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PREFACE.

The rapidity with which the second edition of this work has been exhausted, is a most satisfactory proof that a collection within convenient compass of all the facts connected with the progress and practice of Photography, was required by the increasing number of amateurs and artists who are interested in its very beautiful phenomena.

In the present edition a new system of arrangement has been adopted, which will, it is thought, prove generally convenient. The first division contains the history of the progress of Photographic discovery, in which the greatest care has been taken to ensure exactness, and to give to each discoverer the full merit of his labours: the date of publication being taken in all cases where it could possibly be obtained.

The second division embraces the science of the art; and it is a section to which the attention of the intelligent student in Photography is particularly directed, as he may, by the knowledge he will thus acquire, relieve himself from many of the annoyances attendant upon frequent failures, and probably advance himself in the path of new discovery. The manipulatory details, given with all necessary minuteness, are included in the third division.

A very large portion of the present volume consists of new matter—the Waxed Paper and the Collodion Processes, amongst other sections, may be referred to; and the appended chapter, On the Production of Pictures for the Stereoscope, will be found to afford much useful information. The additional woodcut illustrations which have been introduced will be found to render important aid to the amateur. I must acknowledge the ready assistance, in the way of correction and information, which has been afforded me by several of the most practised photographic artists of the metropolis. To Mr. Claudet and Mr. Horne, in particular, I am indebted for many novel and most useful details in the practice of the Daguerreotype and the Collodion processes; and to Mr. Sandford, who has furnished me with many valuable facts relating to the preparation of paper for Photography, I am under many obligations. Those gentlemen who have kindly hastened to supply me with the results of their practice, which is duly acknowledged in the text, will accept my thanks. In conclusion, let me hope that the arrangement of the present volume will be found an improvement upon the former editions, and that this Manual may deserve to maintain its place as a Text-Book on Photography.

ROBERT HUNT.

London, Dec. 1852.

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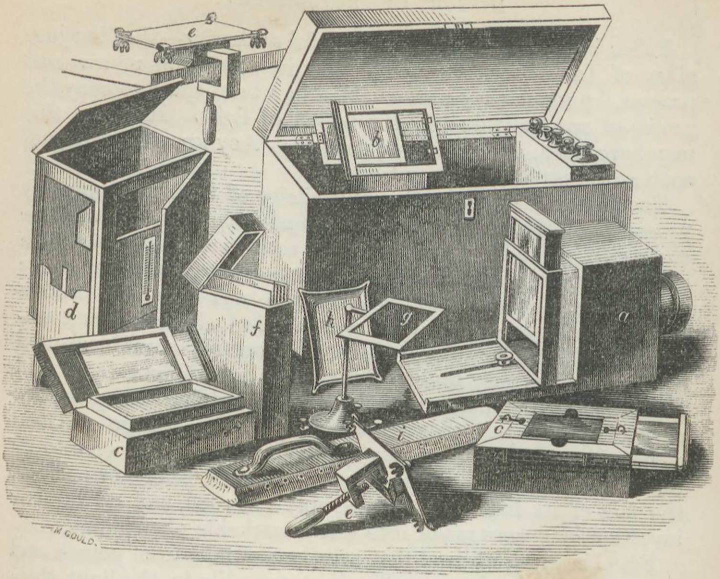


CHAPTER I.

EARLY RESEARCHES ON THE CHEMICAL ACTION OF THE SOLAR RAYS.

It is instructive to trace the progress of a discovery, from the first indication of the truth, to the period of its full development, and its application to purposes of ornament or utility. The progress of discovery is ordinarily a slow process, and it often happens that a great fact is allowed to lie dormant for years, or for ages, which, when eventually revived, is found to render a fine interpretation of some of Nature's harmonious phenomena, and to minister to the wants or the pleasures of existence. Photography is peculiarly illustrative of this position.

The philosophers of antiquity appear to have had their attention excited by many of the more striking characters of light. Yet we have no account of their having observed any of its chemical influences, although its action on coloured bodies—deepening their colour in some cases, and discharging it in others—must have been of every-day occurrence. The only facts which they have recorded are, that some precious stones, particularly the amethyst and the opal, lost their sparkle by prolonged exposure to the rays of the sun.

It has been stated—but on doubtful authority—that the jugglers of India were for many ages in possession of a secret process, by which they were enabled in a brief space to copy the profile of any individual by the action of light. However this may have been, it does not appear that they know anything of such a process in the present day.

The alchemists, amidst the multiplicity of their manipulatory processes, in their vain search for the *philosopher's stone* and the *elixir vitæ,* stumbled upon a peculiar combination of silver with chlorine, which they called horn silver—as, by fusion, the white powder they obtained by precipitation was converted into a horn-like substance, chlorine as a chemical element being unknown to them. They observed that this horn silver was blackened by light, and as they taught that "silver only differed from gold in being mercury interpenetrated by the sulphureous principle of the sun's rays," they concluded that this change was the commencement of the process by which their dreams were to be realised. Failing, however, to produce gold from horn silver, the fact of its blackening was simply recorded, and no further investigations were made into this remarkable phenomenon.

Petit, in 1722, noticed that solutions of nitrate of potash and muriate of ammonia crystallised more readily in the light than they did in darkness.

The illustrious Scheele (1777), in his admirable *Traité de l'Air et du Feu,* gave us the first philosophical examination of the peculiar change in the salts of silver, and showed the dissimilar powers of the different rays of light in effecting this change. He writes, "It is well known that the solution of silver in acid of nitre poured on a piece of chalk, and exposed to the beams of the sun, grows black. The light of the sun reflected from a white wall has the same effect, but more slowly. Heat without light has no effect on this mixture." Again, "Fix a glass prism at the window, and let the refracted sun-beams fall on the floor; in this coloured light put a paper strewed with *luna cornua,* and you will observe that this horn-silver grows sooner black in the violet ray than in any of the other rays."

Senebier repeated these experiments, and he states that he found chloride of silver darkened in the violet ray in fifteen seconds to a shade which required the action of the red ray for twenty minutes. He also experimented on the influence of light in bleaching wax.

In the Philosophical Transactions for 1798 will be found a memoir by Count Rumford, entitled, "An Inquiry concerning the Chemical Properties that have been attributed to Light." In this paper a number of experiments are brought forward to prove that all the effects produced upon metallic solutions by bright sunshine can be obtained by a prolonged exposure to a temperature of 210° Fahrenheit. We are now, however, in a position to show that the chemical effects produced by rays of dark heat are of a very different character from those usually attributed to light, but which it will be shown have no illuminating power. Mr. Robert Harrup, in a communication to Nicholson's Journal in 1802, refuted the experiment of Count Rumford, showing that several salts of mercury were reduced by light alone, and not heat.

In 1801, Ritter proved the existence of rays a considerable distance beyond the visible spectrum, which had the property of speedily blackening chloride of silver. These researches excited the attention of the scientific world: M. Bérard, Seebeck, Berthollet, and others, directed their attention to the peculiar condition of the different rays in relation to their luminous and chemical influences; while Sir William Herschel and Sir Henry Englefield investigated the calorific powers of the coloured rays, and were followed in these investigations by Seebeck and Wunsch. Dr. Wollaston pursued and published an interesting series of experiments on the decomposition effected by light on gum guaiacum. He found that paper washed with a solution of this gum in spirits of wine, had its yellow colour rapidly changed to green by the violet rays, while the red rays had the property of restoring the yellow hue. Sir Humphry Davy observed that the puce-coloured oxide of lead became, when moistened, red by exposure to the red ray, and black when exposed to the violet ray; that hydrogen and chlorine entered into combination more rapidly in the red than in the violet rays, and that the green oxide of mercury, although not changed by the most refrangible rays, speedily became red in the least refrangible.

These, and some curious observations by Morichini and Configliachi, M. Bérard and Mrs. Somerville, on the power of the violet rays to induce magnetism in steel needles, are the principal points of discovery in this branch of science, previously to the announcement of the Daguerreotype. Seebeck and Berzelius investigated this involved subject: it has again and again engaged the attention of experimentalists; but to the present time it may be regarded as an unsettled point, whether magnetism can be induced in steel by the solar rays.

A statement has been made by the French, to the effect that M. Charles was in possession of a process by which portraits could be obtained by the agency of sunlight, producing a dark impression upon a prepared surface. This is, however, exceedingly doubtful, and even the Abbé Moigno, in his Répertoire, states, that M. Charles never disclosed any fact connected with his hypothetical discovery, and that he left no evidence behind him of ever being in possession of such a secret process: we may therefore fairly infer that this is a vain boast.

In addition to the interesting facts already mentioned, it will be instructive to add a few particulars of other inquiries pursued about the same time on various phenomena connecting themselves with the solar radiations. Although these do not bear directly on Photography, they stand in very close relation with it, and will serve possibly to indicate lines of research which have not been fully followed out.

Desmortiers in 1801 published a paper in Gilbert's Annals, entitled "Recherches sur la Décoloration spontanée du Bleu de Prusse," subsequently translated into Nicholson's Journal, in which he has mentioned the influences of the solar rays in producing the change. Böckman about the same time observed that the two ends of the spectrum acted differently on phosphorus; and Dr. Wollaston, examining the chemical action of the rays of the spectrum, arrived at nearly the same results as Ritter. He states, "This and other effects usually attributed to light are not in fact owing to any of the rays usually perceived."

Attention having been directed by Dr. Priestley in 1779 to the influence of light on plants, numerous inquirers were started on this track, and the valuable researches of Senebier, Ingenhousz, De Candolle, Saussure and Ritter, were the result; Saussure inferring from his experiments that the blue rays were most active in producing the decomposition of carbonic acid by the leaves. These are already too well known to require anything beyond this incidental notice; but in 1801 Labillardière communicated to the Philomathic Society his discovery that light was necessary to the development of pores in plants, and subsequently, we find Victor Michellotti of Turin, in a paper, "Experiments and Observations on the Vitality and Life of Germs," stating that light has a decided action on those germs which are exposed to it, that this action is prejudicial to them, and it manifests its action by retarding their expansion if the light be weak, or a reflected light; or by the total extinction of their life, if it be very intense, as that which comes directly from the sun."

M. Macaire Prinsep again states, "that sheltering leaves from the action of light prevents their change of colour in the autumn; that if the entire leaf was placed in the dark, it fell off green; if only a part, the rest of the parenchyma changed colour, and the covered portion retained its original colour."

Those appear to be the more important researches in connection with this particular section of the inquiry, until the correction of the statements of Saussure were published by Dr. Daubeny, who satisfactorily proved that light, the *luminous* power as represented by the yellow rays, as distinguished from the *chemical* power or blue rays, was the most active in producing the decomposition of carbonic acid by the leaves of plants; and these results were confirmed by my own researches published in the Reports of the British Association.* Although these influences upon living organisms are directly connected with the chemical actions of the solar rays, the phænomena, being of a very complicated character, require an enlarged series of researches before any correct deductions approaching to the generality of a law can be made.

The earliest recorded attempts at fixing the images of the camera obscura by the chemical influence of light, are those of Wedgwood and Davy, published in the Journal of the Royal Institution of Great Britain, in June, 1802. Neither of these experimentalists succeeded in producing a preparation of sufficient sensitiveness to receive any impression from the subdued light of the camera obscura. By the solar microscope, when the prepared paper was placed very near the lens, Sir H. Davy procured a faint image of the object therein; but being unacquainted with any method of preventing the further action of light on the picture, which is, of course, necessary to secure the impression, the pursuit of the subject was abandoned.

Wedgwood was certainly the first person who made any attempts to use the sunbeam for delineating the objects through which it permeated: it is therefore necessary that some more particular account should be given of his processes. In 1802 he published a paper in the Journal of the Royal Institution, under the following title: "An Account of a Method of Copying Paintings upon Glass, and of making Profiles by the Agency of Light upon Nitrate of Silver; with Observations by H. Davy." From this communication the following extracts, containing the more important indications, are made.

"White paper, or white leather, moistened with solution of nitrate of silver, undergoes no change when kept in a dark place, but, on being exposed to the daylight, it speedily changes colour, and after passing through different shades of grey and brown, becomes at length nearly black. The alterations of colour take place more speedily in proportion as the light is more intense. In the direct beam of the sun, two or three

* Report of Seventeenth Meeting, 1847, p. 17.

minutes are sufficient to produce the full effect; in the shade several hours are required; and light transmitted through different coloured glasses acts upon it with different degrees of intensity. Thus, it is found that red rays, or the common sunbeams, passed through red glass, have very little action upon it; yellow and green are more efficacious; but blue and violet light produce the most decided and powerful effects.

"When the shadow of any figure is thrown upon the prepared surface, the part concealed by it remains white, and the other parts speedily become dark. For copying paintings on glass, the solution should be applied on leather; and in this case it is more readily acted on than when paper is used. After the colour has been once fixed on the leather or paper, it cannot be removed by the application of water, or water and soap, and it is in a high degree permanent. The copy of a painting or the profile, immediately after being taken, must be kept in an obscure place; it may, indeed, be examined in the shade, but in this case the exposure should be only for a few minutes: by the light of candles or lamps, as commonly employed, it is not sensibly affected. No attempts that have been made to prevent the uncoloured parts of the copy or profile from being acted upon by light, have as yet been successful. They have been covered by a thin coating of fine varnish, but this has not destroyed their susceptibility of becoming coloured; and even after repeated washings, sufficient of the active part of the saline matter will adhere to the white parts of the leather or paper to cause them to become dark when exposed to the rays of the sun. Besides the applications of this method of copying that have just been mentioned, there are many others; and it will be useful for making delineations of all such objects as are possessed of a texture partly opaque and partly transparent. The woody fibres of leaves, and the wings of insects, may be pretty accurately represented by means of it; and in this case it is only necessary to cause the direct solar light to pass through them, and to receive the shadows upon leather.

"The images formed by means of a camera obscura have been found to be too faint to produce, in any moderate time, an effect upon the nitrate of silver. To copy these images was the first object of Mr. Wedgwood in his researches on the subject; and for this purpose he first used nitrate of silver, which was mentioned to him by a friend as a substance very sensible to the influence of light; but all his numerous experiments as to their primary end proved unsuccessful. In following these processes, I have found that the images of small objects, produced by means of the solar microscope, may be copied without difficulty on prepared paper. This will probably be a useful application of the method: that it may be employed successfully, however, it is necessary that the paper be placed at but a small distance from the lens. (*Davy.*)

"In comparing the effects produced by light upon muriate of silver with those produced upon the nitrate, it seemed evident that the muriate was the most susceptible, and both were more readily acted upon when moist than when dry—a fact long ago known. Even in the twilight, the colour of the moist muriate of silver, spread upon paper, slowly changed from white to faint violet; though, under similar circumstances, no immediate alteration was produced upon the nitrate.

"Nothing but a method of preventing the unshaded parts of the delineations from being coloured by exposure to the day, is wanting to render this process as useful as it is elegant."

An experiment on the dark rays of Ritter, by Dr. Young, included in his Bakerian Lecture,[1] is a very important one. Dr. Young, after referring to the experiments of Ritter and Wollaston, goes on to say: "In order to complete the comparison of their properties (the chemical rays) with those of visible light, I was desirous of examining the effect of their reflection from a thin plate of air capable of producing the well-known rings of colours. For this purpose I formed an image of the rings, by means of the solar microscope, with the apparatus which I have described in the Journals of the Royal Institution; and I threw this image on paper dipped in a solution of nitrate of silver, placed at the distance of about nine inches from the microscope. In the course of an hour, portions of three *dark rings* were very distinctly visible, much smaller than the brightest rings of the coloured image, and coinciding very nearly, in their dimensions, with the rings of violet light that appeared upon the interposition of violet glass. I thought the dark rings were a little smaller than the violet rings, but the difference was not sufficiently great to be accurately ascertained: it might be as much as $\frac{1}{30}$ or $\frac{1}{40}$ of the diameters, but not greater. It is the less surprising that the difference should be so small, as the dimensions of the coloured rings do not by any means vary at the violet end of the spectrum so rapidly as at the red end. The experiment in its present state is sufficient to complete the analogy of the invisible with the visible rays, and to show that they are equally liable to the general law, which is the principal subject of this paper:" that is, the interference of light.

M. B. G. Sage, in the "Journal de Physique, 1802," mentions a fact observed by him, that "the realgar which is sublimated at

1 Philosophical Transactions, 1804.

the Solfaterra under the form of octahedral crystals, known under the name of *ruby of arsenic*, effloresces by the light;" and that ordinary native realgar from Japan changes to orpiment by exposure to sunshine.

In 1806, Vogel exposed fat, carefully protected from the influence of the air, to light, and found that it became in a short time of a yellow colour, and acquired a high degree of rancidity. Vogel subsequently discovered that phosphorus and ammonia exposed to the sun's rays were rapidly converted into phosphuretted hydrogen, and a black powder, phosphuret of ammonia. He also noticed that the red rays produced no change on a solution of corrosive sublimate (bichloride of mercury) in ether, but that the blue rays rapidly decomposed it. Dr. Davy, much more recently, repeated a similar set of experiments to those of Vogel. He found that corrosive sublimate was not changed by exposure; but that the *Liquor Hydrarg. Oxymur.* of the old London Pharmacopœia quickly underwent decomposition in the sunshine, depositing calomel (chloride of mercury.)

Seebeck, in, and subsequently to 1810, made some important additions to our knowledge of the influences of the solar radiations, the most striking of his statements being *the production of colour on chloride of silver;* the violet rays rendering it brown, the blue producing a shade of blue, the yellow preserving it white, and the red constantly giving a red colour to that salt. Sir Henry Englefield, about the same time, was enabled to show that the phosphorescence of Canton's phosphorus was greatly exalted by the blue rays.

Gay-Lussac and Thénard, being engaged in some investigations on chlorine, on which elementary body Davy was at the same time experimenting, observed that hydrogen and chlorine did not combine in the dark, but that they combined with great rapidity, and often with explosion, in the sunshine, and slowly in diffused light. Seebeck collected chlorine over hot water, and, combining it with hydrogen, placed different portions of it in a yellowish-red bell glass and in a blue one. In the blue glass combination took place immediately the mixture was exposed to daylight; but without explosion. The mixture in the red glass was exposed for twenty minutes without any change; but it was found that the chlorine had undergone some alteration, probably a similar one to that subsequently noticed by Dr. Draper, who found that chlorine having been exposed to sunshine would unite with hydrogen in the dark. If the gases were placed in a white glass and exposed to sunshine, they exploded; but if the gas had been previously exposed to the action of the solar radiations in the yellow-red glass, it combined with hydrogen in the white glass in the brightest sunshine without any explosion.

Berzelius noticed some peculiar conditions in the action of the solar rays upon the salts of gold; and Fischer pursued some researches on the influence of the prismatic rays on horn silver.

The most important series of researches, however, were those of Berard in 1812, which were examined and reported on by Berthollet, Chaptal, and Biot. These philosophers write: "He (M. Berard) found that the chemical intensity was greatest at the violet end of the spectrum, and that it extended, as Ritter and Wollaston had observed, a little beyond that extremity. When he left substances exposed for a certain time to the action of each ray, he observed sensible effects, though with an intensity continually decreasing in the indigo and blue rays. Hence we must consider it as extremely probable, that if he had been able to employ reactions still more sensible, he would have observed analogous effects, but still more feeble, even in the other rays. To show clearly the great disproportion which exists in this respect between the energies of different rays, M. Berard concentrated, by means of a lens, all that part of the spectrum which extends from *the green to the extreme violet;* and he concentrated, by means of another lens, all that portion which extends from *the green to the extremity of the red.* This last pencil formed *a white point so brilliant that the eyes were scarcely able to endure it; yet the muriate of silver remained exposed more than two hours to this brilliant point of light without undergoing any sensible alteration.* On the other hand, when exposed to the other pencil, which was much less bright and less hot, it was blackened in less than six minutes." This is the earliest intimation we have of any hypothesis that the luminous and chemical powers may be due to dissimilar agencies. On this, the Commissioners remark :—"If we wish to consider solar light as composed of *three distinct substances*, one of which occasions *light*, another *heat*, and the third *chemical combinations*, it will follow that each of these substances is separable by the prism into an infinity of different modifications, like light itself; since we find by experiment, that each of the three properties, *chemical*, *colorific*, and *calorific*, is spread, though unequally, over a certain extent of the spectrum. Hence we must suppose, on that hypothesis, that there exist *three spectrums* one above another; namely, a calorific, a colorific, and a chemical spectrum. We must likewise admit that each of the substances which compose the three spectrums, and even each molecule of unequal refrangibility which constitutes these substances, is endowed, like the molecules of visible light, with the property of being polarized by reflection, and of escaping from reflection in the same positions as the luminous molecules, &c."

From the time when the difficulty of fixing the photographs stopped the progress of Davy and Wedgwood, no discoveries were made until 1814, when M. Niépce, of Chalons, on the Soane, appears to have first directed his attention to the production of pictures by light.

It does not seem that his early attempts were very successful; and after pursuing the subject alone for ten years, he, from an accidental disclosure, became acquainted with M. Daguerre, who had been for some time endeavouring, by various chemical processes, to fix the images obtained with the camera obscura. In December, 1829, a deed of copartnery was executed between M. Niepce and M. Daguerre, for mutually investigating the subject.

M. Niepce had named his discovery Heliography.[1] In 1827, he presented a paper to the Royal Society of London, on the subject; but as he kept his process a secret, it could not, agreeably with one of their laws, be received by that body. This memoir was accompanied with several photographs on metal (plated copper and pewter) and on glass plates; which were afterwards distributed in the collections of the curious, some of them still existing in the possession of Mr. Robert Brown, of the British Museum. They prove M. Niepce to have been then acquainted with a method of forming pictures, by which the lights, semi-tints, and shadows, were represented as in nature; and he had also succeeded in rendering his *Heliographs*, when once formed, impervious to the further effects of the solar rays. Some of these specimens appear in a state of advanced etchings; but this was accomplished by a process similar to that pursued in common etchings.

The ease with which nitric acid could be applied to etch these Heliographic plates will be apparent when the process of obtaining the pictures is clearly understood.

[1] Sun-drawing: a more appropriate name than Photography, since there are reasons for believing that *light* is not the agent producing those so-called "light-drawn" pictures.

CHAPTER II.

HELIOGRAPHY. THE PROCESS OF M. NIEPCE.

M. Niepce was the first inquirer who appears to have produced *permanent* pictures by the influence of the sun's rays. This process—Heliography—is in many respects peculiar, which renders it necessary, although his preparation was only acted on by an exposure of many hours to full sunshine, to give a particular account of it; the more so, as some points of considerable interest require further elucidation.

The substance employed by M. Niepce was *asphaltum*, or bitumen of Judea. He thus directs its preparation:—"I about half fill a wine-glass with this pulverised bitumen; I pour upon it, drop by drop, the essential oil of lavender,[1] until the bitumen is completely saturated. I afterwards add as much more of the essential oil as causes the whole to stand about three lines above the mixture, which is then covered and submitted to a gentle heat until the essential oil is fully impregnated with the colouring matter of the bitumen. If this varnish is not of the required consistency, it is to be allowed to evaporate slowly, without heat, in a shallow dish, care being taken to protect it from moisture, by which it is injured, and at last decomposed. In winter, or during rainy weather, the precaution is doubly necessary. A tablet of plated silver, or well cleaned and warm glass, is to be highly polished, on which a thin coating of the varnish is to be applied cold, with a light roll of very soft skin: this will impart to it a fine vermilion colour, and cover it with a very thin and equal coating. The plate is then placed upon heated iron, which is wrapped round with several folds of paper, from which by this method all moisture had been previously expelled. When the varnish has ceased to simmer, the plate is withdrawn from the heat, and left to cool and dry in a gentle temperature, and protected from a damp atmosphere. In this part of the operation a light disc of metal, with a handle in the centre,

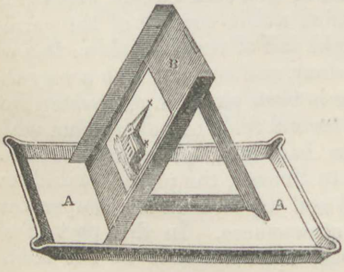
[1] The English oil of lavender is too expensive for this purpose. An article sold as the French oil of lavender, redrawn, is very much cheaper, and answers in every respect as well, if not better.

should be held before the mouth, in order to condense the moisture of the breath."

