheets and rolls of paper, for certain processes, manufacturers of such paper use machines to do this work.

By means of a machine, paper can be coated more uniformly than is possible by hand.

In the following, we describe and illustrate a SENSITIZING MACHINE, designed by Bertsch (according to Ed. Liesegang):

Fig. 8 is a side elevation, Fig. 9 a front elevation, and Fig. 10 a plan or top view of the entire machine. Fig. 11 is a detail view, showing the arrangement of the three rollers, T, R and U, and the glass scraper X, which may be placed between the rollers R and U, so as to press against the paper and remove a surplus of the liquid. The principal parts of this machine are a number of rollers, P, T, R, U, S and V. The paper to be prepared, being rolled up on the roller P, is carried over the tension segment A, and between the rollers R and T. The latter roller is covered with felt, and revolves in the fountain F, which contains the sensitizing liquid. The inside of the fountain is lined with gutta-percha.

The screws B serve to regulate the distance between the rollers T and R. The paper, after passing the roller R, is carried over the roller U, the table C, and the roller V. An endless cloth, stretched over the rollers S and V, and moving over the top of the table C, carries the paper farther. The motion of the endless cloth is obtained by the rotation of the roller S, which is driven from U. The wheels H H, over which rubber rings are sprung, press upon the paper—still wet—

which is supported by the endless cloth, and, in this manner, the paper is kept under tension and moved forward.

The rollers are driven, one from the other, by means of gear-wheels, and are set in motion by the fly-wheel I, which is fastened to the shaft of the roller U, and provided with a handle by which it is turned. The fountain roller T is covered with felt, and applies the sensitizing solution to the paper. The paper, leaving the endless cloth, passes over a number of rollers (not shown in the figures), and is finally dried upon laths.

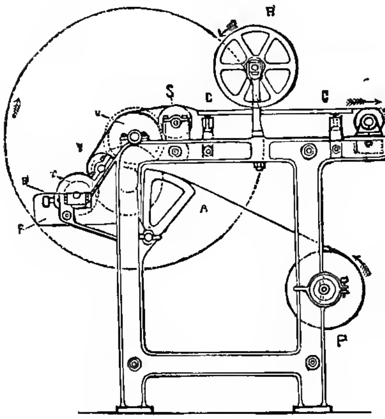


Fig. 8.

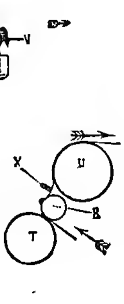


Fig. 11.

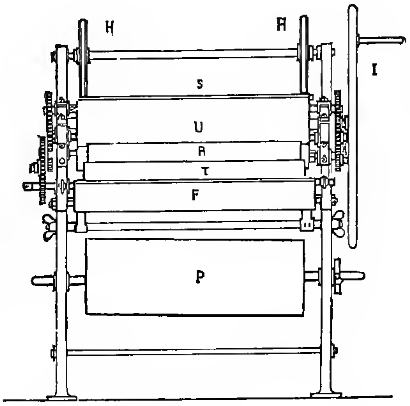


Fig. 9.

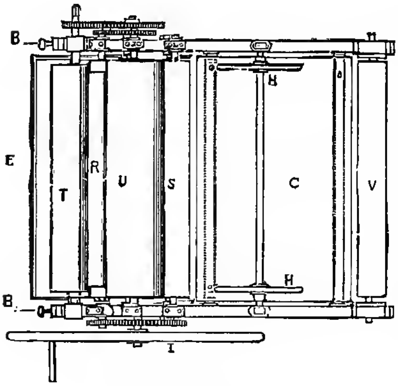


Fig. 10.

The ratio of the gearing is so selected, that T moves considerably faster than R, and opposite to the same.

Before the machine is set in motion, the roller T is withdrawn from the roller R, by means of the screws B, and swiftly turned, in order to wet its felt covering uniformly. After this has been done, the paper is guided over the tension segment A, and the roller R; then the roller T is brought in contact with the paper on roller R, the fly slowly turned, and the paper guided over the roller U, and under the wheels H. Then the machine is set in regular motion, so that the fly-wheel will make from 30 to 40 revolutions per minute.

Every time, after using the machine, the sensitizing solution remaining must be removed, and the fountain and the rollers cleaned by washing them with plenty of water.

In Fig. 12, we illustrate A Brush, recommended by a friend of the writer, for Coating Large Sheets by Hand. This brush consists of two thin boards, of suitable form, well varnished with shellac, between which a number of thicknesses of cotton or woolen flannel are placed, so as to project at one side, and which are then fastened together by means of wood-screws. The brush may be made as wide as the width of the paper, and a trough, as that shown in Figs. 4 and 5, of corresponding length, may be used for the solution.

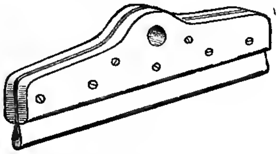
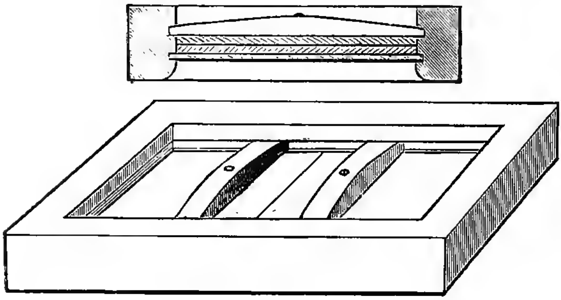


Fig. 12.

VI.

PRINTING FRAMES.

The printing or copying process is very simple, and, with a little attention, may be learned in a short time. A copying frame, of suitable size, is the only apparatus required. This apparatus has been made in various ways, but all have the same object in view, namely, to hold the paper in close contact with the tracing, drawing, negative, or other original.



Figs. 13 and 14.

The Cheapest Miniature Printing Frame is the toy known as the "Transparent Drawing Slate," and may be used, by beginners, to practice with. The *ground* glass plate, in this frame, will necessitate a somewhat longer exposure, for copying, than a clear, transparent plate would.

A Cheap and Convenient Printing Frame of small size, similar in construction to a transparent drawing-slate, but more substantially made, is illustrated in Figs. 13 and 14.

Another Kind of Printing Frame is shown in Figs. 15, 16 and 17. This frame is so constructed, that the original drawing or negative to be copied, or the sensitized paper, may be longer than the frame and project over the ends of it. The projecting part of the paper may be rolled up, wrapped and protected from the action of light. This

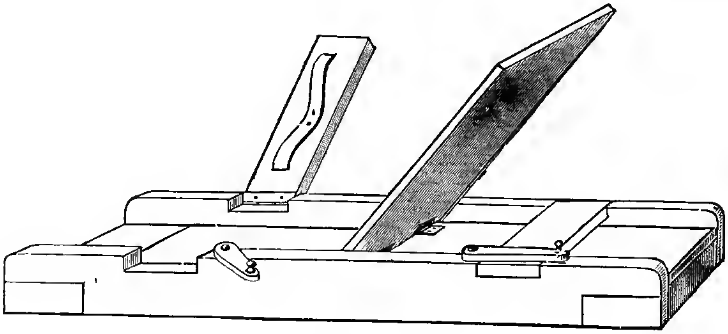
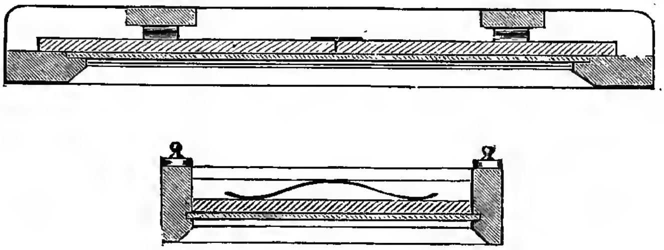


Fig. 15.

arrangement enables the operator to copy different small drawings, or parts of large drawings, one after the other, on one sheet of paper.



FIGS. 16 AND 17.

Figs. 18 and 19 represent a type of printing frame frequently met with.

THE GLASS FOR A PRINTING FRAME should be plate glass, with a perfectly even surface, and of sufficient thickness (¼″ to ½″) to withstand the pressure.

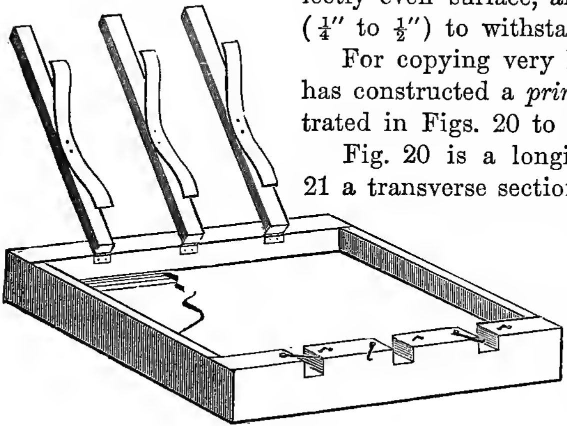


FIG. 18.

For copying very large drawings, *the author* has constructed a *printing frame*, which is illustrated in Figs. 20 to 24.

Fig. 20 is a longitudinal section, and Fig. 21 a transverse section, of the whole apparatus. Figs. 22 to 24 are detail views. Fig. 22 shows the ratchet-wheel and pawl of the eccentric shaft; Fig. 23 a portion of the framed glass, and Fig. 24 a part of an axle, with a wheel. The scale of Fig. 20 is ½ inch to a foot, that of Fig. 21 is 1½ inches to a foot. Figs. 22 to 24 are drawn in ¼ of full size. The apparatus consists of a board, mounted on wheels, and resembling a platform-car; a stand, provided with rails for the former to run upon, and a plate of glass held in a frame. The board is covered with a blanket of felt, billiard-cloth, or the like.

The stand, with the rails, is placed close to a window. The rails extend out of the building, and are trussed to the wall. The stand is somewhat longer than twice the length of the board.

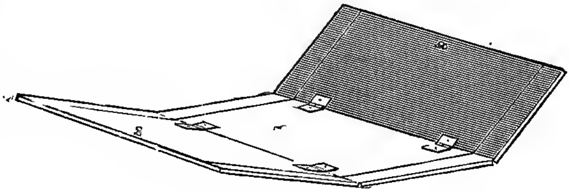


FIG. 19.

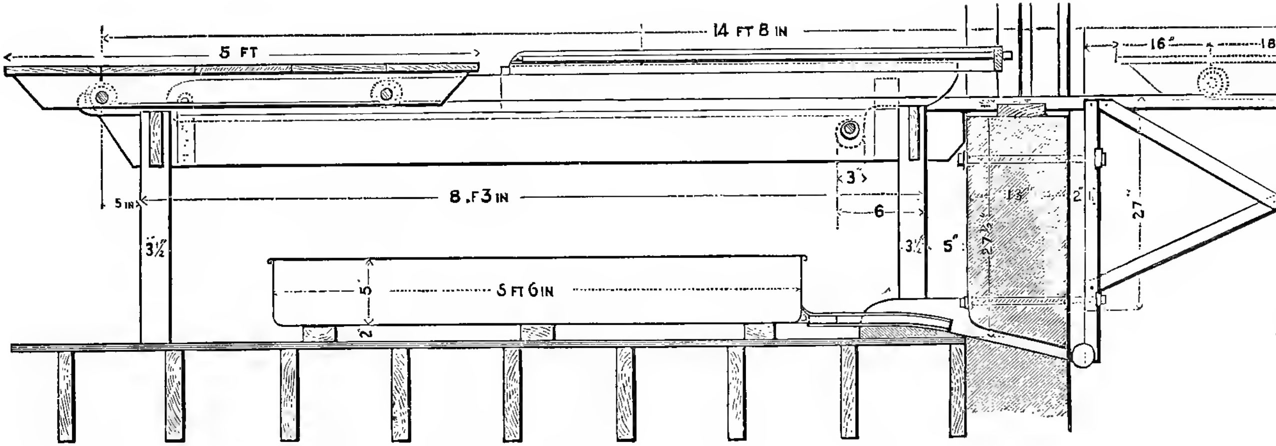


FIG. 20.

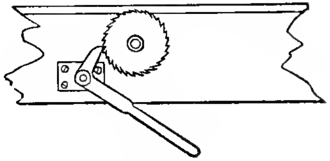


FIG. 22.

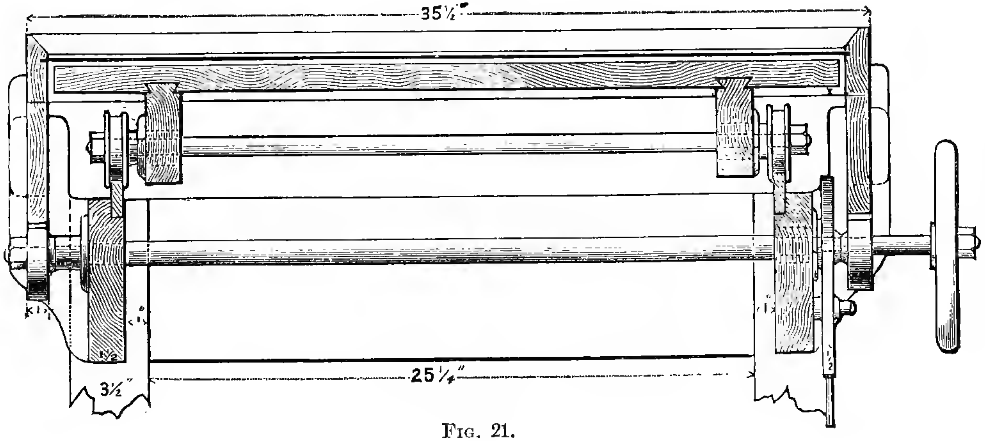


FIG. 21.

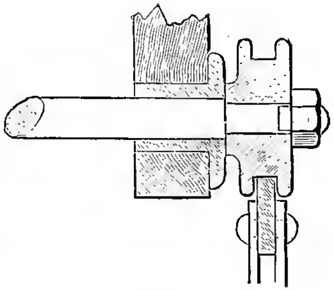


FIG. 24.

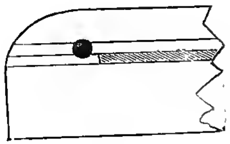


FIG. 23.

At the sides of the stand, long, wooden lifters are arranged, for elevating and lowering the glass plate. These lifters are pivoted to brackets, at the end of the stand, opposite the window, and rest, near the window, upon eccentrics. The latter are fastened to a shaft, which is journaled in the stand. This shaft is also provided with a hand-wheel, by which it can be turned, and with a ratchet-wheel, which allows the shaft to be turned only in one direction, except when the pawl is released. The glass plate is bounded, on three sides, by a wooden frame, and on the fourth side by a small iron or steel bolt, joining the longitudinal sides of the frame at their inner ends. By means of the eccentric shaft, the lifters, and with them the glass plate, can be raised and lowered. When elevated, the glass plate rests upon the lifters, and the board may be rolled back alone. In order to place the copying paper and the original upon the platform, this and the lifted glass plate must occupy the positions in which they are drawn in full lines in the longitudinal section, Fig. 20. The light must be subdued by a curtain (of an inactinic color), which is attached to the window. If there are other windows in the room, near the printing frame, they should also be provided with curtains for this purpose. A number of smooth sheets of paper, which are, together, a little thicker than the head of a thumb-tack, are to be placed under the sensitized paper. The original, projecting, toward the window, a little over these sheets, is fastened, by means of thumb-tacks, to the board. When this has been done, the platform is rolled, a short distance, under the elevated glass plate; then the glass is let down, by turning the eccentric shaft slowly, until its inner end rests and presses upon the paper on the board, the other end of the glass plate, near the window, still remaining supported by the side arms, but only slightly elevated. (We should here mention that the inner lower edge of the glass must be made smooth by means of a triangular saw-file.) The platform-car is then rolled farther under the glass, whereby the projecting ends, of the longitudinal sides of the frame of the glass plate, will touch the window-sash. The rounded corner of the glass tends to smoothen the paper on the board. This action should be assisted by rubbing, with the hands, crosswise over the original, and starting from the center, while sliding it under the glass. Before the original is entirely under the glass, the ratchet-wheel is released from its pawl and the eccentric shaft turned, so that the whole glass plate will rest upon the board and clear the lifters. Then the board is pushed entirely under the glass, the curtain raised, the window opened, and the platform, loaded with the glass plate, rolled out into the sunshine. This position is indicated, in Fig. 20, by dotted lines. If tacking the original to the board should be objectionable, the platform, with the papers, may be rolled at once entirely under the elevated glass plate, which is then let down upon it. After the exposure to the action of the light, the frame is rolled in, the window out and preserved in the dark for the next treatment.

The Latest Improvements in Printing Frames are: (1) The application of air-cushions, in place of the felt or cloth blankets, to insure a perfect contact of the sensitized paper and the original.

(2) An apparatus for producing a partial vacuum between an india rubber blanket and the glass plate, so as to cause the exterior atmospheric air to press the blanket, the sensitized paper, and the drawing or original, firmly against the glass.

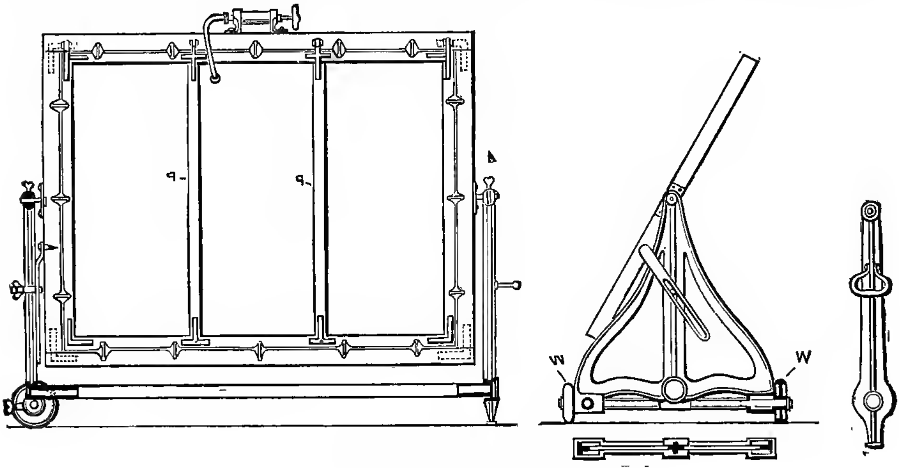
(3) Printing frames, with curved surfaces and without a glass plate (especially adapted for large prints).

The Air-Cushion is generally made of two sheets of vulcanized india rubber, of the same size, which are connected, air-tight, by their edges. In some cases it consists of one sheet of india rubber, fastened to the edges of a thin and flexible plate of zinc, tin, iron, or the like. The cushion is filled with air, either by blowing into it with the mouth through a suitable pipe, or by means of bellows, or with an air-pump consisting of an india rubber ball, terminating in a hose and provided with suitable valves, which is operated by alternately compressing the ball and releasing it from the pressure.

A printing frame, provided with an air-cushion, has been patented by Street (United States patent No. 263,242).

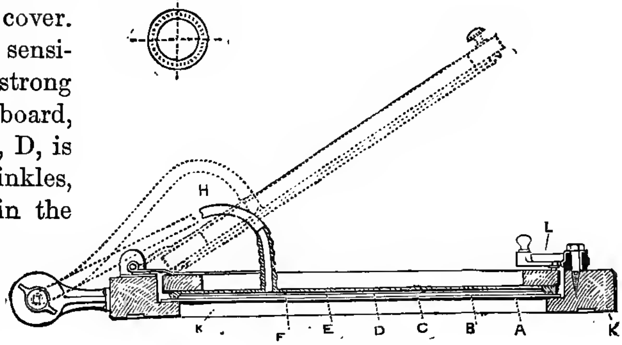
An advantage of the vacuum printing frame is, that the glass plate will not be strained, since the atmosphere presses equally on both sides of the glass, and, therefore, thinner glass plates may be used.

In Figs. 25 to 32, we illustrate the Pneumatic Heliographic Printing Frame, by Hugo Sack (United States patent No. 324,960). The frame K holds the glass plate A, which is of common white window glass, but without flaws. The original, B, to be copied, and the sensi-



Figs. 25, 26, 27 and 28.

tized paper, C, are placed upon the glass. The rubber cover F has two beads extending around one side, near the edges, and is fastened to a second frame. This second frame fits loosely into the opening of the main frame K, to which it is hinged, and can be pressed lightly against the glass plate by means of the swivels L, whereby the projecting beads will effect an air-tight joint between the glass A and the rubber F. Inside of the beads, a woolen fabric, E, which allows the air to escape through its porous mass, is pasted to the rubber cover. Between this and the sensitized paper C, a strong pressed-board or cardboard, or a thin pasteboard, D, is put, to prevent the wrinkles, etc., which may be in the original drawing, from affecting the porous woolen cloth.



FIGS. 29 AND 32.

The hose H connects the space, between the rubber cover F and the glass plate, with an air-pump, which is shown in detail in Figs. 30 and 31, and which is fastened to the frame K, and also serves as a handle for the frame. (See Figs. 25 and 29.)

After the air in the frame has been rarefied by means of the pump, the external atmospheric pressure, acting equally upon the glass plate and the rubber cover, will press the sensitized paper forcibly against the drawing. The frame is now ready for exposure to light. By turning back the nut N of the hose-coupling (Fig. 30), the air will be allowed to enter the suction-pipe, and the vacuum will be relieved.

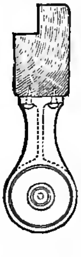


FIG. 31.

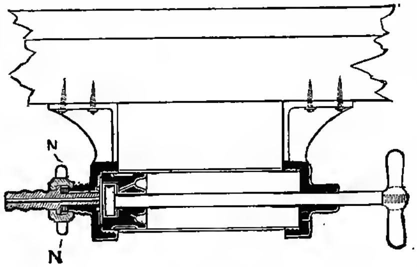


FIG. 30.

Fig. 25 illustrates an apparatus of this kind, of large size, in elevation. In small sizes, the cross-pieces q q, in the frame of the rubber cover, are not necessary. The printing frame is conveniently supported by a rolling stand, shown in Figs. 25 to 28. It will be noticed that this stand rests upon three points; namely, on two wheels and one leg, and, therefore, will stand firmly everywhere, even on a floor which is not perfectly smooth. The two wheels are attached to separate axles, which can be moved in and out, and fastened to the frame, by means of set-screws. In this manner the gauge of the wheels W W may be changed. When adjusted to the smallest gauge, the frame can conveniently pass through narrow doors, and, with extended axles, it can not easily be upset by the wind.

PROF. CLEAVES' HELIOGRAPHIC PRINTING FRAME WITHOUT A GLASS PLATE merely consists of a cylinder, having a length exceeding that of the widest drawing to be reproduced, and a diameter such that the longest tracing to be used can be wrapped around it and still leave sufficient space for the clamps by which it is drawn and held into place.

The cylinder is smoothly covered with felt, and the sensitive paper carefully wrapped about it. The tracing to be copied is drawn over the whole, and held smoothly in place, by spring clamps, which seize its ends.

It is found easy to lay the tracing smoothly over the surface and to draw it into contact, and that the work done by this method is even better and more certain than that produced by the ordinary plate-glass apparatus, even with the air-cushion now so successfully used with it.

It is easy, with a little care and with some practice, to make these prints absolutely perfect—much easier than with glass.

The apparatus being ready for use, it is mounted on a cradle, supported by its gudgeons, and is revolved in the sunlight by means of a cord, leading from some convenient line of shafting; or it may be turned by hand, until the exposure is satisfactorily completed. It requires a little more time to print a sheet by this method than by the old, as the tracing and the underlying sensitive paper are exposed but one half at a time to the rays of the sun. With exceptionally large prints, however, for which only this process would be employed, this is not an important matter. They are not likely to be made every day. *(Extract from memoranda presented by Prof. R. H. Thurston, at Washington Meeting of Mechanical Engineers, 1887.)*

VII.

HOW TO USE THE PRINTING FRAME.

THE main requirement, for obtaining definite and clear copies, is to bring the original in perfect contact with the sensitized paper. This is easily effected with small sheets of paper. The pressure of the springs or screws of the printing frame, or the weight of the glass plate and a single blanket of flannel, or a number of sheets of paper, is sufficient for this purpose. Large sheets of paper, which are often kinky, sometimes render it difficult to place them smoothly into the ordinary plate-glass apparatus. In such cases, thick blankets of flannel, or woolen cloth, or an air-cushion, may be used to advantage. An excellent method, recommended by Prof. Vogel, when many copies are to be made from the same drawing, is to stretch the original upon the glass plate, just as draughtsmen stretch their paper upon the drawing-board. This is done by bending over about ½ inch of the sheet around the edges, dampening the back of the paper, except the margin bent over, by means of a wet sponge, applying mucilage to the margin and fastening the paper to the glass. The writer sometimes stretches the original (a tracing, drawing, engraving, or paper negative) over a frame, and places it, with the sensitive paper underneath, between two glass plates, the lower of which is a little smaller than the inside of the frame. With an ordinary glass plate frame, we proceed as follows: The frame is opened, and the drawing, tracing, or other orignal, is placed upon the glass plate, which has been previously cleaned. The sensitive paper is placed upon the original, and after this has been smoothened and brought into the correct position, the blanket, or a number of sheets of blotting or other soft paper, is placed on top of this. The frame is then closed and examined from the outside, to see whether the original is smooth, shows no wrinkles and touches the glass uniformly. If this should not be the case, or if the sensitive paper should not be in the right position, the frame must again be opened, or partly opened, and, by means of drawing and rubbing the papers and the blanket, and by inserting pieces of soft paper, the whole must be made perfectly smooth.

The sensitized paper is placed, in all kinds of frames, with the prepared side touching the original, except in cases where very thick originals are to be copied, and where the sensitive paper is very thin. In such cases, positive prints, in regard to position, may be obtained from positives by putting the back of the sensitive paper upon the face of the original.

Care must be taken that the prepared paper be dry before it is put into the printing frame, otherwise the original would be stained, wrinkled and spoiled, and this would cause the prints also to be defective and indistinct.

It is evident that the sensitized paper must be handled and placed into the frame in weak light.

The original drawing or tracing, or the negative, must be placed into the frame in one of the following positions:

(1) If the positive tracing, drawing, or engraving to be copied, is made on very thin paper or tracing cloth, and if a print positive in regard to position is wanted, the face, or picture side, of the original must come in contact with the glass.

(2) If a negative is to be copied, and a positive copy is wanted, or if a negative print is to be made from a positive original, the back of the original must touch the glass. Also, when the original positive drawing, writing or engraving is made on thick paper, the back of the same must be in contact with the glass (for, if the opaque lines of an original, on thick paper, were to touch the glass plate, the resulting print would not be distinct, as the light would spread in the paper under the opaque lines). To be sure, the print will be negative, in regard to position; but, if this is objectionable, a positive can be made from it.

VIII.

EXPOSURE TO THE ACTION OF LIGHT.

In regard to the time of exposure to light required in each special process, to obtain a useful print, a definite number of minutes and seconds can not be given. This time depends as much upon the intensity of the light, and upon the thickness and the degree of transparency of the paper of the original, as upon the sensitiveness to light of the chemicals used in the process.

It is evident that at about noon, when the sunlight is the most powerful, the printing process will go on a great deal faster than in the morning or afternoon, when the light possesses a smaller amount of actinic power. It is also evident that it requires a longer time for light to pass through thick paper than through thin or very translucent paper, and that from very thick drawings no prints will result.

The author has, however, succeeded in taking excellent blue prints from patent drawings which were made on Reynolds' bristol-board (three sheets thick), by first making a negative on thin Helios paper, and then, from this, as many positives as were wanted. The exposure for the negative blue print required 3 days, in the best sunlight in June. The positives were copied in from 40 to 45 minutes. The exposure for a negative, on bromide of silver paper, through a similar original drawing, would require less than one minute in the light from a student-lamp.

Furthermore, the color of the paper of the original comes into consideration. Drawings on yellowish paper require more time for copying than those on perfectly white paper; and drawings or engravings on paper of a certain yellow color that excludes almost all actinic rays of light can not be copied at all.

Much of the success in sunlight printing depends upon the ink used in the execution of the original. If the lines of the original are perfectly black and opaque, the copies will be good and well defined, and an over-exposure will do no harm; but if pale ink was used in the original, the prints will be poor. When drawings or engravings executed with pale ink are to be copied, it is recommended, by some authorities, to print in the shade, or to weaken the light by stretching a sheet of thin white or light-blue paper over the printing frame.

As it is almost impossible to determine beforehand how long the exposure must be continued, the printing frame must be taken, from time to time, into weak light, in order to ascertain how far the process has advanced. For this purpose, printing frames are so constructed, that a part may be opened and the print examined, while, in the other part, the print and the original are kept in contact and prevented from slipping. With a large frame this operation is very troublesome, and, in certain processes, we can not judge from the color of the print whether it has been exposed sufficiently long. For this reason it is advisable to use a small glass plate, under which are exposed small strips of the same paper, below a small drawing made on the same material as the original. From time to time one of these strips may be pulled out and treated as the process requires, and the progress of the main print thus ascertained. In some quick-acting processes, it becomes necessary to cover the printing frame and the small glass plate, or to take them in the dark or in weak light, during the time that the specimen is being tested.

IX.

SILVER PRINTS.

The heliographic process in which silver salts are the sensitive elements, although an invention of a later day than the Herschel-type, is the oldest process of this kind adopted by architects and engineers for copying drawings. For this reason we will first treat of this process. It was first practically introduced by Romain Talbot, and has been taught as a regular subject of instruction, by Prof. Vogel, at the Berlin Polytechnic High School, since the autumn of 1870. During the winter of 1872–73, the number of students who took instruction in the art of sun-drawing, from Prof. Vogel, was as high as sixty.

Romain Talbot mentions—in a price-list which bears the date March, 1873—757 firms, offices, architects, engineers, artists and scientists, who had ordered sensitive paper and apparatus, for this purpose, from him.

1. The Salts of Silver,

used in solar printing, and which we will consider in order, are:

Chloride of Silver,	Iodide of Silver,
Bromide of Silver,	Nitrate of Silver.

Chloride of Silver, $Ag\ Cl$ *or* $Ag_2\ Cl_2$.—Chloride of silver occurs, in nature, as a rare mineral, of yellowish-gray color, and is then known as horn silver. It is found in Mexico and Peru, as also in Saxony and Siberia. As early as the year 1546, Fabricius noticed that horn silver turned black in the light. The first remark, in reference to the cause of the change of color in silver salts, is due to the distinguished Swedish chemist, Scheele, in 1777. Artificially, chloride of silver is precipitated as a white, curdy mass, when solutions of a chloride and of a silver salt are brought together. If this white precipitate is kept in the dark, it will remain white for an unlimited time; but when exposed to sunlight, the white chloride becomes tinted with a purple color, which will increase in depth as the action of the light continues. It is decomposed by solutions of the caustic alkalies—which convert it into oxide—but not by the carbonates. After the formation of the oxide, in this way, the addition of sugar reduces it and revives the silver (Levol). Chemically, chloride of silver is a compound of two elements, metallic silver and chlorine. Both elements appear to be but loosely compounded, as the influence of light partially decomposes the chloride of silver—both in the dry and in the wet state—very slowly if pure, and quickly if organic matter be present; free chlorine gas is given off, and a compound containing less chlorine is left behind. This last compound is not white, but of a violet-black color. When the white, precipitated chloride is heated, it melts, and, on cooling, becomes a grayish, crystalline mass, which cuts like horn, constituting the mineral called horn silver.

IODIDE OF SILVER, $Ag\ I$ *or* $Ag_2\ I_2$.—Iodide of silver is also a compound of two chemical constituents, metallic silver and iodine. It is a grayish or bluish-black solid, of a metallic luster, somewhat resembling plumbago. When freshly prepared, it has a yellow color. This compound is obtained by pouring a solution of iodide of potassium into a solution of nitrate of silver; it will then be precipitated as a yellow powder.

In preparing *chloride* of silver, for photographic purposes, it is immaterial in what order the solutions are mixed; whether the chloride is poured into the silver solution, or vice-versa, the result will be the same and have the same properties. Not so in the preparation of the *iodide* of silver; here it is very important to mix the solutions in the right order. If the silver solution is poured into the iodide of potassium solution—and not, as above stated, the iodide of potassium into the silver solution—the precipitate will be lighter in color, nearly white, and, what is most remarkable, will not be affected by light.

BROMIDE OF SILVER, $Ag\ Br$ *or* $Ag_2\ Br_2$.—Silver bromide occurs, native, in Chili and Mexico, as *bromargyrite*, usually in small yellow or greenish masses; also, mixed with the chloride, as *embolite*. It is obtained, on adding a bromide of an alkali-metal to a solution of nitrate of silver, as a white, curdy precipitate. When suspended in water, it is easily decomposed by chlorine. The fused bromide is scarcely acted upon by light, but the precipitated bromide, when exposed to light, quickly assumes a grayish-white color.

NITRATE OF SILVER, $Ag\ N\ O_3$.—Silver nitrate is obtained by dissolving metallic silver in nitric acid and evaporating the solution to dryness, or until it is strong enough to crystallize on cooling. The crystals are colorless, transparent, anhydrous tables. For pharmaceutical purposes, the crystals are fused and poured in silver molds of the size of a goose-quill. In this form, it is known as *lunar caustic* or *lapis infernalis.* For heliographic purposes, the crystallized salt should always be used. The nitrate of silver is, in itself, not sensitive to light, but it becomes so if brought in contact with organic substances. For example, a piece of paper saturated with a solution of this salt, quickly becomes brown in the light, and finally black. One drop of the solution placed on the skin, or on white linen, will leave a fixed spot.

2. PERMANENT SENSITIVE CHLORIDE OF SILVER PAPER.

The *prepared albumen or arrow-root paper* of commerce contains a certain quantity of a soluble chloride, chiefly *sodium chloride*, $Na\ Cl$ (common salt), or *chloride of ammonium*, $H_4\ N\ Cl$ (sal-ammoniac); so that this paper, in order to be sensitized, needs only to be brought in contact with a solution of silver nitrate to form, in the paper, chloride of silver, and to impart to it, without any other manipulation, a high degree of sensibility to light.

Plain writing or drawing paper must first be impregnated by a solution of such a soluble chloride before being sensitized. For this purpose, we immerse the paper in a filtered solution of

Common Salt, ...	1 part.	. . . (1).
Water, ...	30 parts.	

It is very important that the paper be uniformly moistened. Air-bubbles must at once be removed with a glass rod or a wooden stick. After about two minutes, the paper is taken out of the bath, and hung up to dry. The surplus of the salt lye must be removed by pressing the lower edge of the sheet between two sheets of clean blotting paper.

When paper, thus prepared, is brought in contact with the solution of silver nitrate, the soluble chloride, in the paper, is converted into the insoluble chloride of silver, and, at the same time, a certain amount of the nitrate of silver solution is absorbed by the paper.

Paper which was only saturated by a solution of silver nitrate, will be found to be a great deal less sensitive to light than that which contains chloride of silver also.

Professional photographers usually buy the salted albumen paper, and do the sensitizing, printing and fixing all in one day.

The sensitized silver paper offered in the market, for copying drawings and the like, differs from that prepared by the professional photographer in as much as it can be preserved for a considerable time, either before printing, or between printing, toning and fixing. This is a great convenience for the draughtsman, who engages the light as his assistant, for copying his drawings, etc. Photographers do not think very much of this sensitized paper, because the beautiful violet or purple tone can not be produced upon it.

The sensitized chloride of silver paper of the market, is mostly glossy albumen paper. The largest sheets are 18″×22″, and cost about $3.00 per dozen. For technical drawings, we often need larger sheets, and plain and heavier paper, which does not curl like unmounted albumen paper, is often preferable. Therefore, we will now endeavor to explain what we have learned, concerning the preparation of durable silver paper, from the works of Vogel, Haugk, Liesegang and others.

The preparation of such paper was, until recently, a trade secret; but the teachers of the light-drawing processes have revealed a great deal—if not the whole—of the secret.

Mr. A. Ost, of Vienna, found a method, for increasing the durability of silver chloride paper, by adding citric acid to the solution of silver nitrate, and Mr. Haugk, by first washing the silvered paper in water, and then fuming it with ammonia, shortly before exposing it to light. By washing the paper in water, it loses a large part of its sensibility, but becomes very durable. The lost sensibility is restored by the later fuming with ammonia. (According to Liesegang.)

Paper Prepared with Citric Acid.—The citro-silver nitrate solution is composed of

Nitrate of Silver, . . .	1 part.	. . . (2).
Distilled Water, ...	12 parts.	
Citric Acid, ...	1 part.	
Alcohol, ...	1 part.	

Plain, salted writing or drawing paper *must be immersed* in the solution. Albumen and arrow-root paper *is to be floated* upon the liquid with the coated side down.

The author has often tried to silver large sheets of salted paper with a tuft of cotton, a sponge, or a brush, but without success.

For each square inch of the bottom surface of the pan, 1 fluid dram, or $\frac{1}{8}$ fluid ounce, of silver salt solution, may be estimated, as a minimum required, provided the bottom is even. The depth of the liquid will then be $\frac{1}{5}$ inch, and it may be used until but one-half of it remains in the pan.

For silvering 100 square feet of paper, about 1 ounce of nitrate of silver is required, or $4\frac{3}{4}$ troy grains for each square foot.

A room lighted by a lamp, or by gaslight, is the best for carrying on the sensitizing process.

A small piece of blotting paper should be caused to adhere to the lowest edge or corner of the sheet, immediately after hanging it up to dry. The blotting paper will adhere, by capillary attraction, and collect the few drops of solution, which would otherwise fall on the floor. If the room be warm, the paper will dry in ten or fifteen minutes.

Paper prepared with the citro-silver nitrate solution, will remain, for about six weeks or longer, in a serviceable condition, but it must be wrapped up in several sheets of paper of a non-actinic color, and must be kept in a perfectly dark and dry place.

The following are recipes for preparing the citro-nitrate of silver paper, as given by various other authorities:

I. According to H. Schuberth.—Take thick, salted albumen or arrow-root paper, and let it float, for one minute, upon the following bath:

Distilled Water, ...	64 parts.	. . . (3).
Nitrate of Silver, . . .	6 parts.	
Citric Acid, ...	2 parts.	
Tartaric Acid, ...	1 part.	

After this, the paper is to be dried, and then drawn slowly through water, and, finally, dried again.

II. According to Liesegang.—Salted albumen or arrrow-root paper is floated upon a solution of

Nitrate of Silver, . . .	5 parts.	. . . (4).
Distilled Water, ...	48 parts.	

and then hung up to dry. Before the paper is perfectly dry, but when it no longer presents a shining surface, each sheet is placed, separately, between blotting paper, and weighted down by means of a heavy board. When perfectly dry, it is floated, for about half a minute, upon a solution of

Distilled Water, . . .	720 parts.	. . . (5).
Citric Acid, ...	15 parts.	
Ammonia Water, . .	3.7 parts.	

It is then dried again, between blotting paper, and preserved in the dark.

III. According to Liesegang.—The salted paper is sensitized in a solution of

Nitrate of Silver, . . .	1 part.	. . . (6).
Distilled Water, ...	12 parts.	

When quite dry, the silvered side of the paper is treated uniformly with a solution of

Citric Acid, ...	1 part.	. . . (7).
Alcohol, ...	48 parts.	

The latter solution may be applied with a sponge.

IV. According to Willis.—The paper is floated upon a solution of

Nitrate of Silver, . . .	1 part.	. . . (8).
Distilled Water, ...	10 parts.	

and, when nearly dry, the drops on the edges are absorbed with blotting paper, and then the paper floated, for about ten seconds, with its back upon a solution of

Citric Acid,	1 part.	(9).
Water,	15 parts.	

When dry, this paper will remain unaltered for two or three months, and have all the properties of freshly sensitized paper.

V. Monkhoven's Sensitizing Solution.

Nitrate of Silver,	12 parts.	(10).
Nitrate of Magnesia.	12 parts.	
Distilled Water,	100 parts.	

Every time, after sensitizing a sheet in this solution, one dram of a one-to-eight solution of nitrate of silver is to be added to the bath for every 100 square inches of paper sensitized.

WASHED SILVER PAPER.—Washed silver paper is prepared in a similar manner. The sensitizing solution, however, contains no citric acid, and merely consists of

Nitrate of Silver,	1 part.	(11).
Distilled Water,	12 parts.	

As soon as the paper is lifted out of this silver bath, and before it is hung up to dry, it is washed several times.

For this purpose, two sufficiently large trays are filled with water, and, as soon as a sheet is taken from the silvering bath, it is immersed in the water in the first pan, turned over several times, and then placed in the second pan.

After a number of sheets have been silvered, and passed from the first to the second tray, the water in the first pan is renewed, and then the sheets, one by one, are returned to the first pan, turned over a few times, and hung up to dry.

By this repeated washing, the paper is rendered exceedingly durable, but, at the same time, in the same degree, less sensitive to light. The sensitiveness can, however, be restored by exposing the paper to the fumes of strong ammonia.

The washed silver paper may be preserved for years, in good condition, if it is kept in a dark place, and wrapped in yellow paper.

FUMING WITH AMMONIA.—Instead of fuming the washed silver paper itself, it is more effective to fume the blankets, or pads of paper, which come in contact with the sensitive paper, in the printing frame. For this fuming process, a tight-closing box is required, which must be provided with a false bottom, consisting of a coarse net-work made of cane or bast, and placed, in such a manner that it can be easily removed, one-half to one inch from the real bottom. Upon the real bottom, one or more plates or dishes (according to the size of the box), containing strong ammonia, are placed; then the false bottom is put into the box, and, upon it, the blankets. The latter are to be turned over several times, and kept in the fuming box until they are thoroughly impregnated, and smell strongly of ammonia. The more ammonia vapors the blankets have absorbed, the more brilliant the prints will be.

If engravings or drawings are to be reproduced, which are made on thick paper, and which will require a long exposure to light, it becomes necessary to paste the sensitive paper, at two corners, to the original, or to provide other means, so that the blankets, or paper pads, may be taken out and replaced, by freshly fumed ones, without moving the sensitive paper out of place. The renewal of the fumed blankets is requisite, if the time of exposure is long, since a part of the ammonia will volatilize unused.

3. ORDINARY CHLORIDE OF SILVER PAPER.

Plain salted paper is immersed in, albumen or arrow-root paper floated upon, a silver solution of

Nitrate of Silver, . . .	10 parts.	. . . . (12).
Distilled Water, ...	100 parts.	

An acid reaction of this bath makes the paper more durable, but difficult to tone in the gold bath. Therefore, it is recommended, for prints on albumen paper, which are intended to be toned, to make the silver bath neutral, or weakly alkaline, by adding to it, drop by drop, a solution of carbonate of soda, or bicarbonate of soda, in ten parts of water, until a white, flaky precipitate of carbonate of silver commences to form. This white precipitate is to be left in the bottle, and not removed in filtering. If the salt solution contains starch (arrow-root or tapioca), or some gelatine, the liquid will not soak so deeply into the paper, as without this addition. It will cause the photographic picture to remain on the surface of the paper, and present a finer and more delicate appearance.

PREPARATION OF PAPER WITH ARROW-ROOT.—For the *preparation of arrow-root paper*, the following approved recipes will serve:

According to Monkhoven.

Water, ...	100 parts.	. . . . (13).
Chloride of Sodium, . .	2 parts.	
Citrate of Sodium, . . .	2 parts.	
Arrow-root, ...	2 parts.	

According to Vogel.

Water, ...	100 parts.	. . . (14).
Chloride of Sodium, . .	2 parts.	
Arrow-root, ...	3½ parts.	

According to Kleffel.

Water, ...	100 parts.	. . . (15).
Chloride of Ammonium,	1 part.	
Arrow-root, ...	3⅓ parts.	
Citric Acid, ...	$\frac{1}{20}$ part.	

The arrow-root flour is to be stirred and thoroughly mixed with some cold water, and then poured, while constantly stirring, into the boiling water.

According to Liesegang, tapioca may be substituted for the arrow-root. The paper is coated with the starch mixture, by means of a brush, first going over the paper, in parallel strokes, in two directions, and then moving the brush in small circles, so as to equalize the coating.

Arrow-root paper should not be floated, on the silver bath, longer than ½ to 1 minute. If the silvering be continued too long (3 minutes), the prints frequently become gray.

A fuming of the arrow-root paper, for about 8 minutes, in the ammonia box, shortly before printing, will make the prints more intense—darker and more brilliant.

PREPARATION OF PAPER WITH GELATINE.—Abney recommends, for prints on dull paper:

First Recipe.

Water, ...	480 parts.	. . . (16).
Chloride of Ammonium, .	6–8 parts.	
Gelatine, ...	1 part.	
Citrate of Sodium, . . .	10 parts.	
Chloride of Sodium, . .	2–3 parts.	

Second Recipe.

Water, ...	480 parts.	. . . (17).
Chloride of Ammonium, .	10 parts.	
Gelatine, ...	1 part.	

The gelatine is first dissolved in the water by heating, then the salts are added, the solution filtered, and the paper floated on the same.

PRESERVATION OF THE ORDINARY CHLORIDE OF SILVER PAPER.—Paper sensitized without citric acid, and not washed, may be preserved, for some time, by placing it between blotting paper that has been saturated with a solution of bicarbonate of potash and then dried.

If kept in a perfectly dry place, paper prepared without citric acid, and not washed, will also remain in a good condition for a long time. For this purpose, a box, closing air-tight, and having two compartments (for example, two drawers), one above the other, is used. The lower compartment contains calcium chloride, or freshly burnt lime, the upper one, which has a perforated bottom, contains the paper.

In such a box, the paper will remain white for months; but, before using the paper, it should be brought to a damp place, for a short time, so as to take up a little moisture, since perfectly dry chloride of silver paper is not sensitive to light.

4. HOW LONG TO EXPOSE SILVER PRINTS.

Silver prints must be printed considerably darker than they are required to be when finished. The exact amount of intensity lost, in the finishing processes, can only be learned by experience; but we may say, approximately, that it is necessary, in order to insure a satisfactory copy, to print for about twice as long a time as that required to give a pleasing result in the frame.

5. FIXING SILVER PRINTS.

The image obtained, by the direct agency of light, has a beautiful color, but the picture is not permanent, for light still continues to act upon the prepared film, and finally obliterates the image. The prints obtained, when taken out of the copying frame, must be made light-resisting, or, as the photographer says, they must be fixed.

The first attempts to copy drawings, engravings and flat bodies, such as leaves of plants, by means of light, were made by Wedgwood and by Sir Humphrey Davy, at the beginning of this century. Unfortunately, these prints were not durable. They had to be kept in the dark, and could only be exhibited in subdued light. If they remained exposed to light for any length of time, the white parts also became black, and the picture disappeared. No means were then known for making the image durable—that is to say, light-resisting.

Not until sixteen years later were such means discovered, in the hyposulphite of soda, by Sir John Herschel, who herewith completed the invention of heliography. Notwithstanding, the discovery of Herschel remained as good as unknown until 1839, when Fox Talbot made use of it in one of his inventions.

The fixing must also be done in weak light. Each impression may be fixed immediately after having been taken out of the printing frame.

It is more profitable, however, to keep the proofs in a dark place until a desired number has been printed, and then fix all of them at the same time.

The prints are taken, one by one, and placed in a suitable dish, containing clean water. They are immersed in the water, turned over, immersed and turned over again, and moved about with the hand. It will then be seen that the water becomes milky if unwashed chloride of silver paper has been used. The water must be changed a few times, until this milkiness disappears almost entirely. The prints are then removed from the water, and placed in another flat dish, containing a sufficient quantity of a solution of hyposulphite of soda. They are kept moving about in this for 10 or 20 minutes, but should not remain too long in this fixing bath. If the white parts of a print are full of gray spots, as may be seen when held up to the light, the fixing is incomplete; but if all these spots have disappeared, the fixing may be considered as complete.

Similar gray spots will also appear if the sheets, at any time between the first washing and fixing, were exposed to strong sunlight. Therefore, all operations, until the fixing is complete, ought to be carried on in feeble light.

The fixing solution is composed of

Hyposulphite of Soda, . .	1 part.	
Water, ...	6 parts.	. . . (18).
Aqua Ammonia, ...	$\frac{1}{2}$ part.	

The last is not absolutely necessary, and may be omitted if not on hand.

A little attention is required in handling the fixing salt, or a solution of the same. If the fingers have been in contact with this salt, they will produce, on silvered paper, or on prints not yet fixed, unavoidable brown spots.

The hyposulphite of soda exhibits its fixing power only when a large quantity of it is brought in contact with the prints.

6. Washing Fixed Silver Prints.

After fixing, it is necessary to wash the prints thoroughly. This is best done in running water; but, if this can not be had, the water used must frequently (from 6 to 8 times) be renewed. After a little practice, the washing process will not take longer than half an hour. It is, however, important to remove the hyposulphite of soda completely, as the least trace of this salt, that may remain in the prints, will cause them to fade.

The simplest and most reliable method of ascertaining whether the prints have been washed sufficiently, is the following:

Prepare a solution of

Iodine,	1 part.	(19).
Iodide of Potassium,	20 parts.	
Water,	600 parts.	

and also a solution of

Starch,	1 part.	(20).
Boiling Water,	100 parts.	

Then mix the

Iodine Solution (19),	1 part.	(21).
With the Starch Solution (20),	1 part.	

When cool, a blue liquid will be obtained, which is easily discolored by hyposulphite of soda. The blue iodide of starch may be preserved for weeks, if a few drops of a solution of carbolic acid are added.

In order to test the rinsing water for hyposulphite of soda, half fill two test-tubes with the blue starch solution. Dilute one of them with pure water, and the other with the last washing water. If the second test-tube contains hyposulphite of soda, it will at once be perceived, by the more or less complete discoloration of the solution, in comparison with the color of the contents of the other test-tube.

For fixing and washing silver prints, japanned tin, or wooden, trays (the latter coated with asphaltum varnish), may be used.

7. Toning Silver Prints.

When prints are removed from the first rinsing water, and immersed in the fixing bath, they undergo a disagreeable change in color. The fainter the copies have been printed, the more disagreeable this change in color will be. In drawings for technical purposes, this change is of no consideration; but in copies of fine drawings, and in reproductions of engravings, and pictures with half tints, the unpleasing tone is objectionable.

In order to give a more agreeable tint to such pictures, they are plunged, *before fixing*, into a solution of chloride of gold. This is called the toning process.

The toning bath, for prints on citro-chloride of silver paper, is composed of

Distilled Water,	20,000 parts.	(22).
Fused Acetate of Soda,	100 parts.	
Chloride of Lime,	$\frac{3}{10}$ parts.	
Chloride of Gold,	$\frac{1}{2}$–$\frac{4}{5}$ parts.	

and is to be used lukewarm.

For copies on washed chloride of silver paper, the following solution is recommended:

Water, ...	1,500–1,800	parts.	. . . (23).
Carbonate of Magnesia, .	1	part.	
Chloride of Gold, . . .	1⅕	parts.	

This solution must be shaken frequently, and, after about 3 hours, filtered, when it will be ready for use. It is to be used cold.

After the prints have been washed, and before fixing, they are put in the gold bath, but not more than three or four at a time.

Take one print from the rinsing water, and place it in the toning solution, at first face downward, and then turn it face upward. Turn it over in this manner several times, so as to allow the gold solution to act equally in all parts. Now take another print—or, perhaps, three or four—and place it in the solution in the same manner as the first. It will be noticed that the prints, during washing, have changed their color; some will become of a brick-red. In the toning bath, they will change to a brown, and gradually to a sort of violet or purple. They must be constantly kept in motion. The best plan is to continually remove the undermost print and place it on top. At first, only one or a few prints, according to the size, should be attempted; after some practice, more may be undertaken. Professional photographers are able to handle several dozen prints, in the toning bath, at the same time. When many prints are toned together, it is a good plan to have two dishes of toning solution, side by side, and lift the sheets out of one into the other, and when they are all in one dish, to turn them over in a mass.

The longer the prints are left in the gold bath, the more marked will be the change of their color, especially those on washed paper. Prints on citro-chloride of silver paper—for which a toning bath according to formula (22) is used—should remain in the bath until they have a violet-black, or, at least, a deep chocolate-brown, color.

Prints on washed paper will change in the gold solution (23) from a light sepia-brown to a brownish violet and black color. The deepest tint will only result, after fixing, in a beautiful dark color if the prints were copied very dark. If this was not the case, the finished prints will be of a pale, blue-gray color. Therefore, it is better to take such prints out of the toning bath, when they have reached the brownish-violet tone. Prints which were taken out of the gold bath too soon, will look fox-brown when finished.

When the prints have passed through the toning bath, and obtained the required tone, they are plunged into water—whereby the process is interrupted—and then fixed in the same manner as if they had not been toned.

It does not injure the prints to immerse them in the fixing bath immediately after having been taken out of the toning bath, but care must be taken that no hyposulphite gets into the gold bath, as this will destroy the toning action and produce yellow spots in the prints. One grain of gold is amply sufficient for 400 square inches of prints. .

8. Liesegang's Combined Toning and Fixing Bath.

Two solutions are made; the first consisting of

Rain Water, ...	1,000 parts.	. . . (24).
Hyposulphite of Soda, ...	250 parts.	
Sulphocyanide of Ammonium, . .	25 parts.	
Acetate of Soda (Crystallized), . .	15 parts.	

and the second, of

Rain Water, ...	100 parts.	. . . (25).
Chloride of Gold, . . .	1 part.	

The second solution is poured into the first, but not the reverse, as the gold would otherwise be separated from it.

The prints, after having been taken out of the printing frame, are washed in water, and then placed in this bath and turned over several times. The tone, at first, becomes a yellowish-brown, then a darker brown, and, finally, a beautiful black. When the desired color has been obtained, the prints are to be taken out of the bath and thoroughly washed in water, as stated on page 36.

9. Silver Prints with Development.

The following rapid printing process is said to have been used, during the last Franco-German war, for copying maps.

The most suitable paper for this process is Steinbach's heliographic paper. The paper is first coated with the following preparation:

Iodide of Potassium, . .	1 part.	. . . (26).
Chloride of Potassium, .	4 parts.	
Distilled Water, ...	100 parts.	

Filter the solution, and then pour it into a porcelain jar, and mix with it 2 parts of the finest arrow-root flour. Then heat the mixture, while continually stirring it with a glass rod, to the boiling point. Let it cool again, and remove the scum formed upon the surface.

Apply the preparation cold, and as uniformly as possible, to the paper, by means of a camel's-hair brush. In a closed portfolio, paper so prepared may be preserved for several days. If it should turn light-red, or if marble-like spots should appear on its surface, it ought not to be condemned on that account. The paper is sensitized by floating it upon the following bath:

Distilled Water, ...	100 parts.	. . . (27).
Nitrate of Silver, . . .	8 parts.	
Citric Acid, ...	½ part.	

Paper thus prepared is extremely sensitive, and must not be brought into strong light for a single moment. It must be placed in the copying frame, in yellow light.

The rapid action of the light is not apparent at once. The exposure is complete when the outlines of the drawing are but faintly marked. After having been taken out of the copying frame, the print is floated, face downward, on a developing solution of

Gallic Acid, ...	1 part.	. . . (28).
Distilled Water, ...	500 parts.	

In this, the picture will gradually develop of a dark-brown color. When sufficiently distinct, it is to be dipped into clean water, in order to prevent the gallic acid from penetrating the paper, and then it is either fixed at once, or first toned and then fixed, in the manner we have already described. All this is, however, to be done in yellow light.

10. Talbot's Calotype Process.

The following are extracts from two of the oldest English patents on heliographic printing with silver salts:

Extract from Patent No. 8842, of Feb. 8, 1841, to William Henry Fox Talbot.

The first part of the preparation of the paper consists in washing one side with a solution of

Crystallized Nitrate of Silver, .	100 grains.	. . . (29).
Distilled Water, ...	6 ounces.	

drying it, and then dipping it in a solution of

Iodide of Potassium, ...	500 grains.	. . . (30).
Water, ...	1 pint.	

keeping it there a minute or two, then dipping it in water, and, afterward, drying it. Paper thus prepared will keep (if not exposed to the light) any length of time.

The second stage, which is best left until the paper is required for use, consists in washing the iodized paper with gallo-nitrate of silver by candlelight. The paper is then dipped in water, and, when dried, is ready for use. The paper thus prepared, termed *calotype paper*, is placed in the camera, so as to receive an image from the lens, the paper being screened until it is secured to its place. The screen being withdrawn, an image is formed on the paper, which is subsequently developed by washing the paper with gallo-nitrate of silver, and drying it before a gentle fire. The fixing process consists in dipping the picture into water, partly drying with blotting paper, and washing it with a solution of

Bromide of Potassium, or Common Salt, .	100 grains.	. . . (31).
Water, ...	8–10 ounces.	

The picture is then washed with water, and, finally, dried. The picture thus obtained is a negative one; that is, it has its lights and shades reversed with respect to natural objects—viz., the lights of the objects are represented by shades, and vice-versa. *A copy of this*, with the natural lights and shades, is obtained by placing a second sheet of sensitive calotype paper, or common photographic paper,* in close contact with the paper containing the picture, putting a board below them and a plate of glass above, and pressing the whole together by screws. The papers thus arranged are exposed to the sun, when a picture with natural lights (a positive picture) is produced on the second sheet, and developed in the same way as the first.

The negative picture, when rendered faint by having furnished several copies, may be revived by washing it, by candle-light, with gallo-nitrate of silver, and then warming it. The revived picture must be fixed as before.

2. To produce a positive picture by a single process. A sheet of calotype paper is slightly discolored, by exposure, for a few seconds, to daylight. It is then dipped in a solution (as above) of iodide of potassium, and afterward in water, lightly dried with blotting paper, and placed in the camera. After five or ten minutes, the paper is withdrawn, and washed with gallo-nitrate of silver, and warmed, as before directed. An image will then appear of a positive kind. . . . . Engravings may be copied in the same way, but the pictures will be inverted. The copy may be strengthened with gallo-nitrate of silver. . . . .

Abridgment of English Patent No. 9753, of June 1, 1843, to W. H. Fox Talbot.

. . . . 1. Since the yellowish tint of some calotype pictures impedes the process of taking copies from them, such a picture is plunged into a bath of some soluble hyposulphite, whereby it is rendered white and permanent. Transparency is imparted to the picture, after this process, by causing melted wax to penetrate into the pores of the paper.

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* "This paper," the patentee observes, "is made by washing good writing paper, first, with a weak solution of common salt, and then, with a solution of nitrate of silver." This had been freely communicated to the public in 1839.

2. During the process of taking the calotype picture, I place a warm plate of iron behind the paper-holder, to communicate warmth to the prepared paper. This makes it more sensitive, and, consequently, the picture is obtained more rapidly. 3. Io-gallic paper is prepared by washing a sheet of iodized paper with a solution of gallic acid water, and drying it. It will keep, for a considerable time, in a press or portfolio. When required for use, it is rendered sensitive by a solution of nitrate of silver, and fit to be used in a camera. The separate use of the nitrate of silver and gallic acid removes the great inconvenience arising from the speedy decomposition of the gallo-nitrate of silver. 4. A sheet of iodized paper is washed over with a mixture of gallic acid and nitrate of silver, usually employed in the calotype process, and dried at a gentle fire. It will keep, in a press, for a considerable time. It is less sensitive than ordinary calotype paper. This paper is as convenient to use, in a copying frame, as the ordinary photographic drawing paper, it being used quite dry, and it has the advantage of being much more sensitive. 5. A copy, or reversed impression, of a photographic picture is taken, in the usual way, but allowed to remain in the light twice the usual or necessary time, in consequence of which it comes out with its shadows too black, and with its lights not sufficiently white to give a pleasant effect. It is then washed, and plunged, for 1 or 2 minutes, into a bath of

Iodide of Potassium, .	500 grains.	. . . (32).
Water, ...	1 pint.	

when the picture becomes brighter, and its lights a pale yellow tint. The effect may be increased by exposure to light. The picture is then washed and plunged into hot hyposulphite, as in (1). The pale yellow tint is thus discharged, and the lights remain of a white color. The picture is permanent, and has a pleasing and peculiar effect of light and shade, not easily attainable. 6. A photographic picture is rendered transparent by waxing it, and a sheet of white or colored paper placed behind it, so as to produce a very pleasant artistic effect, or various beautiful tones of color. . . . . 9. . . . . . I take writing paper of a good quality, destitute of water mark, and dip it into a salt water bath containing

Common Salt, . . .	3–4 ounces.	. . . (33).
Water, ...	1 gallon.	

It is then wiped and dried. I then take a solution of

Nitrate of Silver, . .	100 grains.	. . . (34).
Distilled Water, . . .	2 ounces.	

and add to it just enough ammonia to form a precipitate, and re-dissolve the same, leaving the solution clear. With this solution, I wash the salted paper above described, and then dry it. Such paper may be preserved in a press, but should be used within 1 or 2 days. This paper may be called copying paper. To obtain, on such paper, a negative or reversed copy of any print, map, photograph, or other original on paper, it is placed in contact with the original, in a copying frame, and placed in the daylight until the copy is effected. The copy is then washed with warm water, kept, afterward, for 2 or 3 minutes, in a solution of hyposulphite of soda dissolved in 10 times its weight of water, and then plunged into 2 or 3 baths of warm water, consecutively, in order to remove all that is soluble in water. It is then dried, and may be waxed, if thought proper, for greater transparency. A good negative picture is obtained, with a camera, upon calotype paper, which is then cleaned by boiling in hyposulphite of soda, and waxed, if thought necessary. The negative being thus prepared, either on copying or calotype paper, is placed in contact with a second sheet of copying paper, in a copying frame, and a positive copy obtained. The other positive copies are similarly obtained. They are then fixed, with hyposulphite of soda, in the same way as the negative copy was. The hyposulphite should be quite free from sulphurous acid, and the copies, both before fixation and afterward, should be dipped into 2 or 3 warm water baths, consecutively, to remove every trace of soluble matter from them.

11. Bromide of Silver Emulsion Process.

Paper coated with bromide of silver gelatine emulsion—the same substance which forms the sensitive film of the modern instantaneous dry plates—affords a means for copying drawings, writings, etc., by lamplight as well as by daylight, even when the originals are made on bristol-board.

Bromide of silver paper is now a standard trade article, used by photographers and amateurs, in a from day to day increasing extent, for contact-printing, for enlarging, for working in crayon, india ink, water or oil colors.

We would recommend all those who intend to try this paper, and whose time is much occupied, to buy the paper already made. Eastman's Permanent Bromide Paper, and Anthony's Gelatino-Bromide Rapid Printing Paper, will give excellent results. They are cut in sheets of various sizes, from 3¼″×4¼″ up to rolls 30″ wide and over 30 feet long, and cost from 18 to 23 cents per square foot. Full instructions accompany each package. Several varieties of this paper are to be had: rough, smooth, thick, or thin. For copying drawings, etc., the thin, smooth paper is the most suitable. There is also a paper in the market especially made for negatives.

For the benefit of those engineers, architects, and draughtsmen, who are fond of experimenting, we will give a short description of the preparation of the bromide paper, and a few formulæ for the emulsion.

The gelatino-bromide paper is, as the dry plates, so very sensitive to light, that a drawing on bristol-board can be copied, in from 6 to 12 seconds, by holding the printing frame, in which the sensitive paper has been placed, underneath the original drawing, about 14 inches from a gaslight, or from the flame of a petroleum (student's) lamp.

Ruby-colored light has, fortunately, not such a great effect upon this substance; it is nearly nonactinic. Were it not for this fact, it would be impossible to cut the paper and place it in the printing frame. A room that can be made perfectly dark, and a lantern having ruby-red glass, or glass covered with paper of this color, are indispensable for preparing silver emulsions, or for manipulating with paper or plates coated with the same. The dark-room lamp must be so constructed, that not one ray of white light can escape from it, as this would destroy the sensitive substance.

After the paper has been cut, in red light, and placed under the original drawing, or negative, in the printing frame, it is best to expose to gas or petroleum light. If it is desirable to expose to daylight, the frame should be held upside down. The time of exposure depends upon the intensity of the light, and the thickness of the paper on which the original, tracing, or negative, is made. Likewise, the emulsion with which the paper is coated may also be made more or less sensitive.

If exposed to the light of a student's lamp, at a distance of about 14 inches, the time required is, in general,

5 to 10 seconds, if the original, or negative, is made on tracing paper, or tracing cloth.