The plate thus prepared is now in a fit state for use, and may be immediately fixed in the correct focus of the camera. After it has been exposed a sufficient length of time for receiving the impression, a very faint outline alone is visible. The next operation is to bring out the hidden picture, which is accomplished by a solvent.

This solvent must be carefully adapted to the purposes for which it is designed: it is difficult to fix with certainty the proportions of its components, but in all cases it is better that it be too weak than too strong; in the former case the image does not come out strongly; in the latter it is completely destroyed. The solution is prepared of one part—not by weight, but volume—of the essential oil of lavender, poured upon ten parts, by measure also, of oil of white petroleum. The mixture, which is first milky, becomes clear in two or three days. This compound will act until it becomes saturated with the asphaltum, which state is readily distinguished by an opaque appearance, and dark brown colour. A tin vessel somewhat larger than the photographic tablet, and one inch deep, must be provided. This is to have as much of the solvent in it as will cover the plate. The tablet is plunged into the solution, and the operator, observing it by reflected light, begins to see the images of the objects to which it has been exposed slowly unfolding their forms, though still veiled by the gradually darkening supernatant fluid. The plate is then lifted out, and held in a vertical position, till as much as possible of the solvent has been allowed to drop away. When the dropping has ceased, we proceed to the last, and not the least important operation, of washing the plate.

This is performed by carefully placing the tablet upon a board, B, fixed at a large angle, in the trough A A, the supports being joined to it by hinges, to admit of the necessary changes of inclination, under different circumstances: two small blocks, not thicker than the tablet, are fixed on the board, on which the plate rests. Water must now be slowly poured upon the upper part of the board, and allowed to flow evenly over the surface of the picture. The descending stream clears away all the solvent that may yet



1.

adhere to the varnish. The plate is now to be dried with great care by a gentle evaporation: to preserve the picture, it is requisite to cover it up from the action of light, and protect it from humidity.

The varnish may be applied indifferently to metals, stone, or glass; but M. Niepce prefers copper plated with silver. To take copies of engravings, a small quantity of wax is dissolved in essential oil of lavender, and added to the varnish already described: the engraving, first varnished over the back, is placed on the surface of the prepared tablet, face towards it, and then exposed to the action of the light. In the camera obscura an exposure of from six to eight hours, varying with the intensity of light, is required; while from four to six hours is necessary to produce a copy of an engraving. The picture, in the first instance, is represented by the contrast between the polished silver and the varnish coating. The discoverer afterwards adopted a plan of darkening the silver by iodine, which appears to have led the way to Daguerre's beautiful process. To darken the tablet, it was placed in a box in which some iodine was strewed, and watched until the best effect was produced. The varnish was afterwards removed by spirit of wine.

Of the use of glass plates M. Niepce thus speaks:—"Two experiments in landscape upon glass, by means of the camera, gave me results which, although imperfect, appear deserving of notice, because this variety of application may be brought more easily to perfection, and in the end become a more interesting department of heliography.

"In one of these trials the light acted in such a way that the varnish was removed in proportion to the intensity with which the light had acted, and the picture exhibited a more marked gradation of tone; so that, viewed by transmitted light, the landscape produced, to a certain extent, the well-known effects of the diorama.

"In the second trial, on the contrary, the action of the luminous fluid having been more intense, the parts acted upon by the strongest lights, not having been attacked by the solvent, remained transparent; the difference of tone resulted from the relative thickness of the coatings of varnish.

"If this landscape is viewed by reflection in a mirror, on the varnished side, and at a certain angle, the effect is remarkably striking; while, seen by transmitted light, it is confused and shapeless: but, what is equally surprising, in this position the mimic tracery seems to affect the local colour of the objects."

A statement that M. Niepce was enabled to engrave by light, went the round of the press; but this does not appear to have been the case. All that the author of heliography effected, was the etching of the plate, after it had undergone its various processes, and the drawing was completed by the action of nitric acid in the usual manner: the parts of the copperplate protected by the varnish remained, of course, unacted on, whilst the other parts were rapidly attacked by the acid. The author remarks that his process cannot be used during the winter season, as the cold and moisture render the varnish brittle, and detach it from the glass or metal.

M. Niepce afterwards used a more unctuous varnish, composed of *bitumen from Judea, dissolved in animal oil of Dippel.* This composition is of much greater tenacity and higher colour than the former, and, after being applied, it can immediately be submitted to the action of light, which appears to render it solid more quickly, from the greater volatility of the animal oil. M. Daguerre remarks, that this very property diminishes still further the resources of the process as respects the lights of the drawings thus obtained. These processes of M. Niepce were much improved by M. Daguerre, who makes the following remarks on the subject:—

"The substance which should be used in preference to bitumen is the residuum obtained by evaporating the essential oil of lavender, which is to be dissolved in alcohol, and applied in an extremely thin wash. Although all bituminous and resinous substances are, without any exception, endowed with the same property—that of being affected by light—the preference ought to be given to those which are the most unctuous, because they give greater firmness to the drawings. Several essential oils lose this character when they are exposed to too strong a heat.

"It is not, however, from the ease with which it is decomposed, that we are to prefer the essential oil of lavender. There are, for instance, the resins, which, being dissolved in alcohol, and spread upon glass or metal, leave, by the evaporation of the spirit, a very white and infinitely sensitive coating. But this greater sensibility to light, caused by a quicker oxidation, renders also the images obtained much more liable to injury from the agent by which they were created. They grow faint, and disappear altogether, when exposed but for a few months to the sun. The residuum of the essential oil of lavender is more effectually fixed, but even this is not altogether uninfluenced by the eroding effects of a direct exposure to the sun's light.

"The essence is evaporated in a shallow dish by heat, till the resinous residuum acquires such a consistency, that when cold it rings on being struck with the point of a knife, and flies off in pieces when separated from the dish. A small quantity of this material is afterwards to be dissolved in alcohol or ether; the solution formed should be transparent, and of a lemon-yellow colour. The clearer the solution, the more delicate will be the coating on the plate: it must not, however, be too thin, because it would not thicken or spread out into a white coat; indispensable requisites for obtaining good effects in photographic designs. The use of the alcohol or ether is to facilitate the application of the resin under a very attenuated form, the spirit being entirely evaporated before the light effects its delineations on the tablet. In order to obtain greater vigour, the metal ought to have an exquisite polish. There is more charm about sketches taken on glass plates, and, above all, much greater delicacy.

"Before commencing operations, the experimenter must carefully clean his glass or metal plate. For this purpose, emery, reduced to an impalpable powder, mixed with alcohol, may be used; applying it by means of cotton-wool: but this part of the process must always be concluded by dry-polishing, that no trace of moisture may remain on the tablet. The plate of metal or glass being thus prepared, in order to supply the wash or coating, it is held in one hand, and with the other the solution is to be poured over it from a flask or bottle having a wide mouth, so that it may flow rapidly, and cover the whole surface. It is at first necessary to hold the plate a little inclined; but as soon as the solution is poured on, and has ceased to flow freely, it is raised perpendicularly. The finger is then passed behind and below the plate, in order to draw off a portion of the liquid, which, tending always to ascend, would double the thickness of the covering: the finger must be wiped each time, and be passed very rapidly along the whole length of the plate from below, and on the side opposite the coating. When the liquid has ceased to run, the plate is dried in the dark. The coating being well dried, it is to be placed in the camera obscura. The time required to procure a photographic copy of a landscape is from seven to eight hours; but single monuments strongly illuminated by the sun, or very bright in themselves, are copied in about three hours.

"When operating on glass, it is necessary, in order to increase the light, to place the plate upon a piece of paper, with great care that the connection is perfect over every part, as, otherwise, confusion is produced in the design by imperfect reflection.

"It frequently happens that when the plate is removed from the camera there is no trace of any image upon its surface: it is therefore necessary to use another process to bring out the hidden design.

"To do this, provide a tin vessel, larger than the tablet, having all round a ledge or border 50 millimeters (2 English inches) in depth. Let this be three quarters full of the oil of petroleum: fix your tablet by the back to a piece of wood which completely covers the vessel, and place it so that the tablet, face downwards, is over but not touching the oil. The vapour of the petroleum penetrates the coating of the plate in those parts on which the light has acted feebly; that is, in the portions which correspond to the shadows, imparting to them a transparency, as if nothing were there. On the contrary, the points of the resinous coating, on which light has acted, having been rendered impervious to the vapour, remain unchanged.

"The design must be examined from time to time, and withdrawn as soon as a vigorous effect is obtained. By urging the action too far, even the strongest lights will be attacked by the vapour, and disappear, to the destruction of the piece. The picture, when finished, is to be protected from the dust by being kept covered with a glass, which also protects the silver plate from tarnishing."

It may perhaps appear to some that I have needlessly given the particulars of a process, now entirely superseded by others, possessing the most infinite sensibility; producing in a few minutes a better effect than was obtained by the Heliographic process in several hours. There are, however, so many curious facts connected with the action of light on these resins, that no treatise on photography could be considered complete without some description of them.

M. Daguerre remarks, that numerous experiments tried by him with these resinous preparations of M. Niepce, prove that light cannot fall upon a body without leaving traces of decomposition; and they also demonstrate that these bodies possess the power of renewing in darkness, what has been lost by luminous action, provided total decomposition has not been effected. This heliographic process must be regarded as the earliest successful attempt at fixing on solid tablets the images of the camera-obscura, and at developing a dormant image. As M. Niepce appears to have allowed the investigation after this period to fall into the hands of Daguerre, further remarks are reserved for the chapter devoted to the history of the daguerreotype.

CHAPTER III.

MR. H. FOX TALBOT'S PHOTOGENIC DRAWINGS, CALOTYPE, &c.

SECTION I.—PHOTOGENIC DRAWING.

ON the 31st of January, 1839, six months prior to the publication of M. Daguerre's process, Mr. Fox Talbot communicated to the Royal Society his photographic discoveries, and in February he gave to the world an account of the process he had devised for preparing a sensitive paper for photographic drawings. In the memoir read before the Royal Society, he states—"In the spring of 1834, I began to put in practice a method which I had devised some time previously, for employing, to purposes of utility, the very curious property which has been long known to chemists to be possessed by the nitrate of silver, namely, its discolouration when exposed to the violet rays of light." From this it appears that the English philsosopher had pursued his researches ignorant of what had been done by others on the continent. It is not necessary to enlarge, in this place, on the merits of the two discoveries of Talbot and Daguerre; but it may be as well to show the kind of sensitiveness to which Mr. Talbot had arrived at this early period, in his preparations; which will be best done by a brief extract from his own communication.

"It is so natural," says this experimentalist, "to associate the idea of *labour* with great complexity and elaborate detail of execution, that one is more struck at seeing the thousand florets of an *Agrostis* depicted with all its capillary branchlets, (and so accurately, that none of all this multitude shall want its little bivalve calyx, requiring to be examined through a lens), than one is by the picture of the large and simple leaf of an oak or a chesnut. But in truth the difficulty is in both cases the same. The one of these takes no more time to execute than the other; for the object which would take the most skilful artist days or weeks of labour to trace or to copy, is effected by the boundless powers of natural chemistry in the space of a few seconds." And again, "to give some more definite idea of the rapidity of the process, I will state, that after various trials, the nearest valuation which I could make of the time necessary for obtaining the picture of an object, so as to have pretty distinct outlines, when I employed the full sunshine, was *half a second.*" This is to be understood of the paper then used by Mr. Talbot for taking objects by means of the solar microscope.

In the Philosophical Magazine, Mr. Fox Talbot published the first account of his *Photogenic* experiments. This term was introduced by this gentleman: and his experiments cannot be better described than in his own words. "In order to make what may be called ordinary photogenic paper, I select, in the first place, paper of a good firm quality and smooth surface. I do not know that any thing answers better than superfine writing paper. I dip it into a weak solution of common salt, and wipe it dry, by which the salt is uniformly distributed throughout its substance. I then spread a solution of nitrate of silver on one surface only, and dry it at the fire. The solution should not be saturated, but six or eight times diluted with water. When dry, the paper is fit for use.

"I have found by experiment that there is a certain proportion between the quantity of salt and that of the solution of silver which answers best, and gives the maximum effect. If the strength of the salt is augmented beyond this point, the effect diminishes, and, in certain cases, becomes exceedingly small.

"This paper, if properly made, is very useful for all photogenic purposes. For example, nothing can be more perfect than the images it gives of leaves and flowers, especially with a summer sun,—the light passing through the leaves, delineates every ramification of their nerves.

"Now, suppose we take a sheet thus prepared, and wash it with a *saturated* solution of salt, and then dry it. We shall find (especially if the paper is kept some weeks before the trial is made) that its sensibility is greatly diminished, and, in some cases, seems quite extinct. But if it is again washed with a liberal quantity of the solution of silver, it becomes again sensible to light, and even more so than it was at first. In this way, by alternately washing the paper with salt and silver, and drying it between times, I have succeeded in increasing its sensibility to the degree that is requisite for receiving the images of the camera obscura.

"In conducting this operation, it will be found that the results are sometimes more and sometimes less satisfactory, in consequence of small and accidental variations in the proportions employed. It happens sometimes that the chloride of silver is disposed to darken of itself without any exposure to light: this shows that the attempt to give it sensibility has been carried too far. The object is to *approach* to this condition as near as possible without *reaching* it, so that the substance may be in a state ready to yield to the slightest extraneous force, such as the feeble impact of the violet rays when much attenuated. Having, therefore, prepared a number of sheets of paper with chemical proportions slightly different from one another, let a piece be cut from each, and, having been duly marked or numbered, let them be placed, side by side, in a very weak diffused light for a quarter of an hour. Then, if any one of them, as frequently happens, exhibits a marked advantage over its competitors, I select the paper which bears the corresponding number to be placed in the camera obscura."

The increased sensitiveness given to paper by alternate ablutions of saline and argentine washes, the striking differences of effect produced by accidental variations of the proportions in which the chemical ingredients are applied, and the spontaneous change which takes place, even in the dark, on the more sensitive varieties of the paper, are all subjects of great interest, which demand further investigation than they have ever yet received, and which, if followed out, promise some most important explanations of chemical phenomena at present involved in uncertainty, particularly those which appear to show the influence of time, an element not sufficiently taken into account, in overcoming the weaker affinities. Few fields of research promise a greater measure of reward than these ; already the art of making sun pictures has led to many very important physical discoveries, but most of the phenomena are yet involved in obscurity.

Section II.—The Calotype.

Although, in order of date, the investigations of Sir John Herschel and others have a priority over those particular experiments of Mr. Talbot's which resulted in the discovery of his very beautiful process, the calotype, yet to avoid confusion it is thought advisable to group together the discoveries of each investigator, where this is practicable, in our historical division.

The earliest productions of Mr. Talbot were simply such preparations as those already described, in which a chloride of silver was formed on the surface of the paper, with some nitrate of silver in excess. These need not be any further described than they have already been.

Early in 1840, drawings on paper were handed about in the scientific circles of London and of Paris, which were a great advance upon anything which had been previously done. These were the results of a new process discovered by Mr. Talbot, and then attracted so much attention, that M. Biot made them the subject of a communication to the Academy of Sciences in Paris. His remarks are printed *in extenso* in the *Comptes Rendus*, from which the following passages are translated, as they bear particularly on many of the defects which still continue to prove annoyances in the photographic process to which they have reference.

Many of the remarks have a peculiar value from the suggestions they contain, and they are worthy of record as marking the period when the French were first made acquainted with the processes on paper, as practised in England. Some disposition has been shown on the part of several continental photographers to claim originality for processes published in England many years before their own were devised, and which singularly resemble them. After remarking that many very important physical facts were being developed by the study of photography, M. Biot continues:—

"It is not to be expected that photogenic drawings, made on paper, can ever equal the clearness and fineness of those obtained on level and polished metallic plates. The texture of paper, its superficial roughnesses, the depth of the imbibitions, and the capillary communication established between the various unequally marked parts of its surface, are so many obstacles to absolute strictness of delineation, as well as to the regular gradation of tints in the camera obscura; and the influence of these obstacles is greater when the chemical operation is slowly carried on. But when there is no pretence or necessity for submitting to the delicacies of art—when it is required, for example, to copy rare manuscripts faithfully—if we have papers which are very susceptible of receiving impressions in the camera obscura, they will suffice perfectly; particularly when they present, like those of Mr. Talbot, the facility of immediately procuring copies of the primitive drawing. It will, therefore, doubtless be found more commodious, and often even more practicable, to put four or five hundred drawings in a portfolio, than to carry about a similar provision of metallic plates with those indispensable protectors, squares of glass, to cover them. Attempts are being made, at this time, to fix the images produced by the Daguerreotye—perfect prints, it is true, but which are as light as the vapour from which they are produced; and, indeed, to bring a voluminous collection of these fragile products through the accidents incident to long, and sometimes perilous voyages, is a task requiring no ordinary care. But whoever has attentively studied the combination of physical conditions whence these admirable images result, will find it very difficult—I am far from saying impossible,—to fix them without destroying, or at least without essentially altering, the causes which produce their charm; and then, for the purposes which I have mentioned, papers very susceptible of impression would still have the advantages of being less troublesome in removal from place to place, as also of more easy preservation.

"The utility of sensitive papers for copying texts was a natural consequence of the clearness of the copies of engravings which Mr. Talbot had already obtained by application, and which were presented to the Academy. He has included others among those just sent: there are also added specimens of this especial application, consisting of copies of a Hebrew psalm, of a Persian Gazette, and of an old Latin chart of the year 1279. Our brethren of the *Académie des Belles Lettres*, to whom I exhibited these impressions, were pleased to remark the fidelity of the characters, and their clearness, by which they are rendered as legible as the original text. Doubtless an old manuscript may be copied more quickly and more accurately by this means than by hand, even when the language in which it is written is understood. However, we must stop here. These copies are obtained by application: we must be enabled to obtain them by immediate radiation in the camera obscura. It is the only means of extending the process to papyrus and other opaque manuscripts, or which are not sufficiently transparent for radiation to traverse them. Moreover, the application of leaves is very difficult when they are bound up in a volume, and cannot be detached from one another.

"But this important extension will require much physical perfecting, towards which experimenters should direct their efforts. The first thing will be to augment the sensibility of the paper as much as possible, in order that the capillary communication of its various parts may not have sufficient time to deteriorate the effects of the local and immediate action of the radiation. I should be led to believe that it is principally to this kind of communication should be attributed the fact remarked by Mr. Talbot, that, in experiments by application, it is more difficult to copy clearly a tissue of black lace spread on a white ground, than white lace on a black ground; two cases of which he here gives examples. But another more hidden and more general difficulty seems to me to proceed from the unequal faculty of various substances for reflecting the radiations which strike them, and perhaps from their aptitude for making them undergo physical modifications. For example, you wish to copy by radiation in the camera obscura a picture painted on canvas, wood, or porcelain: the different colouring substances employed by the painter are placed and distributed in such a manner that each of them absorbs certain portions of the total incidental light, and reflects especially towards your eye the complementary portions, wherein predominate the rays proper to form the tint of which it would give you the sensation. But the chemically active reagent which the same parts of the picture receive and reflect is distinct from the light which affects your retina. In order that the chemical effect which it produces on the sensible paper, or on M. Daguerre's layer of iodine, may present, in light or in shade, the equivalent of the coloured parts, it is requisite —1st, that this reflected radiation be chemically active; 2d, that the energy of its action be proportional to the intensity of illumination operated in the eye by the portion of luminous radiation reflected from the same point of the picture. Now this latter concordance certainly should not be fulfilled in an equal degree, by the various colouring matters, which affect the eye in the same manner, and which the painter may substitute for one another in his work. Substances of the same tint may present, in the quantity, or the nature of the invisible radiations which they reflect, as many diversities, or diversities of the same order, as substances of a different tint present relative to light: inversely they may be similar in their property of reflecting chemical radiations, when they are dissimilar to the eye: so that the differences of tint which they presented in the picture made for the eye, will disappear in the chemical picture, and will be confused in it in a shade, or of an uniform whiteness. These are the difficulties generally inherent in the formation of chemical pictures; and they show, I think, evidently, the illusion of the experimenters who hope to reconcile, not only the intensity, but the tints of the chemical impressions produced by radiations, with the colours of the objects from which these radiations emanate. However, the distant or near relations of these two species of phenomena are very curious to study, not only as regards the photogenic art, *since that name has, very improperly, been given it*, but likewise as regards experimental physics. I doubt not that examples of these peculiarities may be remarked in the images of natural objects and coloured pictures executed by the Daguerreotype; but very apparent ones may be seen among Mr. Talbot's present impressions. Thus, some of them represent white porcelain vases, coloured shells, a candlestick (of metal) with its taper, a stand of white hyacinths. The whole of these objects are felt and perceived very well in their chemical image; but the parts which reflect the purely white light, probably also the radiations of every kind, are, relatively to the others, in an exaggerated proportion of illumination, which, it seems to me, must result, partially, from the capillary communication during the continuance of the action; so that the inequality would be less if the paper were more sensitive or more rapidly acted on. In the hyacinth, the stalk and the green leaves have produced scarcely a faint trace of their configuration; but they are strongly defined, especially in the parts of the outline, where more or less perfect specular reflection takes place. The points of the candlestick (metallic) where this reflection occurred, are copied by white stains locally applied, and which deteriorate the effect of the whole by their disproportion. But this is seen especially in a picture by Correggio, the frame of which was very vividly copied, whilst the figure on the canvas was hardly perceptible. This disproportion of lustre in the reproduction of some white parts, especially when they are dull and consequently very radiating, is sensible in certain parts of views taken by Mr. Talbot, to the point of rendering difficult the interpretation of the object to which they belong. However, these views are very satisfactory, as being obtained on paper, in the present season. Moreover, by an advantage peculiar to the chemical preparation which Mr. Talbot uses, it appears that the operations once completed, the drawings are no longer alterable by radiation, even acting with much energy. Indeed, we have here, as an example, four proofs of the same view of Mr. Talbot's house, with an identical disposition of lights and shades: so that some, at least, if not three out of four, must have been procured by superposition. Mr. Talbot is right in representing this property of reproduction as an especial advantage of his process, and it would indeed be very useful in voyages. I have exposed one of these drawings to the action of the sun, not very powerful, it is true, for several hours, and I have not perceived the slightest alteration in the lights. I think I understand that, in Mr. Talbot's opinion, the shades alone are strengthened under this influence. According to what I have just said, it should be expected that the triumph of this process, as of every other photogenic reproduction, would take place with objects of white and dull plaster. Indeed, Mr. Talbot's parcel contains eight copies of busts and statues; six of which chiefly, of various forms and sizes, present very remarkable results, especially taking into consideration the unfavourable season at which they were produced. Truly, there is not found in them the strict perfection of trace, nor the admirable gradations of lights and shades, which constitute the charm of M. Daguerre's impressions; and I again repeat it, that my expressions may not be exaggerated. But I also repeat, that representations on sensitive papers must be considered as principally applicable to a different object, which does not impose such strict conditions of art, requiring only faithful images, sufficiently clear in their details to be readily recognised, and which, moreover, being obtained with rapidity, by an easy manipulation, may be kept with very little care, comprised in great number in a small compass, and moved from place to place with facility. Mr. Talbot's papers already present many of these essential qualities, with the advantage of being able to furnish numerous copies immediately. His efforts, and those of others occupied with the same subject, will conclude by adding to them everything which may be desirable, provided that expectation, or the pretension of a perfection of art physically incompatible with operations on paper, do not give a false direction to their endeavours. However, not to appear to despair too much of the future, I may add that the height of success would consist in discovering a substance very susceptible of receiving impressions, which might be applied on a papyraceous leaf without penetrating deep into it, and which might, however, be fixed in it after the operation, as in Mr. Talbot's impressions. It does not seem necessary even that the first impression thus rapidly obtained should copy the lights and shades in their proper places, provided that its transparency and fixedness were such, that we might deduce them from the application of copies wherein the inversion would be corrected. And perhaps, by this decomposition of the problem into two successive operations, one of the best ways is opened by which it may be resolved."

Numerous improvements have been introduced, but still physical difficulties, such as those which he has indicated, surround the photographic processes, and even where M. Biot has proved wrong in his conjectures, his remarks form a curious chapter in the history of the art.

Mr. Talbot's description of his process, the patent for which is dated 1841, is as follows[1] :—

Take a sheet of the best writing-paper, having a smooth surface, and a close and even texture. The water-mark, if any, should be cut off, lest it should injure the appearance of the picture. Dissolve 100 grains of crystallised nitrate of silver in six ounces of distilled water. Wash the paper with this solution with a soft brush on one side, and put a mark on that side, whereby to know it again. Dry the paper cautiously at a distance from the fire, or else let it dry spontaneously in a dark room. When dry, or nearly so, dip it into a solution of iodide of potassium, containing 500 grains of that salt dissolved in one pint of water, and let it stay two or three minutes in the solution. Then dip the paper into a vessel of water, dry it lightly

[1] August 13, 1852.—Mr. Talbot has, by a letter in the *Times* of to-day, given his patents to the public. The letter is printed in the Appendix.

with blotting-paper, and finish drying it at a fire, which will not injure it even if held pretty near: or else it may be left to dry spontaneously. All this is best done in the evening by candle-light: the paper, so far prepared, is called *iodized paper*, because it has a uniform pale-yellow coating of iodide of silver. It is scarcely sensitive to light, but nevertheless it ought to be kept in a portfolio or drawer until wanted for use. It may be kept for any length of time without spoiling or undergoing any change, if protected from sunshine. When the paper is required for use, take a sheet of it, and wash it with a liquid prepared in the following manner:—

Dissolve 100 grains of crystallised nitrate of silver in two ounces of distilled water; add to this solution one-sixth of its volume of strong acetic acid. Let this be called mixture A.

Make a saturated solution of crystallised gallic acid in cold distilled water. The quantity dissolved is very small. Call this solution B.

Mix together the liquids A and B in equal volumes, but only a small quantity of them at a time, because the mixture does not keep long without spoiling. This mixture Mr. Talbot calls the *gallo-nitrate of silver*. This solution must be washed over the iodized paper on the side marked, and being allowed to remain upon it for half a minute, it must be dipped into water, and then lightly dried with blotting-paper. This operation in particular requires the total exclusion of daylight; and although the paper thus prepared has been found to keep for two or three months, it is advisable to use it within a few hours, as it is often rendered useless by spontaneous change in the dark.

Paper thus prepared is exquisitely sensitive to light; an exposure of less than a second to diffused daylight being quite sufficient to set up the process of change. If a piece of this paper is partly covered, and the other exposed to daylight for the *briefest possible period of time*, a very decided impression will be made. This impression is latent and invisible. If, however, the paper be placed aside in the dark, it will gradually *develop itself*; or it may be brought out immediately by being washed over with the gallo-nitrate of silver, and held at a short distance from the fire, by which the exposed portions become brown, the covered parts remaining of their original colour. The pictures being thus procured, are to be fixed by washing in clean water, and lightly drying between blotting paper, after which they are to be washed over with a solution of bromide of potassium, containing 100 grains of that salt, dissolved in eight or ten ounces of water; after a minute or two, it is again to be dipped into water, and then finally dried.

Such was, in all its main features, the description given by Mr. Talbot in his specification of his process for producing the Calotype, or *beautiful picture* (as the term signifies) : he in a second patent included the points stated in the next section.

Section III.—Improvements in Calotype.

Such is the term employed by Mr. Talbot, and these improvements consist of the following particulars, constituting that gentleman's second claim.

1. Removing the yellowish tint which is occasioned by the iodide of silver, from the paper, by plunging it into a hot bath of hyposulphite of soda dissolved in ten times its weight of water, and heated nearly to the boiling point. The picture should remain in the bath about ten minutes, and be then washed in warm water and dried.

Although this has been included by Mr. Talbot in his specification, he has clearly no claim to it, since in February 1840 Sir John Herschel published, in his Memoir " On the Chemical Action of the Rays of the Solar Spectrum," a process of fixing with the *hot* hyposulphite of soda.

After undergoing the operation of fixing, the picture is placed upon a hot iron, and wax melted into the pores of the paper to increase its transparency.

2. The calotype paper is rendered more sensitive by placing a warm iron behind in the camera whilst the light is acting upon it.

3. The preparation of *io-gallic paper*, which is simply washing a sheet of iodized paper with gallic acid. In this state it will keep in a portfolio, and is rendered sensitive to light by washing it over with a solution of nitrate of silver.

4. Iodized paper is washed with a mixture of twenty-six parts of a saturated solution of gallic acid to one part of the solution of nitrate of silver ordinarily used. It can then be dried without fear of spoiling, may be kept a little time, and used without further preparation.

5. The improvement of photographic drawings by exposing them twice the usual time to the action of sunlight. The shadows are thus rendered too dark, and the lights are not sufficiently white. The drawing is then washed, and plunged into a bath of iodide of potassium, of the strength of 500 grains to each pint of water, and allowed to remain in it for one or two minutes, which makes the pictures brighter, and its lights assume a pale-yellow tint. After this, it is washed, and immersed in a hot bath

of hyposulphite of soda until the pale-yellow tint is removed, and the lights remain quite white. The pictures thus finished have a pleasing and peculiar effect.

6. The appearance of photographic pictures is improved by waxing them, and placing white or coloured paper behind them.

7. Enlarged copies of Daguerreotypes and calotypes can be obtained by throwing magnified images of them, by means of lenses, upon calotype paper.

8. Photographic printing. A few pages of letterpress are printed on one side only of a sheet of paper, which is waxed if thought necessary, and the letters are cut out and sorted; then, in order to compose a new page, a sheet of white paper is ruled with straight lines, and the words are formed by cementing the separate letters in their proper order along the lines. A negative photographic copy is then taken, having white letters on a black ground; this is fixed, and any number of positive copies can be obtained. Another method proposed by the patentee is to take a copy by the camera obscura from large letters painted on a white board.

9. Photographic publication. This claim of the patentee consists in making, first, good negative drawings on papers prepared with salt and ammonio-nitrate of silver; secondly, fixing them by the process above described; thirdly, the formation of positive drawings from the negative copy, and fixing.

These claims are taken from the specification as published in the Repertory of Patent Inventions.

Section IV.—Pictures on Porcelain Tablets.

A third patent has been obtained by Mr. Talbot, mainly involving the use of porcelain as a substitute for glass, and contains some useful facts noticed by Mr. Malone.

The first part of the patentee's invention consists in the use of plates of unglazed porcelain, to receive the photographic image. A plate intended for photographic purposes should be made of the finest materials employed by the manufacturers of porcelain; it should also be flat, very thin, and semi-transparent; if too thin, so that there would be a chance of breaking, it may be attached by means of cement to a piece of glass, to give it strength. The substance of the plate should be slightly porous, so as to enable it to imbibe and retain a sufficient quantity of the chemical solutions employed. To prepare the plate for use, it is first required to give it a coating of albumen, or white of eggs, laid on very evenly, and then gently dried at a fire. According as the plate is more or less porous, it requires more or less of the albuminous coating; it is best to employ a very close-grained porcelain, which requires but little white of egg. The prepared plate may be made sensitive to light in the same way in which a sheet of paper is rendered sensitive; and we generally find the same methods applicable for photographic pictures on paper, applicable to those on porcelain plates, and one of the processes employed by the patentee is nearly the same as that patented by Mr. Talbot in 1841. The prepared plate is dipped into a solution of nitrate of silver, made by dissolving twenty-five grains of nitrate in one ounce of water: or the solution is spread over the plate uniformly with a brush; the plate is then dried, afterwards dipped into a solution of iodide of potassium, of the strength of about twenty-five grains of iodide to one ounce of water, again dried, and the surface rubbed clean and smooth with cotton. The plate is now of a pale-yellow colour, owing to the formation on its surface of iodide of silver. The plate, prepared as above directed, may be kept in this state until required, when it is to be rendered sensitive to light by washing it over with a solution of gallo-nitrate of silver, then placed in the camera; and the image obtained is to be rendered visible, and sufficiently strengthened, by another washing of the same liquid, aided by gentle warmth. The negative picture thus obtained is fixed by washing it with water, then with bromide of potassium, or, what is still better, hyposulphite of soda, and again several times in water. The plate of porcelain being semi-transparent, positive pictures can be obtained from the above-mentioned negative ones by copying them in a copying-frame.

The picture obtained on porcelain can be altered or modified in appearance by the application of a strong heat, a process not applicable to pictures taken on paper. With respect to this part of their invention, the patentees claim:—"The obtaining by means of a camera, or copying-frame, photographic images or pictures upon slabs or plates of porcelain." The second part relates to the process which has been discovered and improved upon by Mr. Malone, who is associated with Mr. Fox Talbot in the patent. "The patentees' improvement is a method of obtaining more complete fixation of photographic pictures on paper. For this purpose, the print, after undergoing the usual fixing process, is dipped into a boiling solution of strong caustic potash, which changes the colour of the print, and usually, after a certain time, acquires something of a greenish tint, which indicates that the process is terminated.

The picture is then well washed and dried, and if the tint acquired by it is not pleasing to the eye, a slight exposure to the vapours of sulphuretted hydrogen will restore to it an agreeable brown or sepia tint. Under this treatment the picture diminishes in size, insomuch that if it were previously cut in two, and one part submitted to the potash process, and the other not, the two halves, when afterwards put together, would be found not to correspond. The advantages of this process for removing any iodine which, even after fixing with the hyposulphite, remains in the paper, is great, and it will tend much to preserve these beautiful transcripts of nature. The patentee then claims as an improvement the use of varnished paper, or other transparent paper, impervious to water, as a substitute for glass, in certain circumstances, to support a film of albumen for photographic purposes. A sheet of writing-paper is brushed over with several coats of varnish on each side: it thus becomes extremely transparent. It is then brushed over on one side with albumen, or a mixture of albumen and gelatine, and dried. This film of albumen is capable of being rendered sensitive to light by exposing it to the vapour of iodine, and by following the rest of the process indicated in the preceding section of this specification. The advantages of using varnished or oil paper do not consist in any superiority of the images over those obtained upon glass, but in the greater convenience of using paper than glass in cases where a large number of pictures have to be made and carried about for considerable distances: besides this, there is a well-known kind of photographic pictures giving panoramic views of scenery, which are produced upon a curved surface by a movement of the object-glass of the camera. To the production of these images glass is hardly applicable, since it cannot be readily bent to the required curve and again straightened; but the case is met by employing talc, varnished paper, oiled paper, &c. instead of glass. It will be seen that the varnished paper acts as a support to the film of albumen or gelatine, which is the surface on which the light acts, and forms the picture. The next improvement consists in forming photographic pictures or images on the surfaces of polished steel plates. For this purpose, one part (by measure) of a saturated solution of iodide of potassium is mixed with 200 parts of albumen, and spread as evenly as possible upon the surface of a steel plate, and dried by the heat of a gentle fire. The plate is then taken, and, whilst still warm, is washed over with an alcoholic solution of gallo-nitrate of silver, of moderate strength. It then becomes very sensitive, and easily receives a photographic image. If the plate be cold, the sensibility is considerably lower. The image obtained is fixed by washing with hyposulphite of soda, and finally with water. The print adheres to the steel with much tenacity, and forms a process very useful to engravers. With respect to this part of the invention, the patentee claims the production of a photographic image upon a plate of steel. Upon a careful examination of this patent, it will be evident that the substitution of porcelain for glass, with very doubtful advantage, constitutes its only real novelty, excepting the process of using potash above described by Mr. Malone. The images on oiled paper are said to be exceedingly good, and this may prove to be a valuable suggestion, of which however we had a modification already in the waxed paper.

Section V.—Instantaneous Process.

The last invention and patent of Mr. Fox Talbot possesses many peculiarities, and as the results are of a remarkable character, it is important that the process should be given uncurtailed in its main particulars. The following description must be regarded as an abstract of Mr. Talbot's communication to the *Athenæum*, Dec. 6, 1851. An experiment was tried in June, at the Royal Institution, in which an instantaneous image was produced; but as the process was the subject of another patent it was not published until the above date. The experiment in question was that of obtaining a photographic copy of a printed paper fastened to a wheel, which was made to revolve as rapidly as possible, by illuminating it for a moment by the light obtained from the discharge of a Leyden battery: the bill was faithfully printed, not even a letter being indistinct.

A glass plate is employed, and Mr. Talbot thus directs that it should be prepared.

1. Take the most liquid portion of the white of an egg, rejecting the rest. Mix it with an equal quantity of water. Spread it very evenly upon a plate of glass, and dry it at the fire. A strong heat may be used without injuring the plate. The film of dried albumen ought to be uniform and nearly invisible.

2. To an aqueous solution of nitrate of silver add a considerable quantity of alcohol, so that an ounce of the mixture may contain three grains of the nitrate. I have tried various proportions, from one to six grains, but perhaps three grains answer best. More experiments are here required, since the results are much influenced by this part of the process.

3. Dip the plate into this solution, and then let it dry spontaneously. Faint prismatic colours will then be seen upon the plate. It is important to remark, that the nitrate of silver appears to form a true chemical combination with the albumen,

rendering it much harder, and insoluble in liquids which dissolved it previously.

4. Wash with distilled water to remove any superfluous portion of the nitrate of silver. Then give the plate a second coating of albumen similar to the first, but in drying avoid heating it too much, which would cause a commencement of decomposition of the silver.

5. To an aqueous solution of proto-iodide of iron add *first* an equal volume of acetic acid, and then ten volumes of alcohol. Allow the mixture to repose two or three days. At the end of that time it will have changed colour, and the odour of acetic acid as well as that of alcohol will have disappeared, and the liquid will have acquired a peculiar but agreeable vinous odour. It is in this state that I prefer to employ it.

6. Into the iodide thus prepared and modified the plate is dipped for a few seconds. All these operations may be performed by moderate daylight, avoiding, however, the direct solar rays.

7. A solution is made of nitrate of silver, containing about 70 grains to one ounce of water. To three parts of this add two of acetic acid. Then, if the prepared plate is rapidly dipped once or twice into this solution, it acquires a very great degree of sensibility, and it ought then to be placed in the camera without much delay.

8. The plate is withdrawn from the camera, and in order to bring out the image it is dipped into a solution of protosulphate of iron, containing one part of the saturated solution diluted with two or three parts of water. The image appears very rapidly.

9. Having washed the plate with water it is now placed in a solution of hyposulphite of soda, which in one minute causes the image to brighten up exceedingly, by removing a kind of veil which previously covered it.

10. The plate is then washed with distilled water, and the process is terminated. In order, however, to guard against future accidents, it is well to give the picture another coating of albumen and of varnish.

"These operations may appear long in the description, but they are rapidly enough executed after a little practice. In the process which I have now described, I trust that I have effected a harmonious combination of several previously ascertained and valuable facts, *especially of the photographic property of iodide of iron, which was discovered by Dr. Woods, of Parsonstown in Ireland; and that of sulphate of iron, for which science is indebted to the researches of Mr. Robert Hunt.* In the true adjustment of the proportions, and in the mode of operation, lies the difficulty of these investigations, since it is possible, by adopting other proportions and manipulations not very greatly differing from the above, and which a careless reader might consider to be the same, not only to fail in obtaining the highly exalted sensibility which is desirable in this process, but actually to obtain scarcely any photographic result at all."

Mr. Talbot proposed the name of *Amphitype*, or doubtful image, for these pictures. This name had, however, been adopted previously, at Mr. Talbot's recommendation, by Sir John Herschel, and in the Collodion processes, to be by and by described, we have similar phenomena, to which the name applies with equal force.

It is not improbable but the high degree of sensibility which is certainly obtained in this process, is rather due to the formation of an iodide of ethyle in the mixture, than to the combination, as Mr. Talbot supposes, of the proto-iodide and the proto-sulphate of iron. My own researches convince me that we should seek for the highest degrees of sensibility amidst the numerous combinations of the ethyle and methyle compounds with the metallic oxides.

CHAPTER IV.

DAGUERREOTYPE—THE DISCOVERY OF M. DAGUERRE.

SECTION I.—THE ORIGINAL PROCESS OF DAGUERRE.

IT has been already stated that Niepce and Daguerre having by accident discovered they were prosecuting experiments of the same kind, entered into a partnership. On the 5th Dec. 1829, Niepce communicated to Daguerre the particulars of the process employed by him, which has been already described (Chap. II), under the term HELIOGRAPHY. Niepce died in July 1333, but he has left some letters which clearly show that he had been a most industrious investigator. One extract appears of particular importance:—"I repeat it, sir," he says, "I do not see that we can hope to derive any advantage from this process (*the use of iodine*) more than from any other method which depends upon the use of metallic oxides, &c." Again, he says, "a decoction of Thlaspi (Shepherd's purse), fumes of phosphorus, and particularly of sulphur, as acting on silver in the *same way as iodine*, and caloric, produce the same effects by oxidising the metal, for from this cause proceeded in all these instances their *extreme sensibility to light*." After the death of M. Nicéphore Niepce, a new agreement was entered into between his son M. Isidore Niepce and Daguerre, that they should pursue their investigations in common, and share the profits whatever they might eventually prove to be.

The discovery of Daguerre was reported to the world early in January, 1839; but the process by which his beautiful pictures were produced was not made known until the July following, after a bill was passed securing to himself a pension for life of 6,000 francs, and to M. Isidore Niepce, the son of M. Niepce above mentioned, a pension for life of 4,000 francs, with one half in reversion to their widows. It is to be regretted, that after the French Government had thus liberally purchased the secret of the process of the Daguerreotype, for "*the glory of endowing the world of science and of art with one of the most surprising* *discoveries that honour their native land*," on the argument that "*the invention did not admit of being secured by patent, for as soon as published all might avail themselves of its advantages*," that it should have been guarded by a patent right in England, which has, however, nearly run its course.

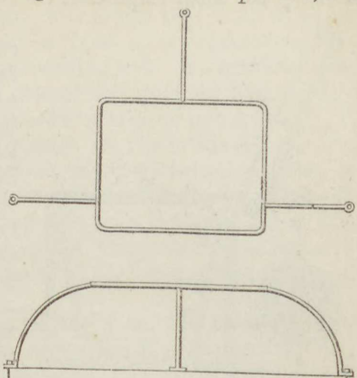
From the primary importance of this very beautiful branch of the photographic art, I shall devote some space to a description of the original process, reserving for the division devoted to the manipulatory details the description of each improvement which has been published, having any practical advantage, either by lessening the labour required, or reducing the expense.

The pictures of the daguerreotype are executed upon thin sheets of silver plated on copper. Although the copper serves principally to support the silver foil, the combination of the two metals appears to tend to the perfection of the effect. It is essential that the silver should be very pure. The thickness of the copper should be sufficient to maintain perfect flatness, and a smooth surface; so that the images may not be distorted by any warping or unevenness. Unnecessary thickness is to be avoided on account of the weight.

The process is divided by Daguerre into five operations. The first consists in cleaning and polishing the plate, to fit it for receiving the sensitive coating on which light forms the picture. The second is the formation of the sensitive *iodurет of silver* over the face of the tablet. The third is the adjusting of the plate in the camera obscura, for the purpose of receiving the impression. The fourth is the bringing out of the photographic picture, which is invisible when the plate is taken from the camera. The fifth and last operation is to remove the sensitive coating, and thus prevent that susceptibility of change under luminous influence, which would otherwise exist, and quickly destroy the picture.

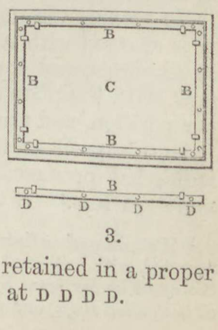
First Operation.—A small phial of olive oil—some finely carded cotton—a muslin bag of finely levigated pumice—a phial of nitric acid, diluted in the proportion of one part of acid to sixteen parts of water, are required for this operation. The operator must also provide himself with a small spirit-lamp, and an iron wire frame, upon which the plate is to be placed whilst being heated over the lamp. The following figures represent this frame. The first view is as seen from above. The second is a section and elevation, showing the manner in which it is fixed.

The plate being first powdered over with pumice, by shaking the bag, a piece of cotton dipped into the olive oil is then carefully rubbed over it with a continuous circular motion, conmencing from the centre. When the plate is well polished, it must be cleaned by powdering it all over with pumice, and then rubbing it with dry cotton, always rounding and crossing the strokes, it being impossible to obtain a true surface by any other motion of the hand. The surface of the plate is now rubbed all over with a pledget of cotton, slightly wetted with the diluted nitric acid. Frequently change the cotton, and keep rubbing briskly, that the acid may be equally diffused over the silver, as, if it is permitted to run into drops, it stains the table. It will be seen when the acid has been properly diffused, from the appearance of a thin film equally spread over the surface. It is then to be cleaned off with a little pumice and dry cotton.



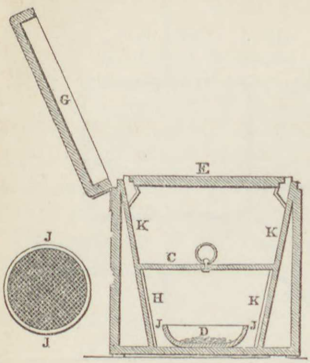
2.

The plate is now placed on the wire frame—the silver upwards, and the spirit lamp held in the hand, and moved about below it, so that the flame plays upon the copper. This is continued for five minutes, when a white coating is formed all over the surface of the silver; the lamp is then withdrawn. A charcoal fire may be used instead of the lamp. The plate is now cooled *suddenly*, by placing it on a mass of metal, or a stone floor. When perfectly cold, it is again polished with dry cotton and pumice. It is necessary that acid be again applied two or three times, in the manner before directed, the dry pumice being powdered over the plate each time, and polished off gently with dry cotton. Care must be taken not to breathe upon the plate, or touch it with the fingers, for the slightest stain upon the surface will be a defect in the drawing. It is indispensable that the last operation with the acid be performed immediately before it is intended for use. Let every particle of dust be removed, by cleaning all the edges, and the back also, with cotton. After the first polishing, the plate C is fixed on a board by means of four fillets, B B B B, of plated copper. To each of these are soldered two small projecting pieces, which hold the tablet near the corners; and the whole is retained in a proper position by means of screws, as represented at D D D D.



3.

Second Operation.—It is necessary for this operation, which is really the most important of all, that a box, similar to figs. 4 and 5, be provided. Figure 4 represents a section, supposed to pass down the middle of the apparatus by the line A B in fig. 5, which represents the box as seen from above. C is a small lid which accurately fits the interior, and divides the boxes into two chambers. It is kept constantly in its place when the box is not in use; the purpose of it being to concentrate the vapour of the iodine, that it may act more readily upon the plate when it is exposed to it. D is the little capsule in which the the iodine is placed, which is covered with the ring, J, upon which is stretched a piece of fine gauze, by which the particles of iodine are prevented from rising and staining the plate, while the vapour, of course, passes freely through it. E is the board with the plate attached, which rests on the four smaller projecting pieces, F, fig. 5. G is the lid of the box, which is kept closed, except when the plate is removed or inserted. H represents the supports for the cover C. K, tapering sides all round, forming a funnel-shaped box within.



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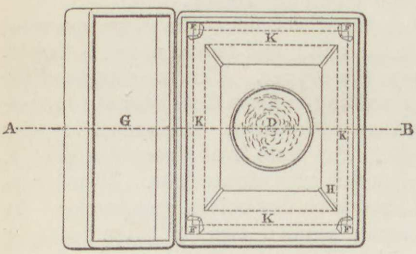


5.

To prepare the plate:—The cover C, being taken out, the cup, D, is charged with a sufficient quantity of iodine, broken into small pieces, and covered with the gauze, J. The board, E, is now, with the plate attached, placed face downwards, in its proper position, and the box carefully closed.

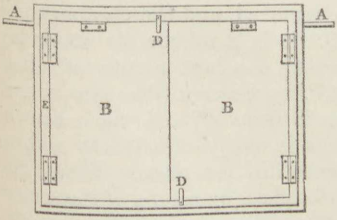
In this position the plate remains until the vapour of the iodine has produced a definite golden yellow colour, nothing more nor less.[1] If the operation is prolonged beyond the point

[1] If a piece of iodine is placed on a silver tablet, it will speedily be surrounded with coloured rings: these being the colours of thin films, as described by Sir Isaac Newton. Close examination will show the formation of *two yellow rings*, one within and the other without the series. If we cover

at which this effect is produced, a violet colour is assumed, which is much less sensitive to light; and if the yellow coating is too pale, the picture produced will prove very faint in all its parts. The time for this cannot be fixed, as it depends entirely on the temperature of the surrounding air. No artificial heat must be applied, unless in the case of elevating the temperature of an apartment in which the operation may be going on. It is also important that the temperature of the inside of the box should be the same as it is without, as otherwise a deposition of moisture is liable to take place over the surface of the plate. It is well to leave a portion of iodine always in the box; for, as it is slowly vaporized, it is absorbed by the wood, and when required it is given out over the more extended surface more equally, and with greater rapidity.