10 to 20 seconds, for originals made on thin writing paper.

30 to 60 seconds, if the light has to pass through thick drawing paper or through bristol-board.

In order to obtain good prints, the originals must be made on paper of a uniform texture, which, if examined by transmitted light, shows no dark spots.

After exposure, the printing frame is placed, upside down, on a table, and quickly covered with a dark cloth. The room is then made dark again, and the frame is emptied in the red light of the dark-room lamp. The print may now be developed at once, or it may be preserved in a book, portfolio, or other perfectly dark place, for hours or days. The developing must also be done in red light.

Developing and Fixing According to Romain Talbot.—Three solutions are to be made:

A.—Oxalate of Potash,	3 parts.	(35).
Boiling Water,	10 parts.	

When cool, this solution is to be filtered.

B.—Protosulphate of Iron,	3 parts.	(36).
Distilled Water,	10 parts.	
Sulphuric Acid for every 10 ounces of Water,	1 drop.	

When the ferrous salt has dissolved, the solution is filtered.

C.—Citric Acid,	1 part.	(37).
Distilled Water,	2 parts.	

Also to be filtered when dissolved.

The *developing bath* is composed of

Solution *A*,	15 volumes.	(38).
Solution *B*,	5 volumes.	
Solution *C*,	1 volume.	

A sufficient quantity of the mixture is then poured into a flat tray (about 1 fluid ounce for every 20 square inches of bottom surface of the tray). Each print is then immersed in the developing bath, avoiding air-bubbles and interruptions. The image will appear in a short time; but it should not appear too quickly, as this is a sign of over-exposure. As soon as the picture has attained the desired strength, it is taken out of the developer, and plunged into pure water, in order to arrest further development. If a number of prints are to be developed, one after the other is treated in the same manner. If the developer becomes too weak, it may be strengthened by adding some of the unused mixture.

For the fixing bath, two solutions are made:

A.—Hyposulphite of Soda,	4 parts.	(40).
Water,	16 parts.	
B.—Pulverized Alum,	1 part.	
Hot Water,	4 parts.	

When a perfect solution has been effected, they are mixed, well shaken, and, after about 12 hours, filtered. The prints, having been developed, and plunged into clean water, are then immersed in this fixing bath, and left in it for about 15 minutes; then they are put in a second fixing bath, consisting of

Hyposulphite of Soda, . .	1 part.	. . . (41).
Water, ...	5 parts.	

The first fixing bath (40) may be used several times, but the second one (41) must be renewed for each batch of prints.

After this double fixing, the prints are washed twice in water, and then hardened in a solution of

Alum, ...	1 part.	. . . (42).
Hot Water, ...	10 parts.	

When the alum is perfectly dissolved, and the solution cooled and filtered, the prints are immersed in the same for about 15 minutes.

Finally, the prints are washed in pure water, and kept in the same for from 3 to 4 hours. The water must be renewed every half hour. Then the prints are ready to be hung up to dry.

EASTMAN'S DIRECTIONS FOR DEVELOPING AND FIXING PRINTS ON HIS PERMANENT BROMIDE PAPER.

Solution No. 1.

Oxalate of Potash, . . .	1 pound.	. . . (43).
Hot Water, ...	48 ounces.	
Acetic Acid, ...	3 drams.	

Solution No. 2.

Proto-Sulphate of Iron, .	1 pound.	. . . (44).
Hot Water, ...	32 ounces.	
Acetic Acid, ...	½ dram.	
(Or, Citric Acid, ...	¼ ounce.)	

Solution No. 3.

Bromide of Potassium, .	1 ounce.	. . . (45).
Water, ...	1 quart.	

These solutions must be kept separate, and only mixed immediately before using.

To Develop.—Take, in a suitable tray,

Solution No. 1, ...	6 ounces.	. . . (46).
Solution No. 2, ...	1 ounce.	
Solution No. 3, ...	½ dram.	

Mix in the order given; use cold. After exposure, soak the paper in water until limp; then immerse in the developer.

The image should appear slowly, and should develop strong, clear and brilliant. When the shadows are sufficiently black, pour off the developer and flood the print with the

Clearing Solution:

Acetic Acid, ...	1 dram.	. . . (47).
Water, ...	32 ounces.	

Do not wash the print after pouring off the developer and before applying the clearing solution. Use a quantity sufficient to flow over the print—say 1 ounce for every 40 square inches. Allow it to set for 1 minute, then pour it off, and apply a fresh portion; repeat the operation a third time, then rinse in pure water, and immerse for 10 minutes in the

Fixing Bath:

Hyposulphite of Soda, .	3 ounces.	. . . (48).
Water, ...	16 ounces.	

After fixing, wash thoroughly 2 hours, and hang up to dry. Use fresh developer for each batch of prints. With a glass-bottomed tray, 7 ounces of developer are sufficient for a 25 × 30 print.

With Eastman's Permanent Bromide Paper, *no toning is required;* the final tones are obtained entirely by development, and range from a soft gray to a rich, velvety black, depending somewhat upon the density of the negative and the quality of light used in printing.

Mr. Eastman recommends, further, to keep the dishes and hands clean, and never to use a tray that has been used for developing with oxalate for anything else.

Preparation of the Gelatine Emulsion.—The following emulsion does not give to paper the highest degree of sensitiveness, but one of fair rapidity.

1st. Let the following 4 solutions be prepared, each in a separate jam-pot:

A.—Bromide of Potassium, . .	4 drams 52 grains.	. . . (49.)
Nelson's No. 1 Gelatine, .	1 dram 8 grains.	
Distilled Water, ...	5 ounces 1 dram.	
Hydrochloric Acid Solution (1 per cent.) . .	3 drams.	

B.—Nitrate of Silver, ...	343 grains.	. . . (50).
Distilled Water, ...	7 ounces.	

C.—Iodide of Potassium, ... 30 grains.
Distilled Water, ... $1\frac{3}{4}$ ounces. } . . . (51).

D.—Hard Gelatine, ... 6 drams 52 grains.
Distilled Water, . . . 8 ounces. } . . . (52).

2d. Let *A* and *D* stand till the gelatine is thoroughly soaked, as indicated by its being quite soft. Then let all the water, not absorbed by the gelatine, be poured off of *D*, and as much water as possible squeezed out of the gelatine.

3d. Place the pots containing *A* and *B* in hot water, till the solutions are at about 120° Fahrenheit; then pour *A* into a large bottle.

From this time, all operations must be performed in the most feeble ruby light possible.

4th. Now add a little of *B* to the gelatine solution already in the large bottle, and shake well. Small additions of *B* are made, so that it is poured, in 10 to 12 stages, into *A*, the whole being well shaken after each addition, and a very thorough agitation being given at the end.

5th. Add *C* to the emulsion in the bottle, and shake again.

6th. Pour the whole emulsion into a glass jam-pot, and place it in a deep saucepan, or similar vessel, containing hot water. A loose lid should cover the jam-pot, to prevent condensed water from dropping off the lid of the saucepan into the emulsion. Then put the lid on the saucepan, and bring the water, as rapidly as possible, to a boil, and let the emulsion remain for 30 minutes in the boiling water.

If, before heating the emulsion, a drop of the same be placed on a glass plate, it will look red by transmitted light. After boiling the emulsion, such a drop will be a more or less near approach to blue in color.

7th. Take off the lids of the saucepan and jam-pot, add the soaked gelatine, *D*, and stir the compound well, to mix it. Then place the pot with the emulsion in a cool, dark place, and allow it to set, which requires, in a moderately cool place, a couple of hours.

This is the best time to interrupt the process, if required to do so, as the emulsion may be left in this state, in a cool and perfectly dark place, for a few days, without being destroyed.

8th. Place an ordinary hair-sieve in a suitable vessel full of cold water, put a lump of the stiff emulsion in a piece of coarse canvas, such as ladies do worsted work on, place under water in the sieve, and twist the canvas up, so as to cause the emulsion to pass through, in fine shreds, into the water in the sieve. Now wash the divided emulsion well for half an hour, either by letting water run into the sieve, or by frequently changing the water in the vessel.

The object of the washing process is to remove the crystallizable nitrate of potash—one of the products of decomposition—and the soluble bromide from the emulsion. The bromide and iodide of silver, formed in preparing the emulsion, and which cause the emulsion to be sensitive to light, are insoluble, and remain in the emulsion.

9th. Remove the sieve, with the emulsion, from the washing vessel, and place it in a convenient position, so that the superfluous water may drain off. This requires at least half an hour.

10th. Re-melt the emulsion, filter through several thicknesses of muslin, and add 2½ ounces of methylated alcohol. The emulsion is now finished, and ready for coating the paper. One fluid ounce of emulsion will cover ½ to ⅝ square feet of paper. The coating should be (before dry and set) about $\frac{1}{44}$ to $\frac{1}{40}$ inch thick. The emulsion may be kept in a bottle, in a dark place, for some time.

The following table compares the proportions of ingredients of the emulsion above described, with a few other formulæ:

	Nitrate of Silver.	Bromide of Potash.	Bromide of Ammon.	Iodide of Potash.	Gelatine (Total).	Nitric Acid.	Alcohol.	Glycerine.	Common Beer.
Fair Rapid, . .	343	292	—	30	480	2	1200	—	—
	365	294	—	—	480	4	1130	1130	—
Much Used, . .	480	—	240	—	480	—	—	—	5760
Slow and Sure,	360	252	252	—	480	—	2160	—	—
	357½	239	239	52	480	4	—	—	—

All in grains.

Some formulæ say that the emulsion must not be boiled, but to apply such a degree of heat as will just liquify the gelatine.

In order to increase the sensitiveness, the emulsification is allowed to proceed for several hours—even for days.

Coating the Paper with the Emulsion.—To coat paper uniformly with gelatine emulsion, by hand, is somewhat difficult. The following method, which Husnick recommends, seems to be the simplest:

The sheet of paper is first plunged into warm water (about 100° F.), then a glass plate—of the same size as, or a little larger than, the paper—is slipped, in the water, under the paper, and with it the paper is lifted out, thus causing it to lie flat on the glass. If the sheet be large, it may be taken out of the water with the hands, and laid upon a glass plate, or a well-varnished board, and squeegeed down. The surplus of the water being drained from the paper, the glass plate, or the board, is placed upon a level table or stand (tripod with adjusting screws). After the water is partly evaporated, the paper being still damp, the edges of the paper are bent up all around, about $\frac{1}{4}$ inch, so as to form a shallow pan; then sufficient of the liquified emulsion, to about half cover the sheet, is poured in the center of the paper, and the glass plate or board tilted in all directions, in order to spread the emulsion evenly. A strip of stiff paper, or a card, may be used to spread it over places not covered. Finally, the glass plate, or board, with the coated paper, is again brought into an accurately level position, and the emulsion allowed to set; then the paper is hung up to dry. This must all be done in the most feeble red light.

Some authorities recommend to use a glass rod for distributing the emulsion; others to float the dampened paper upon the emulsion, which is kept liquid in a water bath, and then to place the paper upon a level glass plate, marble or slate slab.

Manufacturers of emulsion paper have machines especially constructed for the purpose of coating the paper in rolls.

X.

PROCESSES WITH SALTS OF IRON.

1. SENSIBILITY OF FERRIC SALTS—PROPERTIES OF FERRIC AND FERROUS SALTS—EARLY DISCOVERIES.

ONE of the first, if not the first, records we have of photography undertaking the duties of a copying clerk, is that by Prof. Alexander Herschel. He tells us how his father, Sir John Herschel, made use of heliography with ferric salts—the Cyanotype or Blue-print Process—for copying his calculations and intricate tables. Sir John Herschel discovered, about the year 1840, that certain of the persalts of iron—the ferric salts—when exposed, in the presence of organic matter, undergo decomposition, and are reduced to the state of proto-salts, or ferrous salts. We are also indebted to Poitevin for numerous interesting developments in this department.

It is now accepted, that all ferric salts, in the presence of organic substances, are more or less sensitive to light. Dr. Eder, of Vienna, has determined the relative sensitiveness of a number of ferric salts. He found that a watery solution of equal molecules of ferric chloride and oxalic acid was the quickest to be decomposed by the action of white daylight. He used solutions containing $\frac{3}{4}$ per cent. of iron, and measured the photo-chemical decomposition by the quantity of ferrous salt formed in the same time, in the same light, and at the same temperature (70° to 77° F.). The results of Dr. Eder's investigation are contained in the following table, in which the quantity of ferrous chloride formed in a certain time, in a solution of ferric chloride and oxalic acid, is placed equal to 100:

1.	Ferric Chloride + Oxalic Acid, ...	100.
2.	Ferric Oxalate, ...	89.
3.	Ferric Ammonium Oxalate, ...	80.
4.	Ferric Tartrate, ...	80.
5.	Ferric Potassium Oxalate, ...	78.
6.	Ferric Chloride + Tartaric Acid, . . .	25.
7.	Ferric Chloride + Citric Acid, ...	19.
8.	Ferric Ammonium Citrate, ...	15.

The figures have only full validity for solutions containing from 1 to 5 per cent. of the ferric salt. With an increasing density, there is, in general, an increasing sensitivity of the solution, and, at the same time, a corresponding decrease in the quantity of ferrous salt formed in the various solutions. This also pertains to paper saturated with the solutions and dried. Dr. Eder exposed to light strips of such paper in a Vogel photometer, and treated them, afterward, with a solution of ferricyanide of potassium, and so received the degrees of sensibility to light in blue color. These tests proved, also, the mixture of ferric chloride and oxalic acid to be the most sensitive of all. Less sensitive is the ferric oxalate; then follows the ammonium and sodium ferric oxalate, and still less decomposed is the ferric oxalate of potassium. The difference of sensitiveness between the double salts is not so great as with the solutions—especially in the sodium and ammonium salts, which are nearly equally sensitive to light.

The process, which goes on when these salts are exposed to the action of light, consists in the separation of carbon, in the form of carbonic acid, and the formation of the corresponding ferrous salts. The process goes on the most regularly with the oxalate, as thereby the liberated quantity of carbonic acid is almost equal to the theoretical amount; much more irregularly with the citrate and tartrate, whereby—beside carbonic acid—acetic acid, oxalic acid, etc., are formed.

Ferricyanide of potassium—or red prussiate of potash—produces, with a ferrous salt, a dark-blue precipitate, but none with a ferric salt.

Ferrocyanide of potassium—or yellow prussiate of potash—produces, with a ferric salt, a dark-blue precipitate; with a ferrous salt, it produces a white or light-blue precipitate, which only gradually becomes darker. The formation of the latter precipitate is retarded, and the action limited to the surface, by the presence of gum arabic. Tannic, gallic, and pyrogallic acid produce, with the peroxide salts of iron, and with the sesquichloride, bluish-black precipitates, but with pure ferrous salt, and with the protochloride, they will not form a precipitate at once—not until these substances have taken up some oxygen from the air.

Poitevin has discovered, 1st, that a dried coating of a solution of ferric chloride and tartaric acid becomes hydroscopic by the influence of light; 2d, that a coating of gelatine, treated with a solution of sesquichloride of iron and tartaric acid, becomes, after drying, completely insoluble, even in boiling water, and that the solubility is restored by the action of light.

The peroxyd salts of iron—as well as the salts of the other heavy metals, silver, uranium, etc., which possess the property of being completely or partially reduced by light, in the presence of organic substances—have, in this condition, also the ability to reduce the salts of the precious metals, silver, gold, and platinum.

Upon the sensitiveness of the ferric salts to light, and the properties of the salts of iron just mentioned, the following processes are based:

HERSCHEL'S PROCESSES, DISCOVERED 1840–1842.—1st. If paper be saturated with a solution of ammonium ferric citrate, and, after drying, be exposed to the action of light, under a drawing, or the like, for a sufficient length of time, a negative impression will result. If this negative impression be thinly coated with a solution of ferrocyanide of potassium and gum arabic, the negative will disappear, and, in its place, a positive, of blue color, will gradually make its appearance on a greenish-yellow ground. This picture must be dried quickly, and, if the image should be indistinct, the coating with the ferrocyanide must be repeated. In strong light these prints will fade; but in the dark their original clearness will be retained.*

2d. If paper be prepared with a solution consisting of equal parts of ferric citrate of ammonium and ferricyanide of potassium, and exposed to the light under a drawing, engraving, etc., washed in water and dried, a picture will be obtained having white lines on a blue surface—that is to say, the picture will be a negative in regard to light and shade. A solution of mercurous nitrate, $Hg_2(NO_3)2+2H_2O$, will cause the picture to disappear. If the paper be washed, dried, and smoothened with a hot flat-iron, the picture will again be developed, but in a brown color. After a few weeks, the picture will disappear again, but can be re-developed by renewed ironing.

3d. If paper is coated with a solution of ferricyanide of potassium, and exposed, under an engraving, to the direct rays of sunlight, for an hour, a negative picture, in white lines upon a blue surface, will result, which may be fixed in a solution of sulphate of sodium (Glauber's salt), and then washing it.†

4th. *Chrysotype Process.*—The paper is floated on a solution of ferric citrate of ammonium. The solution must have such a strength, that the paper, when dry, looks yellow—not brown. After exposure to light, the print is floated upon a diluted and neutral solution of chloride of gold. This developer may be also applied by means of a soft brush. The image appears at once, in a purple tone, which gradually becomes darker the longer it is exposed to the solution. Thereafter the print is washed in water—which must be renewed several times—and then fixed in a weak solution of iodide of potassium, washed again, and finally dried. From a positive drawing, a negative in white lines upon a purple ground will be obtained.

POITEVIN'S DIRECT PROCESS (Ink Pictures).—The process, published in 1860 by Poitevin, and by means of which positive prints, in writing ink, are produced from a drawing or engraving, is the following: Paper is floated on a solution of

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*Atheneum, 1842–1845.

†The exposure must last much longer than one hour.—THE AUTHOR.

Ferric Chloride,	10 parts.	(53).
Tartaric Acid,	3 parts.	
Distilled Water,	100 parts.	

Certain French papers, sized with starch, are the best for this process. The paper should be left in contact with this solution but a short time, and must be dried quickly, by moderate heat. The paper, so prepared, has a lemon-yellow color, and must be exposed, under a positive (tracing, drawing, etc.), until the ground appears perfectly white, and the image, in pale yellow lines, is visible. In order to make the appearance of the picture more distinct, a little sulphocyanide of ammonium may be added to the sensitizing solution. This addition will color the paper red, and, after exposure, a red picture on a white surface will be obtained. After the print has been taken out of the copying frame, it is drawn through water into which powdered white chalk has just previously been stirred. Then it is plunged into a solution of gallic, tannic, or pyrogallic acid, in which the yellow or red lines of the image will gradually become dark bluish-black. When developed, the print is washed in rain water. Hard water would color it brown. The tint of the print varies according to the developer used. Gallic acid will produce the deepest color. The bluish-black picture can be converted into a blue one by washing it in a solution of ferricyanide of potassium, to which a little sulphuric acid has been added.

Herschel's Method of Converting Iron Prints into Iodide of Starch Pictures.—The paper is coated with a solution of ferric chloride, and exposed, under a positive (for example, a drawing), until a yellow image on a white surface is visible. Then it is immersed in a solution of iodide of calcium and starch. The iodide becomes liberated, and forms, with the starch, the dark-blue iodide of starch, which gives an intense shade to the lines which were pale in the iron picture.

Halleur's, Reynolds' and Phipson's Processes.—About the same time, and independently of each other, Reynolds and Dr. Phipson discovered a copying process with ferric oxalate of ammonium. Phipson published a synopsis of his process in October, 1861, and, soon after this, Reynolds communicated his discovery, as a novelty, to the Chemical Society of Dublin. Phipson floated the paper on a solution of ferric oxalate of ammonium for about 10 minutes, exposed the same, when dry, under a negative, and developed the print by first washing it in distilled water, and then plunging it, for a moment, into a solution of manganate of potassium, to which a few drops of ammonia had been added. In this bath, the originally yellow picture quickly turned brown. He then washed the prints again, and immersed them, for half an hour, in a solution of pyrogallic acid, washed another time in water, and then dried them. The prints had a dark-brown color. Reynolds also sensitized the paper with ferric oxalate of ammonium, but he developed the prints with a solution of nitrate of silver. Both of these methods seem to be anticipated by D. G. E. H. Halleur, who published, in 1853, in his book on "The Art of Photography," the following process for obtaining negatives from positives, and vice-versa: Dissolve

Ferric Ammonium Oxalate, . 1 part. }
Water, ... 10 parts. } . . . (54).

and with it sensitize the paper. When dry, the paper has a yellow color, which turns brown in the light. The faint image comes out strongly in the developer. Ferricyanide of potassium, nitrate of silver, ammonia, or chloride of gold may be used as developers.

If potassium ferricyanide (red prussiate of potash) is used as the developer, it should not be too much diluted, and it may be applied by means of a brush. The blue picture consists of Turnbull's blue. The prints are fixed by simply washing in water.

Nitrate of silver solution furnishes dark brown-black pictures, which are also fixed by plunging them into water.

Nitrate of silver and ammonium produce grayish-black prints, which are also to be fixed in water.

Chloride of gold gives purple-colored images, which turn darker in the light.

Halleur mentions, also, that paper, prepared with ferric ammonium oxalate, or citrate, may be treated with a solution of red prussiate of potash, before exposure to light.

2. Modern Processes by which Copies in White Lines upon a Blue Ground are Produced from a Drawing or Tracing.

All the preceding methods, and several others, remained almost unnoticed, by engineers, architects, or draughtsmen, for a number of years. Perhaps the reason for this lay in the fact that celebrated authorities did not speak very highly of iron pictures.

Marion, of Paris, was the first who, about twelve years ago, undertook to manufacture sensitized "Blue Print Paper" according to Herschel's discoveries. The imported "Papier Ferro Prussiate," of Marion, was that on which the author made his first blue prints. The attention of American scientific and technical periodicals was attracted, in 1878, to this method of copying drawings, writings, etc., which is now the most extensively used heliographic process. It is especially adapted for large working drawings. The iron salt mostly used is the double salt — citrate of iron and ammonium.

There are two methods in use for producing "Blue Prints" with ferric salts.

In the one method, the ferric salt and the ferricyanide of potassium are applied to the paper in one solution, while, in the other, the paper is coated only with the solution of a ferric salt, and, after exposure to light, the prints are developed by a solution of the ferricyanide. Not all ferric salts are equally suitable for either method. The first method—in which the salts are used in one solution—is the simplest, as one bath is saved; but the friends of the other method claim that the exposure required is five or six times as long as that needed when the paper is coated with the ferric salt only. The formulæ for the sensitizing solution, given by different authorities, vary more or less.

Recipes for the Sensitizing Solution for Blue Prints without Development.—The following is one of *Sir John Herschel's recipes*, in his son's (Prof. Alexander Herschel) own words. (According to "London Photo News.")

"The solution for treating the copying paper is as under:

"Citrate of Iron (or Ammonium Citrate), .	140 grains.	. (55).
Ferricyanide of Potash, ...	120 grains.	
Dissolved together in Water, ...	2 fluid ounces.	

"The solution can be kept in a glass-stoppered bottle, well wrapped up in a dark cloth, or shut up in a dark cupboard, for any length of time. It is applied to the paper by means of a brush, or tuft of cotton-wool, and the surface dried in the dark. Two or three minutes' bright sunshine suffice, if the original is on thin or tracing paper, for printing, and the fixing is done by washing in clear water for a few minutes."

The following formula is used, in the laboratory at Willett's Point, with most excellent results. (According to Jas. S. Pettit.)

Solution No. 1.

Double Citrate of Iron and Ammonia, . . .	1 ounce.	. . (56).
Water, ...	4 ounces.	

Solution No. 2.

Red Prussiate of Potassium, ...	1 ounce.	. . (57).
Water, ...	4 ounces.	

For use, mix equal quantities, and float paper for 2 minutes.

Captain G. Pizzighelli calls this process "Negative Cyanotype Process," and gives the following instructions: Well glue-sized paper is (by means of a wide brush, or a mechanical device) quickly coated with the following solution:

Ferric Ammonium Citrate,	10 parts.	(58).
Red Prussiate of Potassium,	8 parts.	
Water,	100 parts.	

When dry, the paper has a greenish-yellow color, and becomes blue in the light, except at those places which are protected against the light by the opaque lines of the drawing.

The printing must be continued until the lines also commence to darken, and partly disappear; then the print is taken out of the copying frame, and simply washed in water, which must be continually renewed until it is no longer colored. During the washing, the lines gradually become clear, and finally appear—pure white upon the blue surface.

If it is desired to give more brilliancy to the picture, it is only necessary to lay the same, after washing, in water which is acidified with 5 per cent. of hydrochloric acid, and to again wash the print thoroughly.

Haugk and *Liesegang* give the following two formulæ for the sensitizing solution:

Water,	80 parts.	(59).
Red Prussiate of Potash,	6 parts.	
Citrate of Iron and Ammonium,	5 parts.	

The solution must be preserved in the dark.

Make the following two stock solutions:

A.—Red Prussiate of Potash,	3 parts.	(60).
Water,	25 parts.	

B.—Ferric Citrate of Ammonium,	1 part.	(61).
Water,	6 parts.	

For use, mix equal volumes of *A* and *B*.

Captain Pizzighelli and *Arthur Baron Huebl* use paper, sensitized with the following solution, in the photometer:

Stock Solution A.

Ferricyanide of Potassium,	8 parts.	(62).
Water,	50 parts.	

Stock Solution B.

Ammonium Ferric Citrate, . . .	10 parts.	(63).
Water, ...	5 parts.	

The sensitizing solution is prepared shortly before use, and consists of 1 volume of solution *A* and 4 volumes of solution *B*.

Note.—A *photometer* serves to judge the correct time of exposure. It is simply a small printing frame—narrow, and long in proportion—made so as to open easily, like a book, and provided with means for holding the sensitive paper, and to prevent it from changing its position, while the frame is being opened. The inside of the glass plate of this instrument is covered with tracing paper, in such a manner that there are squares or rectangles covered with 1, 2, 3, 4, etc., thicknesses of paper. On that strip of tracing paper which is in contact with the sensitive paper numbers are printed or written, in opaque ink, corresponding with the number of thicknesses. When a strip of paper, coated with the above solution, is exposed to light, in the instrument, one number after the other will become visible, in yellow lines, upon a blue or light-green surface. When the number—which must be just plainly visible—for a certain kind of print has been determined and noted, by a few experiments, the correct time of exposure may be judged at, with certainty, in all future cases.

The author uses, for his Blue Prints, a stock solution composed of

Red Prussiate of Potash, . . .	5 ounces avoirdupois.	(64).
Water, ...	32 fluid ounces.	

After the red prussiate of potash has been dissolved—which requires from 1 to 2 days—the liquid is filtered. This solution remains in a good condition for a long time. Whenever it is required to sensitize paper, dissolve, for every 240 square feet of paper,

Citrate of Iron and Ammonium, .	1 ounce avoirdupois.	(65).
Water, ...	4¼ fluid ounces.	

and mix this with an equal volume of the red prussiate stock solution.

The reason for making a stock solution of the red prussiate of potash is, that it takes a considerable time to dissolve, and because it must be filtered. There are many impurities in this chemical, which can be removed by filtering. Without filtering, the solution will not look clear. The author makes no stock solution of the ferric citrate of ammonium, because such a solution soon becomes moldy and unfit for use. This ferric salt is brought into the market in a very pure state, and does not need to be filtered after being dissolved. It dissolves very rapidly. In the solid form, it may be preserved for an unlimited time, if kept in a well-stoppered bottle, and protected against the moisture of the atmosphere. A solution of this salt, or a mixture of it with the solution of red prussiate of potash, will remain in a serviceable condition for a number of days; but it will spoil, sooner or later, according to atmospheric conditions.

The greater part of what has been said before, about sensitizing and printing in general, also has reference to *blue prints.* (See pages 8, 9, and 23 to 26.) If the sensitizing is to be done by hand, the author prefers to apply the solution by means of a sponge, as described on page 8.

If pure chemicals and suitable paper are used, and the paper is quickly dried in moderate heat, and kept tightly rolled, or pressed between boards, protected from light and moisture, it will remain in a good condition for a long time. After the paper has been sensitized, it should not be put in a drawer while still damp, because the air in the drawer would become moist, and the paper would then dry too slowly and be spoiled, as the sensitizing chemicals would soak too deeply into the fibres of the paper, and it would be impossible to receive pure white lines. The paper should be hung up to dry in a warm and dark room, and never be stored away in a close space before perfectly dry. The best prints, however, will be obtained when freshly sensitized paper is used.

Four ounces of sensitizing solution, for blue prints, are amply sufficient for coating 100 square feet of paper, and cost about 6 cents.

In washing the prints, after they are taken out of the printing frame, the instructions given by Pizzighelli must be strictly observed. If the prints are only soaked in a small quantity of water, the water will be colored and become a dyeing liquid, and not only will the lines not turn out perfectly white, but the backs of the prints will also become tinted.

Dr. Vogel sensitizes the paper with a mixture of the following two solutions:

A.—Red Prussiate of Potash, . . .	10 parts.	(66).
Water, ...	100 parts.	

B.—Ferric Oxalate of Potassium, .	10 parts.	(67).
Water, ...	100 parts.	

The two solutions are mixed, in the dark, and the paper coated, with the mixture, by means of a sponge.

The exposure and fixing in water is done in the same way as usual with blue prints.

A French sensitizing solution consists, according to "La Nature," of

Ferric Tartrate of Potash,	15 parts.	(68).
Red Prussiate of Potash,	12 parts.	
Rain Water,	250 parts.	

RECIPES FOR THE SENSITIZING SOLUTION FOR BLUE PRINTS WITH DEVELOPMENT.—*Poitevin's sensitizing solution* consists of

Ferric Chloride,	10 parts.	(69).
Tartaric Acid,	3 parts.	
Water,	100 parts.	

The paper is coated, as thinly and uniformly as possible, with this solution, and dried in a moderate heat. The prints are developed with a weak solution of red prussiate of potash.

Carey Lea's Method, according to "Silver Sunbeam."—The sensitizing solution is composed of

Double Oxalate of Iron and Ammonium,	1 ounce.	(70).
Rain Water,	5 ounces.	

Prepare and filter this solution in a dark room. Float the paper on it for a minute or more, and then hang it up to dry. So prepared, the paper has a pale-yellow color. As long as it is secluded entirely from light, it may be preserved for an indefinite time. If exposed, under a tracing, or negative, to the direct rays of the sun, 3 to 4 minutes will be sufficient. A faint image is produced upon the paper; for where the light has acted, the yellow color has become bleached or decolorized.

The print must be developed immediately, otherwise the actinic impression becomes annihilated. The developer consists of

Ferricyanide of Potassium,	20 grains.	(71).
Oxalic Acid,	20 grains.	
Water,	from 12–15 ounces.	

The prints are immersed in this solution for 2 or 3 minutes. The image starts out with great rapidity, and is of a blue color. No further fixing is required than that of washing in water for about 10 minutes. Too much washing is injurious.

Carey Lea's Formulæ, according to Haugk or Liesegang.—Formula for the sensitizing solution:

Oxalate of Iron and Ammonium,	8–10 parts.	(72).
Oxalic Acid,	½ part.	
Water,	500 parts.	

The paper is floated, for 1 minute, on this solution, and then dried. The exposure requires, in the sun, from 2 to 3 minutes; in diffused light, ¼ hour. The picture is developed by immersing the print in a weak solution of red prussiate of potash.

The addition of the oxalic acid to the sensitizing bath causes the white parts to come out perfectly clear.

Dr. Vogel gives, for iron prints with development, the following recipe for the sensitizing solution:

Potassium Ferric Oxalate, . . 10 parts.
Water, ... 100 parts. } . . (73).

The developer for *blue prints* consists of

Ferricyanide of Potassium, . . 10 parts.
Water, ... 100 parts. } . . (74).

Developer for *sepia-colored prints:*

Nitrate of Silver, ... 1 part.
Water, ... 100 parts. } . . (75).

Red Prussiate of Potash Prints.—Drawings, etc., may be reproduced, by the action of light, on paper which is only coated with a solution of

Ferricyanide of Potassium, . . 1¼ parts.
Water, ... 100 parts. } . . (76).