As, according to the season of the year, the time for producing the required effect may vary from five minutes to half an hour, or more, it is necessary, from time to time, to inspect the plate. This is also necessary, to see if the iodine is acting equally on every part of the silver, as it sometimes happens that the colour is sooner produced on one side than on the other, and the plate, when such is the case, must be turned one quarter round. The plate must be inspected in a darkened room, to which a faint light is admitted in some indirect way, as by a door a little open. The board being lifted from the box with both hands, the operator turning the plate towards him rapidly, observes the colour. If too pale, it must be returned to the box; but if it has assumed the violet colour it is useless, and the whole process must be again gone through.

From description, this operation may appear very difficult; but with a little practice the precise interval necessary to pro-



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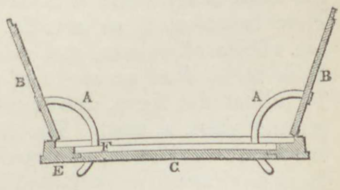
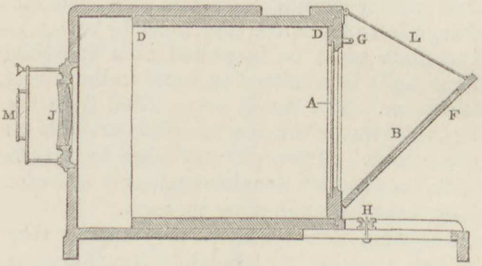


7.

one half of the circle with a card, and expose the other part to light, the rings will be found to change colour, the outer and the inner yellow darkening the most readily, and to an equal shade; thus proving the advantage of obtaining this yellow tone.

duce the best effect is pretty easily guessed at. When the proper yellow colour is produced, the plate must be put into a frame, which fits the camera obscura, and the doors are instantly closed upon it, to prevent the access of light. The figures represent this frame, fig. 6, with the doors, B B, closed on the plate; and fig. 7, with the doors opened by the half circles, A A. D D are stops by which the doors are fastened until the moment when the plate is required for use. The third operation should, if possible, immediately succeed the second: the longest interval between them should not exceed an hour, as the iodine and silver lose their requisite photogenic properties.[1] It is necessary to observe, that the iodine ought never to be touched with the fingers, as we are very liable to injure the plate by touching it with the hands thus stained.

Third Operation.—The third operation is the fixing of the plate at the proper focal distance from the lens of the camera obscura, and placing the camera itself in the right position for taking the view we desire. Fig. 8 is a perpendicular section, lengthwise, of Daguerre's camera. A is a ground glass by which

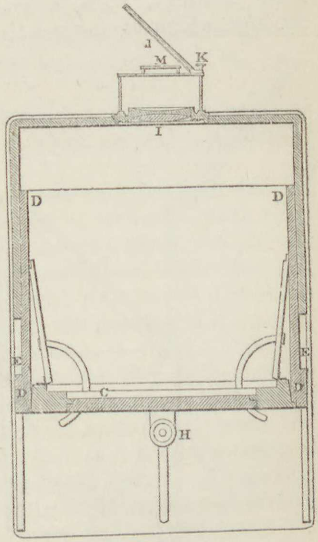


8.

the focus is adjusted; it is then removed, and the photographic plate substituted, as in C, fig. 9. B is a mirror for observing the effects of objects, and selecting the best points of view. It is inclined at an angle of 45°, by means of the support, L. To adjust the focus, the mirror is lowered, and the piece of ground glass, A, used. The focus is easily adjusted by sliding the box, D, out or in, as represented in the plate. When the focus is adjusted, it is retained in its place by means of the screw, H. The object glass, J, is achromatic and periscopic; its diameter is about one inch, and its focal distance rather more than four-

[1] This is contrary to the experience of the author of this volume; and Dr. Draper, of New York, states that he has found the plates improve by keeping a few hours before they are used; and M. Claudet states, that even after a day or two the sensibility of the plates is not impaired.

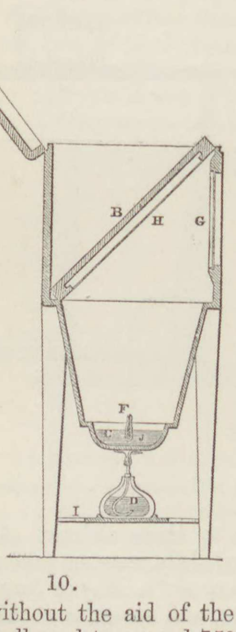
teen inches. M, is a stop a short distance from the lens, the object of which is to cut off all those rays of light which do not come directly from the object to which the camera is directed. This instrument reverses the objects; that which is to the right in nature being to the left in the photograph. This can be remedied by using a mirror outside, as K J, in figure 9. This arrangement, however, reduces the quantity of light, and increases the time of the operation one-third. It will, of course, be adopted only when there is time to spare. After having placed the camera in front of the landscape, or any object of which we desire the representation, our first attention must be to adjust the plate at such a distance from the lens, that a neat and sharply defined picture is produced. This is, of course, done by the obscured glass. The adjustment being satisfactorily made, the glass is removed, and its place supplied by the frame containing the prepared plate, and the whole secured by the screws. The doors are now opened by means of the half circles, and the plate exposed to receive the picture. The length of time necessary for the production of the best effect, varying with the quantity of light, is a matter which requires the exercise of considerable judgment, particularly as no impression is visible upon the tablet when it is withdrawn from the camera. At Paris this varies from three to thirty minutes. The most favourable time is from seven to three o'clock. A drawing which, in the months of June and July, may be taken in three or four minutes, will require five or six in May or August, seven or eight in April and September, and so on, according to the season. Objects in shadow, even during the brightest weather, will require twenty minutes to be correctly delineated. From what has been stated, it will be evident that it is impossible to fix, with any precision, the exact length of time necessary to obtain photographic designs; but by practice we soon learn to calculate the required time with considerable correctness. The latitude is, of course, a fixed element in this calculation. In the



9.

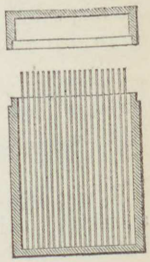
sunny climes of Italy and southern France, these designs may be obtained much more promptly than in the uncertain clime of Great Britain. It is very important that the time necessary is not exceeded,—prolonged solarization has the effect of blackening the plate, and this destroys the clearness of the design. If the operator has failed in his first experiment, let him immediately commence with another plate; correcting the second trial by the first, he will seldom fail to produce a good photograph.

Fourth Operation.—The apparatus required in this operation is represented by fig. 10. A, is the lid of the box; B, a black board with grooves to receive the plate; C, cup containing a little mercury, J; D, spirit lamp; F, thermometer; G, glass through which to inspect the operation; H, tablet as removed from the camera; I, stand for the spirit lamp. All the interior of this apparatus should be covered with hard black varnish. The board and the affixed plate being withdrawn from the camera, are placed at an angle of about 45° within this box—the tablet with the picture downwards, so that it may be seen through the glass G. The box being carefully closed, the spirit lamp is to be lighted and placed under the cup containing the mercury. The heat is to be applied until the thermometer, the bulb of which is covered with the mercury, indicates a temperature of 60° Centigrade, (140° Fahr.) The lamp is then withdrawn, and if the thermometer has risen rapidly, it will continue to rise without the aid of the lamp; but the elevation ought not to be allowed to exceed 75° Cent. (167° Fahr.)



10.

After a few minutes, the image of nature impressed, but till now invisible, on the plate, begins to appear; the operator assures himself of the progress of this development by examining the picture through the glass, G, by a taper, taking care that the rays do not fall too strongly on the plate, and injure the nascent images. The operation is continued till the thermometer sinks to 45° Cent. (113° Fahr.) When the objects have been strongly illuminated, or when the plate has been kept in the camera too long, it will be found that this operation is completed before the thermometer has fallen to 55° Cent. (131° Fahr.) This is, however, always known by observing the sketch through the glass.



11.

After each operation the apparatus is carefully cleaned in every part, and in particular the strips of metal which hold the plate are well rubbed with pumice and water, to remove the adhering mercury and iodine. The plate may now be deposited in the grooved box, (fig. 11), in which it may be kept, excluded from the light, until it is convenient to perform the last fixing operation.

Fifth Operation.—This process has for its object the removal of the iodine from the plate of silver, which prevents the further action of the light.

A saturated solution of common salt may be used for this purpose, but it does not answer nearly so well as a weak solution of the hyposulphite of soda. In the first place, the plate is to be placed in a trough of water, plunging and withdrawing it immediately; it is then to be plunged into one of the above saline solutions, which would act upon the drawing if it was not previously hardened by washing in water.

To assist the effect of the saline washes, the plate must be moved to and fro, which is best done by passing a wire beneath the plate. When the yellow colour has quite disappeared, the plate is lifted out, great care being taken that the impression is not touched, and it is again plunged into water. A vessel of warm distilled water, or very pure rain-water boiled and cooled, being provided, the plate is fixed on an inclined plane, and the water is poured in a continuous stream over the picture. The drops of water which may remain upon the plate must be removed by forcibly blowing upon it, for otherwise, in drying, they would leave stains on the drawings. This finishes the drawing, and it only remains to preserve the silver from tarnishing and from dust.

The shadows in the daguerreotype pictures are represented by the polished surface of the silver, and the lights by the adhering mercury, which will not bear the slightest rubbing. To preserve these sketches, they must be placed in cases of pasteboard, with a glass over them, and then framed in wood. They are now unalterable by the sun's light.

The same plate may be employed for many successive trials, provided the silver be not polished through to the copper. It is very important, after each trial, that the mercury be removed immediately by polishing with pumice-powder and oil. If this be neglected, the mercury finally adheres to the silver, and good drawings cannot be obtained if this amalgam is present.

Section II. — Improvements in Daguerreotype.

It was announced that the inventor of the daguerreotype had succeeded in improving the sensibility of his plates to such an extent as to render an *instantaneous exposure* sufficient for the production of the best effects; consequently, securing faithful impressions of moving objects. In a communication with which I was favoured from M. Daguerre, he said,—"Though the principle of my new discovery is certain, I am determined not to publish it before I have succeeded in making the execution of it as easy to every body as it is to myself. I have announced it immediately at the Royal Academy of Paris, merely to take date, and to ascertain my right to the priority of the invention. By means of that new process, it shall be possible *to fix the images of objects in motion, such as public ceremonies, market-places covered with people, cattle, &c.—the effect being instantaneous.*"

In 1844, M. Daguerre, in a letter to M. Arago, published this process; but it proved so complex in its manipulatory details, and so very uncertain, that it has not been adopted. As it is, however, curious, and involves the use of some agents not ordinarily employed, it is thought advisable to include it within this volume. We quote from the Comptes Rendus for April 1844:—

"You have been kind enough to announce to the Academy that I had arrived, by a series of experiments, at recognising in a certain manner that, in the present state of my process, the layer sensible to light being too thin, could not furnish all the gradation of tints necessary for reproducing nature with relief and firmness; indeed, although the proofs hitherto obtained are not deficient in purity, they leave, with a few exceptions, much to be desired with relation to general effect and relief.[1]

[1] On the plate cleaned by means of the layer of water, as I have pointed out, very fine impressions are very rapidly obtained, but which are also wanting in relief, on account of the thinness of the sensible layer.

"It is by superposing on the plate several metals, reducing them to powder by friction, and by acidulating the empty spaces which the molecules leave, that I have been enabled to develope galvanic actions which permit the employment of a much thicker layer of iodide, without having to fear, during the operation of light in the camera obscura, the influence of the liberated iodine.

"The new combination which I employ, and which is composed of several metallic iodides, has the advantage of giving a sensible layer capable of receiving impressions simultaneously by all the degrees of tone, and I thus obtain, in a very short space of time, the representation of objects vividly enlightened with demi-tints, all of which retain, as in nature, their transparency and their relative value.

"By adding gold to the metals which I first used, I am enabled to avoid the great difficulty which the use of bromine, as an accelerating substance, presented. It is known that only very experienced persons could employ bromine with success, and that they were able to obtain the maximum of sensibility only by chance, since it is impossible to determine this point very precisely, and since immediately beyond it the bromine attacks the silver, and is opposed to the formation of the image.[1]

"With my new means, the layer of iodine is always saturated with bromine, since the plate may, without inconvenience, be left exposed to the vapour of this substance for at least half the necessary time; for the application of the layer of gold is opposed to the formation of what is called the veil of bromine. This facility must not, however, be abused; for the layer of gold, being very thin, might be attacked, especially if too much polished.[2] The process which I am about to give may, perhaps, be found rather complicated; but, notwithstanding my desire to simplify it as much as possible, I have been led, on the contrary, by the results of my experiment, to multiply the substances employed, all of which play an important part in the whole process. I regard them all as necessary for obtaining a complete result, which must be the case, since I have only gradually arrived at

[1] Every one knows that the dry vapour of bromine is more favourable than that which is obtained by means of a solution of bromine in water; for the latter has the inconvenience of carrying with it moisture which condenses on the surface of the plate. The employment of the oil, which I indicate further on, neutralises this effect, and gives to the vapour of bromine diluted with water the same property as that of dry bromine.—*These notes are Daguerre's.*

[2] This is so true, that if an impression be made on a plate which has been fixed several times, it may be exposed to the vapour of bromine as many times more than the necessary time it has received layers of gold.

discovering the properties of these different metals, one of which aids in promptitude, the other in the vigour of the impression, &c.[1]

"From the concurrence of these substances arises a power which neutralises all the unknown effects which so often oppose the formation of the image.[2] I think, besides, that Science and Art should not be interrupted by the consideration of a more or less long manipulation; we should be contented to obtain beautiful results at this price, especially when the means of execution are easy. The galvanic preparation of the plate does not present any difficulty. The operation is divided into two principal parts: the first, which is the longest, may be made a long time previously, and may be regarded as the completion of the manufacture of the plate. This operation, being once made, serves indefinitely; and, without recommencing it, a great number of impressions may be made on the same plate. The new substances employed are:—Aqueous solution of bichloride of mercury: Solution of cyanide of mercury: White oil of petroleum, acidulated with nitric acid: Solution of chlorine of gold and platinum. These are prepared as follows:—

"**Aqueous Solution of Bichloride of Mercury.**—8 grains of bichloride of mercury in 10,000 grains of distilled water.

"**Solution of Cyanide of Mercury.**—A flask of distilled water is saturated with cyanide of mercury, and a certain quantity is decanted, which is diluted with an equal quantity of distilled water.

"**Acidulated White Oil of Petroleum.**[3]—This oil is acidulated by mixing with it one-tenth of pure nitric acid, leaving it for at least 48 hours, occasionally agitating the flask. The oil which is acidulated, and which then powerfully reddens litmus paper,

[1] I will only observe that the employment of all the metals which I indicate further on is indispensable; but the mode of applying them may be varied.

[2] For, by multiplying these elements as in a pile, this power is augmented, and we are thus enabled to make the most indolent radiations act in the same time; such as those of green and red.

[3] The most suitable oil of petroleum is of a greenish yellow tint, and takes, at different angles, azure reflections.

I have given the preference to this oil over the fixed oils, because it always remains limpid, although strongly acidulated. My object in employing an acidulated oil is to reduce the metals to powder, and to retain this powder on the surface of the plate, at the same time giving greater thickness to the layer by its unctuous properties; for the naphtha which results from the distillation of this oil does not produce the same effect, because, being too fluid, it carries away the powder of the metals. It is for the same reason that I have lately recommended the employment of essence of lavender rather than that of essence of turpentine.

is decanted. It is also a little coloured, but remains very limpid.

"**Solution of Chloride of Gold and Platinum.**—In order not to multiply the solutions, I take the ordinary chloride of gold, used for fixing the impressions, and which is composed of 15 grains of chloride of gold, and 50 grains of hyposulphite of soda, to a quart of distilled water. With respect to chloride of platinum, 4 grains must be dissolved in 3 quarts of distilled water; these two solutions are mixed in equal quantities.

"FIRST PREPARATION OF THE PLATE.—For the sake of brevity in the following description, I will abridge the name of each substance. Thus, I will say, to designate the aqueous solution of bichloride of mercury, *sublimate;* for the solution of cyanide of mercury, *cyanide;* for the acidulated oil of petroleum, *oil;* for the solution of chloride of gold and platinum, *gold and platinum;* and for the oxide of iron, *rouge* only.

"The plate is first polished with sublimate and tripoli, and afterwards with rouge,[1] until a beautiful black is arrived at. Then, the plate is laid on the horizontal plate, and the solution of cyanide is poured on it and heated over a lamp, as in fixing an impression with chloride of gold. The mercury is deposited, and forms a whitish layer. The plate is allowed to cool a little, and, after having poured off the liquid, it is dried by rubbing with cotton and sprinkling with rouge.

"It is now necessary to polish the whitish layer deposited by the mercury. With a piece of cotton steeped in oil and rouge this layer is rubbed until it becomes of a fine black. In the last place, it may be rubbed very strongly, but with cotton alone, in order to render the acidulated layer as thin as possible. The plate is afterwards placed on the horizontal plane, and the solution of gold and platinum is poured on. It is heated in the ordinary manner; it is then allowed to cool, the liquid is poured off, and it is dried by gentle friction with cotton and rouge. This operation must be performed with care, especially when the impression is not immediately continued; for, otherwise, some lines of liquid would be left on the plate, which it is difficult to get rid of. After this last friction the plates should

[1] If I prefer, for polishing, rouge to other substances, it is not because I recognise in it a photogenic property, but because it *burnishes* better, and because it assists in fixing the layer of gold, rendering it less susceptible of being removed in scales when heated too much. The galvanic plates, when there are neither marbles nor black stains (which sometimes happened originally) receive better than others the application of metals, and, consequently, the chloride of gold adhering to it more firmly, is not removed in scales.

be only dried, and not polished. This includes the first preparation of the plate, which may be made a long time previously.

"SECOND PREPARATION.—I do not think it fit to allow a longer interval than twelve hours to intervene between this operation and iodising the plate. We left the plate with a deposit of gold and platinum. In order to polish this metallic layer, the plate is rubbed with a piece of cotton, and oil and rouge, until it again becomes black; and then with alcohol and cotton only, in order to remove this layer of rouge as much as possible. The plate is again rubbed very strongly, and passing several times over the same places, with cotton impregnated with cyanide. As this layer dries very promptly, it might leave on the plate traces of inequality: in order to avoid this, the cyanide must be again passed over it, and, while the plate is still moist, we quickly rub over the whole surface of the plate with cotton imbibed with a little oil, thus mixing these two substances; then, with a piece of dry cotton, we rub, in order to unite, and, at the same, to dry the plate, taking care to remove from the cotton the parts which are moistened with cyanide and oil. Finally, as the cotton still leaves traces, the plate is likewise sprinkled with a little rouge, which is removed by gently rubbing.

"Afterwards, the plate is again rubbed with cotton impregnated with oil, only in such a manner as to make the burnish of the metal return; it is then sprinkled with rouge, and then very gently rubbed round, to remove all the rouge, which carries with it the superabundance of the acidulated layer.[1] Finally, it is strongly rubbed with a rather firm pledget of cotton, in order to give the last polish.[2]

"It is not necessary often to renew the pledgets of cotton imbibed with oil and rouge; they must only be kept free from dust. I have said above that the first preparation of the plate may serve indefinitely; but it will be comprehended that the second must be modified, according to whether we operate on a plate which has received a fixed or an unfixed impression.

[1] This must be done as gently as possible; for otherwise the rouge would adhere to the plate, and would form a general film.

[2] In operating on a plate a long time after it has received the first preparation, it is necessary, before employing the acidulated oil and red oxide, to manipulate, as I indicate further on, for the plate which has received a fixed impression. This precaution is necessary for destroying the stains which time may have developed.

" *On the Fixed Impression.*—The stains left by the washing water must be removed with rouge and water slightly acidulated with nitric acid (at 36° Fahr. at this season [April?], and less in summer). Afterwards, the plate must be polished with oil and rouge, in order to remove all traces of the image. The operation is then continued just as I have described for the second preparation of the new plate, and beginning with the employment of alcohol.

" *On the Unfixed Impression* (*but whose sensible layer has been removed in the ordinary manner*).—First, the plate must be rubbed with alcohol and rouge, in order to remove the traces of oil which serve for receiving the foregoing impression. We afterwards proceed as indicated above for the new plate, beginning with the employment of alcohol.

" The summary of the operations will include in the First Preparation—1. Corrosive sublimate, with tripoli first, and rouge afterwards, in order to polish the plate: 2. Cyanide of mercury, heated and dried with cotton and rouge: 3. Acidulated oil, with rouge for polishing the layer of mercury: 4. Gold and platinum, heated and dried with cotton and rouge.

" And in the Second Preparation—5. Acidulated oil, with rouge, for polishing the layer of gold and platinum: 6. Absolute alcohol, for removing, as much as possible, the oil and rouge: 7. Cyanide of mercury, employed cold, and rubbed only with cotton: 8. Oil rubbed very strongly, and equalised in the last place with rouge sprinkled on it.

" Then on the Fixed Proof we use—1. Nitric acid at 36° F. with rouge for removing the stains: 2. Oil with rouge for removing the traces of the image and for polishing. Continue then as above, setting out from No. 6, alcohol, &c.

" And on the Unfixed Proof—Alcohol with rouge for removing the traces of oil, and continuing as above, beginning from No. 6, alcohol, &c.

" **On Iodising.**—The colour of the impression depends on the tint given to the metallic iodide; it may, therefore, be varied at will. However, I have found the violet rose colour most suitable.

" For transmitting the iodine to the plate, the sheet of cardboard may be replaced by an earthenware plate deprived of enamel. The iodine transmitted by this means is not decomposed. It is useless, I may even say injurious, to heat the plate before exposing it to the vapour of iodine.

" **Washing with Hyposulphite of Soda.**—In order to remove the sensitive layer, the solution of hyposulphite of soda must not be too strong, because it destroys the sharpness of the impression. 60 grammes of hyposulphite are sufficient for 1 quart of distilled water."

The elaborate nature of this process is a barrier against its use, since the results are not at all superior to those obtained by the ordinary daguerreotype, as it is now practised, and the labour to be expended on the preparation infinitely greater.

CHAPTER V.

THE PHOTOGRAPHIC PROCESSES ON PAPER OF SIR JOHN HERSCHEL.

The researches of Sir John Herschel have been principally directed to the investigation of the physical laws which regulate the chemical changes we have been considering. His analyses of the prismatic spectrum have been most complete, and, as far as they have been carried out, go to prove the operation of forces other than those with which we are acquainted.

At the same time, however, as this philosopher has been engaged in investigations of this high order, he has, from the multitude of his experiments, been successful in producing several processes of great beauty. There are not any which are to be regarded as peculiarly sensitive—they are indeed for the most part rather slow—but the manipulation required is of the easiest character, and the results are most curious and instructive.

The philosophy which is for ever united with the scientific investigations of Sir John Herschel is too valuable to be omitted from any description of the processes which he recommends: the following quotations are therefore taken from his communication to the Royal Society, and linked together by my own remarks in such a manner as it is hoped will be most easily understood by the unscientific amateur.

Section I.—Cyanotype.

The processes in which cyanogen is employed are so called. Sir John Herschel thus introduces the subject of his experiments with these salts :—" I shall conclude this part of my subject by remarking on the great number and variety of substances which, now that attention is drawn to the subject, appear to be photographically impressible. It is no longer an insulated and anomalous affection of certain salts of silver or gold, but one which, doubtless, in a greater or less degree pervades all nature, and connects itself intimately with the mechanism by which chemical combination and decomposition is operated. The general instability of organic combinations might lead us to expect the occurrence of numerous and remarkable cases of this affection among bodies of that class, but among metallic and other elements inorganically arranged, instances enough have already appeared, and more are daily presenting themselves, to justify its extension to all cases in which chemical elements may be supposed combined with a certain degree of laxity, and so to speak in a *tottering equilibrium*. There can be no doubt that the process, in a great majority, if not in all, cases which have been noticed among inorganic substances, is a deoxidising one, so far as the more refrangible rays are concerned. It is obviously so in the cases of gold and silver. In that of the bichromate of potash it is most probable that an atom of oxygen is parted with, and so of many others. A beautiful example of such deoxidising action on a non-argentine compound has lately occurred to me in the examination of that interesting salt, the ferrosesquicyanuret of potassium, described by Mr. Smee in the Philosophical Magazine, No. 109, September 1840, and which he has shown how to manufacture in abundance and purity, by voltaic action on the common, or yellow ferrocyanuret. In this process nascent oxygen is absorbed, hydrogen given off; and the characters of the resulting compound in respect of the oxides of iron, forming as it does Prussian blue with protosalts of that metal, but producing no precipitate with its persalts, indicate an excess of electro-negative energy, a disposition to part with oxygen, or, which is the same thing, to absorb hydrogen (in the presence of moisture), and thereby to return to its pristine state, under circumstances of moderate solicitation, such as the affinity of protoxide of iron (for instance) for an additional dose of oxygen, &c.

"Paper simply washed with a solution of this salt is highly sensitive to the action of light. Prussian blue is deposited (the base being necessarily supplied by the destruction of one portion of the acid, and the acid by decomposition of another). After half an hour or an hour's exposure to sunshine, a very beautiful negative photograph is the result, to fix which, all that is necessary is to soak it in water in which a little sulphate of soda is dissolved, to ensure the fixity of the Prussian blue deposited. While dry the impression is dove-colour or lavender blue, which has a curious and striking effect on the greenish-yellow ground of the paper, produced by the saline solution. After washing, the ground colour disappears, and the photograph becomes bright blue on a white ground. If too long exposed, it gets 'over sunned,' and the tint has a brownish or yellowish tendency, which however is removed in fixing: but no increase of intensity beyond a certain point is obtained by continuance of exposure.

"If paper be washed with a solution of ammonio-citrate of iron, and dried, and then a wash passed over it of the yellow ferrocyanuret of potassium, there is no immediate formation of true Prussian blue, but the paper rapidly acquires a violet-purple colour, which deepens after a few minutes, as it dries, to almost absolute blackness. In this state it is a positive photographic paper of high sensibility, and gives pictures of great depth and sharpness; but with this peculiarity, that they darken again spontaneously on exposure to the air in darkness, and are soon obliterated. The paper, however, remains susceptible to light, and capable of receiving other pictures, which in their turn fade, without any possibility (so far as I can see) of arresting them; which is to be regretted, as they are very beautiful, and the paper of such easy preparation. If washed with ammonia or its own carbonate, they are for a few moments entirely obliterated, *but presently reappear, with reversed lights and shades.* In this state they are fixed, and the ammonia, with all that it will dissolve, being removed by washing in water, their colour becomes a pure Prussian blue, which deepens much by keeping If the solution be mixed, there results a very dark violet-coloured. ink, which may be kept uninjured in an opaque bottle, and will readily furnish, by a single wash, at a moment's notice, the positive paper in question, which is most sensitive when wet.

"It seems at first sight natural to refer these curious and complex changes to the instability of the cyanic compounds; and that this opinion is to a certain extent correct, is proved by the photographic impressions obtained on papers to which no iron has been added beyond what exists in the ferrocyanic salts themselves. Nevertheless, the following experiments abundantly prove that in several of the changes above described, the *immediate action* of the solar rays is not exerted on these salts, but on the iron contained in the ferruginous solution added to them, which it deoxidizes or otherwise alters, thereby presenting it to the ferrocyanic salts in such a form as to precipitate the acids in combination with the peroxide, or protoxide of iron, as the case may be. To make this evident, all that is necessary is *simply to leave out the ferrocyanate* in the preparation of the paper, which thus becomes reduced to a simple washing over with the ammonio-citric solution. Paper so washed is of a bright yellow colour, and is apparently little, but in reality highly sensitive to photographic action. Exposed to strong sunshine, for some time indeed, its bright yellow tint is dulled into an ochrey hue, or even to grey, but the change altogether amounts to a moderate per-centage of the total light reflected, and in short exposures is such as would easily escape notice. Nevertheless, if a slip of this paper be held for only four or five seconds in the sun (the effect of which is quite imperceptible to the eye), and when withdrawn into the shade be washed over with the ferrosesquicyanate of potash, a considerable deposit of Prussian blue takes place on the part sunned, and none whatever on the rest; so that on washing the whole with water, a pretty strong blue impression is left, demonstrating the reduction of iron in that portion of the paper to the state of protoxide. The effect in question is not, it should be observed, peculiar to the ammonio-citrate of iron.

"The ammonio- and potassio-tartrate fully possess, and the perchloride *exactly neutralized*, partakes of the same property: but the experiment is far more neatly made, and succeeds better, with the other salts."

In further development of these most interesting processes Sir John Herschel says:—"The varieties of cyanotype processes seem to be innumerable, but that which I shall now describe deserves particular notice, not only for its pre-eminent beauty while in progress, but as illustrating the peculiar power of the ammoniacal and other persalts of iron above mentioned to receive a latent picture, susceptible of development by a great variety of stimuli. This process consists in simply passing over the ammonio-citrated paper on which such a latent picture has been impressed, *very sparingly and evenly*, a wash of the solution of the common yellow ferrocyanate (prussiate) of potash. The latent picture, if not so faint as to be quite invisible (and for this purpose it should not be so), is negative. As soon as the liquid is applied, which cannot be in too thin a film, the negative picture vanishes, and by very slow degrees is replaced by a positive one of a violet-blue colour on a greenish-yellow ground, which at a certain moment possesses a high degree of sharpness, and singular beauty and delicacy of tint. If at this instant it be thrown into water, it passes immediately to Prussian blue, losing at the same time, however, much of its sharpness, and sometimes indeed becoming quite blotty and confused. But if this be delayed, the picture, after attaining a certain maximum of distinctness, grows rapidly confused, especially if the quantity of liquid applied be more than the paper can easily and completely absorb, or if the brush in applying it be allowed to rest on, or to be passed twice over any part. The effect then becomes that of a coarse and ill-printed woodcut, all the strong shades being run together, and a total absence prevailing of half lights.

"To prevent this confusion, gum-arabic may be added to the prussiated solution, by which it is hindered from spreading unmanageably within the pores of the paper, and the precipitated Prussian blue allowed time to agglomerate and fix itself on the fibres. By the use of this ingredient also, a much thinner and more equable film may be spread over the surface; and *when perfectly dry*, if not sufficiently developed, the application may be repeated. By operating thus I have occasionally (though rarely) succeeded in producing pictures of great beauty and richness of effect, which they retain (if not thrown into water) between the leaves of a portfolio, and have even a certain degree of fixity—fading in a strong light, and recovering their tone in the dark. The manipulations of this process are, however, delicate, and complete success is comparatively rare.

"If sulphocyanate of potash be added to the ammonio-citrate or ammonio-tartrate of iron, the peculiar red colour which that test induces on persalts of the metal is not produced, but it appears at once on adding a drop or two of dilute sulphuric or nitric acid. This circumstance, joined to the perfect neutrality of these salts, and their power, in such neutral solution, of enduring, undecomposed, a boiling heat, contrary to the usual habitudes of the peroxide of iron, together with their singular transformation by the action of light to proto-salts, in apparent opposition to a very strong affinity, has, I confess, inclined me to speculate on the possibility of their ferruginous base existing in them, not in the ordinary form of peroxide, but in one isomeric with it. The non-formation of Prussian blue, when their solutions are mixed with prussiate of potash, and the formation in its place of a deep violet-coloured liquid of singular instability under the action of light, seem to favour this idea. Nor is it altogether impossible that the peculiar 'prepared' state superficially assumed by iron under the influence of nitric acid, first noticed by Keir, and since made the subject of experiment by M. Schönbein and myself, may depend on a change superficially operated on the *iron itself* into a new metallic body isomeric with iron, unoxidable by nitric acid, and which may be considered as the radical of that peroxide which exists in the salts in question, and possibly also of an isomeric protoxide. A combination of the common protoxide with the isomeric peroxide, rather than with the same metal in a simply higher stage of oxidation, would afford a not unplausible notion of the chemical nature of that peculiar intermediate oxide to which the name of 'Ferroso-ferric' has been given by Berzelius. If (to render my meaning more clear) we for a moment consent to designate such an isomeric form of iron by the name siderium, the oxide in question might be regarded as a sideriate of iron. Both phosphorus and arsenic (bodies remarkable for sesqui-combinations) admit isomeric forms in their oxides and acids. But to return from this digression.

"If to a mixture of ammonio-citrate of iron and sulphocyanate of potash, a small dose of nitric acid be added, the resulting red liquid, spread on paper, spontaneously whitens in the dark. If more acid be added till the point is attained when the discoloration begins to relax, and the paper when dry retains a considerable degree of colour, it is powerfully affected by light, and receives a positive picture with great rapidity, which appears at the back of the paper with even more distinctness than on its face. The impression, however, is pallid, fades on keeping, nor am I acquainted at present with any mode of fixing it.

"If paper be washed with a mixture of the solutions of ammonio-citrate of iron and ferrosesquicyanate of potash, so as to contain the two salts in about equal proportions, and being then impressed with a picture, be thrown into water and dried, a negative blue image will be produced. This picture I have found to be susceptible of a very curious transformation, preceded by total obliteration. To effect this it must be washed with solution of proto-nitrate of mercury, which in a little time entirely discharges it. The nitrate being thoroughly washed out and the picture dried, a smooth iron is to be passed over it, somewhat hotter than is used for ironing linen, but not sufficiently so to scorch or injure the paper. The obliterated picture immediately reappears, not blue, but brown. If kept for some weeks in this state between the leaves of a portfolio, in complete darkness, it fades, and at length almost entirely disappears. But what is very singular, a fresh application of the heat revives and restores it to its full intensity.

"This curious transformation is instructive in another way. It is not operated by light, at least not by light alone. *A certain temperature* must be attained, and that temperature suffices in total darkness. Nevertheless, I find that on exposing to a very concentrated spectrum (collected by a lens of short focus) a slip of paper duly prepared as above (that is to say, by washing with the mixed solutions, exposure to sunshine, washing, and discharging the uniform blue colour so induced as in the last article), its whiteness is changed to brown over the whole region of the red and orange rays, *but not beyond* the luminous spectrum. Three conclusions seem unavoidable:—1st, that it is the heat of these rays, not their light, which operates the change; 2ndly, that this heat possesses a peculiar chemical quality which is not possessed by the purely calorific rays outside of the visible spectrum, though far more intense; and, 3rdly, that the heat radiated from obscurely hot iron abounds especially in rays analogous to those of the region of the spectrum above indicated."

Sir John Herschel then proceeds to show that whatever be the state of the iron in the double salts in question, its reduction by blue light to the state of protoxide is indicated by many other reagents. Thus, for example, if a slip of paper prepared with the ammonio-citrate of iron be exposed partially to sunshine, and then washed with the bichromate of potash, the bichromate is deoxidised, and precipitated upon the sunned portion, just as it would be if directly exposed to the sun's rays.

I have proved this fact with a great number of preparations of cobalt, nickel, bismuth, platinum, and other salts which have been thought hitherto to be insensible to solar agency; but if they are partially sunned, and then washed with nitrate of silver, and put aside in the dark, the metallic silver is slowly reduced upon the sunned portion. In many instances days were required to produce the visible picture; and in one case, paper, being washed with neutral chloride of platinum, was sunned, and then washed in the dark with nitrate of silver: it was some weeks before the image made its appearance, but it was eventually perfectly developed. This specimen has been kept for some years, and continues constantly to improve in clearness and definition.

Section II.—Chrysotype.

A process of an analogous character to that which has just been described, and in which the chloride of gold is an agent, must be next described: this was discovered at the same time as the cyanotype, and has been termed the chrysotype.

"In order to ascertain whether any portion of the iron in the double ammoniacal salt employed had really undergone deoxidation, and become reduced to the state of protoxide, as supposed, I had recourse to a solution of gold exactly neutralised by carbonate of soda. The proto-salts of iron, as is well known to chemists, precipitate gold in the metallic state. The effect proved exceedingly striking, issuing in a process nowise inferior in the almost magical beauty of its effect to the calotype process of Mr. Talbot, which in some respects it nearly resembles; with this advantage, as a matter of experimental exhibition, that the disclosure of the dormant image does not require to be performed in the dark, being not interfered with by moderate daylight. As the experiment will probably be repeated by others, I shall here describe it *ab initio*. Paper is to be washed with a moderately concentrated solution of ammonio-citrate of iron, and dried. The strength of the solution should be such as to dry into a good yellow colour, not at all brown. In this state it is ready to receive a photographic image, which may be impressed on it either from nature in the camera obscura, or from an engraving on a frame in sunshine. The image so impressed, however, is very faint, and sometimes hardly perceptible. The moment it is removed from the frame or camera, it must be washed over with a neutral solution of gold of such strength as to have about the colour of sherry wine. Instantly the picture appears, not, indeed, at once of its full intensity, but darkening with great rapidity up to a certain point, depending on the strength of the solutions used, &c. At this point nothing can surpass the sharpness and perfection of detail of the resulting photograph. To arrest this process and to fix the picture (so far at least as the further agency of *light* is concerned), it is to be thrown into water very slightly acidulated with sulphuric acid, and well soaked, dried, washed with hydrobromate of potash, rinsed, and dried again.

"Such is the outline of a process to which I propose applying the name of *Chrysotype*, in order to recall, by similarity of structure and termination, the *Calotype* process of Mr. Talbot, to which, in its general effect, it affords so close a parallel. Being very recent, I have not yet (June 10, 1842) obtained a complete command over all its details, but the termination of the session of the Society being close at hand, I have not thought it advisable to suppress its mention. In point of *direct* sensibility, the chrysotype paper is certainly inferior to the calotype; but it is one of the most remarkable peculiarities of gold as a photographic ingredient, that *extremely feeble impressions once made by light go on afterwards darkening spontaneously and very slowly, apparently without limit, so long as the least vestige of unreduced chloride of gold remains in the paper.* To illustrate this curious and (so far as applications go) highly important property, I shall mention incidentally the results of some experiments made, during the late fine weather, on the habitudes of gold in presence of oxalic acid. It is well known to chemists that this acid, heated with solutions of gold, precipitates the metal in its metallic state; it is upon this property that Berzelius has founded his determination of the atomic weight of gold. Light, as well as heat, also operates this precipitation; but to render it effectual, several conditions are necessary:—1st, the solution of gold must be neutral, or at most *very* slightly acid; 2nd, the oxalic acid must be added in the form of a neutral oxalate; and 3rdly, it must be present in a certain considerable quantity, which quantity must be greater the greater the amount of free acid present in the chloride. Under these conditions, the gold is precipitated by light as a black powder if the liquid be in any bulk, and if merely washed over paper a stain is produced, which, however feeble at first, under a certain dosage of the chloride, oxalate, and free acid, goes on increasing from day to day and from week to week, when laid by in the dark, and especially in a damp atmosphere, till it acquires almost the blackness of ink; the unsunned portion of the paper remaining unaffected, or so slightly as to render it almost certain that what little action of the kind exists is due to the effect of casual dispersed light incident in the preparation of the paper. I have before me a specimen of paper so treated in which the effect of thirty seconds' exposure to sunshine was quite invisible at first, and which is now of so intense a purple as may well be called black, while the unsunned portion has acquired comparatively but a very slight brown. And (which is not a little remarkable, and indicates that in the time of exposure mentioned the *maximum* of effect was attained) other portions of the same paper exposed in graduated progression for longer times, viz. 1 min., 2 min., and 3 min., are not in the least perceptible degree darker than the portion on which the light had acted during thirty seconds only.

"If paper prepared as above recommended for the chrysotype, either with the ammonio-citrate or ammonio-tartrate of iron, and impressed, as in that process, with a latent picture, be washed with nitrate of silver instead of a solution of gold, a very sharp and beautiful picture is developed, of great intensity. Its disclosure is not instantaneous; a few moments elapse without apparent effect; the dark shades are then first touched in, and by degrees the details appear, but much more slowly than in the case of gold. In two or three minutes, however, the maximum of distinctness will not fail to be attained. The picture may be fixed by the hyposulphite of soda, which alone, I believe, can be fully depended on for fixing argentine photographs.

"The best process for fixing any of the photographs prepared with gold is as follows:—As soon as the picture is satisfactorily brought out by the auriferous liquid, it is to be rinsed in spring water, which must be three times renewed, letting it remain in the third water five or ten minutes. It is then to be blotted off and dried, after which it is to be washed on both sides with a somewhat weak solution of hydriodate of potash. If there be any free chloride of gold present in the pores of paper, it will be discoloured, the lights passing to a ruddy brown; but they speedily whiten again spontaneously, or at all events on throwing it (after lying a minute or two) into fresh water, in which, being again rinsed and dried, it is now perfectly fixed."

SECTION III.—PHOTOGRAPHIC PROPERTIES OF MERCURY.

"As an agent in the daguerreotype process, it is not, strictly speaking, photographically affected. It operates there only in virtue of its readiness to amalgamate with silver properly prepared to receive it. That it possesses *direct* photographic susceptibility, however, in a very eminent degree, is proved by the following experiment. Let a paper be washed over with a weak solution of periodide of iron, and, when dry, with a solution of proto-nitrate of mercury. A bright yellow paper is produced, which (if the right strength of the liquids be hit) is exceedingly sensitive while wet, darkening to a brown colour in a very few seconds in the sunshine. Withdrawn, the impression fades rapidly, and the paper in a few hours recovers its original colour. In operating this change of colour, the whole spectrum is effective, with the exception of the thermic rays beyond the red.

"Proto-nitrate of mercury simply washed over paper, is slowly and feebly blackened by exposure to sunshine. And if paper be impregnated with the ammonio-citrate of iron, already so often mentioned, partially sunned, and then washed with the proto-nitrate, a reduction of the latter salt, and consequently blackening of the paper, takes place very slowly in the dark over the sunned portion, to nearly the same amount as in the direct action of the light on the simply nitrated paper.

"But if the mercurial salt be subjected to the action of light in contact with the ammonio-citrate or tartrate, the effect is far more powerful. Considering, at present, only the citric double salt, a paper prepared by washing first with that salt and then with the mercurial proto-nitrate (drying between) is endowed with considerable sensibility, and darkens to a very deep brown, nay, to complete blackness, on a moderate exposure to good sun. Very sharp and intense photographs of a negative character may be thus taken. They are, however, difficult to *fix*. The only method which I have found at all to succeed has been by washing them with bichromate of potash and soaking them for twenty-four hours in water, which *dissolves out* the chromate of mercury for the most part; leaving, however, a yellow tint on the ground, which resists obstinately. But though pretty effectually fixed in this way against *light*, they are not so against *time*, as they fade considerably on keeping.

"When the proto-nitrate of mercury is mixed, in solution, with either of the ammoniacal double salts, it forms a precipitate, which, worked up with a brush to the consistence of cream, and spread upon paper, produces very fine pictures, the intensity of which it is almost impossible to go beyond. Most unfortunately, they cannot be preserved. Every attempt to fix them has resulted in the destruction of their beauty and force; and even when kept from light, they fade with more or less rapidity, some disappearing almost entirely in three or four days, while others have resisted tolerably well for a fortnight, or even a month. It is to an over-dose of tartaric acid that their more rapid deterioration seems to be due, and of course it is important to keep down the proportion of this ingredient as low as possible. But without it I have never succeeded in producing that peculiar velvety aspect on which the charm of these pictures chiefly depends, nor anything like the same intensity of colour without over-sunning."

Section IV.—Ferro-Tartrate of Silver.

Extending his inquiries still further into these very remarkable changes, the following process presented itself to Sir J. Herschel, which is in many respects remarkable.

If nitrate of silver, specific gravity 1·200, be added to ferro-tartaric acid, specific gravity 1·023, a precipitate falls, which is in great measure redissolved by a gentle heat, leaving a black sediment, which, being cleared by subsidence, a liquid of a pale yellow colour is obtained, in which a further addition of the nitrate causes no turbidness. When the total quantity of the nitrated solution amounts to about half the bulk of the ferro-tartaric acid, it is enough. The liquid so prepared does not alter by keeping in the dark.

Spread on paper, and exposed wet to the sunshine (partly shaded) for a few seconds, no impression seems to have been made; but by degrees (although withdrawn from the action of the light) it developes itself spontaneously, and at length becomes very intense. But if the paper be thoroughly dried in the dark (in which state it is of a very pale greenish-yellow colour), it possesses the singular property of receiving a dormant or invisible picture; to produce which (if it be, for instance, an engraving that is to be copied), from thirty seconds' to a minute's exposure in the sunshine is requisite. It should not be continued too long, as not only is the ultimate effect less striking, but a picture begins to be visibly produced, which darkens spontaneously after it is withdrawn. But if the exposure be discontinued before this effect comes on, an invisible impression is the result, to develope which all that is necessary is to breathe upon it, when it immediately appears, and very speedily acquires an extraordinary intensity and sharpness, as if by magic. Instead of the breath, it may be subjected to the regulated action of aqueous vapour by laying it in a blotting-paper book, of which some of the outer leaves on both sides have been damped, or by holding it over warm water.

Many preparations, both of silver and gold, possess a similar property, in an inferior degree; but none that I have yet met with, to anything like the extent of that above described.

These pictures do not admit of being permanently fixed; they are so against the action of light, but not against the operations of time. They slowly fade out, even in the dark; and in some examples which I have prepared, the remarkable phenomenon of a restoration after fading, but with reversed lights and shades, has taken place.

Section V.—The Amphitype.

The following very remarkable process was communicated by Sir John Herschel, at the meeting of the British Association at York. The process cannot be regarded as perfect, but from its beauty when success is obtained, and the curious nature of all its phenomena, it is deemed important to include it, in the hope of inducing some investigator to take it up.

Sir John Herschel says, alluding to the processes just described, "I had hoped to have perfected this process so far as to have reduced it to a definite statement of manipulations which would insure success. But, capricious as photographic processes notoriously are, this has proved so, even beyond the ordinary measure of such caprice. * * * Paper proper for producing an amphitype picture may be prepared either with the ferro-tartrate or the ferro-citrate of the protoxide or the peroxide of mercury, or of the protoxide of lead, by using creams of these salts, or by successive applications of the nitrates of the respective oxides, singly or in mixture, to the paper, alternating with solutions of the ammonio-tartrate or ammonio-citrate of iron, the latter solution being last applied, and in more or less excess. * * * Paper so prepared and dried takes a negative picture, in time varying from half an hour to five or six hours, according to the intensity of the light; and the impression produced varies in apparent force from a faint and hardly perceptible picture to one of the highest conceivable fulness and richness both of tint and detail, the colour in this case being a superb velvety brown. This extreme richness of effect is not produced except lead be present either in the ingredients used, or *in the paper itself*. It is not, as I originally supposed, due to the presence of free tartaric acid. The pictures in this state are not permanent. They fade in the dark, though with very different degrees of rapidity, some (especially if free tartaric or citric acid be present) in a few days; while others remain for weeks unimpaired, and require whole years for their total obliteration. But though entirely faded out in appearance, the picture is only rendered dormant, and may be restored, changing its character from negative to positive, and its colour from brown to black (in the shadows) by the following process:—A bath being prepared by pouring a small quantity of solution of per-nitrate of mercury into a large quantity of water, and letting the sub-nitrated precipitate subside, the picture must be immersed in it (carefully and repeatedly clearing off the air-bubbles), and allowed to remain till the picture (if any where visible) is entirely destroyed, or if faded, till it is judged sufficient from previous experience; a term which is often marked by the appearance of a feeble positive picture of a bright yellow hue on the pale yellow ground of the paper. A long time (several weeks) is often required for this, but heat accelerates the action, and it is often complete in a few hours. In this state the picture is to be very thoroughly rinsed and soaked in pure warm water, and then dried. It is then to be well ironed with a smooth iron, heated so as barely not to injure the paper, placing it, for better security against scorching, between smooth clean papers. If, then, the process have been successful, a perfectly black positive picture is at once developed. At first it most commonly happens that the whole picture is sooty or dingy to such a degree that it is condemned as spoiled, but on keeping it between the leaves of a book, especially in a moist atmosphere, by extremely slow degrees this dinginess disappears, and the picture disengages itself with continually increasing sharpness and clearness, and acquires the exact effect of a copper-plate engraving on a paper more or less tinted with pale yellow.