According to Herschel, these prints must be fixed, after having been taken out of the printing frame, in a solution of sulphate of soda. The author formerly used, for this purpose, a solution of

Sulphate of Soda (Glauber's Salt), ... 1 part.
Water, ... 24 parts. } . . (77).

but, after having made a large number of these prints, he found that washing in water is sufficient to fix them.

The greatest objection to red prussiate prints is, that they require a very long exposure to light.

Niepce prepared the paper with a solution of

Ferricyanide of Potash, . . . 1 part.
Water, ... 5 parts. } . . (78).

He exposed until the prints became light-blue, then took them out of the printing frame and developed with a saturated solution of bichloride of mercury (corrosive sublimate), washed them in water, and poured over them a solution of oxalic acid, which had been heated to 120° to 130° F.

The oxalic acid solution, as well as the sublimate solution, was saturated cold.

After washing 3 or 4 times, the prints were dried.

On account of the extreme virulence of the bichloride of mercury, as a poison, these prints have no practical value whatever.

TONING BLUE PRINTS.— *Converting blue prints into dark blue-black or dark-violet prints.*

When blue prints are treated with a solution of

Potassa Hydrate (Caustic Potassa),	1 part.	(79).
Water, ...	300 parts.	

the blue color (Prussian blue) will be decomposed, and a rusty, yellowish-brown substance — ferric hydrate — will be left on the paper. If, then, a solution consisting of

90 per cent. Alcohol, ...	25 parts.	(80).
Water, ...	30 parts.	
Gallic Acid, ...	4 parts.	

be poured over the print, the rusty color — the peroxide of iron — will give place to a fine violet-black, which is identical with common writing ink. (According to Marion and Winkler.)

CONVERTING BLUE PRINTS INTO BROWN PRINTS.—The dried blue print is immersed in a solution of

Aqua Ammonia, containing 22 per cent. of the Am. Gas, .	1 part.	(81).
Distilled Water, ...	9 parts.	

and left in the same until the blue color has entirely disappeared, which will take from 2 to 4 minutes. The print is rinsed in clean water, and then plunged into a filtered solution of

Tannic Acid, ...	1 part.	(82).
Distilled Water, ...	50 parts.	

and kept in the same for about 12 hours. If, after this time, the color of the print be not as dark as desired, it may be intensified by adding to the bath a few drops of ammonia water. After one or a few minutes, it is taken out of the solution and thoroughly washed in plenty of water. The prints, having changed their color in this manner, are very beautiful, and resemble sepia drawings. ("Phila. Photo.")

A greenish tone may be given to blue prints by immersing them, after washing, in a 1 per cent. solution of sulphuric acid.

Silver Negative and Blue Positive Prints.

A Patent Process of Making Photographic Copies, or Fac-Similes of Drawings, etc. Abridgment of U. S. Patent No. 259,094, of June 6, 1882, to Sager Chadwick, of Philadelphia, Pa.

To produce this copy, or fac-simile, the following process and mixture of ingredients are employed: First clean a glass plate with aquafortis and wash it. Then coat it with the following solution:

Gelatine,	120 grains.	(83).
Chrome-Alum,	30 grains.	
Water,	10 ounces.	

When dry, flow over it collodion prepared as follows:

Alcohol,	10 ounces.	(84).
Ether,	10 ounces.	
Gun Cotton,	100 grains.	
Iodide of Potassium,	40 grains.	
Iodide of Cadmium,	60 grains.	
Bromide of Cadmium,	60 grains.	

Then immerse the plate in a bath of the following solution:

Distilled Water,	10 ounces.	(85).
Nitrate of Silver (C. P.),	1 ounce.	
Nitric Acid (C. P.),	1 drop.	

After an immersion of about 5 minutes, the plate is taken out and drained; then placed in a dark-slide, and exposed, in a camera, for about 3 minutes, to the drawing to be reproduced. The plate is then taken to a dark room, and flowed with the following solution:

Protosulphate of Iron,	½ ounce.	(86).
Protosulphate of Iron and Ammonia,	½ ounce.	
Acetic Acid,	1 ounce.	
Water,	16 ounces.	

When the image has been developed, the plate is fixed with a solution of the following proportions:

Cyanide of Potassium,	1 ounce.	(87).
Water,	8 ounces.	

When fixed, the plate or image is intensified with a weak solution of sulphuret of potassa. When the plate has become dry, it is ready to print from, by placing back of it, in a pressure frame, paper, or other support, material prepared in the following manner:

Red Prussiate of Potassium, .	120 grains.	. . (88).
Citrate of Iron and Ammonia,	140 grains.	
Water, ...	1 ounce.	
Gum Arabic, ...	10 grains.	

or other equivalent known substitute, soluble in water, is applied to the paper by means of a sponge, and then exposed to sunlight for from 5 to 10 minutes. When printed, the material is placed in clean water and thoroughly washed. The result is a fac-simile of the original, with blue lines on a plain ground.

What I claim as my invention is:

1. The process hereinbefore described of producing fac-similes in ferroprussiate colors, which consists, essentially, in combining gum arabic, or an equivalent substitute, with the ferroprussiate sensitizing solution, forming the lines or image thereon by exposure to light, and then divesting the ground or field of soluble and surplus prussiate by means of water, substantially in the manner and for the purpose set forth.

2. The sensitizing solution, consisting of gum arabic, or an equivalent substance, mixed with ferroprussiate of potash, and ammonia and iron chemically combined with a vegetable acid, as and for the purpose set forth.

3. Processes by Means of which Positive Copies, in Blue Lines Upon a White or Light-Colored Ground, are Produced from a Drawing or Tracing — Direct or Positive Cyanotypes.

The principles on which these processes are based have been mentioned already on pages 52 and 53, when we began to treat of iron prints. We have also stated Herschel's method of producing prints, in blue lines, from an original in black lines. Herschel coated the faint negative iron print thinly, with yellow prussiate of potash mixed with gum arabic. Later investigators discovered that it is more practicable, and that better prints are obtained, when the gum is mixed with the sensitizing solution.

The best results are obtained, by these processes, from originals made on very thin paper, tracing paper or tracing cloth, with perfectly opaque ink. The paper for these prints must also be well sized, so that the sensitizing solution will be kept on the surface of the paper. Glue-sized paper is preferable.

Henri Pellet's Process, According to U. S. Patent.

Clarisse Zoe Joltrain, of Paris, was the first to manufacture Sensitized Paper for a Direct or Positive Cyanotype Process (under the name "Papier Gommoferric"), according to Pellet's Patent, No. 241,713, dated May 17, 1881, of which the following is an abridgment:

The sensitizing liquor can be prepared in a number of ways. The following compositions, which can be used singly or mixed, and in which the proportion for each ingredient can be varied with the nature of the paper, or surface, on which the reproduction is to be effected, the time to be consumed, and the rapidity with which the operations are to be performed in the reproduction, the intensity of the impression to be obtained, and similar conditions, are given as examples, viz:

First Type.

Perchloride of Iron, at 45° Baume, .	8 cub. centimeters =130 minims.	. . (89).
Oxalic Acid, ...	6 grams =93 grains troy.	
Water to make the whole amount to	100 cub. centimeters =3 fluid ounces+183 minims.	

Other salts of iron can be used in place of the perchloride. This liquor can be used alone, or with thickening substances—such as gelatine, isinglass, gum, dextrine, glycerine, and other gummy or mucilaginous materials. These can also be added, in varying proportions, to the liquors hereinafter indicated.

Second Type.

Perchloride of Iron, at 45° Baume, .	15 cub. centimeters =243 minims.	. . (90).
Citrate of Soda or Potassa, . . .	8 grams =123 grains troy.	
Water to bring the whole to . . .	100 cub. centimeters =3 fluid ounces+183 minims.	

Third Type.

Perchloride of Iron, at 45° Baume, . . .	10 per cent.	. . (91).
Water, ...	90 per cent.	

The surface of the article or object on which the reproduction is to be effected is impregnated with the liquid selected, and immediately, or after desiccation, is passed through an alkaline bath, peroxide of iron (ferric oxide) being deposited. The operation of sensitizing is completed by means of oxalic, citric, or similar acid, or corresponding salts, with or without gummy or mucilaginous substances.

Fourth Type.

$$\left.\begin{array}{l}\text{Citrate of Iron, or Ammoniacal Citrate of Iron,}\\ \qquad\qquad 3-5\text{ grams}=46-77\text{ grains troy.}\\ \text{Water to make 100 cub. cent.}=3\text{ fluid oz.}+183\text{ minims.}\end{array}\right\}\ \ .\ \ .\ \ (92).$$

A solution of citrate of iron has been heretofore used, with red prussiate (ferricyanide of potassium), to obtain white lines on a blue ground. I have discovered that, by omitting the red cyanide of potassium and adding a thickening material, this new liquor would give the results before indicated.

Fifth Type.

$$\left.\begin{array}{ll}\text{Perchloride of Iron, at 45° Baume,}\ . & 6-8\text{ cub. centimeters}\\ & \quad =97-130\text{ minims.}\\ \text{Tartaric, Citric, or similar Acid,}\ . & 6-8\text{ grams}\\ & \quad =93-123\text{ grains troy.}\end{array}\right\}\ \ .\ \ .\ \ (93).$$

ammonia, in variable quantities, according to the proportions of other materials; divers thickening or gummy materials in varying proportions.

The sensitized paper is prepared by hand, or by a machine, with a brush, sponge, or other suitable agent. Having been prepared with the liquor of any of the types before mentioned, it is exposed to light under the drawing, bit of lace, or design to be reproduced. After exposure, it is passed through a bath of yellow prussiate (ferrocyanide of potassium), the bath being concentrated, or dilute, neutral, slightly acid, or slightly alkaline, hot, or cold. The parts corresponding to the black portions of the design, or pattern, become blue. After washing, the paper is passed through a discharging bath (dilute acid or divers salts), and rubbed on its upper surface or not, as may be required.

The operation can be modified. For example: After washing, the paper (without passing through the acid bath) can be simply rubbed lightly on its surface. The result is a yellow background. The paper can also be passed through an alkaline bath (lime, sucrate of lime, and other salts in which Prussian blue is soluble), and then through acid, if desired. The paper used can be blue, colored, silvered, gilded, and with or without previous designs. To the sensitized liquid there can be added soluble or insoluble coloring matter.

The liquors and methods of operation already indicated can be used on glass, porcelain, metals, wood, and other materials, if it is desired, to obtain photographic negatives.

The reproduced lines can be brought out, so as to appear blue-black, by the application of two or more successive layers of a liquor of uniform or varying density for the two layers.

Two layers can also be applied in various other ways: first, by using the acidulated gum and then the perchloride; second, by using the perchloride and then the acidulated gum; third, by using the gum alone and then the acidulated perchloride; fourth, by using the acidulated perchloride and then the gum.

Blue-black lines can also be obtained, with a single layer, by modifying the proportions of the salt of iron and the organic acid.

The liquor which is commonly employed by me is composed of: first, gum, 10 to 12 per cent.; second, salt of iron (perchloride at 45° Baume), 8 to 12 per cent.; third, citric, tartaric, or similar acid, $1\frac{5}{10}$ to 3 per cent.

The quantity of gum can be increased according to the paper used, and to the atmospheric conditions. The density of the liquor, and relative proportions of the gum, salt of iron, and acid, should also be modified according to the paper employed, the sensitiveness to be obtained, and the manner of treating the paper.

Another important point to be noticed is, that the density should vary with the temperature or humidity of the air. In general, the greater the heat the less the density of the liquor.

Instead of wholly immersing the sheet of paper in the bath of prussiate—which furnishes a more or less blue ground—the sheet may be simply floated on the surface. A perfectly white ground can be thus obtained, and less prussiate used. The time required for development, by the prussiate, varies with the density of the developing liquid—which should always be as concentrated as possible—and with the accuracy of the placing of the paper.

By modifying the thickness of the layer, and the quantity of the iron salt, paper can be obtained of great sensitiveness; and this can be varied, to adapt the papers to different countries and seasons, and to various meteorological conditions.

As soon as the design is sufficiently developed by the prussiate, the paper is passed through water, and a bath of dilute sulphuric, hydrochloric, or other suitable acid or substance.

The gummy matter is readily detached from the paper, and, after immersion for a sufficient time, it is separated by a jet of water, all blue parts remaining more or less adherent. The design then appears of a blue-black color. A solid blue-black impression can also be obtained by drying the paper after passing through the bath of prussiate. It is then passed through the water and the acid.

Ordinary blue impressions can be deepened to blue-black by weak solutions of various alkalies, and by an operation of washing, which is discontinued at the proper point. Moreover, blue-black impressions obtained can be made to undergo the modifications which are often effected upon Prussian blue. For example, by treating with a dilute solution of soda, washing well, and making the impression black with tannic and other solutions.

With alkalies alone—by contact, longer or shorter, according to the strength of the solution—a variety of tints can be produced. In the case of paper improperly treated, with too little or too much liquor, it suffices to pass it (by machine or by hand) through a weak liquor, or pure water, to restore its properties. Thus there need be no loss of paper in the manufacture.

The paper can be sensitized on the side opposite the first layer. For particular purposes, both surfaces can be treated by one operation, or by two, so as to form designs on both sides. These proofs can be bound into book form.

The blue or black can be strengthened by the addition of a few drops of chlorine water, nitric acid, or other similar compound, to the acid bath or washing water.

Papers which have been defectively prepared, can be restored to their original condition by washing with a roller, or by hand, in water acidulated with hydrochloric, sulphuric, or other mineral acid, and can, when dry, be used again.

Having thus fully explained the said invention, and the manner of carrying the same into effect, what I claim is:

1. The method of producing directly, in dark or colored lines, drawings, lace patterns, and other devices, by forming, upon the surface on which the reproduction is to be effected, a sensitized layer, containing a salt of iron—as ferric salt—and tartaric or other organic acid, afterward exposing the said layer to light, under the pattern or device, and, finally, developing the parts protected by the opaque or semi-opaque portions of the pattern or device, with yellow prussiate of potash, which forms coloring matter by combining with the unaltered materials of the sensitized layer, substantially as described.

2. The method of reproducing patterns or designs, by exposing a surface sensitized with a layer of a salt of iron and an organic acid, together with gummy matter, and afterward developing the protected parts of the sensitized layer with yellow prussiate of potash, or other suitable chemical liquid, substantially as described.

3. As a material for reproducing designs and patterns directly in dark lines—by the aid of transmitted light, and of a bath for developing the protected portions of the sensitized layer—paper, paper-cloth, cloth, or like fabric, provided with a sensitive layer of gummy matter, ferric salt, and an organic acid, substantially as described.

4. The method of reproducing patterns or designs, by exposing to light, under a pattern of the character indicated, a surface sensitized with a salt of iron—as ferric salt—and citric or oxalic acid, and

afterward developing the sensitive material, upon the protected parts, by means of yellow prussiate of potash, or other chemical liquid, which produces colored lines by combining with the said sensitive material, substantially as described.

The author has tried Pellet's process, several times, with the liquids according to the first and fourth types, and with liquor commonly employed by Pellet, without succeeding in producing good prints. The background was always more or less colored.

CAPTAIN G. PIZZIGHELLI'S AND L. V. ITTERHEIM'S MODIFICATION OF HERSCHEL'S POSITIVE CYANOTYPE PROCESS.—The following three stock solutions are to be prepared:

A.—	Gum Arabic,	20 parts.	(94).
	Water,	100 parts.	
B.—	Ferric Ammonium Citrate,	50 parts.	(95).
	Water,	100 parts.	
C.—	Ferric Chloride,	50 parts.	(96).
	Water,	100 parts.	

Solution *A* will become sour in a few days, and then be unfit for use; *B* and *C* will remain unchanged, in closed vessels, for several weeks. For use, mix

A,	20 volumes.	(97).
B,	8 volumes.	
C,	5 volumes.	

and in the order given, as otherwise the gum will coagulate. The mixture is, at first, liquid, but, in a few minutes, will become viscid, and, after a few hours, it will have the consistency of soft butter. In this condition, it is the most suitable for the preparation of the paper, and maintains its usefulness, for several days, if kept in the dark and in a closed vessel.

Well glue-sized, hard drawing paper is absolutely necessary for this process. Soft, poorly sized paper will permit the sensitive mixture to soak too deeply into its pores, and blue spots will appear in the prints.

Pizzighelli recommends the endless drawing paper, known as the "Imperial Animal-Sized Drawing Paper." The author has used "Helios" with fair results.

In order to sensitize the paper, it is fastened to a drawing board or table by means of thumb-tacks; then the mixture is applied, by means of a wide, flat, bristle brush, as uniformly and quickly as possible, but not too heavily. As soon as the brush begins to stick to the paper, the surface is equalized with badger softeners. Some operators of this process use a velvet brush (a small board covered with velvet) for coating the paper with the mixture, whereby the equalization of the layer with the softener is not required.

The operation of coating the paper may be performed in subdued daylight, but the sensitized paper must be dried quickly in a dark and warm place. It must be preserved, either pressed flat or rolled with the coated surface toward the outside—because it has a tendency to curl in the opposite direction—and protected from light and moisture.

The exposure to light is sufficient when the yellow picture, upon a dark-brown surface, is plainly visible, which will require, in the sun, from 3 to 10 minutes; in diffused light, 15 minutes or more. (The original should always be on tracing paper, or tracing cloth, for this process.)

In order to develop the picture, the print is placed upon a drawing board, and, by means of a soft hair brush (of otter's or camel's hair), quickly—without pressing hard—coated in parallel and joining strokes, with the following solution:

Yellow Prussiate, ...	20 parts.	(98).
Water, ...	100 parts.	

The image will appear, in a few seconds, in a dark-blue color. If the time of exposure was too short, blue spots will also appear in places where they should not be; sometimes the entire sheet will become blue. If the exposure to light was continued too long, the developing of the blue picture will proceed very slowly, and some of the lines will not appear at all. For the purpose of determining the correct time of exposure, it is necessary to expose, under a small glass plate and tracing, strips of the same prepared paper, at the same time and in the same light, alongside of the printing frame. By withdrawing one of the strips, from time to time, and treating it with the yellow prussiate solution, the exact state of the process can be ascertained. During the time that the strip is being developed, the printing frame—and the glass plate which serves as a photometer—must be covered or taken into subdued light. When those places alone, on the strips, upon which the light did not act, and no other parts, become blue, the print has been exposed sufficiently long, and must be taken out of the frame and developed in the manner described. Pizzighelli gives the instruction to remove the yellow prussiate solution, as soon as all the details have appeared, quickly and without delay, by means of a strong jet of water from a hydrant. The author, however, finds that this can easily be overdone, and that portions of the blue drawing may be entirely removed from the print if the developer was not allowed to act for a length of time sufficient for the formation of Prussian blue, not only on the surface, but through the entire film, to the paper. This time is but short, and the deep indigo-blue lines will soon begin to spread. In all cases, a blue liquid will flow all over the sheet. If the exposure was continued for a sufficient length of time, this blue liquid will not spoil the print, and the coloration which it produces can easily be distinguished from the blue spots, which spring up and continually increase in number and size, if the print was insufficiently exposed to the action of light. How long the yellow prussiate solution may be allowed to act upon the print, before the lines begin to spread, will soon be learned from practice. After the image has been developed, the author floats the print, back upward, for a few minutes, on water, until the lines may be recognized from the back. This is an indication that the developing process has continued, in the lines of the floating sheet, through the film and into the superficial pores of the paper. Then the print is turned over, and the greenish-blue film, which has formed on the surface, removed by means of a soft camel's hair brush. When this has been done thoroughly, the print, which is now of a considerably lighter blue than when just developed, is immersed in *clean* water, and allowed to remain there until most of the gum film has dissolved. If left long enough in the water bath, this film will entirely dissolve, the paper will have a uniform light-yellow tint, and the blue lines of the picture will become somewhat darker.

Any time after the greenish-blue film has been removed from the print, by means of a brush or a jet of water, the print is immersed in a discharging bath of

Hydrochloric Acid, ...	1 part.	. . (99).
Diluted with Water, ...	10 parts.	

Pellet recommends to substitute sulphuric acid for a part of the hydrochloric acid (Bull Soc. Franç., 1880, 234), in order to diminish the formation of muriatic acid vapors.

Such an acid bath may be composed of

Water, ...	100 parts.	. . (100).
Hydrochloric Acid, . . .	8 parts.	
Sulphuric Acid, ...	3 parts.	

In mixing, the acid should be poured into the water—not vice-versa—and not into a tray, but into a bottle or jug.

In the acid bath, the gum film scales off from the paper, the blue lines—which faded in washing—again become darker, and a blue picture, on pure white paper, is obtained.

Finally, the prints are again washed in water, and then hung up to dry. Some operators of this process add a little alum to the last rinsing water, in order to restore the sizing of the paper, which suffered a little in the previous bath.

Pizzighelli immerses the print in the acid bath as soon as it has been washed by a strong jet of water after development. But if the prints are first soaked in water—as we recommend—the major portion of the gum film is removed, and they need only to be left in the acid bath a few minutes; beside which this bath may thus be used for a greater number of sheets.

The following interesting notes, concerning this process, were also originally published by Pizzighelli: The positive cyanotype process is especially adapted for copying tracings executed in black and perfectly opaque lines. A comparison of this with the common blue print process seems to be superfluous, and a comparison with the new heliographic methods—which furnish black lines on a white surface—shows that the latter processes, in general, deserve to be preferred, but that the gum and ferric-salt process is, by all means, worthy of a full estimation, on account of its simplicity and rapidity.

For very fine drawings, with partly gray lines, the anthracotype process is, at present, indispensable, especially as it permits versatile applications. Itterheim's nigrotypie also furnishes excellent results, but, so far, only in the hands of its inventor.

The gum and ferric-salt process, on the other hand, may be practiced, with success, by persons not skilled in photographic operations. The preparation of the paper, the printing, and the development, require but little time. Therefore, this process can be highly recommended.

The addition of the quantity of gum arabic above given is absolutely necessary. The gum not only acts as a thickening agent, to prevent the solution from penetrating the paper, but it also possesses the property of forming, when dry, with iron salts, a substance resembling horn, which does not easily dissolve in water, and which causes the developer to act only superficially, and to but slowly penetrate the film.

Very peculiar, and difficult to explain, is the phenomenon presented by this process—that aqueous developing solutions easily penetrate the parts of the gum-iron film upon which the light did not act. This peculiarity exhibits itself in the fact that the blue image—consisting of Prussian blue—goes through the film to the surface of the paper, to which it adheres, while the precipitate, on those parts which were exposed to the influence of the rays of light, is only formed on the surface of the film. More striking is the phenomenon of the unexpected action of red prussiate of potash upon the film. Any one who is familiar with the reaction of ferrous salts, would expect a negative picture (white lines upon a blue surface); but this is not obtained. If a solution of ferricyanide of potassium is used for developing, a positive blue image will appear—just as with the yellow prussiate, but somewhat slower and of a greenish color—which, in the hydrochloric acid bath, also becomes blue—as with the yellow prussiate of potash developer. It is supposed that this abnormal behaviour of the ferric gum film is due to the fact that the film loses its penetrability in the light.

The proportion of the ferric salts may be changed, from those given in the recipe, without affecting the chances of success. In general, it may be said that a larger proportion of ferric chloride diminishes the sensibility to light, but furnishes pictures of darker color.

Ferric ammonium citrate alone, with or without gum arabic, will give no good results.

The quantity of gum given in the recipe, has proved to be the best. Less gum will often cause blue spots in the paper; a larger amount will make the solution so thick that it becomes impossible to coat the paper uniformly with it.

Gold or silver solutions have no developing effect on paper coated with a mixture of gum arabic and ferric salt solutions.

This process is generally credited to Pizzighelli alone, but he himself states that he has worked out this process according to his own experiments, and according to information from L. v. Itterheim, who also permitted him to publish his communications.

COLLACHE'S DIRECT BLUE PRINT PROCESS.—Collache received a patent, in France, in the year 1880, on the following process:

Sensitizing Solution.

Water,	1 fluid ounce.	(101).
Gum Arabic,	32–46 grains troy.	
Sesquichloride of Iron Solution, 45° Baume,	18–27 minims.	
Citric Acid,	9–13½ grains troy.	

The solution is to be applied to the paper twice by means of a brush. The first coating must be dry before the second is applied.

Developing and acid bath is the same as in the Pizzighelli process. The prints may also be developed with nitrate of silver.

This sensitizing mixture has the consistency of dissolved gum arabic, and can be applied to the paper easier than that of the foregoing process. The prints have a lighter blue color, and do not look so brilliant as those obtained by the Pizzighelli process.

JOLTRAIN'S POSITIVE BLUE PRINT PROCESS.—*According to Liesegang.*

Sensitizing Solution.

Water,	1 fluid ounce.	(102).
Gum Arabic,	114 grains troy.	
Ferric Chloride Solution, at 45° Baume,	48 minims.	
Ferric Sulphate,	23 grains troy.	
Tartaric Acid,	18 grains troy.	

The author uses 31 grains troy of the solid sesquichloride of iron instead of 48 minims of the solution, and 25 fluid minims of tersulphate of iron solution (according to U. S. Pharmacopoeia) in place of the 23 grains of the solid ferric sulphate.

The developer and the discharging bath are the same as in the Pizzighelli process.

The following table contains the proportion of the ingredients of the sensitizing solution for the direct blue print process, according to various authorities:

PROCESS.	THE SENSITIZING SOLUTION IS COMPOSED OF									DEVELOPER IS COMPOSED OF	
	Water, liquid ounces.	Gum Arabic, grains troy.	Citrate of Iron and Am., grains troy.	Sesquichloride of Iron, grs. troy.	Sulphate of Iron, grains troy.	Tersulphate of Iron, grains troy.	Citric Acid, grains troy.	Tartaric Acid, grains troy.	Common Salt, grains troy.	Yellow Pruss. of Potash, ounces.	Water, ounces.
Pizzighelli, accord. to Liesegang, . .	1	58	52	34	. .	. . .	. . .	. .	. .	1	8.4
Pizzighelli, accord. to Spon, ...	1	64	42	26½	. .	.	. . .	.		1	4
Pizzighelli, acc. to Lon. Pho. News,	1	60	27	28	. .	. . .	. . .	.	. .	1	5
H. Pellet, accord. to his U. S. Patent,	1	48 – 58	. . .	28 – 41	. .	.	2.4 – 14	. .	. . .	1 Satu	4 rated.
H. Pellet, accord. to Photo News, . . .	1	120	.	38	.	.	. . .	19	14	1 Satu	3 – 4 rated.
H. Pellet, accord. to Scientific Am., of Oct. 25, 1884, . . .	1	255	. .	74	51	. .	. . .	41	31	. . .	. . .
Collache, accord. to Liesegang, ...	1	31 – 45	. .	13 – 20	. .	.	8½–13	. . .	. .	1	8.4
Joltrain, accord. to Liesegang, ...	1	107	. .	31	. .	21	. . .	17		1	8.4

Corrections on Blue Prints.—Blue spots on positive blue prints may be removed, and corrections on negative blue prints may be made, with solutions of alkalies; for example, with lime water—that is, the water from which the hydrate of lime separates, on standing, when quick lime is slaked in water—or with a solution of

Caustic Potassa, ...	1 part.	. . (103).
Water, ...	25 parts.	

These alkaline solutions may be applied by means of a small brush, or a writing or drawing pen.

For corrections and alterations of negative blue prints, the author, however, prefers white writing ink, because all the alkaline solutions are apt to spread and blot.

4. Processes by means of which Positive Copies, in Dark-Violet Lines upon a White or Light-Colored Surface, are Reproduced from a Tracing in Black Lines (Ink Pictures).

Poitevin's Process.—From the description of Poitevin's ink-process, which was given at the beginning of this chapter, it will be seen that Poitevin uses no mucilaginous substance with the sensitizing solution. This is the reason why the solution penetrates too deeply into the paper, and sometimes goes entirely through it, so that the back appears as yellow as the face. This, again, causes the surface of the finished prints to be always more or less tinted. Recent operators of this process mix with the sensitizing solution gum arabic or gelatine; some operators size the paper, before sensitizing, with a 1 to 30 arrow-root flour solution. But even with gum or gelatine, it is still difficult to always obtain a perfectly white surface.

Colas' Formula.—The sensitizing solution consists of

Water, ...	30 parts.	. . (104).
Gelatine, ...	1 part.	
Solution of Perchloride of Iron, at 45° Baume, . .	3 parts.	
Tartaric Acid, ...	1 part.	
Tersulphate of Iron, . . .	1 part.	

A solution of perchloride of iron, at 45° Baume, has a specific gravity of 1.45, and contains 50 per cent. of sesquichloride of iron, and 50 per cent. of water.

The developing solution is composed of

Water, ...	50 parts.	. . (105).
Alcohol, ...	10 parts.	
Gallic Acid, ...	1 part.	

The author, finding it difficult to apply the sensitizing solution uniformly, and to prevent the formation of an infinite number of small air-bubbles, modified this recipe as follows:

The Author's Modification—Sensitizing Solution.

Water,	15 ounces.	(106).
Gum Arabic,	1 ounce.	
Sesquichloride of Iron (solid),	$\frac{3}{4}$ ounce.	
Tartaric Acid,	$\frac{1}{2}$ ounce.	
Monsel's Salt ($2Fe_2O_3$, $5SO_3$),	$\frac{1}{2}$ ounce.	

This solution will remain in good condition for a long time. It is applied to the paper, by means of a soft brush, as thinly and as uniformly as possible. It is best to use the prepared paper as soon as it is dry.

The exposure to light must be continued until the parts of the paper affected by the light are perfectly white, and the picture is visible in yellow lines.

(This refers to all processes under this head.)

Developing Solution.

Gallic Acid,	$\frac{1}{4}$ ounce avoirdupois.	(107).
Water,	80 fluid ounces.	

Or, Gallic Acid,	1 part.	(108).
Water,	333 parts.	

This solution may be applied by means of a camel's hair brush, or the print may be immersed in the solution. As soon as the picture has been developed, the sheet must be plunged into water and washed thoroughly. The lines of the picture consist of ordinary writing ink. It is not necessary to develop the prints as soon as they are taken from the printing frame.

The author has often printed during the light part of the day, preserved the prints in a dark place, and developed them in the evening.

The prints may also be developed as positive blue prints. For this purpose they are immersed in water, wherein the gum film dissolves a great deal sooner in those places which were affected by the light than in those on which the light did not act. After this, the prints are developed with a dilute and acidified solution of red prussiate of potash, either by means of a brush, or by immersing the prints in this solution. If the surface, also, of the paper becomes tinted blue, the print was either not long enough in the water bath, and the gum-iron film not entirely removed, or the exposure was not sufficient. When developed, the prints are washed again, in order to remove the red prussiate of potash, and then they are hung up to dry.

A. FISCH'S METHOD OF REPRODUCTION OF DRAWINGS IN BLACK LINES UPON A WHITE SURFACE. (INK PICTURES.)—Four solutions to be made:

A.—Gum Arabic, ...	78 parts.	. . (109).
Water, ...	850 parts.	
B.—Acetic Acid, ...	78 parts.	. . (110).
Water, ...	336 parts.	
C.—Ferric Sulphate, ...	48 parts.	. . (111).
Water, ...	414 parts.	
D—Sesquichloride of Iron, . .	120 parts.	. . (112).
Water, ...	120 parts.	

Pour *C* into *B*, add *A*, and then, while constantly stirring, the solution of sesquichloride of iron.

With this mixture the paper is thinly coated, by means of a brush, and quickly dried at a temperature not exceeding 100° F.

The paper will remain in a serviceable condition for about 2 weeks. The exposure, under tracing paper, requires, in the sun, from 10 to 12 minutes. The unprotected parts of the paper must lose their yellow color in the light. When the ground is perfectly white, the print is floated on a solution of

Gallic Acid or Tannin, .	31–46 parts.	. . (113).
Oxalic Acid, ...	1¼ parts.	
Water, ...	1,700 parts.	

without wetting the back of the prints. Wash well and dry.

5. POITEVIN'S DIRECT POSITIVE CARBON PRINTS.

Upon Poitevin's discovery, that a mixture of gelatine, ferric chloride, tartaric acid, and water, becomes insoluble—even in hot water—on drying, this and the following process are based:

The paper is first coated with a solution of gelatine, colored with fluid Japan drawing ink. One part of gelatine to about 30 parts of water is a good proportion. The best way of coating the paper is to float it upon the hot gelatine solution. The so-called carbon or pigment paper (paper coated with a mixture of gelatine and a pigment), which is especially manufactured for another (patented) carbon process, is also suitable for this process.