"I ought to observe, that the best and most uniform specimens which I have procured have been on paper previously washed with certain preparations of uric acid, which is a very remarkable and powerful photographic element. The intensity of the original negative picture is no criterion of what may be expected in the positive. It is from the production, by one and the same action of the light, of either a positive or a negative picture, according to the subsequent manipulations, that I have designated the process thus generally sketched out, by the term "*Amphitype*;" a name suggested by Mr. Talbot, to whom I communicated this singular result; and to this process or class of processes (which I cannot doubt when pursued will lead to some very beautiful results) I propose to restrict the name in question, though it applies even more appropriately to the following exceedingly curious and remarkable one in which silver is concerned. At the last meeting I announced a mode of producing, by means of a solution of silver in conjunction with ferro-tartaric acid, a dormant picture brought out into a forcible negative impression by the breath, or moist air. The solution then described, and which had at that time been prepared some weeks, I may here incidentally remark, has retained its limpidity and photographic properties quite unimpaired during the whole year since elapsed, and is now as sensitive as ever—a property of no small value. Now, when a picture (for example, an impression from an engraving) is taken on paper washed with this solution, it shows no sign of a picture on its back, whether that on its face be developed or not; but if, while the actinic influence is still fresh upon the face (*i. e.* as soon as it is removed from the light), the *back* be exposed for a very few seconds to sunshine, and then removed to a gloomy place, a positive picture, *the exact complement of the negative one on the other side*, though wanting of course in sharpness if the paper be thick, *slowly and gradually makes its appearance* there, and in half an hour acquires considerable intensity. I ought to mention that the ferro-tartaric acid in question is prepared by precipitating the ferro-tartrate of ammonia by acetate of lead, and decomposing the precipitate by dilute sulphuric acid."

Section VI.—The Colouring Matter of Flowers.

The results obtained by Sir John Herschel on the colouring juices of flowers are too remarkable to be omitted in a treatise in which it is desirable that every point should be registered up to the date of publication, which connects itself with the phenomena of chemical change applied to photography.

"In operating on the colours of flowers, I have usually proceeded as follows:—The petals of the fresh flowers, or rather such parts of them as possessed a uniform tint, were crushed to a pulp in a marble mortar, either alone, or with addition of alcohol, and the juice expressed by squeezing the pulp in a clean linen or cotton cloth. It was then spread on paper with a flat brush, and dried in the air without artificial heat, or at most with the gentle warmth which rises in the ascending current of air from an Arnott stove. If alcohol be not added, the application on paper must be performed immediately, since exposure to the air of the juices of most flowers (in some cases even but for a few minutes) irrecoverably changes or destroys their colour. If alcohol be present, this change does not usually take place, or is much retarded; for which reason, as well as on account of certain facilities afforded by its admixture in procuring an even tint (to be presently stated), this addition was commonly, but not always, made.

"Most flowers give out their colouring matter readily enough, either to alcohol or water. Some, however, as the Escholzias and Calceolarias, refuse to do so, and require the addition of alkalies, others of acids, &c. When alcohol is added, it should, however, be observed that the tint is often apparently much enfeebled, or even discharged altogether, and that the tincture, when spread on paper, does not reappear of its blue intensity till after complete drying. The temporary destruction of the colour of the blue heartsease by alcohol is curious, nor is it by any means a singular instance. In some, but in very few cases, it is destroyed, so as neither to reappear on drying, nor to be capable of revival by any means tried. And in all cases long keeping deteriorates the colours and alters the qualities of the alcoholic tinctures themselves; so that they should always be used as fresh as possible.

"If papers tinged with vegetable colours are intended to be preserved, they must be kept perfectly dry and in darkness. A close tin vessel, the air of which is dried by quicklime (carefully enclosed in double paper bags, well pasted at the edges to prevent the dust escaping), is useful for this purpose. Moisture (as already mentioned, especially assisted by heat) destroys them for the most part rapidly, though some (as the colour of the *Senecio splendens*) resist obstinately. Their destructibility by this agency, however, seems to bear no distinct relation to their photographic properties.

"This is also the place to observe that the colour of a flower is by no means always, or usually, that which its expressed juice imparts to white paper. In many cases the tints so imparted have no resemblance to the original hue. Thus, to give only a few instances, the red damask rose of that intense variety of colour commonly called by florists the black rose, gives a dark slate blue, as do also the clove carnation and the black hollyhock: a fine dark brown variety of sparaxis gave a dull olive green; and a beautiful rose-coloured tulip, a dirty bluish green; but perhaps the most striking case of this kind is that of a common sort of red poppy (*Papaver Rheum*), whose expressed juice imparts to paper a rich and most beautiful blue colour, whose elegant properties as a photographic material will be further alluded to hereafter.[1]

"This change of colour is probably owing to different causes in different flowers. In some it undoubtedly arises from the escape of carbonic acid, but this, as a general cause for the change from red to blue, has, I am aware, been controverted. In some (as is the case with the yellow ranunculi) it seems to arise from a chemical alteration depending on absorption of oxygen; and in others, especially where the expressed juice coagulates on standing, to a loss of vitality or disorganization of the molecules. The fresh petal of a single flower, merely crushed by rubbing on dry paper, and instantly dried, leaves a stain much more nearly approximating to the original hue. This, for example, is the only way in which the fine blue colour of the common field veronica can be imparted to paper. Its expressed juice, however quickly prepared, when laid on with a brush, affords only a dirty neutral grey, and so of many others. But in this way no even tint can be had, which is a first requisite to the experiments now in question, as well as to their application to photography.

"To secure this desirable evenness of tint, the following manipulation will generally be found successful:—The paper should be moistened at the back by sponging aud blotting off. It should then be pinned on a board, the moist side downwards, so that two of its edges (suppose the right-hand and lower ones) shall project a little beyond those of the board. The board being then inclined twenty or thirty degrees to the horizon, the alcoholic tincture (mixed with a very little water, if the petals themselves be not very juicy) is to be applied with a brush in strokes from left to right, taking care *not to* go over the edges which rest on the board, but *to* pass clearly over those which project, and observing also to carry the tint from below upwards by quick sweeping strokes, leaving no dry spaces between them, but keeping up a continuity of wet surface. When all is wet, cross them by another set of strokes from above downwards, so managing the brush as to leave no floating liquid on the paper. It must then be dried as quickly as possible over a stove, or in a current of warm air; avoiding, however, such heat as may

[1] A semicultivated variety was used, having dark purple spots at the bases of the petals. The common red poppy of the chalk (*Papaver hybridum*) gives a purple colour much less sensitive and beautiful.

injure the tint. The presence of alcohol prevents the solution of the gummy principle, which, when present, gives a smeary surface; but the evenness of tint given by this process results chiefly from that singular intestine movement which always takes place when alcohol is in the act of separation from water by evaporation; a movement which disperses knots and blots in the film of liquid with great energy, and spreads them over the surrounding surface.

"*Corchorus Japonica.*—The flowers of this common and hardy but highly ornamental plant are of a fine yellow, somewhat inclining to orange, and this is also the colour the expressed juice imparts to paper. As the flower begins to fade *the petals whiten*,—an indication of their photographic sensibility which is amply verified on exposure of the stained paper to sunshine. I have hitherto met with no vegetable colour so sensitive. If the flowers be gathered in the height of their season, paper so coloured (which is of a very even and beautiful yellow) begins to discolour in ten or twelve minutes in clear sunshine, and in half an hour is completely whitened. The colour seems to resist the first impression of the light, as if by some remains of vitality, which being overcome, the tint gives way at once, and the discolouration, when commenced, goes on rapidly. *It does not even cease in the dark when once begun.* Hence it happens that photographic impressions taken on such paper, which, when fresh, are very sharp and beautiful, fade by keeping, visibly from day to day, however carefully preserved from light. They require from half an hour to an hour to complete, according to the sunshine. Hydriodate of potash cautiously applied retards considerably, but does not ultimately prevent, this spontaneous discharge.

"*Common Ten Weeks' Stocks: Mathiola annua.*—Paper stained with the tincture of this flower is changed to a vivid scarlet by acids, and to green by alkalies; if ammonia be used the red colour is restored as the ammonia evaporates, proving the absence of any acid quality in the colouring matter sufficiently energetic to coerce the elastic force of the alkaline gas. Sulphurous acid whitens it, as do the alkaline sulphites; but this effect is transient, and the red colour is slowly restored by free exposure to air, especially with the aid of light, whose influence in this case is the more remarkable, being exactly the reverse of its ordinary action on this colouring principle, which it destroys irrecoverably, as above stated. The following experiments were made to trace and illustrate this curious change:—

"Two photographic copies of engravings taken on paper tinted with this colour were placed in a jar of sulphurous acid gas, by which they were completely whitened, and all traces of the pictures obliterated. They were then exposed to free air, the one in the dark, the other in sunshine. Both recovered, but the former much more slowly than the latter. The restoration of the picture exposed to the sun was completed in twenty-four hours, that in the dark not till after a lapse of two or three days.

"A slip of the stained paper was wetted with liquid sulphurous acid, and laid on blotting-paper similarly wetted. Being then crossed with a strip of black paper, it was laid between glass plates and (evaporation of the acid being thus prevented) was exposed to full sunshine. After some time, the red colour (in spite of the presence of the acid) was considerably restored in the portion exposed, while the whole of the portion covered by the black paper remained (of course) perfectly white.

"Slips of paper, stained as above, were placed under a receiver, beside a small capsule of liquid sulphurous acid. When completely discoloured, they were subjected (on various occasions, and after various lengths of exposure to the acid fumes, from half an hour to many days) to the action of the spectrum; and it was found, as indeed I had expected, that *the restoration of colour was operated by rays complementary to those which destroy it in the natural state of the paper;* the violet rays being chiefly active, the blue almost equally so, the green little, and the yellow, orange, and most refrangible red, not at all. In one experiment a pretty-well defined red solar image was developed by the *least* refrangible red rays also, being precisely those for which in the unprepared paper the discolouring action is abruptly cut off. But this spot I never succeeded in reproducing; and it ought also to be mentioned, that, according to differences in the preparation not obvious, the degree of sensibility, generally, of the bleached paper to the restorative action of light, differed greatly; in some cases a perceptible reddening being produced in ten seconds, and a considerable streak in two minutes, while in others a very long time was required to produce any effect. The dormancy of this colouring principle, under the influence of sulphurous acid, is well shown by dropping a little weak sulphuric acid on the paper bleached by that gas, which immediately restores the red colour in all its vigour. In like manner alkalies restore the colour, converting it at the same time into green.

"*Papaver orientale.*—The chemical habitudes of the sulphurous acid render it highly probable that its action, in inducing a dormant state of the colorific principle, consists in a partial deoxidizement, unaccompanied, however, with disorganization of its molecules. And this view is corroborated by the similar action of alcohol already spoken of; similar, that is, in kind, though less complete in degree. Most commonly, vegetable colours, weakened by the action of alcohol, are speedily restored on the total evaporation of the ingredient. But one remarkable instance of absolute dormancy induced by that agent has occurred to me in the case of *Papaver orientale*, a flower of a vivid orange colour, bordering on scarlet, the colouring matter of which is not extractable otherwise than by alcohol, and then only in a state so completely masked as to impart no more than a faint yellowish or pinkish hue to paper, which it retains when thoroughly dry, and apparently during any length of time, without perceptible increase of tint. If at any time, however, a drop of weak acid be applied to paper prepared with this tincture, a vivid scarlet colour is immediately developed; thus demonstrating the continued though latent existence of the colouring principle. On observing this, it occurred to me to inquire whether, in its dormant state, that principle still retained its susceptibility of being acted on by light, since the same powerful and delicate agent which had been shown, in so many cases as to constitute a general law, capable of disorganising and destroying vegetable colours actually developed, might easily be presumed competent to destroy the capacity for assuming colour, in such organic matter as might possess it, under the influence of their otherwise appropriate chemical stimuli. A strip of the paper was therefore exposed for an hour or two to the spectrum, but without any sensible effect, the whole surface being equally reddened by an acid. As this experiment sufficiently indicated the action of light, if any, to be very slow, I next placed a strip, partly covered, in a south-east window, where it remained from June 19 to August 19, receiving the few and scanty sunbeams which that interval of the deplorable summer of 1841 afforded. When removed, the part exposed could barely be distinguished from the part shaded, as a trifle yellower. But on applying acid, the exposed and shaded portions were at once distinguished by the assumption of a vivid red in the latter, and the former remaining unchanged.

"A mezzotinto picture was now pressed on a glazed frame over another portion of the same paper, and abandoned on the upper shelf of a green-house to whatever sun might occur from August 19 to October 19. The interval proved one of almost uninterrupted storm, rain, and darkness. On removal, no appearance whatever of any impressed picture could be discerned, nor was it even possible to tell the top of the picture from the bottom. It was then exposed in a glass jar to the fumes of muriatic acid, when, after a few minutes, the development of the dormant picture commenced, and slowly proceeded, disclosing the details in a soft and pleasing style. Being then laid by in a drawer, with free access of air, the picture again faded, by very slow degrees, and on January 2, 1842, was found quite obliterated. Being then subjected to the acid vapour the colour was reproduced.

"*Viola odorata.*—Chemists are familiar with the colour of this flower as a test of acids and alkalies, for which, however, it seems by no means better adapted than many others; less so, indeed, than that of the *Violar tricolor*, the common purple iris, and many others which might be named. It offers, in fact, another and rather a striking instance of the simultaneous existence of two colouring ingredients in the same flower, comporting themselves differently, not only in regard to light but to chemical agents. Extracted with alcohol, the juice of the violet is of a rich blue colour, which it imparts in high perfection to paper. Exposed to sunshine, a portion of this colour gives way pretty readily, but a residual blue, rather inclining to greenish, resists obstinately, and requires a very much longer exposure (for whole weeks, indeed) for its destruction, which is not even then complete. Photographic impressions, therefore, taken on this paper, though very pretty, are exceedingly tedious in their preparation, if we would have the lights sharply made out.

"*Sparaxis tricolor ?, var.—Stimulating Effects of Alkalies.*—Among a great many hybrid varieties of this genus, lately forwarded to me from the Cape, occurred one of a very intense purplish-brown colour, nearly black. The alcoholic extract of this flower in its liquid state is rich crimson-brown. Spread on paper, it imparted a dark olive-green colour, which proved perfectly insensible to very prolonged action, either of sunshine or the spectrum. The addition of carbonate of soda changed the colour of this tincture to a good green, slightly inclining to olive, and which imparted the same tint to paper. In this state, to my surprise, it manifested rather a high degree of photographic sensibility, and gave very pretty pictures with a day or two of exposure to sunshine. When prepared with the fresh juice there is hardly any residual tint, but if the paper be kept, a great amount of indestructible yellow remains outstanding. The action is confined chiefly to the negative end of the spectrum; all but the first five or six parts beyond the yellow show little more than a trace of action. A photograph impressed on this paper is reddened by muriatic acid fumes. If then transferred to an atmosphere of ammonia, and when supersaturated the excess of alkali allowed to exhale, it is fixed, and of a dark green colour. Both the tint and sharpness of the picture, however, suffer in this process.

"*Red Poppy : Papaver Rheum?*—Among the vegetable colours totally destroyed by light, or which leave no residual tint, at least when fresh prepared, perhaps the two most rich and beautiful are those of the red poppy and the double purple groundsel (*Senecio splendens*). The former owes its red colour in all probability to free carbonic acid, or some other (as the acetic), completely expelled by drying: for the colour its tincture imparts to paper, instead of red, is a fine blue very slightly verging on slate-blue. But it has by no means the ordinary chemical characters of blue vegetable colours. Carbonate of soda, for instance, does not in the least degree turn the expressed juice green; and when washed with the mixture, a paper results of a light slate-grey, hardly at all inclining to green. The blue tincture is considerably sensitive, and from the richness of its tone and the absence of residual tint, paper stained with it affords photographic impressions of great beauty and sharpness, some of which will be found among the collection submitted with this paper for inspection.

"*Senecio splendens.*—This flower yields a rich purple juice in great abundance and of surprising intensity. Nothing can exceed the rich and velvety tint of paper tinted while it is fresh. It is, however, not very sensible to light, and many weeks are necessary to obtain a good photographic impression."

In the progress of my own researches on this subject, I found that the green colouring matter of the leaves of herbaceous plants, when spread upon paper, changed with tolerable rapidity when exposed to sunshine. There are, however, some very curious points connected with the phenomena of these changes which demand a far more extensive investigation than they have yet received.

I find that the juices taken from the leaves in the spring, change more rapidly than when expressed from the same plants in the autumn; and the juices of those flowering plants which have been cultivated under the artificial circumstances of a store-house, or conservatory, are more readily affected than such as are grown in the open air. Many of the experiments just described furnish very instructive examples of the operations of the solar rays upon organic bodies, from which we may deduce important truths connected with natural phenomena.

There are several other very curious observations made by this eminent experimentalist, which might with much propriety have been included in this section. Many of these will find a place in the scientific details; and the formation of precipitates on glass plates will be described in the chapter devoted to their consideration.

CHAPTER VI.

PROCESSES BY THE AUTHOR AND OTHERS.

SECTION I.—MR. PONTON'S PROCESS. (BICHROMATE OF POTASH.)

UNDER the general term of the Chromatype, I would propose to include all those processes which involve the use of any of the salts of chromium. It was originally introduced to distinguish a particular process which I discovered, and published at the meeting of the British Association at Cork, in August 1843; but it appears very convenient to adopt the principle introduced by Sir John Herschel, of grouping the phenomena of photography under a general heading, derived from the most prominent chemical preparation employed.

There are many preparations which are affected by light in a similar manner to the salts of silver. Several have been tried as photographic materials, but as yet without much success, with the exception of the bichromate of potash, which was first announced as a useful photographic agent by Mr. Mungo Ponton, in the Edinburgh New Philosophical Journal; from which I quote Mr. Ponton's own account.

"When paper is immersed in the bichromate of potash, it is powerfully and rapidly acted on by the sun's rays. When an object is laid in the usual way on this paper, the portion exposed to the light speedily becomes tawny, passing more or less into a deep orange, according to the strength of the light. The portion covered by the object retains the original bright yellow tint which it had before exposure, and the object is thus represented yellow upon an orange ground, there being several gradations of shade, or tint, according to the greater or less degree of transparency in the different parts of the object.

"In this state, of course, the drawing, though very beautiful, is evanescent. To fix it, all that is required is careful immersion in water, when it will be found that those portions of the salt which have not been acted on by the light are readily dissolved out, while those which have been exposed to the light are completely fixed on the paper. By the second process the object is obtained white upon an orange ground, and quite permanent. If exposed for many hours together to strong sunshine, the colour of the ground is apt to lose in depth, but not more so than most other colouring matters. This action of light on the bichromate of potash differs from that upon the salts of silver. Those of the latter which are blackened by light are of themselves insoluble in water, and it is difficult to impregnate paper with them in a uniform manner. The blackening seems to be caused by the formation of oxide of silver.

"In the case of the bichromate of potash, again, that salt is exceedingly soluble, and paper can be easily saturated with it. The agency of light not only changes its colour, but deprives it of solubility, thus rendering it fixed in the paper. This action appears to consist in the disengagement of free chromic acid, which is of a deep red colour, and which seems to combine with the paper. This is rendered more probable from the circumstance that the neutral chromate exhibits no similar change. The best mode of preparing paper with bichromate of potash is to use a saturated solution of that salt; soak the paper well in it, and then dry it rapidly at a brisk fire, excluding it from daylight. Paper thus prepared acquires a deep orange tint on exposure to the sun. If the solution be less strong, or the drying less rapid, the colour will not be so deep. A pleasing variety may be made by using sulphate of indigo along with the bichromate of potash, the colour of the object and of the paper being then different shades of green. In this way, also, the object may be represented of a darker shade than the ground."

Paper prepared with the bichromate of potash, though as sensitive as some of the papers prepared with the salts of silver, is much inferior to most of them, and is not sufficiently sensitive for the camera obscura. This paper, however, answers quite well for taking drawings from dried plants, or for copying prints. Its great recommendation is its cheapness, and the facility with which it can be prepared. The price of the bichromate of potash is about two shillings per pound, whilst the nitrate of silver is five shillings the ounce.

As the deep orange ground of these pictures prevents the permeation of the chemical rays of light, it is very easy to procure any number of facsimiles of an engraving, by transfer from the first negative photograph. The correct copies have a beautiful sharpness; and, if carefully managed, but little of the minute detail of the original engraving is lost.

The most interesting photographic paper prepared with the bichromate of potash is a kind described by M. E. Becquerel. He states,—It is sufficient to steep a paper prepared in Mr.

Ponton's manner, and upon which there exists a faint copy of a drawing, in a solution of iodine in alcohol, to wash this paper in alcohol, and then dry it: then the parts which were white become blue, and those which were yellow remain more or less clear.

M. E. Becquerel has pursued his investigations into the action of the chromic acid on organic compounds, and has shown that the mode of sizing the papers influences their colouration by light, and that with unsized paper colouration is effected only after a long time. Perceiving that the principal reaction resulted from the chromic acid contained in the bichromate of potash, on the starch in the size of the paper, it occurred to M. E. Becquerel, that, as starch has the property of forming with iodine a combination of a very fine blue colour, it should produce deep shades of that tint, whilst the lights still remained an orange-yellow.

His method of proceeding is to spread a size of starch very uniformly over the surface of the paper. It is then steeped in a weak alcoholic solution of iodine, and afterwards washed in a great quantity of water. By this immersion it should take a very fine blue tint. If this is uniform, the paper is considered fit for the experiment: in the contrary case it is sized again. It is then steeped in a concentrated solution of bichromate of potash, and pressed between folds of blotting paper, and dried near the fire. To be effective, it should be very dry.

It is now fit for use. When the copy is effected, which requires in sunshine about five minutes, the photograph is washed and dried. When dry, it is steeped in a weak alcoholic solution of iodine, and afterwards, when it has remained in it some time, it is washed in water, and carefully dried with blotting paper, but not at the fire, for at a little below 100° Fahr. the combination of iodine and starch discolours.

If it be considered that the drawing is not sufficiently distinct, this immersion may be repeated several times; for by this means may be obtained the intensity of tone that is desired, which intensity can be changed at will by employing a more concentrated solution of iodine.

When the paper is damp, the shades are of a very fine blue, but when it is dry the colour becomes deep violet. If while the drawing is still wet it be covered with a layer of gum arabic, the colour of the drawing is greatly preserved, and more beautiful when it is dry. When a paper is thus prepared it loses at first a little of its tone, but it afterwards preserves its violet tint.

The Chromatype Process.—This process, devised by the author, is a pleasing one in its results: it is exceedingly simple in its manipulatory details, and produces very charming positive pictures by the first application.

The chromatype is founded on the above process of Mr. Ponton's, but it was found in practice that the bichromate of potash alone would not produce the desired effect: the following method was therefore adopted:—

One drachm of sulphate of copper is dissolved in an ounce of distilled water, to which is added half an ounce of a saturated solution of bichromate of potash; this solution is applied to the surface of the paper, and, when dry, it is fit for use, and may be kept for any length of time without spoiling. When exposed to sunshine, the first change is to a dull brown, and if checked in this stage of the process we get a negative picture, but if the action of the light is continued, the browning gives way, and we have a positive yellow picture on a white ground. In either case, if the paper, when removed from the sunshine, is washed over with a solution of nitrate of silver, a very beautiful positive picture results. In practice, it will be found advantageous to allow the bleaching action to go on to some extent; the picture resulting from this will be clearer and more defined than that which is procured when the action is checked at the brown stage. To fix these pictures it is necessary to remove the nitrate of silver, which is done by washing in *pure* water: if the water contains any muriates the picture suffers, and long soaking in such water obliterates it, or if a few grains of common salt are added to the water the apparent destruction is very rapid. The picture is, however, capable of restoration; all that is necessary being to expose it to sunshine for a quarter of an hour, when it revives; but instead of being of a red colour, it becomes lilac, the shades of colour depending upon the quantity of salt used to decompose the chromate of silver which forms the shadow parts of the picture.

Mr. Bingham remarks on this process, that if we substitute sulphate of nickel for the sulphate of copper, the paper is more sensitive, and the picture is more clearly developed by nitrate of silver.

The following modification of this process possesses some advantages. If to a solution of the sulphate of copper we add a solution of the neutral chromate of potash, a very copious brown precipitate falls, which is a true chromate of copper. If this precipitate, after being well washed, is added to water acidulated with sulphuric acid, it is dissolved, and a dichromatic solution is formed, which, when spread upon paper, is of a pure yellow. A very short exposure of the papers washed with this solution is quite sufficient to discharge all the yellow from the paper, and give it perfect whiteness. If an engraving is to be copied we proceed in the usual manner; and we may either bring out the picture by placing the paper in a solution of carbonate of soda or potash, by which all the shadows are represented by the chromate of copper, or by washing the paper with nitrate of silver. It may sometimes happen that, owing to deficient light, the photograph is darkened all over when the silver is applied: this colour, by keeping, is gradually removed, and the picture comes out clear and sharp.

If the chromate of copper is dissolved in ammonia, a beautiful green solution results, and if applied to paper acts similarly to those just described.

The chromatype pictures, under certain conditions, afford a beautiful example of the changes which take place, slowly, in the dark, from the combined operations of the materials employed.

If we take a chromatype picture after it has been developed by the agency of either nitrate of silver, or of mercury, and place it aside in the dark, it will be found, after a few weeks, to have darkened considerably both in the lights and shadows. This darkening slowly increases, until eventually the picture is obliterated beneath a film of metallic silver or mercury; but, while the picture has been fading out on one side, it has been developing itself on the other, and a very pleasing image is seen on the back. After some considerable time the metal on the front gives way again, the paper slowly whitens, and eventually the image is presented on both sides of the paper of equal intensity, in a good neutral tint upon a grey ground. These results, it will be remembered, are of a very similar character to those already described as peculiar to the amphitype process of Sir John Herschel.

Section II.—The Ferrotype.

This process, which is of remarkable sensibility, was discovered by the author, and published in the Athenæum, under the name of the Energiatype; but from a desire to group all those pictures under a general head into which iron salts enter as an element, the present name is preferred. The preparation of the paper is as follows:—Good letter paper (Whatman's is the best) is washed over with the following solution, viz.: Five grains of succinic acid (it is important that succinic free from any oil of amber, or adventitious matter, should be obtained) are to be dissolved in one fluid ounce of water, to which are added about five grains of common salt, and half a drachm of mucilage of gum arabic. When dry, the paper is drawn over the surface of a solution of sixty grains of nitrate of silver in one ounce of distilled water. Allowed to dry in the dark, the paper is now fit for use, is of a pure white, retains its colour, and may be preserved for a considerable time in a portfolio, until wanted for use.

The preparation of this paper is by no means difficult, but requires care and attention. The solutions must be applied very equally over the paper, which should be immediately hung upon a frame or clothes' horse to dry, Extreme care must be taken that the paper be not exposed to light, after the nitrate of silver solution has been applied, until required for use. Many of the disappointments experienced by the experimenters on the energiatype are occasioned by a neglect of this precaution; as, although no apparent effect may have been produced by the exposure, the clearness of the subsequent picture will be seriously injured. The succinic acid must also be very pure. We shall now briefly describe the method of applying this process to the different purposes for which it is best adapted, premising that the varying circumstances of time, place, and light, will render necessary such modifications of the following directions as the experience of the operator may suggest. As a general rule, an open situation, sunshine, and, if possible, the morning sun, should be preferred, as the image is sharper, and the colour produced more intense, and less affected by the subsequent fixing process.

In the camera, for a building or statue, an exposure of half a minute in strong sunshine is usually sufficient; for a portrait, taken under ordinary conditions, two or three minutes are required.

When the paper is taken from the camera, nothing is visible upon it; but by attending to the following directions the latent picture will quickly develope itself. Having mixed together about one drachm of a saturated solution of *protosulphate of iron* and two or three drachms of *mucilage of gum arabic*, pour a small quantity into a flat dish. Pass the prepared side of the paper taken from the camera rapidly over this mixture, taking care to ensure complete contact in every part. If the paper has been sufficiently impressed, the picture will almost immediately appear, and the further action of the iron must be stopped by the application of a soft sponge and plenty of clean water. Should the image not appear immediately, or be imperfect in its details, the iron solution may be allowed to remain upon it a short time;

but it must then be kept disturbed, by rapidly but lightly brushing it up, otherwise numerous black specks will form and destroy the photograph. Great care should be taken that the iron solution does not touch the back of the picture, which it will inevitably stain, and, the picture being a negative one, be rendered useless as a copy. A slight degree of heat will assist the development of the image where the time of exposure has been too short.

The picture should be carefully washed to take off any superficial blackness, and may then be permanently fixed by being soaked in water to which a small quantity of ammonia, or, better still, hyposulphite of soda, has been added. The paper must again be well soaked in clean water, to clear it from the soluble salts, and may then be dried and pressed.

Exact copies of prints, feathers, leaves, &c., may be taken on the succinated paper by exposing them to the light in the copying-frame, until the margin of the prepared paper, which should be left uncovered, begins to change colour very slightly. If the object to be copied is thick, the surface must be allowed to assume a darker tint, or the light will not have penetrated to the paper.

Positive copies of the camera negatives are procured in the same manner as the copies of the prints, &c., just described. Instead, however, of using the iron solution, the paper must be exposed to the light, in the frame, a sufficient time to obtain perfect copies. The progress of the picture may be observed by turning up the corner of the paper, and, if not sufficiently done, replacing it exactly in the same position. They should be fixed with hyposulphite, as before directed.

At the meeting of the British Association at York in 1844, I showed, by a series of photographs, that the *protosulphate of iron* was most effective in developing any photographic images, on whatever argentiferous preparation they may have been received. Every subsequent result has shown that with proper care it is the most energetic agent for developing with which we are acquainted. The difficulty of obtaining, and of preserving, the salt free of any peroxide, or a basic salt which falls as a brownish-yellow powder, has been the principal cause why it has not been so generally employed as the gallic acid: this can be insured by adding a few drops of sulphuric acid to the solution of the protosulphate of iron, and some iron filings. Mr. Robert Ellis has recommended the use of the protonitrate of iron as a developing agent.

Section III.—The Catalysotype.

This process of Dr. Woods' is capable of producing pictures of superior excellence. Owing to the inconstancy of the iodine compounds, it is a little uncertain, but, care being taken to insure the same degree of strength in the solutions, a very uniform good result may be obtained. The process and its modifications are thus described by the inventor.

" While investigating the property which sugar possesses, in some instances, of preventing precipitation, I noticed that when syrup of ioduret of iron was mixed in certain proportions with solution of nitrate of silver, the precipitate was very quickly blackened when exposed to the light, and I thought that, if properly used, it might be employed with advantage as a photographic agent. If not entirely without profit, it would hardly repay the trouble of reading the history of all the experiments I tried in order to prove whether or not this idea were correct; for there were many difficulties to be overcome, and unexpected hinderances to be surmounted, before I could be certain of success. However, the results at which I have arrived make me hope that my trouble has not been thrown away, and that a photographic process has been discovered, which is more manageable and more satisfactory than any which has before been used; and I think that the pictures produced by it are more minutely and delicately brought out, and the time for their production at least not longer than is required by any other method.

" To enter very minutely into the particulars, or to explain the rationale of the process, would be too tedious; however, it is so simple, that those who will feel any pleasure in trying it will, I am sure, easily succeed, and to attempt any explanation of its theory would, in the present state of our knowledge of light, be advancing a mere hypothesis: I will, therefore, only state generally the method in which the paper is prepared, and then, briefly giving my reasons for such parts of the process as are not at first sight obvious, will thereby enable the experimenter to be guarded against the failures that these precautions are intended to overcome.

" Let well-glazed paper (I prefer that called wove post) be steeped in water to which hydrochloric acid has been added in the proportion of two drops to three ounces. When well wet, let it be washed over with a mixture of syrup of ioduret of iron half a drachm, water two drachms and a half, tincture of iodine one drop.

"When this has remained on the paper for a few minutes, so as to be imbibed, dry it lightly with bibulous paper, and being removed to a dark room, let it be washed over evenly, by means of a camel-hair pencil, with a solution of nitrate of silver, ten grains to the ounce of distilled water. The paper is now ready for the camera. The sooner it is used the better; as when the ingredients are not rightly mixed it is liable to spoil by keeping. The time I generally allow the paper to be exposed in the camera varies from two to thirty seconds; in clear weather, without sunshine, the medium is about fifteen seconds. With a bright light, the picture obtained is of a rich brown colour; with a faint light, or a bright light for a very short time continued, it is black. For portraits out of doors, in the shade on a clear day, the time for sitting is from ten to fifteen seconds.

"If the light is strong, and the view to be taken extensive, the operator should be cautious not to leave the paper exposed for a longer period than five or six seconds, as the picture will appear confused from all parts being equally acted on. In all cases, the shorter the time in which the picture is taken the better.

"When the paper is removed from the camera no picture is visible. However, when left in the dark, without any other preparation being used, for a period which varies with the length of time it was exposed, and the strength of the light, a negative picture becomes gradually developed, until it arrives at a state of perfection which is not attained, I think, by photography produced by any other process.[1] It would seem as if the salt of silver, being slightly affected by the light, though not in a degree to produce any visible effect on it if alone, sets up a catalytic action, which is extended to the salts of iron, and which continues after the stimulus of the light is withdrawn. The catalysis which then takes place has induced me to name this process, for want of a better word, the Catalysotype. Sir J. Herschel and Mr. Fox Talbot have remarked the same fact with regard to other salts of iron, but I do not know of any process being employed for photographic purposes, which depends on this action for its development, except my own.

[1] The picture, when developed, is not readily injured by exposure to moderate light; it ought, however, to be fixed, which may be done by washing it with a solution of bromide of potassium, fifteen or twenty grains to the ounce, or iodide of potassium, five grains to the ounce. It may either be applied with a camel-hair pencil or by immersion. The picture must then be well washed in water to remove the fixing material, which would cause it to fade by exposure to light.

"My reason for using the muriatic solution previous to washing with the ioduret of iron is this: I was for a long time tormented by seeing the pictures spoiled by yellow patches, and could not remedy it, until I observed that they presented an appearance as if that portion of the nitrate of silver which was not decomposed by the ioduret of iron had flowed away from the part. I then recollected that Sir J. Herschel and Mr. Hunt had proved that iodide of silver is not very sensitive to light, unless some free nitrate be present. I accordingly tried to keep both together on the paper, and after many plans had failed, I succeeded by steeping it in the acid solution, which makes it freely and evenly imbibe whatever fluid is presented to it. I am sure that its utility is not confined to this effect, but it was for that purpose that I first employed it.

"My reason for adding the tincture of iodine to the syrup is, that having in my first experiments made use of, with success, a syrup that had been for some time prepared, and afterwards remarking that fresh syrup did not answer so well, I examined both, and found in the former a little free iodine; I therefore added a little tincture of iodine with much benefit, and now always use it in quantities proportioned to the age of the syrup.

"The following hints will, I think, enable any experimenter to be successful in producing good pictures by this process. In the first place, the paper used should be that called wove post, or well-glazed letter paper. When the solutions are applied to it, it should not immediately imbibe them thoroughly, as would happen with the thinner sorts of paper. If the acid solution is too strong, it produces the very effect it was originally intended to overcome; that is, it produces yellow patches, and the picture itself is a light brick colour on a yellow ground. When the tincture of iodine is in excess, partly the same results occur; so that if this effect is visible, it shows that the oxide of silver which is thrown down is partly re-dissolved by the excess of acid and iodine, and their quantities should be diminished. On the contrary, if the silver solution is too strong, the oxide is deposited in the dark, or by an exceedingly weak light, and in this case blackens the yellow parts of the picture, which destroys it. When this effect of blackening all over takes place, the silver solution should be weakened. If it be too weak, the paper remains yellow after exposure to light. If the ioduret of iron be used in too great quantity, the picture is dotted over with black spots, which afterwards change to white. If an excess of nitrate of silver be used, and a photograph immediately taken before the deposition of the oxide takes place, there will be often after some time a positive picture formed on the back of the negative one.

The excess of the nitrate of silver makes the paper blacker where the light did not act on it, and this penetrates the paper; whereas the darkening produced by the light is confined to the surface. The maximum intensity of the spectrum on the paper, when a prism of crown glass is used, lies between the indigo and blue ray. The difference of effect of a strong and weak light is beautifully shown in the action of the spectrum: that part of the paper which is exposed to the indigo ray is coloured a reddish brown, and this is gradually darkened towards either extremity, until it becomes a deep black.

"I have not had many opportunities of experimenting with the catalysotype, but it certainly promises to repay the trouble of further investigation. The simplicity of the process, and the sensibility of the paper, should cause it to be extensively used. It has all the beauty and quickness of the calotype, without its trouble, and very little of its uncertainty; and, if the more frequent use of it by me, as compared with other processes, does not make me exaggerate its facility of operation, I think it is likely to be practised successfully by the most ordinary experimenters."

Dr. Woods subsequently made the following addition:—

"Since the preceding paper was written, I have been experimenting with the catalysotype, and one day having had many failures, which was before quite unusual with me, I am induced to mention the cause of them, for the benefit of subsequent experimenters. The paper I used was very stiff and highly glazed, so that the solution first applied was not easily imbibed. The blotting paper was very dry and bibulous. When using the latter, I removed nearly all the solution of iron from the first, and, of course, did not obtain the desired result.

"While varying the process in endeavouring to find out the cause just mentioned, I discovered that the following proportions gave very fine negative pictures, from which good positive ones were obtained:—Take of syrup of ioduret of iron, distilled water, each two drachms; tincture of iodine, ten to twelve drops: mix. First brush this over the paper, and, after a few minutes, having dried it with the blotting paper, wash it over in the dark (before exposure in the camera) with the following solution, by means of a camel-hair pencil:—Take of nitrate of silver one drachm; pure water one ounce: mix. This gives a darker picture than the original preparation, and consequently, one better adapted for obtaining positive ones: it also requires no previous steeping in an acid solution. To fix the picture let it be washed first in water, then allowed to remain for a few minutes in a solution of hydriodate of potassa (five grains to the ounce of water) and washed in water again. The paper I use is the common unglazed copy paper, but such as has a good body. I have tried the same paper with the original preparation, and find it to answer exceedingly well; it does not require in this case, either, an acid solution. The same precautions and hints apply to the amended as to the original process; such as, when it blackens in the dark, there is too much caustic used; when it remains yellow, or that it is studded with yellow spots, too much iodine; when marked with black spots, too much iron. It is necessary to mention these, on account of the varying strength of the materials employed."

Section IV.—Ferrocyanide of Potassium.

At the meeting of the British Association at Plymouth in 1841, I first directed attention to the use of the ferroprussiate of potash in combination with the iodide of silver. The process resulting from this being very important in many points, the abstract of the paper then read, as given in the Transactions of the Sections, is reprinted.

The author having been engaged in experiments on those varieties of photographic drawings which are formed by the action of the hydriodic salts on the darkened chloride of silver, and with a view to the removal of the iodide formed by the process from the paper, was led to observe some peculiar changes produced by the combined influences of sunshine and the ferrocyanate of potash. It was found that the ordinary photographic paper, if allowed to darken in sunshine, and then slightly acted on by any hydriodic salt, and, when dry, washed with a solution of the ferrocyanate of potash, became extremely sensitive to light, changing from a light brown to a full black by a moment's exposure to sunshine. Following out this result, it was discovered that perfectly pure iodide of silver was acted on with even greater rapidity, and thus it became easy to form an exquisitely sensitive photographic paper.

The method recommended is the following:—

Highly glazed letter paper is washed over with a solution of one drachm of nitrate of silver to an ounce of distilled water; it is quickly dried, and a second time washed with the same solution. It is then, when dry, placed for a minute in a solution of two drachms of the hydriodate of potash in six ounces of water, placed on a smooth board, gently washed by allowing some water to flow over it, and dried in the dark at common temperatures. Papers thus prepared may be kept for any length of time, and are at any time rendered sensitive by simply washing them over with a solution formed of one drachm of the ferro-cyanate of potash to an ounce of water.

These papers, washed with the ferrocyanate, and dried in the dark, are, in this dry state, absolutely insensible, but they may at any moment be rendered sensitive by merely washing them with a little cold clean water.

Papers thus prepared are rendered quite insensible by being washed over with the above hydriodic solution. They are, however, best secured against the action of time by a solution of ammonia. The yellow colour of the paper militates against its being used as the original from which copies may be taken; but even this colour may be removed by employing hot hyposulphite of soda.

Upon paper thus prepared the curious result of an impressed coloured spectrum was first obtained.

Section V.—The Fluorotype,

So called from the introduction of the salts of fluoric acid, consists of the following process of manipulation:—

{ Bromide of potassium, 20 grains.
{ Distilled water . . . 1 fluid ounce.
{ Fluoride of sodium . . 5 grains.
{ Distilled water . . . 1 fluid ounce.

Mix a small quantity of these solutions together when the papers are to be prepared, and wash them once over with the mixture, and, when dry, apply a solution of nitrate of silver, sixty grains to the ounce of water. These papers keep for some weeks without injury, and become impressed with good images in half a minute in the camera. The impression is not sufficiently strong when removed from the camera for producing positive pictures, but may be rendered so by a secondary process.

The photograph should first be soaked in water for a few minutes, and then placed upon a slab of porcelain, and a weak solution of the proto-sulphate of iron brushed over it; the picture almost immediately acquires an intense colour, which should then be stopped directly by plunging it into water *slightly* acidulated with muriatic acid, or the blackening will extend all over the paper. It may be fixed by being soaked in water, and then dipped into a solution of hypo-sulphite of soda, and again soaked in water as in the other processes.

Mr. Bingham has the following remarks on this process, and he gives a modified form, into which a new photographic element is introduced.

"We find it is better to add to the proto-sulphate of iron a little acetic or sulphuric acid: this will be found to prevent the darkening of the lights of the picture to a great extent, and it will be found better not to prepare the paper long before it is required for use, this being one reason why the picture often becomes dusky on application of the proto-sulphate.

"Reasoning upon the principle that the action of light is to reduce the salts of silver in the paper to the metallic state, and that any substance which would reduce silver would also quicken the action of light, we were led to the following experiment:—The protochloride of tin possesses the property of reducing the salts both of silver and of gold: a paper was prepared with the bromide of silver, and previously to exposing it to light it was washed over with a very weak solution of the chloride of tin; the action of light upon the paper was exceedingly energetic; it was almost instantaneously blackened, and a copy of a print was obtained in a few seconds."

The use of fluorides has been recently introduced as a novelty by some French photographers, but reference to the author's Researches on Light, published in 1844, will distinctly show that he was the first to employ these salts, which were, however, first suggested by Sir John Herschel.

Section VI.—Bromide of Silver and Mercurial Vapour.

In my first publication on this subject, in Griffin's Scientific Miscellany, I introduced the following process, which, although it has never yet been properly worked out, involves many points of interest:—Some extremely curious results, which are omitted from their not having any practical bearing, led me to examine the effect of the mercurial vapour on the pure precipitated iodides and bromides. I was long perplexed with some exceedingly anomalous results, but being satisfied from particular experiments that these researches promised to lead to the discovery of a most sensitive preparation, I persevered in them. Without stopping to trace the progress of the inquiry, I may at once state, that I have the satisfaction of being enabled to add to the present treatise an account of a process which serves to prepare *papers* that are much more sensitive than Daguerre's iodidated plates. The exquisite delicacy of these new photographic papers may be imagined, when I state *that in five seconds in the camera obscura, I have, during sunshine, obtained perfect pictures; and that, when the sky is overcast, one minute is quite sufficient to* *produce a most decided effect.* The action of light on this preparation does, indeed, appear to be instantaneous. On several occasions I have procured, in less than a second, distinct outlines of the objects to which the camera has been pointed, and even secured representations of slowly moving bodies. With this great increase of sensitiveness, we of course secure greater sharpness of outline, and more minute detail. It should be understood that the process is a negative one, from which positive pictures may be procured on the ordinary photographic paper by transfer.

To prepare this very sensitive paper we proceed as follows:—Select the most perfect sheets of well-glazed satin post, quite free from specks of any kind. Placing the sheet carefully on some hard body, wash it over on one side by means of a very soft camel's hair pencil, with a solution of sixty grains of the bromide of potassium, in two fluid ounces of distilled water, and then dry it quickly by the fire. Being dry, it is again to be washed over with the same solution, and dried as before. Now, a solution of nitrate of silver, one hundred and twenty grains to the fluid ounce of distilled water, is to be applied over the same surface, and the paper quickly dried in the dark. In this state the papers may be kept for use. When they are required, the above solution of silver is to be plentifully applied, and the paper placed *wet* in the camera, the greatest care being taken that no day-light, not even the faintest gleam, falls upon it, until the moment when we are prepared, by removing the screen, to permit the light, radiated from the objects we wish to copy, to act in producing the picture. After a few seconds, the light must be again shut off, and the camera removed into a dark room. It will be found, on taking the paper from the box, that there is but a very slight outline, if any, as yet visible. Place it aside, in *perfect darkness*, until quite dry, then fix it in a mercurial vapour box, and apply a very gentle heat to the bottom. The moment the mercury vaporizes, the picture will begin to develope itself. The spirit lamp must now be removed for a short time, and when the action of the mercury appears to cease, it is to be very carefully applied again, until a well-defined picture is visible. The vaporization must now be suddenly stopped, and the photograph removed from the box. The drawing will then be very beautiful and distinct; but much detail is still clouded, for the development of which it is only necessary to place it cautiously in the dark, and allow it to remain undisturbed for some hours. There is now an inexpressible charm about the picture, equalling the delicate beauty of the daguerreotypes; but being still very susceptible of change, it must be viewed by the light of a taper only. The nitrate of silver must now be removed from the paper by well washing in soft water to which a small quantity of salt has been added, and it should be afterwards soaked in water only. When the picture has been dried, wash it quickly over with a soft brush, dipped in a warm solution of the hyposulphite of soda, and then well wash it for some time in the manner directed for the ordinary photographs, in order that all the hyposulphite may be removed. The drawing is now fixed, and we may use it to procure positive pictures, many of which may be taken from one original. The transfers procured from this variety of negative photographs have more decision of outline, and greater sharpness in all their minute detail, than can be procured by any other method. This is owing to the opacity produced by the curious combination of mercury and the bromide of silver, which is not, I believe, described in any chemical work.

This very beautiful process is not without its difficulties; and the author cannot promise that, even with the closest attention to the above directions, annoying failures will not occur. It often happens that some accidental circumstance, generally a projecting film, or a little dust, will occasion the mercurial vapour to act with great energy on one part of the paper, and blacken it, before the other portions are at all affected. Again, the mercury will sometimes accumulate along the lines made by the brush, and give a streaky appearance to the picture, although these lines were not at all evident before the mercurial vapour was applied.

The action, however, of this photographic preparation is certain; and although a little practice may be required to produce finished designs, yet very perfect copies of nature may be effected with the greatest possible ease and certainty.

I have stated that the paper should be placed wet in the camera: the same paper may be used dry, which is often a great convenience. When in the dry state, a little longer exposure is required, and instead of taking a picture in four or five seconds, two or three minutes are necessary.

I cannot conclude without remarking, that it appears to me that this process, when rendered complete by the improvement of its manipulatory details, will do much towards realizing the hopes of those who were most sanguine of the ultimate perfection of photography; and will convince others who looked upon the art as a philosophical plaything, that the real utility of any discovery is not to be estimated from the crude specimens produced in its infancy, ere yet its first principles were evident to those who pursued it with an eager hope.

I have purposely retained the words which I employed in 1841, being satisfied that we shall eventually witness their realization in the production of a most beautiful and sensitive process.

Section VII.—Positive Photographs by One Process.