When dry, this paper is immersed, in subdued light, in a solution of

Sesquichloride of Iron, . .	10 parts.	. . (114).
Tartaric Acid, ...	3 parts.	
Water, ...	100 parts.	

and dried again in the dark. The film on the paper, so prepared, is insoluble in hot water; but, after having been exposed to the action of light, it has lost this property, and is then soluble. If such paper is exposed under a tracing or line-drawing, and then immersed or floated, upside down, in a tray containing hot water, the film will dissolve in all parts except those where the black lines of the tracing prevented the light from acting, and a positive copy, in black lines upon a white surface, will result.

6. Poitevin's Process by means of which Positive Copies in Printing Ink are Received from a Tracing in Black Lines.

Paper coated with gelatine (without a pigment) is sensitized in the same solution as in the foregoing process. After having been exposed to the action of light, the print is immersed in cold water, wherein the parts upon which the light did act will absorb water and swell up. Then the print is placed upon a glass plate, or straight board, superficially dried, and, by means of a leather roller, is inked with a fatty printing ink. Those places only upon which the light did not act will take up the ink; the other parts, which absorbed the water, will repel it, and a positive copy will result from a positive tracing.

7. Dr. Zoellner's Iodide of Starch Process.

In May, 1863, Dr. F. Zoellner read, before the Berlin Polytechnic Society, a paper on the following simple and cheap process for reproducing engravings, drawings, manuscripts, etc., invented by him:

Thin and smooth paper, of a uniform texture, is first to be sized with starch. If paper which was sized with starch in its manufacture is used, this operation is not necessary. When dry, the paper is sensitized with a mixture of

Concentrated Sol. of Sesquichloride of Iron,	1 volume.	. . (115).
Concentrated Solution of Ferric Oxalate, . .	6 volumes.	
Distilled Water, ...	13 volumes.	

This solution may be preserved in a dark place, and in a well-stoppered bottle, for a long time. Floating the paper upon the solution, for from 30 to 60 seconds, is the best method of sensitizing in this process. The prepared paper may be preserved, in a portfolio, protected from light, for over 2 weeks, without losing its sensitiveness.

The exposure, through thin and translucent originals, requires, in the sun, but a few minutes; in diffused light, from $\frac{1}{4}$ to $\frac{1}{2}$ hour.

The image is invisible after the action of light; but it appears at once, intensely blue, by treating it with a solution of iodide of potassium in diluted albumen.

The developing solution is prepared as follows:

The whites of two eggs are beaten to froth, and allowed to stand several hours; then the liquid albumen, which has collected at the bottom of the vessel, is decanted, and diluted with one third of its volume of distilled water. In this diluted solution of albumen, 78 grains troy of iodide of potassium are dissolved.

The developing solution is applied by means of a wide varnishing brush, and, before it is dry, is washed off with clean water.

The prints may be developed as soon as they are taken out of the printing frame, or this operation may be postponed for from 6 to 12 hours. The developed and washed prints are to be dried in the open air.

8. The Platinum Process.

According to Pizzighelli and Huebl, all platinum salts are, in the presence of organic substances, sensitive to light—that is to say, they are reduced in the light. Nevertheless, the following processes must be classified with *iron prints*, as a ferric salt, and not a salt of platinum, is the principal sensitive substance.

Mr. William Willis, Jr., was the first inventor of a successful, practical platinum process, after a number of investigators had made a variety of interesting but imperfect discoveries. Mr. Willis found that certain salts of platinum are reduced to a metallic condition by a solution of ferrous oxalate in oxalate of potassium. The sensitizing solution applied contains chloroplatinite of potassium and ferric oxalate. The prepared paper has a lemon-yellow color. After exposure to the action of light, a faint picture is visible. In those portions of the print which were affected by the light, the ferric oxalate has been reduced, partly or wholly, to ferrous oxalate, while, in the parts on which the light did not act, the ferric oxalate remains unaltered. The picture is developed by being floated on a hot solution of potassic oxalate. This bath produces, in the film, a concentrated solution of a platinum salt, and the reducing power of the nearly insoluble ferrous oxalate comes into action. The following is an abstract of one of Willis's patents. His earlier patent bears the date February 8, 1876.

The firm of Willis & Clements, No. 1112 Hunter Street, Philadelphia, Pa., are the proprietors of Willis's patents. They furnish the materials required for this process, and sell licenses to work the same.

William Willis, Jr.'s, Photo-Chemical Printing.

Abridgment of U. S. Patent No. 213,484, dated March 18, 1879.

According to the said invention, I proceed as follows: That is to say, I coat paper with an aqueous solution, which I term the "coating solution," each fluid ounce of which contains 15 grains potassic chloroplatinite, or double chloride of potassium and platinum, 70 grains ferric oxalate, or oxalate of iron (with enough oxalic acid to render this ferric oxalate freely soluble), and 2 grains of plumbic chloride, or chloride of lead. I then dry the paper, and expose it to light, under or behind the negative, or other object, from which the picture or image is to be produced on the so-prepared paper. On removing the paper from this negative, or other object, an image or picture is usually faintly visible. I then float the said paper, face downward, on, or immerse it in, a hot aqueous solution, which I term the "developing solution," each fluid ounce of which contains 120 grains potassic oxalate, or oxalate of potash, and 7 grains potassic chloroplatinite, or double chloride of potassium and platinum. This solution quickly deepens in color, or blackens, the picture or image produced on the coated paper by the action of light. I then wash the paper in a weak solution of some acid (preferably oxalic acid), and finish by washing it in plain water.

For coating or treating the paper, or other surface, previous to its insolation or exposure to light, I may use other salts of platinum, or salts of other metals than those above named—such as salts of gold, of iridium, or of palladium, or mixtures of these with other salts; but it is essential, in all cases, that ferric oxalate form one of the ingredients or constituents of the coating or coatings applied to the said surfaces.

The following are examples of the manner in which I vary the composition of the coating solution or solutions:

1st. I sometimes substitute 15 grains of iridium chloride for the potassic chloroplatinite used, as above specified. All other operations the same.

2d. In some instances, I proceed as in the first-described method, but substitute, for the 2 grains plumbic chloride, 4 grains mercuric chloride; the treatment being otherwise conducted as in the first-described method.

3d. In other cases, I omit the plumbic chloride in the coating compound or solution.

Instead of effecting the coating of the paper, or other surface, with the aforesaid salts, by using the same all in one solution, I may, in some instances, find it desirable to apply such salts in different and successive solutions, and dry the paper, if necessary, between the successive coatings.

Claims—1. The process herein described, of producing photographic pictures by coating the surface of paper, wood, or other material, with a compound consisting of the double chloride of potassium and platinum and oxalate of iron, exposing the material thus prepared under a negative, and developing and toning the image by means of a solution of oxalate of potash and the double chloride of potassium and platinum, substantially as specified.

2. A sensitive coating, for the production of photographic pictures, consisting of the double chloride of potassium and platinum, or other similar salt, and oxalate of iron dissolved in oxalic acid, substantially as specified.

3. A developing and toning compound, for photographic pictures produced upon the sensitive compound herein mentioned, consisting of oxalate of potash and the double chloride of potassium and platinum, substantially as specified.

PIZZIGHELLI'S AND HUEBL'S RECIPES.—In the year 1882, the Photographic Society of Vienna awarded the Voigtlaender medal in gold to a treatise on "The Platinotypy," written by Captain Joseph Pizzighelli and Captain A. Baron Huebl. From the practical part of this work, we select the following recipes and remarks:

The paper must not be too thin, or tinted blue with ultramarine, because such paper becomes yellow in the acid bath. Paper tinted with cobalt-blue is the most suitable. The paper mill in Rives manufactures paper which is especially adapted for platinum prints. The paper must be coated with a gelatine or arrow-root solution, or the like. The strength of such a sizing solution depends upon the sizing which the paper already has, as the pores of the paper should not be entirely closed. A gelatine coating imparts to the prints a bluish-black tone; an arrow-root sizing, a brown-black tone. The following solutions are suitable for Rives paper:

Gelatine Solution.

Phototype Gelatine, . . .	10 parts.	. . (116).
Water, ...	800 parts.	
Alum, ...	3 parts.	
Alcohol, ...	200 parts.	

The gelatine is left in the cold water for about half an hour, in order to swell up; then the water is poured off, and heated to about 140° F. The gelatine is then put into the water, and, when it has dissolved, the alum, and then the alcohol, is added. Finally, the solution is filtered, through a piece of clean linen or muslin, into a porcelain or other tray, which is a little larger than the sheets to be sized. In a warm room (at 65° F.), the solution will not become torpid. The paper may be floated upon the solution, or immersed in the same. In order to immerse the sheets conveniently, the solution must cover the bottom of the tray to the depth of at least $1\frac{3}{16}''$.

The addition of the alum makes the gelatine insoluble after drying. The alcohol prevents the formation of air-bubbles, to a certain extent.

Arrow-root Solution.

Arrow-root Flour, ...	10 parts.	. . (117).
Boiling Water, ...	800 parts.	
Alcohol, ...	200 parts.	

The arrow-root is ground in a mortar, with a little cold water, and then, while constantly stirring, poured into the boiling water; after a few ebullitions, the vessel is taken from the fire, the alcohol added, and the solution decanted into a dish.

In preparing paper with arrow-root or with gelatine, it should first be immersed with that side down which is to become the picture-side, then turned over, and air-bubbles carefully removed. The paper may remain, for 2 to 3 minutes, in the solution; then it should be taken out, with a swift motion, and hung up to dry. The room must be warm enough, so that the gelatine drops off, and does not collect and solidify at the edge of the paper. When the paper is dry, the operation must be repeated, and the paper hung up to dry, in a reverse position from that in which it was suspended the first time. This must be done in order to distribute the coating more uniformly.

Linen and other fabrics are treated in the same manner as paper, but, after the second sizing, they should be stretched in a frame, to which they may be fastened with thumb-tacks.

Wood is to be planed and sand-papered, and then coated repeatedly with a 3 per cent. arrow-root solution, until it ceases to absorb the liquid.

Stock Solutions.

A.—Chloroplatinite Solution.

Chloroplatinite of Potassium, . .	1 part.	. . (118).
Distilled Water, ...	6 parts.	

This solution is perfectly air and light resisting. The platinum salt must be made by, or bought of, a chemist. It may be tested for pureness in two ways: 1. 1 part of the salt must be perfectly soluble in 6 parts of water; 2. Such solution must have no acid reaction.

B.—Normal Ferri-Oxalate Stock Solutions.

To a solution of ferric oxalate, containing, per fluid ounce, 1½ drams, or 90 grains troy, of ferric oxalate [$Fe_2(C_2O_4)_3$].
Add so much (solid) crystallized oxalic acid that, together with the free acid already in the solution, it amounts to from 6 to 8 per cent. of the ferric oxalate. (119).

The commercial ferric oxalate solution may be tested with a solution of red prussiate of potash, which ought not to produce a blue coloration;

and by boiling and diluting the solution with ten volumes of distilled water, whereby it should remain clear. The first test will detect the presence of a ferrous salt; the second, that of a basic ferric oxalate. Ferric oxalate, in solid form, can not be prepared so as to have the same composition every time.

C.—Normal Chlorate of Potassium with the Ferric Oxalate Stock Solution:

Stock Solution *B*,	8 fluid ounces.	(120).
Chlorate of Potassium,	15 grains troy.	

Solutions *B* and *C* must be preserved with perfect exclusion of light.

Sensitizing Solutions.

A.—Normal Solution:

Platinum Solution *A*,	24 volumes.	(121).
Ferric Oxalate Solution *B*,	22 volumes.	
Distilled Water,	4 volumes.	

This solution produces soft effects and deep blacks. For well-sized and highly-calendered paper the water may be omitted.

B.—Solution for obtaining results having the character of silver prints:

Platinum Solution *A*,	24 volumes.	(122).
Ferric Oxalate Solution *B*,	14 volumes.	
Chlorate-containing Solution *C*,	8 volumes.	
Distilled Water,	4 volumes.	

C.—Solution for the reproduction of drawings, engravings, etc.:

Platinum Solution *A*,	24 volumes.	(123).
Chlorate-containing Solution *C*,	22 volumes.	
Distilled Water,	4 volumes.	

If pencil drawings are to be reproduced, or when perfectly black lines are not desired, the solution may be diluted with an equal volume of water.

Sensitizing.—The paper is stretched over a glass plate, which is held in position by four strips of wood nailed to a board. The corners of the glass plate are cut off obliquely. The stretching of the paper is effected by means of four india-rubber straps, which are fastened to wooden clamps. Each corner of the paper being gripped by a clamp, the other ends of the rubber straps are attached to the board by means of hooks, so that the straps stretch the paper in the direction of the diagonals.

Small sheets of paper may be fastened to a straight drawing-board by means of thumb-tacks.

The sensitizing solution must be mixed immediately before use, because it gradually decomposes, even in the dark. For paper of the above-mentioned quality,

1 fluid ounce	of sensitizing solution will cover	10½	square feet of paper.
1 fluid dram	" " "	190	square inches of paper.
1 minim	" " "	3.15	" " "
6 minims	" " "	19	" " "

For copies on paper, linen, or wood, on which deep-black prints are wanted, it may be estimated that, for every 1,000 square inches of superficial area, 2 to 2½ grains troy of the solid chloroplatinite of potassium are required; or, for every 100 square feet of surface, 29 to 36 grains troy of the salt. The sensitizing solution may be applied by means of a flannel pad, or with a soft bristle brush, but the latter must not be mounted or bound in metal.

The sensitizing is best done in weak daylight, because, in yellow lamplight, it is difficult to see whether any portion of the paper is left uncovered by the yellow liquid. The flannel pad must be renewed every 15 minutes, or the brush washed, from time to time, in clean water. As soon as the dampness on the surface has disappeared, the sensitized sheet is hung up in a dark room, near the stove, or in a drying box, to be thoroughly dried at a temperature of from 86° to 104° F. The drying ought not to take longer than ten minutes. Absolute dryness of the paper is an indispensable condition, in order to obtain fine prints. The paper must be kept absolutely dry before, during, and after exposure to light. For this purpose, it is put into a tubular box, at the bottom of which a smaller perforated box, containing calcium chloride, has been placed. The latter is wrapped in mull. In case a part of the chloride of calcium should become wet, it must be taken out, and placed on a shovel, and dried on a stove, or over a fire, then wrapped again and replaced. Care must be taken that no particle of the calcium gets into the main box, or comes in contact with the paper. It is well to always have some dry chloride of calcium on hand, to substitute at once for such as may have become wet. In order to keep the paper dry in the printing frame, a sheet of india-rubber cloth may be placed between the blanket and the lid. Should any moisture remain, the paper will lose a part of its sensitiveness, the prints obtained will not be clear and distinct, and the white parts will not be pure.

Copying.—The copying requires, in this process, more attention than in other processes. The impression of the light produces a relatively weak, but distinctly visible image. The yellow color of the paper changes, in the light, at first to brown, and then again becomes lighter (orange-colored), so that the deepest shadows of a picture appear lighter than the medium tints. After exposure to light, the prints may be developed at once, or preserved in a calcium box until evening. It is of importance, however, that the chloride of calcium should not be allowed to come in contact with the paper, as this would cause yellowish-white spots in the finished prints.

The Developing Solution is a cold, saturated and acidified solution of oxalate of potassium, which is heated to from 176° to 185° F.

Developing.—Small prints may be placed in a tray, and the hot developing solution poured over them. For large prints this method is not practicable, and the application of a guttered, enameled iron tray is to be preferred. A developing tray, of this kind, is placed in another vessel, which is a little larger than the tray, and serves as a water-bath. It may be made of zinc or of galvanized iron. The water for the second vessel, and the oxalate of potassium solution, may be heated, in other vessels, on a stove, or over a flame, and poured, while hot, into the apparatus. A small gas flame, or an alcohol lamp, is sufficient to maintain the temperature of the developer, especially when the tray is fitted with a cover—which may be made of zinc or galvanized iron. The tray must be a little longer than the width of the widest print. In order to develop a print, the cover is taken from the tray, and the print drawn slowly through the developer. The action takes place at once, and the brown, or orange, color of the print is converted into a deep black.

In order to protect the fingers, the print is taken hold of, at two corners, by means of horn or bone pincers. If parts of the print should not come in contact with the oxalate solution—for instance, in consequence of air-bubbles—the print may be drawn, a second time, through the solution. Over-exposed prints can often be saved by lowering the temperature of the developer; under-exposed ones, by increasing the heat of the same—if necessary, to the boiling point.

It should again be remembered that the developer must have an acid reaction. It should, therefore, be tested, from time to time, with litmus paper, and, when found necessary, be acidified with oxalic acid.

After having been used, the developer is poured into a bottle, and may be used over and over again. When crystals commence to form, the evaporized water is to be replaced; and when the quantity becomes too small, fresh oxalate of potassium solution is to be added.

The developer must also be kept in a dark place.

Finishing the Prints.—Immediately after being developed, the prints are immersed in an acid bath, composed of

$$\left.\begin{array}{ll}\text{Hydrochloric Acid, ...} & \text{1 part.}\\ \text{Water, ...} & \text{80 parts.}\end{array}\right\} \ . \ . \ (124).$$

and left therein, until all of the iron salt, that may be in the paper, has been completely removed. The diluted acid must be replaced as often as it shows the slightest yellow tinge. If the prints are left, for about 10 minutes, in each acid bath, the latter must generally be replaced 3 times.

Finally, the prints are washed for 10 or 15 minutes in water, which must also be renewed several times, in order to remove the muriatic acid; then they are hung up to dry.

Prints on Wood or Linen are treated in the same manner as those on paper.

CAPTAIN PIZZIGHELLI'S NEW PLATINOTYPE PROCESS WITHOUT DEVELOPMENT.—The importance of the modifications of Pizzighelli's direct platinotype process, now to be described, will be apparent when we state that the old iron solution—so different and troublesome to prepare—is no longer necessary, its place being taken by a double oxalate of sodium and iron (sodium-ferric oxalate).

Captain Pizzighelli says: In relation to my recent memoir on the "Direct Platinotype Process," I remarked, that, in all probability, some of the definite double salts of ferric oxalate might be employed; and, since that time, I have continued my experiments in this direction, not only with double salts prepared by myself, but also with samples obtained from the firm of Schuchardt, in Goerlitz. The result must be considered as very satisfactory, and, as far as simplicity goes, the method leaves nothing to be desired.

Of the double salts experimented with, the sodium-ferric oxalate proved the most satisfactory, the corresponding potassium salt giving less sensitiveness; while the ammonium salt, although giving greater sensitiveness, gives less brilliant images than the sodium salt, and, moreover, images having a tendency to a cold, bluish tone. Still, for very hard negatives, and in the reproduction of pencil drawings, the ammonium salt may, perhaps, occasionally be used with advantage.

In the preparation of the sensitive paper, considerable variation is allowable, and the following three methods give results which are nearly identical.

First Method.—Arrow-root paste is prepared with 1 part of arrowroot and 10 parts of water, and, when this is cold, it is applied to the paper with a sponge—one sheet, 18″×22½″, requiring from 15 to 20 grammes (4 to 5 drams) of the paste. When the paste has been well distributed with the sponge, it is equalized and smoothed with a badger softener, and the sheet is hung up to dry. After drying, the process is repeated, and the sheet is again dried. To coat it smoothly, a sheet takes about 5 minutes. The arrow-root paper can be stored, for use, in a dry place, when it is sensitized with a preparation made in the manner about to be described.

Four solutions are required: *A*, *B*, *C*, and *D*.

A.—Chloroplatinite of Potassium,	1 part.	(125).
Distilled Water,	6 parts.	

B.—Sodium-ferric Oxalate,	40 parts.	(126).
Sodium Oxalate Solution (3 per cent.)	100 parts.	
Glycerine,*	3 parts.	

In preparing the solution *B*, the sodium oxalate solution is warmed to about 40° or 50° C. (104° or 122° F.), and then the sodium-ferric oxalate is dissolved in it. On cooling, a little saline matter separates; so filtration is necessary.

C.—Solution *B*,	100 parts.	(127).
Potassium Chlorate,	0.4 parts.	

D.—Mercuric Chloride Solution (5 per cent.)	20 parts.	(128).
Sodium Oxalate Solution (3 per cent.)	40 parts.	
Glycerine,	1.8 parts.	

For sensitizing a sheet (demy size) of 300 square inches, when *black tones* are desirable, we must take

Solution *A*,	5 millilitres = 80 minims.	(129).
Solution *B*,	6 millilitres = 96 minims.	
Solution *C*,	2 millilitres = 32 minims.	

For hard negatives, the quantity of solution *C* must be diminished, and *B* must be increased to the same extent; whereas, for specially soft negatives, the reverse holds good.

For *brown tones*, the following is used:

Solution *A*,	80 minims.	(130).
Solution *B*,	64 minims.	
Solution *C*,	64 minims.	

The above sensitizing solution gives a sepia-brown tone, and intermediate tints can be obtained by increasing the proportion of *C*, and correspondingly diminishing *D*.

The application of the sensitizing solution to the paper is effected by means of a suitable brush (not tin-mounted), followed by the use of the softener as before. The sheet is then dried, at about 86° or 104° F. (30° or 40° C.)

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*The addition of glycerine to this and the following solutions is only necessary in very dry weather.

Second Method.—In this method, the sodium oxalate—in fact, the developing agent—is not added to the iron solution, but mixed with the arrow-root used for sizing; and the arrow-root paste used has the following composition:

Arrow-root,	2 parts.	(131).
Sodium Oxalate Solution, containing 3 per cent.,	100 parts.	

The method of coating the paper with the starch paste is the same as already described.

Sensitizing the Paper.—The solutions *A*, *B*, *C*, and *D*, used, have the same composition as in the case of the first method, only the iron solution *B* is made up with water, instead of sodium oxalate solution.

In order to prevent mistake, the series is given below as A_2, B_2, C_2, and D_2:

A_2.—Potassium Chloroplatinite,	1 part.	(132).
Distilled Water,	6 parts.	
B_2.—Sodium-ferric Oxalate,	4 parts.	(133).
Distilled Water,	10 parts.	
C_2.—Solution B_2,	100 parts.	(134).
Potassium Chlorate,	0.4 parts.	
D_2.—Mercuric Chloride Solution (5 per cent.),	20 volumes.	(135).
Sodium Oxalate Solution (3 per cent.),	40 volumes.	
Glycerine,	1.8 volumes.	

The general directions, as to the series *A*, *B*, *C*, and *D*, apply equally to the preparation and use of the series A_2, B_2, C_2, and D_2.

Third Method.—This method is a simplification, as the sizing of the paper is not a separate operation, the thickening material being mixed with the sensitizing preparation. For this method, four solutions, which are designated A_3, B_3, C_3, and D_3, must be prepared, and the composition of these solutions is as follows:

A_3.—Potassium Chloroplatinite,	1 part.	(136).
Distilled Water,	6 parts.	
B_3.—Sodium-ferric Oxalate,	40 parts.	(137).
Powdered Gum Arabic,	40 parts.	
Solution of Sodium Oxalate (3 per cent.)	100 parts.	
Glycerine,	3 parts.	

To prepare B_3, the sodium oxalate solution is first heated to 40° or 50° C. (104° or 122° F.), when the iron salt and glycerine are stirred in.

After the former is completely dissolved, the solution is transferred to a mortar, when the gum is gradually added, and thoroughly incorporated. This being done, the mixture is allowed to stand at rest, for some hours, in order that small agglomerations of gum may thoroughly dissolve, after which the whole is again incorporated, and then squeezed through a cloth.

C_3.—Solution B_3,	100 parts.	(138).
Potassium Chlorate,	0.4 parts.	

D_3.—Mercuric Chloride Solution (5 per cent.),	20 parts.	(139).
Sodium Oxalate Solution (3 per cent.),	40 parts.	
Powdered Gum Arabic,	24 parts.	
Glycerine,	1.8 parts.	

Solution D_3 is mixed in a similar way to that recommended in case of B_3.

The proportions in which A_3, B_3, C_3, and D_3 are to be mixed for use are analogous to those of the first method, and the following may be mentioned as suitable for black images under ordinary conditions:

A_3.—Platinum Solution,	5 volumes.	(140).
B_3.—Iron and Gum Solution,	5 volumes.	
C_3.—Gum and Chlorate Solution,	2 volumes.	

When, however, sepia-brown images are required, the following may be used:

A_3.—Platinum Solution,	5 volumes.	(141).
C_3.—Gum and Chlorate Solution,	4 volumes.	
D_3.—Mercuric Iron and Gum Solution,	4 volumes.	

The application of the mixture is made with the brush, according to the instructions already given, and during the application numerous small bubbles are formed; but these can be disregarded, as they disappear completely when the coating is smoothed with the badger softener. The gum layer dries with a light gloss, but no particular precautions are necessary in drying.

It should be mentioned, that the third method appears to be, on the whole, the most convenient, and the most worthy of recommendation.

After drying, the paper should be preserved in the chloride of calcium box; but the paper prepared as now recommended seems to be far less prone to alteration than that prepared by the older methods, as specimens kept for 10 days, without any special precautions, gave results quite as good as those obtained on paper which had been kept in the chloride of calcium box.

Nothing very special is to be said about the printing, except that the action of the light must go on until the image shows the intensity it should have when finished—in short, there should be no over-printing.

The printing being finished, the paper is immersed in the following:

Hydrochloric Acid, ...	1 volume.	. (142).
Ordinary Water, ...	80 volumes.	

This solution is changed two or three times—in fact, until it shows no further trace of yellow color—after which there is nothing to be done but to wash the platinotype print in water, and to dry.

Under-printed images may be developed in a cold solution of sodium or potassium oxalate; and, in conclusion, it should be mentioned, that the iron salt, in the solid form—as also its solution, and the mercuric solution—should be kept in the dark.

Photo News.—Phil. Photographer.—Photo. Corresp.

XI.

PROCESSES WITH SALTS OF CHROMIUM.

THE chromic salts, which are used in heliography (bichromate of potassium [$K_2Cr_2O_7$] and bichromate of ammonium), have properties similar to those of the ferric salts. When a chromate, in the presence of an organic substance, is exposed to the action of light, the organic substance takes away oxygen from the chromate, and the chromic acid is reduced to brown chromo-chromic oxide. Certain organic substances, such as albumen, gelatine, sugar, etc., hereby alter their nature. The heliographic processes with chromium salts may be divided into two distinct groups. The first group includes those processes in which either the reduced or the unaltered chromate is used in producing the picture; the second contains all those processes in which the nature of the organic substance, either in the altered or in the unchanged parts, is applied in forming the image.

Those prints produced by a process of the first group — in which the chromate alone forms the pale image — may be intensified or toned by various re-agents. Lead, silver, and mercury salts, will produce, respectively, a yellow, red, and brown color. Certain chromium compounds, also, act as mordants for fixing certain dye-stuffs, such as alizarine, logwood, yellow-wood.

The changes in the nature of organic substances, which are caused by chromates when they are reduced by light — and which are made use of in the processes of the second group — are the following: A chromate, or bichromate, can be dissolved, and mixed with glue or gelatine in hot water, or with gum arabic or albumen in cold water, without either of these substances suffering a change at once, on account of the chromic salt. If a plate of glass, or a sheet of paper, be coated with such a solution, and allowed to dry in the dark, it becomes firm, and yet remains soluble in water. As soon as the film is, however, influenced by light, and the chromate is reduced to a chromic oxide salt, the film of glue, gelatine, gum, or albumen is tanned — that is to say, is made insoluble in water. This discovery was first made by Fox Talbot, in 1852, and applied for producing steel-plate engravings.

If, after exposure to light, a sheet of paper, that has been coated with chromated gelatine, is rubbed with a moist sponge, the paper will imbibe the water at those places on which the light had not been able to act. It is, also, a singular fact, that, if printing ink is then applied, it will only adhere to those places that were affected by the light. This fact was discovered by Poitevin, the meritorious discoverer in photographic chemistry.

If bichromated gelatine, or gum, is mixed with sugar, grape sugar, honey, or glycerine, and a sheet of paper, or a plate of glass, metal, porcelain, or the like, be coated with such a solution, and dried, the film will be hygroscopic, but, if exposed to light under a drawing, it will lose this property in all those parts which were not protected by the opaque lines of the drawing, and upon which the light could act. If, now, such a print is brought to a damp place, or breathed upon, and then lampblack, or another impalpable powder, is dusted over the print, the powder will only adhere to those places which were protected from the light by the black lines of the drawing, and which absorbed moisture.

Upon these changes in the nature of chromated gelatine, albumen, etc., not only a large number of heliographic processes, but also a large number of photo-mechanical printing processes — such as Photo-lithography, Woodburytypy, Artotypy, Phototypy, Pyrotypy, etc.— are based.

1. Processes in which the Reduced Chromate Forms the Base of the Picture — Mungo Ponton's Chromium Prints.

Mungo Ponton was the first to succeed in making chromium prints. He published his discovery, in 1839, in the New Philosophical Journal. Ponton saturated paper with a solution of bichromate of potash, dried it in the dark, exposed it under a drawing, and fixed by washing in water. The resulting print is a negative in white lines on a very pale greenish-brown ground. According to Hunt and Burnett, bichromate of copper furnishes a more intensive copy than bichromate of potassium. Such bichromate of copper prints may be colored reddish-brown by a solution of red prussiate of potash. Bichromate of copper is formed on mixing solutions of sulphate of copper (blue vitriol) and bichromate of potassium. A brown negative print may be obtained, from a positive, on paper sensitized with the solution given in Haleur's chromate of silver process, by developing it with a solution of red prussiate of potash.

M. Guardabasiti's Process.—The paper is sensitized by immersing the same, for 5 minutes, in a cold saturated solution of bichromate of potassium. When dry, the paper is exposed to light, under a drawing (or, if a positive print is desired, under a negative), until the image is visible on the back of the paper. The parts affected by the light will look reddish-brown. Then the print is floated on water, picture-side up, until all the chromic salt, which was not altered by the light, is dissolved.

Then the print is floated upon a solution of

Saturated Solution of Nitrate of Mercury,	4 parts.	(143).
Bichromate of Potassium, ...	1 part.	
Water, ...	28 parts.	

The solution must be filtered, and be made some time before it is used. It must have a greenish color, and be transparent. The print is floated upon this solution, picture-side down, for 15 or 20 minutes, until it has an intensive red color, and, after it has been thoroughly washed, it is immersed in diluted ammonia water, consisting of

Strong Ammonia Water, ...	1 part.	(144).
Distilled Water, ...	50 to 75 parts.	

wherein the color of the print changes to brown. The print is washed again, and then fixed and toned dark in a bath of

Chloride of Gold, ...	1 part.	(145).
Dissolved in Distilled Water, . .	7,500 parts.	

Then the print is washed in water, for the last time, dried, and finally varnished with a solution of

Shellac, ...	8 parts.	(146).
Alcohol, ...	100 parts.	

Photo. Mitth., Vol. 4.

R. B. West's Patents on Photographic Printing.

Abridgment of U. S. Patent No. 273,206, dated February 27, 1883.

First. The bath for rendering the paper sensitive to light. I prepare a bath as follows:

Take of Potassium Bichromate, . .	3 parts.	(147).
Magnesium Sulphate, ...	1 part.	
Mercuric Chloride	1 part.	

Mix, and dissolve in the smallest quantity of boiling water required for solution and crystallizing.

Of this Compound take	75 grains	(148).
To each ounce of Water employed in the bath.		

The paper is floated in this bath for, say, 3 minutes, and is then dried in the dark. When required for printing, it is placed under the negative a sufficient time to make the lighter shades in the print visible, the time varying, say, from 3 to 10 minutes, under direct sunlight. The exposed portions of the print will be light-brown upon a yellow ground. So soon as this condition is attained, the paper is taken from beneath the negative, and soaked in pure water, say, for 20 minutes. If the negative be very intense, such as to require 10 or more minutes of direct exposure to the sunlight, the soaking should be continued longer—say to about half an hour. This is desirable, because it facilitates the subsequent developing. The excess of bichromate being removed, leaves the whites of a faint-yellow tint. Where pure whites are required, it becomes necessary to destroy all traces of bichromate, where the light has not acted, and which are not easily removed by soaking. For this purpose the print is immersed, for 1 or 2 minutes, in a solution of

Acid Sulphite of Sodium, . . .	1 part.	(149).
Water, ...	99 parts.	

To prepare the developer, I take of

Gallic Acid, ...	2 parts.	(150).
Ferrous Sulphate, ...	3 parts.	
Aluminum and Ammonium Sulphate,	3 parts.	
Sodium Hyposulphite, ...	24 parts.	

The ferrous sulphate, aluminum and ammonium sulphate, and sodium hyposulphite, are each dried separately, until free from water of crystallization, and are then pulverized, and mixed with the gallic acid. This compound will keep, and retain all its properties, if protected from dampness.

Of this Composition take	15 grains.	(151).
Water, ...	1 ounce.	

To develop the print, lay it in a suitable dish, and pour upon it the developing solution, to cover it, say, ¼ inch in depth; or, if several prints are to be developed at the same time, take enough of the solution to cover all the prints. While they are in the solution, move them frequently, so as to expose them equally to the developing solution. When the development of the print is completed—which will generally require about 10 minutes—the excess of the developer, absorbed by the paper, is removed by soaking the print, for half an hour, in water slightly acidulated with acetic acid; after which, and when dry, the picture can be mounted. Its subsequent treatment may be, substantially, that usually applied to photographic prints. The sodium hyposulphite and alum, in the developer, exert a reducing action, which prevents the ferrous salt from becoming oxidized readily when in solution and exposed to the air, and enables the bath to be used repeatedly for several days, if, after use, the precaution is taken of putting it in a tightly-corked bottle, which should be filled by the solution.

Any color, from black to brown, can be obtained, after soaking out the developer, by immersing the print, from 1 to 5 minutes, in a bath composed of

Sensitizing Bath, ...	1 part.	. (152).
Water, ...	2 parts.	

the time of contact with the bichromate determining the shade, and, after such treatment, soak in water, until the yellow tint is entirely removed.

If desired to change the color of a print to reddish-brown, subject it, after development, to a bath composed of

Carbonate of Soda, ...	1 ounce.	. (153).
Water, ...	1 quart.	

and dry immediately.

In case it be necessary to bleach the picture, it should be done after development, and before any change of color is effected, and may be well done by subjecting the print to a solution of

Citrate of Ammonia, ...	1 part.	. (154).
Water, ...	20 parts.	

The paper may be prepared for sensitizing by any of the known processes; but I find a very good result is obtained from the following treatment: Take paper of a good quality, coat it with a mixture composed of

Starch, ...	7 parts.	. (155).
White Sugar, ...	2 parts.	
Glycerine, ...	2 parts.	
Boiling Water, ...	200 parts.	
Solution of pure Caustic Potash,	¼ part.	

or sufficient to cause the coating to dry with an even surface. The first three ingredients are mixed with a little cold water, and then stirred into the boiling water. The coating is applied by floating the paper upon the mixture, in the manner usually employed in the application of albumen to paper. After drying, the paper is dipped in a solution of

Acetic Acid,	2 parts.	(156).
Water,	98 parts.	

and, when again dried, it is ready for use. In cases where the intensity and appearance of the print are of little importance, paper may be used without this treatment. Albumen paper does not, under my improved process, produce so good results, chiefly on account of its density.

From my experiments, I believe the proportions for the sensitizing and developing baths above given produce the best results; but these proportions may be varied, to some extent, without departing from my invention.

By this process, I am enabled to produce photographic prints fully equal to those produced by the employment of silver; and it will be evident, to those skilled in this art, that the cost of the production is very much less than by the usual process employing nitrate of silver. The printing is also more rapid than by the usual process, and colors may be more readily applied to the print than when the print is prepared under the usual process.

Abridgment of U. S. Patent No. 341,083, dated May 4, 1886.

This invention relates to an improvement in the preparation of paper for printing photographs, the paper being specially adapted to photographic printing under the process for which Letters Patent No. 273,206 were granted to me February 27, 1883, parts of the invention, however, being applicable to other processes of printing; and the invention consists in coating both sides of the paper with a preparation of starch. The paper best adapted is that known in the market as "B. F. K. Rives, No. 74."

The bath, in which the paper is to be coated, is prepared after the following formula:

Potato Starch,	6 ounces.	(157).
Glycerine,	2 ounces.	
Sodium Citrate (nearly, but not quite, neutral),	$\frac{1}{4}$ ounce.	
Pure Water,	220 ounces.	

To prepare the bath, take, say, $\frac{1}{10}$ of the water, boil it, to expel the air, then cool. In this, mix the starch, glycerine, and citrate. Heat the remainder of the water until it boils; then remove from the fire, and immediately add the ingredients previously mixed with the first portion of water.

After the one surface has been thus presented to the bath, and completely coated, the sheet is at once removed, and inverted, presenting the other side, which is allowed to float, for a few seconds, on the surface, and then the paper is suspended and dried; and, for the best results, the drying should be rapid.

The starch coating has a strong adhesive quality, and attaches the paper permanently to the card. The glycerine makes the paper more flexible when dry than it otherwise would be. The sodium citrate makes the starch more homogeneous, and improves the whites of the pictures.

Abridgment of U. S. Patent No. 345,753, dated July 20, 1886.

1. To Sensitize the Paper.—To produce the best results, the paper is first coated, upon both sides, with a starch solution. The sensitizing solution is prepared from the following formula:

Potassium Bichromate,	8 parts.	(158).
Mercuric Chloride,	4 parts.	
Aluminum Sulphate,	1 part.	

For convenience, these may be in powder. For the bath, take pure water, according to the size of the bath, and, to each ounce of water, add 50 grains of the above-mentioned compound, and thoroughly dissolve the same in the water. The paper is immersed in the bath, so as to wet both sides, not to exceed 1 minute. The paper is dried—may be by artificial heat, but coal-gas, or kindred vapors, should be avoided, as injurious to the surface—and the paper thus sensitized should be used the same day, to produce the best results; but it may be kept several days, in a dark, cool, damp place. The 1 part of aluminum sulphate may be omitted, if less contrast is desired, without materially affecting the result.

2. Printing.—The printing should be carefully watched, during its progress, and should be carried only so far as to make visible all that is desired to show in the finished print. When a sufficient number of prints have accumulated, they must be washed, for 20 or 30 minutes, in clear water, and then developed.

3. Developing.—The compound, from which the developing bath is made, is from the following formula:

Gallic Acid,	15 parts.	(159).
Pyrogallol,	1 part.	
Ferrous Sulphate,	15 parts.	
Sodium Hyposulphite (dried),	100 parts.	
Aluminum and Ammonium Sulphate (dried),	15 parts.	
Potassium Bitartrate,	12 parts.	

These should be kept in stock, dried. Each of the ingredients required dried, is obtained so by fusing the commercial article, and maintaining it in that condition until the water of crystallization is driven off. This process of drying is necessary, to prevent decomposition of the compound. If possible, the ingredients should be in a fine, granulated condition, rather than in powder. The proportions called for above are weighed out after the materials have been dried. When mixed, they should be immediately packed in tight dry bottles. The compound will then keep indefinitely.

To prepare the developing bath, it should be made the same day that it is required for use. Add 10 grains of the dried composition to each ounce of water.

The test of the good working quality of the ingredients may be made as follows: After the solution has stood for 20 minutes, it should not indicate an inky appearance, or any trace of it, but, on the contrary, should remain colorless for, at least, 24 hours. The print should be developed in from 5 to 10 minutes, but prolonged immersion should not reduce the intensity of the print. If it is so reduced, an excess of acid is indicated. If the development of a cabinet print (6½"×4¾"), in 2 fluid ounces of bath, should produce an inky appearance of the bath, or trace of it, it would indicate an excess of alkali in the bath, which should be corrected. 2 fluid ounces of the bath is an ample allowance for each cabinet print to be developed. Several prints may be developed in succession, if the bath is allowed to repose some minutes between the development of each print. During the developing operation, the bath should be rocked, but in no case should the bath be crowded.

The method of developing is as follows: After the prints have been washed, for 20 or 30 minutes, they are placed in the developing bath, until their color changes from yellow, or light-brown, to violet-black. The development is completed when, on holding the print up to the light, no brown tint is seen in the shadows. When it has arrived at this condition, a prolonged immersion in the developer will produce no change, either in the shadows or high-lights. If, however, the print has become bronzed by prolonged exposure, it will not perfectly develop. To prevent this bronzing — which occurs from a thick nagative — the clearer portions should be deadened, either by an application to the back, or by roughening the varnish with retouching-powder.

4. BLEACHING. — After the print has been taken from the developing bath, it should be thoroughly rinsed in pure water; but the whites will not be sufficiently pure without more or less bleaching. For this purpose, a bath, from the following formula, is prepared:

Bromine, ...	1 ounce.	. (160).
Bromide of Potassium, . .	2 ounces.	
Water, ...	10 ounces.	

This should be kept from the light. When it is required to bleach the whites of prints, add enough of the bleaching solution to water to color light-yellow or amber; then immerse the prints, until sufficiently whitened. If the shadows are too dark, add a little acetic acid to the bath. A deep bath will produce better results than a shallow one. As soon as the prints are bleached, they may be at once mounted, if the color is satisfactory; if not, they may be transferred to the toning bath.

5. TONING. — I employ the following formula, for the preparation of the compound for the toning bath, and which may be kept in stock:

Potassium Nitrite, ...	4 parts.	. (161).
Lead Nitrate, ...	1 part.	

The potassium nitrite may be prepared from potassium nitrate, or saltpetre, by melting in a crucible, and keeping at a red heat, for 2 hours. For the toning bath, for each ounce of water, add 5 grains of the toning compound. The prints are immersed in this bath after bleaching. When acetic acid has been added to the bleaching bath, it is better to wash the prints before toning. This toning, it will be observed, is the reverse of silver toning. If a cold-gray and black are desired, a trace of mercuric chloride, added to the bath, will produce that result. A larger proportion of the mercuric chloride will produce a greenish-black.

Abridgment of U. S. Patent No. 345,938, dated July 20, 1886.

This invention relates to an improvement in the process of photographic printing, described in another application, Serial No. 167,289. In that application, the paper is sensitized by subjection to a bath, consisting of a solution, in water, of potassium bichromate and mercuric chloride. After the paper has been properly dried, it is printed upon, by exposure to light, under a negative, in the usual manner. The photographic prints thus produced are of a yellow color, which, not always being desirable, the object of my present invention is to change this yellow tint to a more desirable violet-black; and the invention consists in the treatment of the prints, as hereinafter described, and particularly recited in the claims. After washing the prints, in clear water, I subject them to a developing bath, produced by a solution of the following compound, in water. The developing compound consists of

Pyrogallol, ...	2 parts.	. (162).
Gallic Acid, ...	8 parts.	
Ferrous Sulphate (dried), or other Ferrous Salt soluble in water,	10 parts.	
Sodium Hyposulphite (dried), . .	80 parts.	

This compound is prepared in mass, and sold for use when required. The solution is made by dissolving the compound, in water, in the proportion of 2 per cent. of the compound to the water. By employing the pyrogallol in the solution, I am enabled to change the color, which it produces, to a brown, or any intermediate shade, by subjecting the prints to a toning bath containing lead nitrite. Without the pyrogallol, a violet-black is produced by an aqueous solution of the three other ingredients; but the color is not subject to change in the toning bath. The ferrous salt referred to is, preferably, ferrous sulphate; but I sometimes use ferrous tartrate, or other ferrous salt, or produce these salts in the bath by adding to the compound an alkaline tartrate, etc.

The advantage in substituting other iron salts for the sulphate is, that by so doing, I can vary the color developed — within certain limits — according to the ferrous salt used and the proportion of pyrogallol, from the violet-black, produced by the sulphate alone, to a warmer tone, using the toning bath only when it is necessary to obtain well-marked browns.

In my previous processes, I added alum to the gallic acid, ferrous sulphate, and sodium hyposulphite, for the purpose of obtaining prints having clear whites; but I find this addition unnecessary with the method of bleaching which I now use, and objectionable, as it prevents the development of a good color. The print should be left in the developing bath from 5 to 10 minutes, then removed from the bath, then washed in clear water, and then may be bleached by the action of a dilute solution of chlorine or bromine. The bleaching action of the halogens should be modified by the presence of an acid, as it is then more even.

The chlorine bath is best prepared by dissolving 1 part of calcium hypochlorite in 300 parts of water, and adding about 2 parts of an acid — preferably phosphoric.

After the prints have been bleached, they may be mounted in the usual manner; or, if a brown color is desirable, they are toned by subjecting them to a bath consisting of

$$\left.\begin{array}{l}\text{A 1 or 2 per cent. Solution of Lead Nitrite, or a Mixture}\\ \quad\text{of Potassium, or Sodium Nitrite, and Lead Nitrite.}\end{array}\right\} \cdot (163).$$

but, should a cold-gray be preferred to the brown, then add, to the toning bath, from 2 to 5 per cent. of mercuric chloride. The prints are then washed in clear water.

The proportions which I have mentioned, for the ingredients in the several compounds and baths, are such as, in practice, have produced the best results; but they may be varied somewhat, without departing from my invention.

I would state that, in order to attain the best results, the paper should possess a considerable degree of porosity, and be thickly coated with starch, on both sides, and the paper should be free from alkaline particles.

2. Processes in which the Unaltered Chromate Forms the Base of the Picture. — Direct Processes.

Halleur's Chromate of Silver Prints. — Paper is sensitized, by means of a brush, with a mixture of equal volumes of

A Saturated Solution of Bichromate of Potassium,
A Saturated Solution of Sulphate of Copper. . (164).

and may be used as soon as dry, or preserved, for some time, in a dark place. By exposure to light, under a drawing, or other positive, the uncovered parts will, at first, become brown, and the picture will appear as a negative. On continued exposure, the brown color becomes lighter, and the picture will then be positive. The exposure, through tracing paper, and in the direct rays of the sun, requires from 25 to 30 minutes. The prints are developed and toned with a solution of nitrate of silver, of any strength. We have used a solution of

Nitrate of Silver, . .	20 grains troy.	. (165).
Distilled Water, . .	1 fluid ounce.	

and applied the same by means of a camel's-hair brush. The beautiful blood-red picture, which appears at once, will be fixed by washing it in pure water. If the water contains a chloride, or if a small amount of sodium chloride (common salt) be dissolved in the water, the picture disappears entirely; but it remains latent in the paper, and can be re-developed by exposing it, still wet, to the direct rays of the sun, and then drying it. The color of the picture will, however, change hereby. According to the quantity of salt used, it will vary from a rose-color to a dark-violet. The longer it is left in the sun, the more the print will gain in beauty.

According to other operators, the sensitizing solution, for this process, is composed of

Bichromate of Potash, . . .	10 grains.	
Sulphate of Copper, ...	20 grains.	. (166).
Distilled Water, ...	1 ounce.	

The author had made over 1,000 prints by this process, which looked very beautiful, but, in about 6 months, nearly all were spoiled, as the ground became green, and the picture faded away.

CROS AND VERGERAND'S CHROMATE OF SILVER PROCESS.—Suitable paper is coated with the following solution:

Bichromate of Ammonia,	2 parts.	(167).
Glucose (Grape-Sugar),	15 parts.	
Water,	100 parts.	

When dry, it is exposed to light, under a drawing, or other positive. As soon as the yellow paper becomes gray, it is removed, and immersed in a bath of

Nitrate of Silver,	1 part.	(168).
Water,	100 parts.	
Acetic Acid,	10 parts.	

The image will immediately appear, of a ruby hue, due to the bichromate of silver formed. The print, on being washed, retains the red impression of the insoluble bichromate, which becomes dark-brown on exposure to sunlight. On submitting the print, when dry, to the fumes of sulphureted hydrogen, or dipping it in a solution of sulphite of copper and potash, it becomes black.

FOXTYPE.—This process has been patented in Great Britain, by its discoverer, Thomas Fox, Esq.

Sensitizing Solution.

Bichromate of Potassium,	1 part.	(169).
Sulphate of Copper,	2 parts.	
Water,	32 parts.	

Ordinary writing or drawing paper is floated upon this solution, for 4 or 5 minutes, and then hung up to dry, in the dark. When dry, the paper is submitted, under a drawing, or transparent positive, to the action of light. The time of exposure is—in the sun—about 2 or 3 minutes.

DEVELOPMENT.—Shavings of logwood are boiled in water, for about 2 hours; the decoction is then filtered, and used hot. The prints are floated upon the developer until they are sufficiently intense. They are then immersed in a hot solution of alum, in order to remove the yellow color from those parts of the paper on which the light has acted. Finally, the prints are washed well, dried, and varnished.

Different shades of color—from blue, purple, light-black, and deep-black—can be obtained by varying the strength of the sensitizing solution, as also the decoction of logwood.

Willis's Aniline Process.—This process is extremely useful for copying plans and other simple line-drawings. It was originally invented and patented by Mr. Wm. Willis, and, later, developed and improved by other investigators. Dr. Vogel has made the most extensive experiments, in regard to the aniline process, and published the results of the same. The Willis patent has expired, and it is to be hoped that this process will now be more extensively used.

The aniline process is founded upon the property of the bichromates of forming, with aniline salts, dark-colored precipitates. The lower oxides of chromium, which are produced by light on paper that has been coated with a solution of bichromate of potash, also re-act upon aniline salts, but, comparatively, only very slightly.

Dr. Vogel says, not every kind of paper is equally suitable for aniline prints. Rives' paper gives, for example, but imperfect results. On Steinbach's paper, he obtained the best prints.

The best sensitizing solution is, according to Vogel, composed of

Bichromate of Potassium, . . .	1 part.	. . (170).
Phosphoric Acid, of 1.126 spec. wt.,	10 parts.	
Water, ...	10 parts.	

The intensity of the color of the finished prints increases with the quantity of the chromate—and more so with the quantity of the phosphoric acid—which the sensitizing solution contains. The sensibility decreases as the quantity of the acid increases.

Dawson gives the following recipe for the sensitizing solution:

Bichromate of Potassium, .	30 grains.	. . (171).
Phosphoric Acid (diluted), .	1 fluid ounce.	
Water, ...	1 fluid ounce.	

According to Reynold, the sensitizing solution is composed of

Concentrated Solution of Bichromate of Potassium, (1 to 10),	4 fluid ounces.	. . (172).
Sulphuric Acid, ...	1½ fluid ounces.	

Dr. Vogel did not succeed with Reynold's solution. The surface of the paper was tinted disagreeably grayish-brown, and the print was weak, and appeared to be sunk into the paper.

The sensitizing is best done by floating the paper upon the solution, for about 1 minute (not longer), and then drying it quickly, in a warm and dark room, or near a stove. If the paper is floated too long, the solution penetrates into the paper, and the back will be colored.

The correct time of exposure to light is of great importance in this process. If the exposure was too short, the ground of the finished prints will also be colored; if it was continued too long, the picture will either not develop at all, or it will come out but partly, or very slowly.

The time of exposure to diffused light required is, for originals,

On tracing paper, . . .	about 10 minutes.
On thin drawing paper, .	about 1 hour.
On thick drawing paper, .	about 2 to 3 hours.

In the direct rays of the sun, the exposure required is only $\frac{1}{3}$ of the time given. In order to determine, with certainty, whether a print has been exposed sufficiently long, it is advisable to expose, with the main printing frame, narrow strips of the same sensitized paper, under a small glass plate, and under similar paper to that on which the original is made, in the manner recommended and described on page 70, in the article on direct cyanotypy.

The developing is done in a shallow box, the size of the largest print. To the inner side of the lid of the fuming box, a few sheets of blotting paper must be fastened, which are to be sprinkled, uniformly, with a solution of

Raw Oil of Aniline, . .	20 to 40 drops.	. . (173).
Benzole, ...	1 ounce.	

The print is placed upon the bottom of the box. The more aniline the solution contains, the quicker the developing process goes on. If the print was not over-exposed, the image appears in a few minutes, and gains continually in intensity. The color is a dirty blue-green-black, which becomes a fine blue when the print is immersed in water. By continuing the fuming process sufficiently long, a dark bluish-black color may be obtained.

The duration of the fuming process depends upon the time the print was exposed to the action of light. Under-exposed prints ought not to be fumed as long as is required to obtain dark-blue or bluish-black pictures, because the ground would also become tinted. Sometimes it happens that the prints become of a green color in the washing water; this can be easily converted into blue, by adding a little ammonia to the washing water. Acid produces a green, alkalies a blue, color.

The washing of the prints in acidified water has the advantage of removing the chrome-oxide from the paper. The ground will become nearly white when the prints, after the first washing in water, are immersed in a bath of

Sulphuric Acid, ...	1 part.	. . (174).
Water, ...	100 parts.	

then washed once more in pure water, and, finally, tinted blue again, by plunging them into diluted ammonia water, consisting of

Ammonia Water, ...	1 part.	. . (175).
Pure Water, ...	100 parts.	

If the paper was sensitized with the solution, according to Dr. Vogel's recipe, and if the time of exposure was correct, the acid bath will hardly be necessary. Sometimes the prints will look spotted, when they get wet in the washing water, although they were perfectly clean before. Such spots will disappear in drying.

The washing water should often be renewed—say eight times—and if the tone should be green, a little ammonia may be added to the fourth water. The prints may be toned a fine and durable green, by immersing the same in a diluted solution of gallic acid.

V. J. M. Gottlieb's Method of Reproducing Drawings and Other Line-Works of Art.

Abridgment of U. S. Patent No. 306,481, dated October 14, 1884.

The following solution is made use of, in preparing the paper; the materials employed being those named, or substances having equivalent chemical properties, and in about the proportions stated:

Bichromate of Potash, . .	9.6	grams.	. (176).
Vanadate of Ammonia, . .	0.015	grams.	
Chloride of Sodium, . . .	9.6	grams.	
Sulphuric Acid (about 98°), .	21	grams.	
Distilled Water, ...	441	grams.	

These substances are to be carefully and thoroughly mixed together. The paper to be sensitized is coated over with this solution, and then allowed to dry, for a few minutes, in a dark place. The reproduction is effected by exposure to the sunlight. After exposure, for the proper length of time, to the action of light—varying, from 10 seconds to 15 minutes, according to the intensity of the light and the transparency of the original drawing—the impression is removed, and developed by steam and aniline oil. To effect this, a few drops of aniline oil are put into the water, or the steam allowed to pass through a cloth upon which the oil is placed. The exposure to the steam and vapor of the aniline oil may be in a closed vessel, or box, or the paper may be passed over the vapors by hand, in the open atmosphere, after which the reproduction is dried quickly, and will be found to be a durable picture, the lines being black, or nearly so, and the surface, or background, of a very light greenish tinge.

I have sometimes added ether, or aqua ammonia, to the solution before-named, for varying the color of the lines, or the background, or for rendering the surface more or less sensitive than that prepared by the aforesaid formula. The ammonia renders the operation more reliable, so that the lines are not injured if the exposure is unnecessarily long.

3. Processes which are Based Upon the Property of a Film of Gelatine, Gum, or the like, Containing a Chromate, to Become Insoluble by the Action of Light.

Abridgment of English Patent No. 2,815, of December 13, 1855, to Alphonse Louis Poitevin.

* * * * One or more films of a concentrated solution of albumen, fibrine, gum arabic, gelatine, or similar organic substance, and a concentrated solution of a chromate or bichromate of potash, or any base which does not precipitate the organic matter of the first solution, are applied to the paper. * * * * * * *

Various liquid and solid colors are applied, upon paper, cloth, glass, and other surfaces, by mixing such colors with the aforesaid mixture of a chromate or bichromate with organic matter, and applying this new mixture, or combination, to the paper or other fabric surface. The photographic impression is produced, upon this prepared surface, by the action of light passing through a negative photographic picture, or an engraving, or other suitable object, or screen, or in the camera obscura, and it is then washed, with a sponge and a large quantity of water. The albumen, or other organic matter, is rendered insoluble at the parts where it has been acted upon by light, and the design is thus produced in the color which has been employed. Mixtures containing different colors may be applied to different parts of the surface, corresponding to different parts of the negative, or screen, employed to produce the photographic impression.

M. Tilhet's Process of Reproducing Drawings and Designs.

*Abridgment of U. S. Patent No. 251,746, dated January 3, 1882.**

This invention has for its object a novel method of reproducing copies of all kinds of drawings, or other designs, and it is applicable to the reproduction of such copies upon any kind of paper, and either in black, red, blue, green, or any other color.

In order to put the invention in operation, the paper upon which the design is to be reproduced, in order to prepare a negative copy, is

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* Patented in France, August 21, 1879; in England, November 26, 1880; in Belgium, November 27, 1880, and in Germany, November 29, 1880.

first passed through a bath, composed of the following materials, in about the proportions given—that is to say:

White Soap,	30 parts, by weight.	(177).
Alum,	30 parts, by weight.	
Flanders Glue,	40 parts, by weight.	
Whites of Eggs, beaten up,	10 parts, by weight.	
Glacial Acetic Acid,	2 parts, by weight.	
Alcohol, at 60°,	10 parts, by weight.	
Water,	500 parts, by weight.	

The paper, after leaving this bath, is then passed through a second bath, composed as follows:

Burnt Umber, ground in Alcohol,	50 parts, by weight.	(178).
Black Pigment,	20 parts, by weight.	
Flanders Glue,	10 parts, by weight.	
Water,	500 parts, by weight.	
Bichromate of Potash,	10 parts, by weight.	

The paper, having been thus treated, must be kept in a dark place.

In order to prepare positive paper for the prints, a bath is used similar to the last, but without the umber, for which black pigment is substituted; or, to obtain colored proofs instead of black ones, the black pigment is replaced by a pigment of red, blue, or any other desired color.

To prepare the copies, the design or drawing is placed in an ordinary photographic printing frame, the back of the design being next to the glass, and a sheet of negative paper, prepared in the way first described, is placed in contact with it. The frame is then exposed to light—2 minutes' exposure being sufficient in good weather. The sensitive paper is then removed from the frame, in a dark place, and is placed in water, when the design becomes visible, in white, and the paper is then allowed to dry.

In order to obtain positive pictures from the negative thus prepared, the latter is placed in the printing frame, with a sheet of the positive paper in contact with it, and, after exposure to light for a sufficient time—that is to say, about 2 minutes—the positive paper is removed, in a dark place, and is plunged into water, which removes the part of the pigment which has not been affected by the light, without its being necessary to touch it.

Any number of copies of the design, or drawing, may be produced, by the novel method described, upon any kind of paper, and in any color or colors.

W. W. Sherman's Process of Producing Photographs in Permanent Pigments.

Abridgment of U. S. Patent No. 332,364, dated December 15, 1885.

I prepare 2 stock solutions, which I call "No. 1," and "No. 2," respectively, the first being used in the sizing of the paper, and the second, in connection with the first — together with pigments and a sensitizing salt — in preparing the paper for printing.

I prepare my stock solution No. 1 by

Soaking Nelson's Photographic Gelatine No. 1, in cold water, for 15 minutes, pouring off the water not taken up by the gelatine, melting the residue, by the aid of heat, and filtering. (179).

To size the paper, take 1 part of the stock solution No. 1 and dilute with 3 parts of water. The paper may be floated on the sizing solution, or drawn through it, or the sizing may be applied by means of a brush, the object being to evenly coat the surface to receive the impression. After sizing, the paper is allowed to dry.

My stock solution No. 2 is made by

Soaking Coignet's Gelatine ½ hour in cold water, pouring off, as before, the water not taken up by the gelatine, and then melting the residue, by the aid of heat, adding to the melted mass 6 times its bulk of water, and filtering. (180).

To prepare the paper for receiving the impression, I

Take ½ fluid ounce of each Stock Solution Nos. 1 and 2, and add 1½ drams of a Saturated Solution of Bichromate of Potash, and a sufficient quantity of pigment — previously mixed with water — to produce results of the desired depth, together with enough water to make the entire mixture 2 fluid ounces. (181).

This mixture is thrown on the paper by means of an atomizer — such as is used by physicians — operated by means of a continuous current of air from a suitable air-pump, or it may be applied by means of the air-brush; all of which operations to be performed in non-actinic light, as well known. The paper is ready for exposure as soon as dry, which exposure is effected, in the usual manner, by allowing the light transmitted through a negative to fall on the paper. The time of exposure varies with the character of the negative and the intensity of the light, but is about $\frac{1}{10}$ of that required by the ordinary silver process, under the same conditions. After exposure, the paper is immersed in water, of temperature from 80° to 120° F., which, in a few minutes, generally suffices to dissolve the gelatine in the unexposed parts. The paper is then placed on a frame covered with sheeting, and washed with a spray of water, consisting of a number of small jets having sufficient force to dislodge the particles of pigment and gelatine from the parts not acted upon by the light.

While the solutions that I have described are such as I prefer to use under ordinary circumstances, these may be varied somewhat, at the will of the operator, under other circumstances. A sizing solution of less solubility tends to produce results having sharper contrasts; the same being true with regard to the solutions with which the pigments are mixed, and, in preparing the paper for printing, I may substitute a saturated solution of bichromate of ammonia for that of potash, to secure a greater degree of sensitiveness, when required, and in case a stronger sizing solution is used than that hereinbefore described, it will be necessary to increase the time of exposure correspondingly; but the constituents and proportions already named have been found generally satisfactory.

If desired, the solution of bichromate of potash, or ammonia, may be omitted from the described mixture of pigment, water, and solutions Nos. 1 and 2, and, after this mixture has been sprayed upon the paper and allowed to dry, the paper may be sensitized by floating it, face down, upon a solution of said bichromate.

LUDWIG VON ITTERHEIM'S NIGROGRAPHIC POSITIVE PROCESS. — Smooth and well sized (glue-sized) drawing paper is coated, by means of a brush, in subdued light, with the following solution:

Gum Arabic,	25 parts.	(182).
Water,	100 parts.	
Potassium Bichromate,	7 parts.	
Alcohol,	1 part.	

The prepared paper will keep — if preserved in a dark place — in a serviceable condition, for a few days. The exposure to diffused light, and under a tracing, requires from 5 to 10 minutes. After exposure, the prints are washed in water until the lines of the drawing appear to be engraved; then they are taken out of the water and dried. When perfectly dry, the entire face of the print is thinly and uniformly coated with a varnish composed of

Strong Alcohol,	20 parts.	(183).
Shellac,	1 part.	
Fine, Impalpable Lampblack,	3 parts.	

This is best done by means of a sponge, and care must be taken that all the deepened lines are filled with the black varnish.

When the black coating is dry, the sheets are immersed in a discharging bath, consisting of

Water, ...	100 parts.	. (184).
Sulphuric Acid, ...	2–3 parts.	

and left therein until the superfluous black can be removed by gentle brushing. The lines of the drawing then appear, in black upon a white surface, and the copies thus obtained will have the same appearance as a good autograph.

CARBON PRINTS, ACCORDING TO HAUGK AND LIESEGANG.—Beat the whites of several eggs to a froth, leave it stand to settle, pour off the liquid part, and dilute this with an equal volume of water; then color the diluted albumen with liquid india-ink. Instead of the albumen, a solution of gum arabic, in water, may be used.

With the black liquid, thin white paper is coated as uniformly as possible, by means of a wide, soft brush. When dry, this paper may be preserved for a long time.

Shortly before use, the paper is sensitized by a solution of

Bichromate of Potassium, . .	1 part.	. (185).
Water, ...	10 parts.	

which is to be applied very freely, to the back of the paper, with a brush. After a few minutes, the solution is equalized, with the nearly dry brush. The sensitizing may be done in subdued daylight, but the drying of the paper must take place in the dark.

The paper is to be placed, in the printing frame, so that the black albumen side comes in contact with the original. The exposure to light is to be continued until the lines of the drawing are plainly visible on the yellow back of the paper. After the print has been taken out of the printing frame, it is plunged into water, for a minute, and then laid on a smooth, clean board, or on a plate of glass. Then the image is developed, under a hydrant, and by means of a soft brush, until all adherent particles of the film on which the light did not act are removed. After this, the print is put in clean water again, in order to remove all the soluble chromium salt from the paper, and, finally, it is hung up to dry. It is evident that, by this process, a negative print will be received from a positive original, but such a negative may be used for making positives, either by the same process or by another.

Carbon Prints, According to the Author. — A saturated Stock Solution of potassium bichromate — which requires about

Potassium Bichromate, . . .	1 part.	(186).
Water, ...	10 parts.	

is filtered; then ammonia water is continually added to the solution, until the reddish color of the latter commences to turn yellow. In a dark place, this solution remains in a serviceable condition for a long time.

Sensitizing Solution.

Of the above Stock Solution,	4 ounces.	(187).
Gum Arabic (powdered), . .	$\frac{1}{2}$ ounce.	
White Granulated Sugar, . .	$\frac{3}{16}$ ounce.	
Lampblack, ...	$\frac{3}{16}$ ounce.	

The lampblack is ground, with a little glycerine and alcohol, by means of a spatula, or a knife, on a porcelain plate, so as to form a stiff paste, and then mixed with the other ingredients. The solution must be continually stirred or shaken, as the lampblack has a tendency to settle at the bottom of the bottle.

After the gum and the sugar have dissolved, the solution is applied to the paper, by means of a bristle brush, in parallel strokes. This must be done very quickly and uniformly. Then the coating is equalized, by passing over the paper, with the brush, in a direction rectangular to the first strokes.

The dry paper should have a medium olive-green color.

When the paper is put into the printing frame, it must be perfectly dry; otherwise the negative, or original, would stick to it.

Success depends, a great deal, upon the correct time of exposure. If the original is on tracing paper, or tracing cloth, the exposure, in the sun, requires from 8 to 10 minutes. The picture will be visible in transmitted light, and, from the strength of it, we may easily judge whether the light has acted for a sufficient length of time.

When the print is taken out of the printing frame, it is soaked in water, until the parts of the film on which the light did not act become so soft that they can easily be removed by means of a camel's-hair brush. As soon as the picture is completely developed, the print is drawn, a few times, through clean water, and then hung up to dry.

If the exposure was insufficient, the image will appear very quickly; but, before the white parts are pure, parts of the picture will be taken away by the brush in developing. If the print was over-exposed, the picture appears very slowly, and it is impossible to remove the coating entirely in some places which should be white. Sometimes such prints may be saved by using warm water for developing.

The quantum of sensitizing solution given above is sufficient for covering 32 square feet of paper.

4. PROCESSES WHICH ARE BASED UPON THE PROPERTY OF BICHROMATED GELATINE, ALBUMEN, ETC., TO RECEIVE FATTY PRINTING INK IN PLACES UPON WHICH LIGHT WAS ALLOWED TO ACT, WHILE THOSE PARTS UNTOUCHED BY LIGHT IMBIBE WATER.

Abridgment of English Patent No. 2,815, of December 13, 1855, to Alphonse Louis Poitevin.

One or more films of a concentrated solution of albumen, fibrine, gum arabic, gelatine, or similar organic substance, and a concentrated solution of a chromate — or bichromate — of potash, or any base which does not precipitate the organic matter of the first solution, are applied to the paper, stone, metal, glass, wood, etc., which is to receive the design. If the impression is to be taken by contact, the film is then dried; if in the camera, it may be used moist. After a sufficient exposure, if the surface has become dry, or has been used in a dry state, it is moistened with water, by means of a sponge, and, while moist, the greasy ink or matter is applied to the surface, to which it will be found to adhere in those parts only which have been affected by the light. The print may be retained on the surface on which it is first produced, or transferred, or printed upon paper or other suitable material, and the operation repeated. A design is thus obtained upon lithographic stone, or other suitable material, from which impressions may be multiplied by the method of lithographic printing — the moistened surface with a greasy ink.

CAPTAIN ABNEY'S PAPYROGRAPHY. — Paper is floated, for 2 minutes, upon a warm solution of

Gelatine, ...	6 parts.	. (188).
Bichromate of Potassium, . .	3 parts.	
Water, ...	100 parts.	

hung up to dry, and floated again on the same solution. The second time, the paper must be hung up to dry in a position opposite to the first, so that the edge which was down the first time will now be up. This will cause the coating to be more uniform. The bichromate may be omitted in the first solution, and the paper, shortly before use, floated on a solution of

Bichromate of Potassium, . .	3 parts.	(189).
Water, ...	100 parts.	

The drying must take place in the dark. After exposure, the print is immersed in a dilute solution of alum, and, when the greater part of soluble chromate has dissolved, placed upon a glass or zinc plate, and superficially dried with blotting paper. Then it is inked-in with lithographic ink, by means of a soft leather or velvet hand-roller.

When this has been done, the print is soaked in water, until all the soluble chromate is removed. If the print was exposed under a negative, the drawing will be in black lines upon a white ground; if a positive was used, in white lines on a black ground.

From such a print, 40 to 50 good impressions may be taken, on an ordinary printing press, or with a wash-wringer, or by laying a piece of paper over the inked print, on the glass or zinc plate, and passing over the same with a clean leather or india-rubber roller. Of course, the print must be re-inked for each impression.

5. DUSTING-IN PROCESSES.

P. H. MANDEL'S PROCESS OF MAKING COPIES OF TRACINGS.

Abridgment of U. S. Patent No. 294,485, dated March 4, 1884.

In carrying out my improvement, I take a pane of glass, which, preferably, will be about the size of the tracing, or illustration, to be copied, and first cover it with very thin collodion. This may be done by pouring the collodion on the pane of glass, flowing it over the glass by tilting it in various directions, and then allowing the surplus to drain off. When the pane of glass becomes dry, I apply, over the collodion, a material which, after drying, will absorb moisture and become slightly tacky, or sticky, except where exposed to the action of the sun's rays, and which, at such portions as are acted upon by the sun's rays, will cease to have the same adaptability to absorb moisture. I have found that this material may be advantageously made by taking, say

Bichromate of Ammonia, . . .	about	2 grams.	(190).
Gum Arabic, ...	about	7 grams.	
Sugar (preferably Grape-Sugar), .	about	3 grams.	
Dissolving in Water, ...	about	150 grams.	

The material thus made may be applied by pouring it on, then flowing it over by tilting the glass in various directions, to cause the material to flow over all parts, and, consequently, allowing the surplus to drain off. The pane of glass thus treated is then dried, in any suitable manner — as, for instance, by setting it over a box, or chamber, heated internally, in any suitable manner, or by placing it in an oven. This should be done in a room similar to a photographer's dark room. When the pane of glass is dry, it is placed in a frame, with the tracing, or other illustration, in contact with its side — which was treated as above described. The tracing, or illustration, may be laid in the frame first, and the glass afterward. Care must, in any case, be taken to have the tracing, or illustration, smooth. The tracing, or illustration, is to be laid, with the side on which the drawing or picture is delineated, toward the treated side of the glass. When the pane of glass and tracing, or illustration, have been fastened in the frame, the whole is turned over, so that the back of the tracing, or illustration, will be exposed to the light. It is left exposed for about 20 seconds, if in the rays of the sun; but if in the shade, or if the weather is cloudy, a longer exposure will be necessary. Artificial light — such as the electric light or calcium light — may be used instead of sunlight. Wherever the light shines through those portions of the tracing, or illustration, which are between the lines, the sensitive material will be changed, so that it will lose its tackiness, or stickiness; but, where the material is covered by the lines, it remains tacky, or sticky. After the proper exposure has been made, the pane of glass, with the tracing, or illustration, upon it, is taken to a room which is like a photographer's dark room. The tracing, or illustration, is then removed from the pane of glass. Before removing the pane of glass from the dark room, I dust lampblack over its treated surface, with a brush, or otherwise.

I have found that I can use the lampblack better, for my purpose, after treating it with milk. I, therefore, place a quantity of lampblack in milk, mix the two together by shaking or stirring, and then pass the mixture through a fine filter, preferably having, as a component part of it, a linen or other cloth. The lampblack, which is caught by the filter, I allow to dry, and then use it. By its treatment with milk, it acquires a sufficient greasiness to enable me to apply it with great uniformity.

I do not here claim the process described for treating lampblack, or coloring matter, and I may make such process the subject of another application for letters patent.

The lampblack so prepared, or otherwise, adheres to the tacky, or sticky, portions of the sensitive material which were covered by the lines of the tracing, or illustration, and does not adhere to the other portions of the material, which were affected by exposure to the light. I now apply, to the sensitive material, a thin collodion. This I may do by pouring the collodion over the material, tilting the pane of glass to cause the collodion to flow over all parts, and then allowing the surplus to drain off. After the collodion has dried, I preferably place the pane of glass in a bath of water, containing about 1 to 1½ grains of nitric acid to each gallon of water. This will neutralize any bichromate of ammonia, which otherwise might produce a yellow hue. While the treated side of the pane of glass is still wet from the bath, I pour or run over it a solution, consisting of 6 grams of gelatine to every 1,200 grams of water. A sheet of tracing muslin, or other material, is now applied to the treated side of the pane of glass, before it has become dry, and is rubbed or pressed down with any suitable device, so as to lie close to the treated side of the glass throughout its extent. It is then left to dry. It may dry in the open air. The tracing cloth, or other material, is finally peeled or stripped off the glass, and carries with it the sensitive material which was applied to the glass, and which had the original tracing, or illustration, delineated on it with the lampblack. That side of the cloth, or other material, on which adheres the sensitive material bearing the copy produced, is, generally, to serve as the front or face, the sensitive material being transparent, so that the lines may be seen through it, although delineated on its side which is next to the cloth, or material; hence the copy, when finished, will be a reproduction of the original, in contradistinction to a negative.

ANTHRACOTYPY.—This process was first described in a handbook by Dr. Alexander Sobacchi, in Lodi, having the title "La Fotantracografia alla portata di tutti." The simplicity of the process attracted the attention of Capt. Pizzighelli, who thought it worth while to study it, and give it a fair trial. His first experiments gave very satisfactory results, and, after a little practice, he obtained prints of such perfection as can not be surpassed by any other heliographic process.

Capt. Pizzighelli communicated a description of the process, in a lecture, in 1881, before the Photographic Society of Vienna, and also published the same in a little pamphlet. He says: Sobacchi's book was published in 1879, and it is a pity that this process—which I will call, analogous to the names of other heliographic processes, Anthracotypy—is only so little known.

Photanthracography, in general, is based upon the property of a heliogram, on a chromated gelatine film, to swell up and become sticky, in warm water (even in cold water), in those parts which were not affected by light, whereby these parts become adapted to receive and to hold dust colors. Those parts of the film upon which the light did act, having obtained a hornish condition, are indifferent to water, and have lost their adhesiveness.

REQUIREMENTS OF THE OBJECTS TO BE REPRODUCED.—Drawings, maps, engravings, or manuscripts, which are to be copied by this process, should be executed on thin paper. The thinner the paper of the original, the finer the prints will turn out. The paper of the original should show no dark or opaque spots, when examined by transmitted light, nor should it have grown yellow by age.

From originals on thick paper, however, sharp copies may also be obtained, but not by one operation. In this case, it is necessary to first make an inverted print, on thin paper, by placing the original in the printing frame so as to face the sensitive paper, and then take, from this inverted print, a copy in the same manner.

Anthracotypy has the advantage, over other heliographic methods, of not requiring originals of perfectly opaque lines, and of reproducing lead-pencil just as well as black ink drawings. No one must, however, expect that a print taken from a pencil drawing will resemble an india-ink drawing, as the copy will look exactly like the original.

The use of drawings, tracings, and photographic negatives and positives, is, at present, restricted to such as are made in lines, since the experiments which have been made with painted drawings, and pictures in half-tones, have not been sufficient to give any information in regard to them.

COATING THE PAPER WITH GELATINE.—Every kind of paper that is well sized, and has a smooth surface, may be used in this process. For extra fine work, the paper should be selected more carefully, and Rives's and Steinbach's photographic papers are preferable. In regard to the gelatine, it may be said, that any kind of a good, white, and not too soft gelatine—which, when converted, with 10 times its weight of water, to a jelly, does not melt below 86° F.—is suitable. The paper may be gelatinized by means of a machine, by floating, or by pouring the gelatine solution over the sheet. We confine ourselves, here, to the consideration of the two latter methods only.

The gelatine solution is prepared, for both methods, in the same manner, namely:

$$\left.\begin{array}{l}4\tfrac{1}{2}\text{ ounces of Gelatine are soaked, for about, 1 hour in}\\ 1\text{ gallon of Water (30 times the weight of the Gelatine).}\end{array}\right\}\ .\ (191).$$

melted in a water bath, and filtered through linen or muslin. If the paper is to be *floated* upon the gelatine, the latter may be filtered at once, in a tray of zinc, or galvanized iron, of suitable size. This tray is to be placed in a second and larger tray, so that its bottom is about 1 inch from the bottom of the first tray. The space between the trays is filled with warm water, which is kept at a constant temperature of 113° to 122° F., by means of an alcohol lamp, or other flame. The sheets are handled and floated in the manner described on page 9. On account of the air-bubbles—which always will form—the four corners of the paper should be carefully lifted up, one after the other, so that the whole lower surface may be examined, and the existing air-bubbles removed, with the tip of the finger, or with a small, pointed, wooden stick. The floating requires from 1 to 3 minutes, according to the thickness of the paper. The sheet is, after this, slowly lifted from the solution, by taking hold of it at two corners, and, when the surplus of the gelatine has dropped off, it is hung up to dry. This will require, in a warm room, from 5 to 6 hours.

The dry sheets are pressed between boards, for about 12 hours, in order to straighten them. Then they are floated upon the gelatine a second time, in the same manner as just described, but, in hanging them up to dry, they should be suspended by the edges which were down during the first drying. This precaution is necessary, in order to distribute the gelatine more uniformly over the sheet.

When the method of pouring the gelatine solution over the sheet is to be used, the gelatine must be filtered into a glass, or bottle, which is to be placed in warm water (113°–122° F.) during the operation. The sheets of paper to be coated are immersed in pure water, one after the other, until they are thoroughly impregnated. Then each sheet is laid smoothly upon a leveled plate of glass, metal, or wood, covered with a sheet of rubber or wax cloth, and passed over with a squeegee, or with a leather roller, in order to remove as much of the water as possible, to destroy air-bubbles, and to cause the sheet to adhere firmly and smoothly to the plate. Then the edges of the paper are turned up about ½ inch, so as to form a shallow pan, and to prevent the gelatine from flowing over the margin. If the paper is thin, the margins bent up must be held in position by strips of wood, placed behind them.

The warm gelatine solution is now poured along the margin, at one edge of the sheet, the plate tilted or inclined, and by means of a card, a brush, or a finger, distributed over the entire surface. When this has been done, the plate, or board, is restored to its level position, and a second sheet may be commenced. In 15 minutes, the gelatine will, generally, be sufficiently torpid, so that the sheet may be lifted from the level plate, and put upon a lattice-work to dry. When the sheets have lost a part of the moisture, so that there is no danger of tearing, they may be hung up vertically, until perfectly dry.

The last-described method of gelatinizing the paper has the great advantage over the first one, that the thickness of the film can be regulated with certainty, by simply measuring the quantity of gelatine which each sheet is to receive; while in the method of floating, the thickness of the coating, and uniformity of the same, depends, to a great extent, upon the temperature of the atmosphere.

The gelatine solution required is,

For	1 square inch of paper surface,			. . . . . 0.01351	fluid ounce.
"	74 square inches	"	"	 1	fluid ounce.
"	1 square foot	"	"	 2	fluid ounces.
"	8 square feet	"	"	 1	pint.
"	64 square feet	"	"	 1	gallon.

The liquid solution will, accordingly, cover the paper about $\frac{1}{40}$ of an inch.

J. Husnik recommends to pour the gelatine solution through a small hair-sieve, which is held very close to the paper, as hereby the formation of air-bubbles may be entirely avoided.

If protected from moisture, the gelatinized paper may be preserved for any length of time.

Sensitizing the Paper.—The paper is sensitized by immersing it for 1 or 2 minutes, in a solution of

Bichromate of Potassium,	1 part.	(192).
Water,	25 parts.	

If it is desirable to dry the paper as quickly as possible, the sensitizing solution may be composed of

Bichromate of Potassium,	1 part.	(193).
Water,	17 parts.	
Alcohol (proof),	8 parts.	

The addition of alcohol also diminishes the formation of air-bubbles.

An addition of ammonia water to the sensitizing solution is, also, an advantage, as the double salt of bichromate of potassium and ammonium, which is then formed, is more sensitive to light, and more durable, than the bichromate of potassium. In preparing the sensitizing solution with ammonia water, 1 ounce of potassium bichromate may be dissolved in 10 or 12 fluid ounces of pure water, and so much ammonia water added until the reddish color of the solution becomes yellow; pure water is added to make the whole amount 17 fluid ounces, and, finally, the 8 ounces of alcohol are added.

The alcohol and ammonia water are, however, not absolutely necessary for obtaining perfect prints.

The sensitizing solution must be used as cold as possible. In summer, it may be kept in an ice-chest, for a few hours, before using it. The reason for using the sensitizing solution cold is, that the solution will dissolve a small amount of the gelatine, and the colder the solution is, the smaller this amount will be. The alcohol assists, also, in preventing the gelatine from being dissolved.

During the sensitizing, the sheets should be turned over a few times, in the bath, and adhering air-bubbles removed by means of a little hair brush.

The sensitizing tray may be made of zinc or galvanized iron. After sensitizing, the sheet is hung up to dry, except when it is intended for very fine work. In this case, it is to be squeegeed down upon a clean plate of polished glass, which was previously thinly coated with talc, wax, or an alcoholic solution of ox-gall (1 to 10), the latter allowed to dry on the same. Before using, the edges of the sheet should be trimmed, and then the sheet taken from the plate. It requires from 5 to 8 hours for the paper to dry on the glass plate—while a free hanging sheet will become dry in from 3 to 4 hours — but the paper receives a perfectly smooth surface, which insures a close contact between the sensitive film and the original drawing.

The sensitizing may be done by weak daylight, as the chromated gelatine, in a wet condition, is but very slightly sensitive to light. The drying, however, must take place in a dark room, because, in a dry state, this paper is more sensitive than chloride of silver paper.

The sensitized sheets may be preserved, for about a week, if a few pieces of sesquicarbonate of ammonium are placed in the same box, or drawer, in which the paper is kept, so that the latter will be in an atmosphere of ammonia vapors. In all cases it should be used as soon as possible. Prints made on freshly prepared paper will always give better satisfaction than when made on old paper.

THE EXPOSURE TO LIGHT requires, for originals made on tracing paper, or tracing cloth, from 20 to 25 minutes, in the sun. When the image is faintly visible, in light-yellow lines upon a brownish surface, the exposure must be discontinued. Over-exposure is less detrimental than under-exposure, because, in the first case, the print may be saved by using warmer water in the next operation of developing; in the second case, the print will be lost.

THE DEVELOPMENT OF THE PICTURE. — The copies, when taken from the printing frame, are plunged into cold water, which must be renewed as often as it receives a yellow coloration from the dissolving chromic salt. Then the prints may be developed at once, before drying, or they may be hung up to dry, and preserved, in this condition, for any length of time. In the latter case, they must first be soaked in cold water, when they are to be developed. In order to develop the image, the print is taken out of the cold water bath, the water allowed to drop off it, and is then immersed for 1 or 2 minutes (not longer), in lukewarm water, of 82° to 86° F. The lines of the print, which were protected from the action of light by the black lines of the original, will now swell up, appear in relief, and become somewhat soft and adhesive. The print is then placed upon an even support of glass, metal, or wood, and, by means of blotting paper, or by touching it with a tuft of soft cotton, or by passing over it with a clean leather roller, is superficially dried.

Then the color, in the form of an impalpable flour, is sifted over the whole sheet, and, by means of a soft marten's-hair brush, is rubbed, in circular movements, over the lines of the print. The color will adhere to the soft and sticky lines, and so a positive picture will appear. Ordinarily the ground will, also, become more or less tinted; but, if this is not caused by under-exposure, it will have no influence upon the final success.

After the dusting-in process is finished, the print is dried in a warm place: in summer, in the sun; in winter, near a stove, or in a drying-box. This is done for the purpose of softening the gelatine still more, so that the loosely adhering particles of the coloring material—in consequence of the superficial melting, and the later drying-in of the gelatine—will be embodied with the gelatine. The drying temperature ought not to exceed 140° F., or the gelatine will flow on the sheet. When the print is perfectly dry, it is plunged into cold water again, laid flat upon a plain support, and the superfluous color removed by means of a soft, wet sponge. If, after this operation, the lines appear clean, and uniformly colored, upon a white surface, the print is hung up to dry, and may be considered finished. If, however, the color adhered only in some parts, and not in others, or when the coloration appears to be too pale, or unequally distributed, the dusting-in process may be repeated, as often as necessary, to obtain a satisfactory result.

All colors which have no tanning effect upon the gelatine, may be applied in this process. For reproducing black line-drawings, lampblack or finely pulverized charcoal are the most suitable. Other colors, such as plumbago, ultramarine-blue, ultramarine-green, sepia, vermilion, and gold and silver bronze may also be used with success.

Causes of Failure may be

1. Unsuitable color.
2. Over-exposure.
3. Old sensitized paper.
4. Unequally gelatinized paper.

For the first and fourth faults, several repetitions of the dusting-in process, for the second and third, an increasing of the temperature of the water bath to 104°, 122°, even to 140° F., will be found of advantage.

Paper, gelatinized as described in this process, can also be used in Papyrography (page 112), and for copies in printing ink (page 78).

XII.

PROCESSES WITH SALTS OF URANIUM.

THE nitrate of the sesquioxide of uranium ($UO_2,2NO_3+6H_2O$), in the presence of organic substances, is reduced by light, as in the case of the sesquichloride of iron. This discovery was first made by M. Niepce de St. Victor, and by Burnett.

The paper, without having undergone any preceding preparation—excepting that of having been excluded from the light for several days—is sensitized with a solution of

Nitrate of Uranium, ...	1 part.	(194).
Water, ...	16 parts.	

The strength of the sensitizing solution varies, according to different authorities, from 1 to 5, to 1 to 33⅓, to 1 to 96. We have used a solution according to formula (194).

The paper may be floated upon the solution, or it may be coated therewith by means of a brush. It must be hung up to dry, in a dark place. The sensitized paper can be preserved, in the dark, for a considerable time. 1 ounce of the solution will cover 9 square feet of paper.

The exposure, beneath a tracing, requires, in the direct rays of the sun, from 10 to 15 minutes; in diffused light, from 1 to 2 hours.

The image thus produced is very faint and indistinct, but it may be brought out, in various colors, by one of the following developers:

Developer for Black Pictures.

Nitrate of Silver, ...	1 part.	(195).
Distilled Water, ...	30 parts.	

The print may be immersed in the solution, or the latter may be applied with a brush. The image comes out very rapidly; in 30 to 40 seconds the development is complete. The prints are fixed by simply washing them thoroughly in water. Some authorities recommend to immerse the prints, before developing, in warm water, of 120° to 140° F., in order to remove all the soluble, unaltered uranic salt. Others use, for the same purpose, cold water, acidified with a few drops of hydrochloric acid. (The nitrate of silver developer is given, by some authorities, as 1 to 17.)

Developer for Red-Brown Prints.

Ferricyanide of Potassium,	1 part.	(196).
Water,	48 parts.	

Proceed as with the nitrate of silver developer. The image will appear in a few minutes, and is then to be rinsed in water.

The red-brown picture thus obtained may be converted into a dark greenish-gray one, by immersing it, before dry, in a solution of

Sesquichloride of Iron,	1 part.	(197).
Distilled Water,	48 parts.	

and washing it again.

Fine green-colored prints are made (according to Dingler's Pol. Jour., v. 152, No. 6), by immersing the red-brown picture in a solution of cobaltous nitrate, for 1 minute, and fixing it in a solution of

Sulphate of Iron,	1 part.	(198).
Sulphuric Acid,	1 part.	
Water,	25 parts.	

Developer for Violet Pictures.

Chloride of Gold,	1 part.	(199).
Water,	240 parts.	

The uranium print is immersed in this solution, and then thoroughly washed.

XIII.

TWO METHODS FOR PRODUCING THE ORIGINAL TRACING AS A NEGATIVE.

The following are two methods by which tracings, in white lines upon a dark surface, may be produced, so that the prints obtained from them, by an indirect process, will be positives, in dark lines upon a white ground. The first of these methods is according to Haugk and Liesegang, and the second was first published in the "American Machinist."

First Method.—The tracing is made on paper with black lithographic or autographic ink. Great care must be taken that the drawing-pen does not cut into the paper.

When the tracing is dry, it is stretched upon a drawing board in the usual manner. Under the tracing, a sheet of blotting paper is to be placed. The entire drawing is then coated, once or oftener, with a concentrated solution of aniline-brown, by means of a wide, soft, flat brush. After drying, the drawing is treated with a tuft of cotton, or a sponge, dipped in oil of turpentine, until all the lines appear, in a clear white upon a dark ground.

Second Method.—The drawing is traced, on paper, with a solution of citrate of iron and ammonia. When dry, the surface of the sheet is blackened by means of a crayon, soft pencil, or plumbago powder. Faber, the lead-pencil manufacturer, offers for sale pulverized graphite, which is very suitable for this purpose. The sheet is then immersed in water, in order to dissolve the ferric salt, and, finally, it is dried.

XIV.

TABLE OF CHEMICALS

MENTIONED IN THIS BOOK, THEIR FRENCH AND GERMAN NAMES,

MOLECULAR WEIGHTS, MOLECULAR FORMULÆ, COMPOSITION,

AVERAGE PRICE,

REMARKS RELATING TO THEIR PRINCIPAL PROPERTIES

AND THEIR PREPARATION.

NAME AND MOLECULAR FORMULA.	Molecular Weight..	100 parts of the Compound contain.	Specific Weight..	Boiling Point, F.	Melting Point, F.	Average Price....	Parts of Water required to dissolve 1 part.		REMARKS.
							cold	boil'g	
Acid, Acetic. *Fr.*—Acide acetique. *Ger.*—Essigsaeure.						per lb	Acetic Acid mixes with water in all proportions.		Acetic acid dissolves essential oils, hydrocarbons—such as camphor, guiacum, and various resins—fibrinic of blood, gelatine, etc., and many other bodies which are insoluble in water.
Acid Acetic, Anhydrous................$C_4H_6O_3$	102	47.06 C; 5.88 H; 47.06 O	....	280°	....	....			
Acid, Acetic Glacial, (Monohydrated)..$C_2H_4O_2$	60	40 C; 6.67 H; 53.33 O	1.0635	243–246°	51°	$0.65			
Acid, Acetic, of maximum density $C_2H_4O_2$+aq.	......	80 $C_2H_4O_2$; 20 H_2O	1.0748	219°	....	....			
Acid, Acetic, diluted (U. S. P.) ...$C_2H_4O_2$+aqua	......	36 $C_2H_4O_2$; 64 H_2O	1,047	....	....	13			
Acid, Carbolic, Cryst. (Phenol)......$C_6H_5(OH)$ *Ger.*—Carbolsaeure.	94	76.58 C; 6.38 H; 17.04 O	1.065 at 64°F.	363°	93–95°	1.50	20–33	......	Carb. Ac. fuses at 108° F. It dissolves in the alkalies, alcohol, ether, and acetic acid. It is a powerful antiseptic. Phenol dissolves sulphur, iodine, indigo, resin, and copal. A chip of pine wood, saturated with an aqueous solution of phenol, plunged into muriatic acid, and then exposed to sunlight, soon becomes colored blue, and, later, brown. Phenol, a little ammonia, and chloride of lime furnish a blue mixture. A solution of phenol added to one of sesquichloride of iron, gives a fine blue color. Chromic acid colors phenol black. Mercuric and argentic salts are reduced by phenol to their metallic state.
Acid, Carbolic, Solution........................	......	....	....	....	....	60	......	......	
Acid, Citric ....$H_3(C_6H_5O_7)$ *Fr.*—Acide citrique. *Ger.*—Citronensaeure	192	37.5 C; 4.17 H; 58.33 O	....	....	....	....	......	......	When heated, crystallized citric acid dissolves in its water of crystallization, and, at a higher temperature, undergoes decomposition.
Acid, Citric, Crystallized..........$C_6H_6O_7+H_2O$	210	91.43 $H_3(C_3H_5O_7)$; 8.57 H_2O	1.6	....	....	75	0.75	0.5	
Acid, Gallic......................$C_7H_6O_5$ (dry) *Fr.*—Acid gallique. *Ger.*—Gallussaeure	170	49.42 C; 3.53 H; 47.05 O	....	....	....	1.50	100	3	On exposure to the air, its solution undergoes spontaneous decomposition; but, it is said, by the addition of a drop of oil of cloves, it may be kept for a long time without change. It is very soluble in alcohol, and but slightly in ether. It is soluble in glycerine in the proportion of 40 grains to the ounce.
Acid, Hydrochloric, Gas; Hydrogen Chloride. *Fr.*—Acide hydrochlorique. HCl *Ger.*—Chlorwasserstoff	36.5	97.26 Cl; 2.74 H	....	....	....	....	......	......	One volume of water, at 32° F., dissolves no less than 505 volumes of this gas.
Acid, Muriatic, Hydrochloric Acid Solution, sp. grav. 1.11 HCl+$8H_2O$ *Fr.*—Acid Muriatique. *Ger.*—Salzsaeure	180.5	20.2 HCl; 79.8 H_2O	1.11	230°	....	20	In all proportions.	In all proportions.	The aqueous solution of HCl is one of the most useful chemicals. It acts upon bases to form chlorides.
Acid, Muriatic, Hydrochloric Acid Solution, sp. gr. 1.17 C.P. HCl+aqua	......	33.9 HCl; 66.1 H_2O	1.17	....	....	25			
Acid, Nitric, sp.gr. 1.52, Hydrogen Nitrate, HNO_3 *Fr.*—Acide Nitrique. *Ger.*—Salpetersaeure	63	54.14 N_2O_5; 45.86 H_2O	1.52 at 60°F.	Not constant	....	....			Nitric acid is an exceedingly powerful oxidizing agent, owing to the ease with which it gives up a part of its oxygen.
Acid, Nitric, Anhydrous, C.P...............N_2O_5	108	25.93 N; 740.7 O	....	....	....	....			
Acid, Nitric, Hydrate ....HNO_3+2H_2O	99	54.14 N_2O_5; 45.86 H_2O	1.41	249°	....	30			

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							cold	boil'g	
Acid, Sulphuric, Anhydrous..............SO_3 *Fr.*—Acide Sulfurique. *Ger.*—Schwefelsaeure.	80	40 S; 60 O	1.97	115°	61°	per glass bulb, $1.00	In all proportions.		Sulphuric acid acts on living tissues as a powerful caustic. It acts powerfully on organic bodies, whether vegetable or animal, depriving them of the elements of water, developing charcoal, and turning them black.
Acid, Sulphuric, Hydrate, C.P............H_2SO_4	98	81.63 SO_3; 18.37 H_2O	1.8426	620°	—15°	per lb 30			
Acid, Oxalic, Crystallized ......$C_2H_2O_4+2H_2O$ *Fr.*—Acide oxalique. *Ger.*—Oxalsaeure.	126	19.05 C; 4.76 H; 76.19 O	....	....	208°	1.00	8	1	Oxalic acid dissolves, also, in alcohol.
Acid, Phosphoric, glacial.................HPO_3 *Fr.*—Acide phosphorique. *Ger.*—Phosphorsaeure.	80	88.75 P_2O_5; 11.25 H_2O	....	....	....	1.50	......	......	Phosphoric acid is slowly soluble in water, and soluble, also, in alcohol. It is characterized by producing white gelatinous precipitates with albumen, and with the soluble salts of lime, baryta, and silver.
Acid, Phosphoric, dituted........................	......	15.64 P_2O_5; 84.36 H_2O	1.124	....	....	50			
Acid, Pyrogallic; Trihydroxyl Benzene. *Ger.*—Pyrogallussaeure. $C_6H_3(OH)_3$	126	57.14 C; 4.76 H; 38.10 O	....	410°	239°	per oz. 40	2¼	......	Pyrogallic acid absorbs oxygen. Mixed with an alkali, it colors and deposits F_2Cl_6 deeply blue. It colors lime-water purple. Is but little soluble in alcohol or ether. Does not precipitate animal glue.
Acid, Salicylic ....$C_6H_4OHCO_2H$ *Fr.*—Acide salicylique. *Ger.*—Salicylsaeure.	138	60.27 C; 4.35 H; 34.78 O	....	....	316–318°	25	......	......	Salicylic acid sublimates at 392° F. without being decomposed, Very little soluble in cold water, but dissolves easily in hot water, alcohol, or ether. The solution is colored by F_2Cl_3 intensively violet. Heated with powdered glass, it is decomposed, phenol being left.
Acid, Tannic; Tannin ....$C_{27}H_{22}O_{17}$ *Fr.*—Acide tannique. *Ger.*—Gerbsaeure; Tannin.	618	52.43 C; 3.56 H; 44.01 O	....	....	....	25	......	......	Pure tannin dissolves easily in water, and in diluted alcohol easier than strong alcohol. Sunlight colors tannin yellow, even in closed vessels.
Acid, Tartaric.........................$C_4H_6O_6$ *Fr.*—Acide tartrique. *Ger.*—Weinsteinsaeure.	150	32 C; 4 H; 64 O	1.74	....	275°	per lb 65	1½	1	T.A. is also soluble in alcohol or ether. It is unalterable in the air, but a weak solution undergoes spontaneous decomposition.
Alcohol, Ethyl, Stronger ....C_2H_6O+aqua *Fr.*—Esprit de vin; Alcool. *Ger.*—Weingeist; Alkohol.	......	92 C_2H_6O; 8 H_2O	0.817 at 60°F.	....	....	per gal. 2.40	In all proportions.		Alcohol absorbs moisture with great avidity, the mixture with water evolving heat, and undergoing contraction in volume. It is capable of dissolving a great number of substances, as, for example, sulphur and phosphorus, in small quantities, iodine and ammonia freely, caustic potassa and soda, but not the carbonates. Among organic substances, it is a solvent of tannin, camphor, resins, volatile oils, and soap. It dissolves the fixed oils sparingly, except castor oil, which is abundantly soluble. All deliquescent salts are soluble in alcohol, except carbonate of potassa.
Alcohol, Rectified Spirit........C_2H_6O+aqua *Fr.*—Esprit de vin rectifiee. *Ger.*—Rectificirter Weingeist.	......	84 C_2H_6O; 16 H_2O	0.838	....	....	....		......	
Alcohol, Ethyl, Absolute ....C_2H_6O *Ger.*—Ethyl Alkohol.	46	52.17 C; 13.05 H; 34.78 O	0.7939 at 60°F.	173°	....	6.00			

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							cold	boil'g	
Aluminium Sulphate........$Al_2(SO_4)_3, 18H_2O$ *Fr.*—Sulfate d'aluminim. *Ger.*—Aluminiumsulfat.	666.8	15.4 Al_2O_3; 36 SO_3; 48.6 H_2O			...C. P.	per oz. $0.25			Alum hardens glue, gelatine, and gum arabic. 10 per cent. of chrome alum makes gelatine insoluble in boiling water. Potassium alum acts not quite as powerful, and is much used as an antiseptic.
Alum; Potassium Alum......*Ger.*—Kali Alaun *Fr.*—Alun........$K_2SO_4+Al_2S_3O_{12}+24H_2O$	948.8	10.83 AlO_3; 33.7 SO_3; 9.94 K_2O; 45.53 H_2O	1.724			per lb 15	18	¾	
Alum; Chrome Alum.....$Cr_2K_2S_4O_{16}+24H_2O$ *Ger.*—Chrom Alaun.	998.4	15.26 Cr_2O; 32.07 SO_3; 9.61 K_2O; 43.06 H_2O				40			
Ammonia Water, Strong...........HH_3+aqua *Fr.*—Eau d'ammoniaque. *Ger.*—Ammoniakfluessigkeit.		26 NH_3; 74 H_2O	0.9	187°		25			Ammonia solution possesses a strong alkaline reaction, turning red vegetable colors blue; it unites with the most powerful acids, forming compounds called the salts of ammonia. It is very volatile, and must be kept in a well-closed bottle.
Ammonium Bromide..................NH_4Br *Fr.*—Bromide d'ammoniaque. *Ger.*—Ammoniumbromid.	98	18.37 NH_4; 81.63 Br	2.379			85			On exposure to air, Am. Bromide gradually becomes yellowish, in consequence of a partial decomposition.
Ammonium Chloride..................NH_4Cl *Fr.*—Sel ammoniac. *Ger.*—Ammoniumchlorid.	53.5	33.65 NH_4; 66.35 Cl	1.528			45	2.72	1	Am. Chloride is, when exposed to air, partially decomposed; it loses ammonia, and becomes acid to test paper.
Ammonium Citrate........................... *Fr.*—Citrate d'ammonium. *Ger.*—Ammoniumcitrat.						per oz. 25			
Ammonium Oxalate, Normal.............. $2(NH_4)C_2O_4+H_2O$ *Fr.*—Oxalate d'ammoniaque. *Ger.*—Neutrales Ammoniumoxalate.						per lb 1.25	28		Neutral Am. Oxalate is obtained by adding, to a solution of 1 part of axalic acid, ammonia until it ceases to be absorbed, which can be detected by smelling. When, to this solution, 1 part of oxalic acid is added, the acid ammonium oxalate will be formed. From the solutions the solid salts may be obtained by crystallization.
Ammonium Oxalate, Acid, $2C_2O_4H(NH_4)+H_2O$ *Fr.*—Binoxalate d'ammoniaque. *Ger.*—Saures Ammoniumoxalate.									
Aniline or Amido-Benzene............ C_6H_7N has also been called Phenylamine. *Fr.*—Aniline; Amidophenase. *Ger.*—Anilin; Phenamid.	93	77.45 C; 7.53 H; 15.05 N	1.036 at 32°F.	358°		2.50			Aniline is as clear and colorless as water, but soon becomes, on exposure to the air, yellow, then brown, and finally it is converted to a dark, resin-like substance. It is nearly insoluble in cold water, but dissolves in alcohol or ether. It is very volatile at all temperatures, and forms, with oxalic acid, the compound $C_2O_4H(NH_4)+C_2O_4N_2+2H_2O$, isomorphous with the corresponding potassium salt.
Arrow-root. *Fr.*—Arrow-root. *Ger.*—Arrow-root									The fecula of the rhizoma of Maranta Arundinacea. It is a pure starch, corresponding in chemical properties with that of wheat and the potato. It is very apt to be musty, and should then be rejected.

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Benzole; Benzene........ C_6H_6 *Ger.*—Benzol.	78	92.31 C; 7.69 H	0.85	176°	32°	per p't. $0.70	......	......	The powers of Benzole, as a solvent, are very extensive. Among the substances soluble in it are sulphur, phosphorus, iodine, many of the resins, mastic, camphor, wax, fatty and oily substances, essential oils, caoutchouc.
Bromine .... Br *Fr.*—Brome. *Ger.*—Brom.	80	100 Br	3	117°	—8°	per oz. 25	33.3		
Cadmium, Bromide .... $CdBr_2$ *Fr.*—Bromide de cadmium. *Ger.*—Cadmiumbromid.	272	41.18 Cd; 58.82 Br	......	......	......	25			
Cadmium, Iodide .... CdI_2 *Fr.*—Iodide de cadmium. *Ger.*—Cadmiumjodid.	366	30.56 Cd; 69.44 I	......	......	......	45			
Calcium Chloride .... $CaCl_2+2H_2O$.. Dried at high temperature ...... $CaCl_2$.. *Fr.*—Clorure de calcium. *Ger.*—Chlorcalcium.	147 111	$27.21Ca;48.30Cl;24.49H_2O$ 36.05 Ca; 63.95 Cl	...... 2.21	....	....	per ℔ 50	...... deliqu	...... escent	On account of its avidity for water, dried Calc. Chloride is used for bringing alcohol to its highest degree of concentration, for drying gases, etc. With ice or snow, it forms a powerful frigorific mixture. The dried salt forms a porous mass.
Cobaltous Nitrate .... $Co(NO_3)_2$ *Ger.*—Saltpetersaures Kobaltoxydul.	182.8	40.92 Co O; 59.08 N_2O_5	......	......	......	......	......	......	Cobaltous salts have the following characters: Solution of potash gives a blue precipitate, changing by heat to violet and red. Ammonia gives a blue precipitate, soluble with difficulty. Potassium ferrocyanide gives a grayish-green precipitate.
Copper, Sulphate, Crystallized.. $CuSO_4,5(H_2O)$ *Fr.*—Sulfate de cuivre. *Ger.*—Kupfervitriol.	249.5	31.85 CuO; 32.07 SO_3; 36.08 H_2O	2.274	......	......	C.P. 50	4	2	Copper sulphate is decomposed by the alkaline carbonates, by borax, acetate and subacetate of lead, acetate of iron, nitrate of silver, corrosive chloride of mercury, tartrate of potassa, and chloride of calcium, and is precipitated by all astringent vegetable infusions. This and the other copper salts give, with excess of ammonia, a deep-blue solution.
Gelatine. — Heinrich's Swiss	......	......	......	......	......	1.25	......	......	Good gelatine, suitable for heliographic purposes, absorbs 5 to 10 times its weight of water, at 60° F., and must not melt, after being so saturated with water, below 77° F. Gelatine dissolves in acetic acid as gum arabic in water.
Fr.—Gelatine. — Coignet, Gold Brand..	......	......	......	......	......	1.10	......	......	
Ger.—Gelatine. — Nelson's No. 1......	......	......	......	......	......	1.38	......	......	
Nelson's No. 2......	......	......	......	......	......	1.00	......	......	
Glucose; Grape Sugar........ $C_6H_{12}O_6$ *Fr.*—Sucre de raisins. *Ger.*—Glycose; Traubenzucker.	180	40 C; 6.67 H; 53.33 O	......	......	......	12			Glycerin is soluble in water (which it absorbs from the air), alcohol, and chloroform, but insoluble in ether. The alkalies and so many metallic salts are dissolved by it, that it ranks next to water as a solvent.
Glycerin; Propenyl Alcohol........ $C_3H_8O_3$ *Fr.*—Glycerine. or $C_3H_5 3(OH)$	92	39.13 C; 8.7 H; 52.17 O	1.27	......	......	......	......	......	
Ger.—Glycerin. Bower's Pure......	......	......	......	......	......	80			

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Gold, Chloride............................$AuCl_3$ *Fr.*—Chloride d'or. *Ger.*—Goldchlorid.	303.5	64.86 Au; 35.14 Cl	....	....	....	per 15 gr. $0.75	....	....	Auric chloride is very deliquescent, and should be kept in well-closed bottles, or in the form of a standard solution, say 1 grain to 1 dram of water. It is also soluble in alcohol and ether. Gold salts form a brown precipitate of metallic gold on addition of ferrous salt.
Gum Arabic .... *Fr.*—Gomme arabique. *Ger.*—Arabischer Gummi.	....	....	1.31-1.48	....	....	....	....	....	Gum arabic is insoluble in alcohol, ether, and the oils. Alcohol precipitates it from its aqueous solution. A solution of borax coagulates it. It forms, with a strong solution of sesquichloride of iron, a brown, semi-transparent jelly.
Iodine..I *Fr.*—Iode. *Ger.*—Jod.	127	....	4.9481	above 392°	239°	per oz. 38	7000	....	Iodine, in presence of a soluble iodide, is freely dissolved in water; it is easily soluble in alcohol. It is liberated from its compounds by both bromine and chlorine. Free iodine forms a remarkable compound with starch, of a splendid blue color.
Iron, Perchloride.......................Fe_2Cl_6 *Fr.*—Sesquichloride de fer. *Ger.*—Eisenchlorid.	325	34.46 Fe; 65.64 Cl	....	....	....	per lb 1.00	....	....	Ferric chloride may be produced by dissolving ferric oxide in hydrochloric acid. The solution is very soluble in water and alcohol. The anhydrous salt forms in brilliant-red crystals when chlorine gas is passed over heated metallic iron.
Iron, Perchloride, Crystallized.$Fe_2Cl_6+12H_2O$..	541	20.70Fe; 39.37Cl; 39.93H_2O							
Iron and Ammonium, Citrate of............... *Fr.*—Citrate de fer et d'ammoniaque. *Ger.*—Ammonium-Ferrid-Citrat. Citronensaures Eisenoxyd-Ammon.	....	....	....	....	....	85	....	....	Citrate of iron and ammonium is prepared by making, first a concentrated solution of citric acid, dividing it in two equal parts, saturating one part with freshly-made ferric hydrate, and neutralizing the other part with ammonia, then mixing the solutions, filtering the compound, and evaporating it to dryness, in thin layers, on flat porcelain or glass plates.
Ferric Hydrate; Hydroxyd...........$Fe_2H_6O_6$ *Fr.*—Fer hydrate. *Ger.*—Eisenoxydhydrat.	214	74.8 Fe_2O_3; 25.2 H_2O	3.94	....	....	....	....	....	Ferric hydrate is prepared by precipitating a solution of ferric sulphate, or chloride with excess of ammonia, and washing several times on a muslin filter. The ferric hydrate falls down as a bulky brownish-red magma, which dissolves in acids, forming the ferric salts. If dried, or kept for some time in the moist pulpy state, it becomes less soluble in acids.

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Ferric Oxalate .... $Fe_2(C_2O_4)_3$ *Fr.*—Oxalate de fer. *Ger.*—Ferridoxalat.									Ferric Oxalate is produced by treating ferric hydrate in a quantity of oxalic acid insufficient to saturate it. It is a yellow powder, almost insoluble in water, but which dissolves in an excess of oxalic acid, forming a solution which is converted, on exposure to light, to ferrous oxalate.
Ferric Ammonium Oxalate .... *Fr.*—Oxalate de fer et d'ammoniaque. *Ger.*—Ammonium-Ferridoxalat.									Ferric amm. oxalate is obtained by adding to a hot solution of acid oxalate of ammonium, freshly prepared and still moist ferric hydrate, filtering and evaporating the solution and allowing the same to crystallize. The green crystals thus obtained are the double salt in question, which must be made and kept in the dark.
Ferric Potassium Oxalate........ *Fr.*—Oxalate de fer et de potasse. *Ger.*—Kalium-Ferridoxalat.									Ferric potassium oxalate is made by saturating a hot solution of acid oxalate of potassium with ferric hydrate.
Ferric Sulphate .... $Fe_2(SO_4)_3+9H_2O$ *Fr.*—Sulfate ferreux. *Ger.*—Ferridsulfat. Schwefelsaures Eisenoxyd.	562	28.45 Fe_2O_2; 42.75 SO_3; 28.8 H_2O	1.97		Pure Com.	per ℔ $0.60 06	1.4	0.3	Ferric sulphate may be obtained by dissolving ferric hydrate in sulphuric acid until saturated. The red liquid thus obtained furnishes, on evaporation to dryness, a buff-colored amorphous mass, which dissolves very slowly when put in water.
Ferric Sulphate Solution........						35			
Ferric Subsulphate; Monzel's Salt .... *Ger.*—Monzel's Salz.						per oz. 10			
Ferric Tartrate .... *Fr.*—Tartrate de fer. *Ger.*—Ferridtartrat.									Fer. Tartrate is obtained by dissolving freshly precipitated ferric hydrate in a cold solution of tartaric acid. The brownish-green solution decomposes on warming, with separation of a basic salt, and in the air it is partly reduced to a ferrous salt. The solution is not precipitated by alkalies.
Ferric Ammonium Tartrate........ *Ger.*—Ammonium-Ferridtartrat.						per ℔ 62			Ferric ammonium tartrate is made in the same way as citrate of iron and ammonium.
Lead Nitrite........ *Fr.*—Nitrite de plomb. *Ger.*—Bleinitrit.						per oz. 25			

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							cold	boil'g	
Magnesia Carbonate..$(MgCO_3)_4Mg(HO)_2 5H_2O$ *Fr.*—Carbonate de Magnesie. *Ger.*—Magnesiacarbonat.	484	....	....	....	....	per lb $0.60	2493	9000	
Magnesia Nitrate ....$MgN_2O_6+6H_2O$ *Fr.*—Nitrate de magnesie. *Ger.*—Magnesiumnitrate.	256	15.6 MgO; 40.2 N_2O_5; 42.2 H_2O	....	....	....	per oz. 10		0.15	
Magnesium Sulphate (dry)......$MgSO_4+7H_2O$ *Fr.*—Sulfate de magnesie. *Ger.*—Magnesiumsulfat.	250	16 MgO; 32 SO_3; 52 H_2O	....	....	....	per lb 25	0.8	0.15	
Mercuric Chloride......................$HgCl_2$ Corrosive Sublimate. *Fr.*—Sublime corrosif. *Ger.*—Quecksilberchlorid.	271	73.8 Hg; 26.2 Cl	5.403	563°	509°	per oz. 15	16	3	Mercuric Chlor. combines with a great number of other metallic chlorides. It forms insoluble compounds with many of the azotized organic principles, as albumen, etc. 7 parts of alcohol dissolve 3 parts mer. chlor. By exposure to sunlight, an aqueous solution of the salt suffers decomposition into calomel, hydrochloric acid, and oxygen. It is likewise decomposed by various organic and inorganic substances.
Platinosochloride of Potassium.......K_2PtCl_4 Chloroplatinite of Potassium. *Ger.*—Kaliumplatinchloruer.	417.4	64.3 $PtCl_2$; 35.7 KCl	....	....	....	6.80	6	......	When a solution of platinous chloride, $PtCl_2$, in hydrochloric acid is mixed with potassium chloride, this double salt deposits in fine, red, prismatic crystals. According to Pizzighelli and Huebl, 74 to 75 grains of the double salt can be obtained from 100 grs. of chloride of platinum ($PtCl_4 2HCl+6H_2O$). Platinous chloride, $PtCl_2$, is produced by drying platinic chloride, and exposing the same for some time to a heat of about 400°F.
Potassium Bicarbonate ....$KHCO_3$ *Fr.*—Bicarbonate de potasse. *Ger.*—Kaliumbicarbonat.	100	47 K_2O; 44 CO_2; 9 H_2O	....	....	....	per lb 40	4	$\frac{5}{6}$	
Potassium Bichromate............$K_2CrO_4CrO_3$ *Fr.*—Bicromate de potasse. *Ger.*—Doppelt Chromsaures Kali.	294.4	31.93 K_2O; 68.07 CrO_3	2.603	....	.. Pure	50	10	......	Bichrom. of potassium is used largely by calico printers. Workingmen handling it are liable to painful ulcerations of the hands. Allowing the solution to come in contact with the skin should, therefore, be avoided.
Potassium Bromide.......................KBr *Fr.*—Bromide de potassium. *Ger.*—Kaliumbromid.	119	32.2 K; 67.8 Br	2.672	....	....	1.00	......	......	Bromide of potassium is a permanent and anhydrous salt, slightly soluble in alcohol. If its aqueous solution be mixed with a little chlorine water, and then shaken with ether, the bromine, separated by the chlorine, will be dissolved by the ether, which will rise to the surface, of a red color. 10 grs. of it require, for complete precipitation, 14.3 grs. of nitrate of silver, and the precipitate formed has a yellow color.

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							cold	boil'g	
Potassium Chlorate ....$KClO_3$ *Fr.*—Chlorate de potassium. *Ger.*—Kaliumchlorat.	122.5	38.45 K_2O; 61.55 Cl_2O_5	2.35	....	....	per ℔ $0.30	17	1⅔	
Potassium Chloride.......................KCl *Fr.*—Chloride de potassium. *Ger.*—Kaliumchlorid.	74.5	52.5 K; 47.5 Cl	1.945	....	....	30	3	1.683	
Potassium Citrate............................ *Fr.*—Citrate de potassium. *Ger.*—Kaliumcitrat.	......	....	....	....	....	1.00			
Potassium Cyanide ....KCN *Fr.*—Cyanide de potassium. *Ger.*—Kaliumcyanid.	65	60.12 K; 18.41 C; 21.47 N	....	....	....	65	2	1	
Potassium Ferricyanide...........K_3Fe 6(CN) Red Prussiate of Potash. *Fr.*—Prussiate rouge de potasse. *Ger.*—Kaliumeisencyanid. Rothes Blutlangensalz.	329	35.68 K; 16.99 Fe; 21.84 C; 25.49 N	1.845	....	....	1.00	3.8	......	When the aqueous solution of potassium ferricyanide is exposed to light, or evaporated, it is partially converted into the ferrocyanide. Its solution forms a delicate test of the ferrous salts, with which it produces a blue precipitate, but with the ferric salts, it only strikes a green or brown color.
Potassium Ferrocyanide ...$K_4Fe(CN)_6+3H_2O$ Yellow Prussiate of Potash. *Fr.*—Prussiate jaun de potasse. Protocyanure jaun de fer et de potasse *Ger.*—Kaliumeisencyanuer. Gelbes Blutlangensalz.	422	36.96 K; 13.27Fe; 17.06C 19.96 N; 12.79 H_2O	1.83	....	....	70	4½	2	Potass'm ferrocyanide crystals when exposed to light decompose superficially, giving off hydrocyanic acid, forming prussian blue, and becoming alkaline. It is characterized by striking a deep-blue color with the ferric salts, a deep-brown one with the salts of copper, a white one with those of zinc, the several precipitates formed being ferrocyanides of the respective metals.
Potassium Hydroxide; Caustic..........HKO *Fr.*—Potasse hydrate. *Ger.*—Kaliumoxydhydrat.	56	83.93 K_2O; 16.07 H_2O	2.1	....	....	per oz. 10	2		
Potassium Iodide...........................KI *Fr.*—Iodide de potassium. *Ger.*—Kaliumjodid.	166	23.5 K; 76.5 I	3.056	....	1182°	40	⅔	½	If a solution of iodide of potassium be mixed with a solution of starch, and a minute quantity of solution of chlorine be added, a blue color will be produced; the chlorine combining with the potassium and thus liberating the iodine which forms a blue compound with starch.

NAME AND MOLECULAR FORMULA.	Molecular Weight..	100 parts of the Compound contain.	Specific Weight..	Boiling Point, F.	Melting Point, F.	Average Price....	Parts of Water required to dissolve 1 part.		REMARKS.
							cold	boil'g	
Potassium Nitrite........................KNO_2 *Fr.*—Nitrite de potassium. *Ger.*—Kaliumnitrit.	85	55.28 K_2O; 44.72 N_2O_3	......	......	......	per oz. $0.20			
Potassium Oxalate, Neutral.....$C_2K_2O_4+H_2O$ *Fr.*—Oxalate de potassium, neutre. *Ger.*—Neutrales Kaliumoxalat.	......	......	2.04	......	......	per ℔ 35	3	......	Neutral oxalate of potassium is obtained by saturating oxalic acid with carbonate of potash and evaporating to crystallization. It is easily soluble in water.
Potassium Oxalate, Acid.......$C_2HKO_4+H_2O$ Hydrogen Potassium Oxalate; Salt of Sorrel. *Ger.*—Saures Kaliumoxalat.	......	......	......	......	......	50	......	......	Acid oxalate of potassium is prepared by dividing a solution of oxalic acid into 2 equal parts, saturating 1 part with carbonate of potash and adding the other. It is only slightly soluble in cold water, and combines with oxalic acid to form potassium quadroxalate, $C_2O_4KH+C_2O_4H_2+2H_2O$. Commercial salt of sorrel, used for the removal of ink stains from linen, consists generally of this compound.
Potassium Permanganate............$K_2Mn_2O_8$ *Ger.*—Kaliumsupermanganat.	316	70.25 (Mn_2O_7); 29.75 K_2O	......	......	cryst.	1.75	......	......	Permanganate of potassium, in consequence of the facility with which it parts with oxygen, is one of the most powerful oxidizing agents known. It causes the combustion of certain inflammable bodies, and imparts oxygen to almost all organic substances. If suddenly heated the crystals detonate, evolving oxygen, and leaving a black residue. Its solution, even with a minute proportion of the salt, has a beautiful lilac color.
Pyrogallol ....$C_6H_3(OH)_3$..	126	57.14 C; 4.76 H; 38.1 O	......	410°	221°	......	......	......	Pyrogallol is obtained by the separation of carbon dioxide from gallic acid. It is readily soluble in water, alcohol, and ether, tastes bitter, and is poisonous; 2 to 4 grains given to a dog, kill it. Pyrogallol reduces solutions of gold, mercury, and silver.
Silver Bromide................AgBr or Ag_2Br_2 *Fr.*—Bromide d'argent. *Ger.*—Silberbromid.	188	57.5 Ag; 42.05 Br	6.353	......	......	per oz. 2.25	......	......	Bromide of silver is obtained on adding a bromide of alkali-metal to a solution of nitrate of silver, as a white curdy precipitate, insoluble in nitric acid, nearly insoluble in dilute ammonia—whereby it is distinguished from the chloride—but easily soluble in concentrated ammonia. The fused bromide is scarcely acted upon by light, but the precipitated bromide, when exposed to light, quickly assumes a grayish-white color.

Name and Molecular Formula.	Molecular Weight..	100 parts of the Compound contain.	Specific Weight..	Boiling Point, F.	Melting Point, F.	Average Price....	Parts of Water required to dissolve 1 part.		Remarks.
							cold	boil'g	
Silver Chloride, Monochloride, or ......AgCl Argentic Chloride. *Fr.*—Chloride d'argent. *Ger.*—Chlorsilber.	143.5	75.27 Ag; 24.73 Cl	5.55	....	....	per oz. $1.50	......	......	Chloride of silver is invariably produced when a solution of a soluble silver salt and a chloride are mixed. It falls as a white, curdy precipitate, quite insoluble in water and nitric acid. 1 part of this salt is soluble in 200 parts of concentrated hydrochloric acid. It is decomposed by light, both in the dry and in the wet state, slowly if pure, and quickly if organic matter be present; it is reduced, also, when put in water with metallic zinc or iron. It dissolves easily in ammonia and in a solution of cyanide of potassium.
Silver Iodide......................AgI or Ag_2I_2 *Fr.*—Iodide d'argent. *Ger.*—Silberjodid, or Jodsilber.	235	46 Ag; 54 I	5.602	....	....	1.75	....	......	Silver iodide is precipitated as a pale-yellow substance, by adding silver nitrate to potassium iodide. It is insoluble or nearly insoluble in ammonia, and in this respect forms an exception to silver salts in general.
Silver Nitrate ....$AgNO_3$ *Fr.*—Nitrate d'argent. *Ger.*—Silbernitrat; Salpetersaures Silber.	170	68 Ag_2O; 32 N_2O_3	4.355	....	....	90	1	½	Nitrate of silver is an anhydrous salt, and is also soluble in alcohol. It blackens when exposed to light, if organic matter of any kind is present. It is frequently used for dyeing hair, and it enters into the composition of the indelible ink for marking linen.
Sodium Acetate, crystallized, $NaC_2H_3O_2+3H_2O$ *Fr.*—Terre foliee minerale. Acetate de soude. *Ger.*—Essigsaures Natron.	136	22.8 Na_2O; 39.7 H_2O; 37.5$(C_2H_3O)_2O$	....	....	....	per ℔ 50	¼	½	Exposed to a dry air, sodium acetate slowly effloresces, and loses about 40 per cent. of its weight. It is soluble in 24 parts of alcohol. The salt should be perfectly neutral to test-paper. When A. S. is melted it is deliquescent, and takes up 7 equivalents of water; it then becomes a liquid supersaturated solution, which crystallizes with evolution of heat immediately a fragment of dry or crystallized sodium acetate is thrown into it.
Sodium Bicarbonate..................$NaHCO_3$ *Fr.*—Bicarbonate de sodium. *Ger.*—Doppelt Kohlensaures; Natron.	84	36.9 Na_2O; 52.37 CO_2 10.73 H_2O	....	....	....	12	8	......	Bicarbonate of soda is permanent in the air, and slightly alkaline to the taste and to turmeric paper. When its solution is exposed to heat, the salt gradually parts with carbonic acid. It can not be dissolved in warm water without partial decomposition.

NAME AND MOLECULAR FORMULA.	Molecular Weight..	100 parts of the Compound contain.	Specific Weight..	Boiling Point, F.	Melting Point, F.	Average Price....	Parts of Water required to dissolve 1 part. cold	boil'g	REMARKS.
Sodium Nitrite .... *Fr.*—Nitrite de sodium. *Ger.*—Natriumnitrit.	......	....	......	......	......	per oz. \$0.20			
Sodium Oxalate, Neutral ......$C_2Na_2O_4+H_2O$ *Ger.*—Neutrales Natriumoxalat.	......	....	......	......	......	per ℔ 2.00	31	16	Neutral Oxalate of Sodium does not crystallize well. These salts are produced similarly to the corresponding potass'm salts.
Sodium Oxalate, Acid........$C_2HNa_2O_4+H_2O$ *Ger.*—Saueres Natriumoxalat.	......	....	......	......	......	......	60	47	Acid Oxalate of Sodium does not form good crystals.
Sodium Sulphate, crystallized, $Na_2SO_4+10H_2O$ Glauber's Salt. *Fr.*—Sulfate de sodium. *Ger.*—Natriumsulfat.	322	19.25 Na_2O; 24.84 SO_3 55.91 H_2O	......	......	86°	55	2.8	0.4	Sodium Sulphate is insoluble in alcohol.
Sodium Sulphite, crystallized..$Na_2SO_3+6H_2O$ *Fr.*—Sulfite de sodium. *Ger.*—Natriumsulfit.	234	26.5 Na_2O; 27.35 SO_2; 46.15 H_2O	......		......	per oz. 05	4	1	Sodium Sulphite should be kept in bottles well-stopped, as it gradually changes, on exposure, into Sulphate of Soda.
Sugar; Sucrose ....$C_{12}H_{22}O_{11}$ *Fr.*—Sucre pur. *Ger.*—Zucker; Saccharose.	342	42.1 C; 6.43 H; 51.47 O	1.606	......	320°	......	⅓	in all proportions	Solutions of Sugar easily reduce the noble metals from their solutions on warming, whilst cupric salts are only slowly decomposed in alkaline solutions of sucrose. Sugar combines with certain metallic oxides, to form definite compounds.
Uranic Nitrate...............$UO_22NO_3+6H_2O$ *Fr.*—Nitrate uranique. *Ger.*—Urannitrat.	504	57.1 UrO_2; 21.4 N_2O_5 21.5 H_2O	......	......	......	90	5	3	Uranic salts yield, with caustic alkalies, a yellow precipitate of alkaline uranate, insoluble in excess of the reagent. Ammonium sulphide forms a black precipitate of uranic sulphide. Potassium ferrocyanide forms a red-brown precipitate.
Water ....H_2O.. *Fr.*—Eau. *Ger.*—Wasser.	18	11.11 H; 88.89 O	1	212°	32°				
Wax; Beeswax................................ *Fr.*—Cire. *Ger.*—Wachs.	......	....	0.96 to 0.965	......	143°	per ℔ 1.20 (white)	......	......	Beeswax is insoluble in water and in cold alcohol or ether. The volatile and fixed oils dissolve it with facility; resin readily unites with it by fusion, and soaps are formed by the action of soda and potassa. It is not affected by acids at ordinary temperatures.

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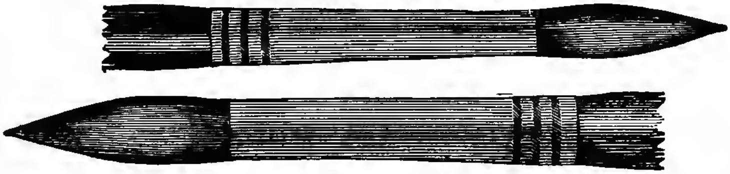


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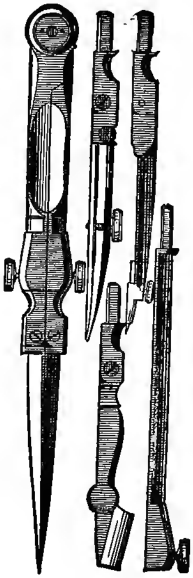

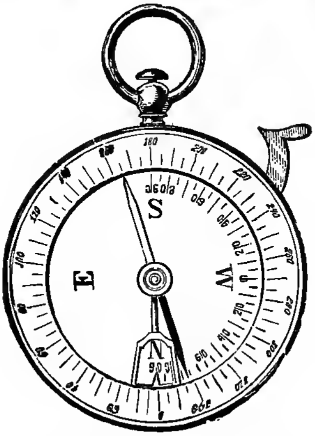
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