About the same time, Mr. Talbot, Sir John Herschel, Dr. Fife, and myself, discovered the very remarkable property of the iodides in bleaching the darkened salts of silver. Many very beautiful results may be thus obtained. The manipulatory details published by Dr. Fife were simple in their character, but arrived at by a long series of inquiries. It is now quite easy to prepare photographic papers on which the hydriodic solutions shall act with perfect uniformity:—

Soak the paper for a few minutes in phosphate or muriate of soda, removing with a soft brush any air-bubbles which may form on it. The superfluous moisture must be wiped off with very clean cotton cloths, and the papers dried at common temperatures. When dry, the paper must be pinned out on a board, and the silver solution spread over it, boldly but lightly, with a very soft sponge brush. It is to be *instantly* exposed to sunshine, and, if practicable, carried into the open air, as the more speedily evaporation proceeds the less does the silver penetrate the paper, and the more delicate it is. The first surface is very irregular, being as before described, and represented in fig. 2. As soon as the surface appears dry, the silver solution must be again applied as before, and the exposure repeated. It must now be exposed until a fine chocolate-brown colour is produced equally on all parts of the surface, and then, until required for use, be carefully preserved from the further influence of light. If the paper is to be kept long, the darkening must not be allowed to proceed so far as when it is to be speedily made use of.

In darkening these papers, the greatest possible attention must be paid to the quantity of light to which they are submitted, every thing depending on the rapidity of the blackening process. The morning sun should be chosen, for the reasons before stated. A perfectly cloudless sky is of great advantage. The injurious consequence of a cloud obscuring the sun during the *last* darkening process, is the formation of a surface which has the appearance of being washed with a dirty brush. This is with difficulty removed by the hydriodates, and the resulting pictures want that clearness which constitutes their beauty.

Papers darkened by the diffused light of a cloudy day are scarcely, if at all, acted on by these salts. Great care must be taken to prevent the silver solution from flowing over the edges of the paper, as thereby an extra quantity of darkened silver is formed on both sides, which requires a long-continued action of the hydriodates and light to bleach.

The kind of paper on which the silver is spread is an object of much importance. A paper known to stationers as satin post, double-glazed, bearing the mark of J. Whatman, Turkey Mill, is decidedly superior to every other kind I have tried. The dark specks which abound in some sorts of paper must be avoided, and the spots made by flies very carefully guarded against. These are of small consequence during the darkening process, but when the hydriodic wash is applied, they form centres of chemical action, and the bleaching process goes on around them, independently of light, deforming the drawing with small rings, which are continually extending their diameters.

The saline washes may be considerably varied, and combined to an indefinite extent, with a continued change of effect, which is singularly interesting. In their application we should be guided, as in the negative process, by their combining proportions. The following list of the salts which will give the best effects, selected from upwards of seven hundred combinations, will show the variety of colours produced. They are placed in the order of the sensitiveness they appear to maintain, when used as nearly as possible under the same circumstances.

	Colour of Picture.
Muriate of Ammonia	*Red, changing to black in the sunshine.*
Chloride of Sodium	*Ditto. ditto.*
Muriate of Strontia	*A fine brown.*
Muriate of Baryta	*A rich brown, inclining to purple.*
Sol. Chloride of Lime	*Very red.*
Sol. Chloride of Soda	*A brick red.*
Iodide of Potassium	*Yellowish brown.*
Chlorate of Potash	*Variable, sometimes yellowish, often a steel blue.*
Phosphate of Soda	*Mouse colour.*
Tartrate of Soda	*Dark brown.*
Urate of Soda	*Yellowish brown.*
Muriate of Iron	*Deep brown, which blackens.*
Bromide of Sodium	*Red brown, of a peculiarly rich tint.*

The change mentioned in the colour of the finished picture is that which arises from a fresh exposure to the solar rays; where no change is mentioned, it is too slight to be worth notice. This phenomenon will presently occupy our attention.

When papers prepared with any of the above, except the phosphates, are soaked for a little time in water, and dried in the sunshine, the picture produced,—it matters not what hydriodate is used,—is rendered peculiarly red, and does not change by re-exposure. By washing some of the papers with weak solution of ammonia, this peculiarity is produced in a very striking manner.

The Solution of Silver.—Take of crystallized nitrate of silver 120 grains, distilled water 12 fluid drachms; when the salt is dissolved, add of alcohol 4 fluid drachms, which renders the solution opaque; after a few hours, a minute quantity of a dark powder, which appears to be an oxide of silver, is deposited, and must be separated by the filter. The addition of the alcohol to the solution was adopted from an observation I made of its influence in retarding the chemical action, which goes on in the shade, of the hydriodates on the salt of silver. Its use is, therefore, to make the action depend more on *luminous influence*, than would be the case without it.

Nitric Ether.—The sweet spirits of nitre not only checks the bleaching process in the shade, but acts with the hydriodic salts to exalt the oxidation of the silver, or increase the blackness of it. In copying lace or any fine linear object, it is a very valuable agent, but it is useless for any other purposes, as all the faintly lighted parts are of the same tint.

Hydrochloric Ether, used as the solvent of the silver, and applied without any saline wash, has a similar property to the nitric ether; but as it is readily acted on by faint light, it is of greater value. However, papers prepared with it must be used within twenty-four hours, as after that they quickly lose their sensitiveness, and soon become nearly useless.

To fix with any degree of certainty the strength of the solution of the hydriodic salts which will in all cases produce the best effects, appears to me impossible; every variety of light to which it has been exposed to darken, requiring a solution of different specific gravity.

In the other divisions will be found some further remarks on the very peculiar physical phenomena presented by the action of the hydriodates on these darkened salts of silver, and details of yet more perfect forms of manipulation developed since these earlier processes were published.

SECTION VIII.—ON THE APPLICATION OF THE DAGUERREOTYPE TO PAPER.

The expense and inconvenience of metallic tablets rendered it in the highest degree desirable that paper should be employed in their place. A very extensive series of experiments at length led to the pleasing conclusion of being enabled to prepare a paper which answered in every respect as well as the silver plates, and in many much better.

This discovery formed the subject of a communication to the Royal Society, which that learned body did me the honour to print in their Transactions. My memoir is entitled,—"*On the Influence of Iodine in rendering several Argentine Compounds, spread on Paper, sensitive to Light; and on a New Method of Producing, with greater distinctness, the Photographic Image.*" This paper contains the substance of the following remarks; but since the publication of the Transactions I have been successful in simplifying the process of preparation.

My experiments established, in the most satisfactory manner, that even on the silver tablets a semi-oxidized surface was presented to the iodine. They also proved that perfectly *pure untarnished silver* was by no means readily acted on by the iodine. From this I was led to prepare oxides of silver in many different ways, which enabled me to spread them over paper, and the result was instructive. Any of the ordinary photographic papers allowed to darken to a full brown, which is a stage of induced oxidation, become, by long exposure to iodine, of a steel-blue or violet colour. If exposed in this state to sunshine for a long period, their colour changes from grey to a clear olive. Now, exposure to sunshine for a minute, or to diffused daylight for five minutes, produces no *apparent* change; but mercurial vapour speedily attacks the portions which have been exposed to light, and a faithful picture is given of whatever may have been superposed. There is, however, a want of sufficient contrast between the lights and shadows. By allowing the first darkening to proceed until the paper acquires the olive colour, which indicates the formation of a true oxide of silver, it will be found, although it is not more speedily acted on by the iodine, that it is more sensitive, and that a better picture is formed. The kind of photographic preparations used appears to have but little influence on the results,—a chloride, iodide, or bromide of silver, allowed to darken, answers equally well.

There are many things, unfortunately, which prevent our availing ourselves of this easy method of producing a tolerably sensitive daguerreotype paper. These are, certain irregular formations of oxides in different states, and the revival of metallic silver in some parts of the surface.

I next spread papers with the pure oxide formed by chemical means, and also the protoxide, and many of its salts. These papers were not very readily affected by iodine, or influenced by light during short exposures.

Silver is revived from its solutions by hydrogen gas; consequently, nothing is more easy than, by washing a paper with nitrate of silver in solution, to procure a fine silver paper, by passing a current of hydrogen gas over it.

A picture of a peculiarly delicate character may be produced on this kind of paper; but it has not the required sensibility, and there is a great want of contrast in the lights and shadows. It may be interesting to state, that the yellow-brown phosphate of silver is as readily acted on by iodine as the oxides, and is quite as sensitive to luminous influence. Phosphuretted hydrogen gas effects the revival of metallic silver, and the surface produced by means of this gas, used as the hydrogen was in the former case, is of a fine steel-blue, which colour arises from a portion of phosphorus having entered into combination with the silver. These kinds of paper comported themselves in every respect as the metallic tablets—were equally sensitive, and produced pictures as delicately beautiful. Unfortunately, however,owing to the spontaneously inflammable nature of the phosphuretted hydrogen gas, it is not safe to operate with it. After various ineffectual contrivances to overcome this difficulty, I was obliged to abandon the use of this gas entirely—warned of the danger I incurred, by several violent but fortunately harmless explosions. The vapour of phosphorus and of sulphur was also tried, and many very beautiful effects were produced. At length, however, I stopped at sulphuretted hydrogen, which answers in every respect.[1]

To prepare this, soak a paper of very firm texture, not too much glazed, in a weak solution of the muriate of ammonia. It must then be wiped with clean cloths, and carefully dried. The paper is then dipped into a weak solution of the nitrate of silver, and the small bubbles which form on its surface are carefully removed with a camel's hair pencil. When the paper is nearly, but not quite, dry, it must be exposed in a closed vessel to sulphuretted hydrogen gas, slowly formed from the sulphuret of

[1] A very interesting account of the revival of gold and silver from their solutions by these gases will be found in a tract on Combustion, published by Mrs. Fulhame.

antimony and hydrochloric acid: in a few minutes it will become of an iron-brown colour, having a fine metallic lustre. It is again to be passed though a solution of silver, somewhat stronger than the first, and dried, taking care that no shadow falls on the paper whilst it is drying. It is then a second time submitted to sulphuration, and, by careful management, the process is now generally completed. If, however, the paper is not considered to be sufficiently dark, it must be once more washed in the solution of silver, and again subjected to the action of sulphuretted hydrogen.

If the above paper be allowed to remain in the sulphuretted hydrogen gas after the maximum blackness is produced, it is again whitened with some quickness. This may be accounted for in two ways: the gas may be mixed with a portion of muriatic acid vapour, or a quantity of chlorine sufficient to produce this effect may be liberated from the preparation on the paper to react on the sulphuret of silver.

The perfection of these papers consists in having a deep black ground to contrast with the mercurial deposit, by which means the pictures have the advantage of being seen equally well in all positions, whereas Daguerre's pictures on the metal plates can only be seen to advantage at certain angles.

The sulphuretted paper may be rendered sensitive in the same manner as the plates by exposure to the vapour of iodine. I, however, prefer drawing the paper *over* a solution thus formed:—A saturated solution of any hydriodic salt is made to dissolve as much iodine as possible, and of this liquid two drachms are mingled with four ounces of water. Care is required that one side only of the paper is wetted, which is by no means difficult to effect, the fluid is so greedily absorbed by it; all that is necessary being a broad shallow vessel to allow of the paper touching the fluid to its full width, and that it be drawn over it with a slow steady movement. When thus wetted, it is to be quickly dried by a warm, but not too bright fire; of course daylight must be carefully excluded. Papers thus iodidated do not lose their sensitiveness for many days if carefully kept from light.

On examining the sheet after the daguerreotype processes in the camera, and of mercurialization, have been completed, a very perfect picture is found upon it: but it is still capable of vast improvement, which is, by the following simple plan, accomplished in a way which is at once magical and beautiful.

Action of Corrosive Sublimate.—Dip one of the daguerreotype pictures, formed on the sulphuretted paper, into a solution of corrosive sublimate: the drawing instantly disappears, but, after a few minutes, it is seen unfolding itself, and gradually becoming far more distinct than it was before; delicate lines, before invisible, or barely seen, are now distinctly marked, and a rare and singular perfection of detail given to the drawing. It may appear, at first sight, that the bichloride of mercury dissolves off the metal, and again deposits it in the form of chloride (calomel). But this does not account for the fact, that if the paper has been prepared with the nitrate of silver, the mercury disappears, and the drawing vanishes, the deposit taking place only on those parts upon which light has acted but feebly; as, for instance, on the venations of leaves, leaving those portions of surface which were exposed to full luminous influence without a particle of quicksilver. When the paper has been either a chloride or iodide, the effect is as above, and the thickness of the deposit is as the intensity of the light has been; consequently, the semi-tints are beautifully preserved. If the drawing remains too long in the solution, the precipitate adheres to the dark parts and destroys the effect. The singularity of this operation will be more striking if the picture has been soaked some time in the solution of the hyposulphite of soda, and then dipped into the bichloride of mercury. As the drawing disappears, a series of circles, formed of a white powder, appear to arise from the paper, generally commencing at the centre, and slowly extending over the whole surface: the powder is afterwards deposited, and the sheet is buried in the precipitate; but on taking the paper from the liquid, and passing a stream of water over it, the precipitate is entirely removed from all the parts except the lights of the picture. I have also found the invisible photographic image become evident, without the aid of mercurial vapour, by simply soaking for some time in a solution of corrosive sublimate.

When these papers are prepared with due care, they are extremely sensitive, and if used for copying engravings during bright sunshine, the effect is *instantaneous*. The great difficulty is to present the paper to the sun, and withdraw it with sufficient celerity. In the weak light of the camera a few minutes during sunshine is quite sufficient for the production of the best effects. One great advantage of these pictures over those procured on the plated copper is, that the mercury does not lie loosely as on the tablets, but is firmly fixed, being absorbed by the paper; therefore these pictures may be kept without injury in a portfolio.

If, instead of immersing the paper in a vessel full of sulphuretted hydrogen gas, a stream of the gas is made to play upon it, it assumes a most richly iridescent surface; the various colours are of different degrees of sensibility, but for surface drawings they may be used; and in copying of leaves or flowers, beautiful pictures, which appear to glow with the natural colours, are procured.

Section IX.—Salts of Gold as Photographic Agents.

It is well known that gold is revived from its ethereal solution by the action of light, and that the same effect takes place when the nitro-muriate of gold is spread on charcoal. We are mainly indebted to Herschel's paper, published in 1840, for the knowledge we possess of gold as a photographic agent.

Considering it probable that the required unstable equilibrium might be induced in some of the salts of gold, I was induced to pursue a great many experiments on this point. In some cases, where the paper was impregnated with a mordant salt, the salt of gold was darkened rapidly, without the assistance of light; in others, the effect of light was very slow and uncertain. By washing paper with muriate of barytes, and then with a solution of the chloride of gold, a paper, having a slight pinky tint, is procured; by exposing this paper to sunshine it is at first *whitened*, and then, but very slowly, a darkening action is induced. If, however, we remove the paper from the light, after an exposure of a few minutes, when a very faint impression, and oftentimes not any, is apparent, and hold it in the steam of boiling water, or immerse it in cold water, all the parts which were exposed to the light are rapidly darkened to a full purple brown, leaving the covered portions on which the light has not acted, a pure white, producing thus a fine negative drawing. If, while such a paper, or any other paper prepared with the chloride of gold, is exposed to the sun, we wash it with a weak solution of the hydriodate of potash, the oxidation is very rapidly brought on, and the darkness produced is much greater than that obtained by the other method; but this plan is not often applicable. I have not yet been enabled to produce with the salts of gold any paper which should be sufficiently sensitive for use in the camera obscura.

Sir John Herschel devoted much attention to the examination of the salts of platinum as well as gold. He found platinum under nearly all circumstances very little sensitive to light, but the following were the results obtained with the salts of gold.

If paper impregnated with oxalate of ammonia be washed with chloride of gold, it becomes, if certain proportions be hit, pretty sensitive to light; passing rather rapidly to a violet purple in the sun. It passes also to the same purple hue in the dark, though much more slowly; so that, as a photographic combination, it is useless.

Paper impregnated with acetate of lead, when washed with perfectly neutral chloride of gold, acquires a brownish-yellow hue, and a sensibility to light, which, though not great, is attended with some peculiarities highly worthy of notice. The first impression of the solar rays seems rather to whiten than to darken the paper, by discharging the original colour, and substituting for it a pale greyish tint, which by slow degrees increases to a dark slate colour. But if arrested while yet not more than a moderate ash grey, and held in a current of steam, the colour of the part acted on by the sunshine, and that only, darkens immediately to a deep purple. The same effect is produced by immersing it in boiling water. If plunged in cold water, the same change comes on more slowly, and is not complete till the paper is dried by heat. A *dry heat*, however, does not operate this singular change.

If a neutral solution of the chloride of gold is mixed with an equal quantity of the solution of bichromate of potash, paper washed with this solution, and exposed to light, speedily changes, first to a deep brown, and ultimately to a bluish black. If an engraving is superposed, we have a negative copy, blue or brown, upon a yellow ground. If this photograph is placed in clean water, and allowed to remain in it for some hours, very singular changes take place. The yellow salt is all dissolved out, and those parts of the paper left beautifully white. All the dark portions become more decided in their character, and according as the solarization has been prolonged or otherwise, or the light has been more or less intense, we have either crimson, blue, brown, or deep black negative photographs.

Section X.—Dr. Schafhaeutl's Negative Process.

At the tenth meeting of the British Association for the Advancement of Science, two new processes on paper, and one on metal, were brought forward by Dr. Schafhaeutl. These processes involve some very delicate manipulatory details, which render them tedious, and, in the hands of the inexperienced, uncertain. However, as they sometimes give very perfect results, it would have been improper to have omitted them.

Penny's improved patent metallic paper is recommended. This is spread with a concentrated solution of the nitrate of silver (140 grains to 2½ drachms of the fused nitrate, to 6 fluid drachms of distilled water), by merely drawing the paper over the surface of the solution contained in a large dish. In order to convert this nitrate into a chloride, the author exposed it to the vapours of boiling muriatic acid. A coating of a chloride of silver, shining with a peculiar silky lustre, was by this method generated on the surface of the paper, without penetrating into its mass; and in order to give to this coating of chloride the highest degree of sensibility, it was dried, and then drawn over the surface of the solution of nitrate of silver again. After having been dried, the paper was ready for use, and by no repetition of this treatment could its sensitiveness be improved.

Even on the ordinary kinds of writing paper, I have found this manipulation produce extreme sensitiveness, but much exact attention is required to prevent any excess of muriatic acid, which, in the state of vapour, is rapidly absorbed by the paper. The whole of the nitrate of silver employed in the first instance must be converted into a muriate, and there the process should stop.

Schafhaeutl's method of fixing is extremely difficult. The drawing is to be steeped for five or ten minutes in alcohol, and, after removing all superfluous moisture by means of blotting paper, and drying it slightly before the fire, the paper thus prepared is drawn through diluted muriatic acid, mixed with a few drops of an acid nitrate of quicksilver, prepared by dissolving quicksilver in pure nitric acid, and again dissolving the crystallised salt to saturation in water acidulated with nitric acid. The addition of the nitrate of mercury requires great caution, and its proper action must be tried first on slips of paper, upon which have been produced different tints and shadows by exposure to light; because, if added in too great a quantity, the lightest shades entirely disappear. The paper having been drawn through the above-mentioned solution, is well washed in water, and then dried in a degree of heat approaching to about 158° Fahr., or, in fact, till the white places assume a very slight tinge of yellow. The appearance of this tint indicates that the drawing is fixed permanently.

Section XI.—Dr. Schafhaeutl's Process on Carbonised Plates.

Metallic plates are covered with a layer of hydruret of carbon, prepared by dissolving pitch in alcohol, and collecting the residuum on a filter. This, when well washed, is spread as equally as possible over a heated even plate of copper. The plate is then carbonised in a closed box of cast iron, and, after cooling, passed betwixt two polished steel rollers, resembling a common copperplate printing press. The plate, after this process, is dipped into a strong solution of nitrate of silver, and instantly exposed to the action of the camera. The silver is, by the action of the rays of the sun, reduced into a perfectly metallic state, and the lights are expressed by the different density of the milk-white deadened silver; the shadows by the black carbonised plate. In a few seconds the picture is finished, and the plate is so sensitive, that the reduction of the silver begins even by the light of a candle. For fixing the image, nothing more is required than to dip the plate in alcohol mixed with a small quantity of the hyposulphite of soda, or of pure ammonia.

These processes are given on the authority of the author; but I have never been successful in producing a good result with either of them. The preparation of the plate requires the skill of an artist combined with the knowledge of a chemist; and even these are not always sufficient to ensure a perfect surface. The revival of the silver is not to be depended on: sometimes it does form a continuous sheet over the parts acted on by the light, but often it is only spangles; and frequently a metallic arborescence will commence in the light parts, and run rapidly into the portions in shadow. The fact is, that light has the property of effecting the revival of the silver spread upon any carbonaceous body, but caloric having the same effect, and being indeed rather more active in the operation than light is, any slight increase of temperature produces a revival of the metal over the parts in shadow.

Reference to the early volumes of Nicholson's Journal will afford ample evidence of these facts, which I have also recently proved. These volumes contain some papers by Count Rumford on the revival of gold and silver from their solutions, by heat and light, when spread upon charcoal or carbonaceous earth. This philosopher has conclusively shown, that this revival is more dependent on the action of heat than light, which accounts, in some measure, for the apparent effect of candlelight. It is, however, possible that this process may, with some modifications, become of importance.

Section XII.—The Influence of Chlorine and Iodine in rendering some kinds of Wood sensitive to Light.

Having on many occasions subjected the simply nitrated photographic paper to the influence of chlorine and iodine in close wooden boxes, I was often struck with the sudden change which light produced on the wood of the box, particularly when it was of deal; changing it in a few minutes from a pale yellow to a deep green. This curious effect frequently occurring, led me to observe the change somewhat more closely, and to pursue some experiments on the subject. These produced no very satisfactory result. They proved the change to depend much on the formation of hydrochloric and hydriodic acids, and the decomposition of water in the pores of the wood. I found well-baked wood quite insusceptible of this very curious phenomenon. The woods of a soft kind, as the deal and willow, were much sooner influenced than the harder varieties, but all the light-coloured woods appeared more or less capable of undergoing this change. All that is necessary is, to place at the bottom of an air-tight box, a vessel containing a mixture of manganese and muriatic acid, or simply some iodine, and fix the piece of wood at some distance above it. Different kinds of wood require to be more or less saturated with the chlorine or iodine, and consequently need a longer or shorter exposure. The time, therefore, necessary for the wood to remain in the atmosphere of chlorine can only be settled by direct experiment. Wood is impregnated very readily with iodine, by putting a small portion in a capsule a few inches below it. It does not appear to me at present that any practical result is likely to arise out of this peculiar property; it is only introduced as a singular fact, which is perhaps worthy a little more attention than my numerous engagements have left me time to devote to it.

CHAPTER VII.

PHOTOGRAPHS ON GLASS PLATES, AND RECENT IMPROVEMENTS.

To Sir John Herschel we are indebted for the first use of glass plates to receive sensitive photographic films.

SECTION I.—PRECIPITATES OF SILVER SALTS.

The interest which attaches to this is so great, and there appear to be in the process recommended by the English experimentalist so many suggestive points, from which future photographists may start, that the passages are given in Sir John Herschel's own words.

"With a view to ascertain how far organic matter is indispensable to the rapid discoloration of argentine compounds, a process was tried which it may not be amiss to relate, as it issued in a new and very pretty variety of the photographic art. A solution of salt of extreme dilution was mixed with nitrate of silver, so dilute as to form a liquid only slightly milky. This was poured into a somewhat deep vessel, at the bottom of which lay horizontally a very clean glass plate. After many days the greater part of the liquid was decanted off with a siphon tube, and the last portions very slowly and cautiously drained away, drop by drop, by a siphon composed of a few fibres of hemp, laid parallel and moistened without twisting. The glass was not moved till quite dry, and was found coated with a pretty uniform film of chloride of silver, of delicate tenuity and chemical purity, which adhered with considerable force, and was very little sensitive to light. On dropping on it a solution of nitrate of silver, however, and spreading it over by inclining the plate to and fro (which it bore without discharging the film of chloride) it became highly sensitive, although no organic matter could have been introduced with the nitrate, which was quite pure, nor could any indeed have been present unless it be supposed to have emanated from the hempen filaments, which were barely in contact with the edge of the glass, and which were constantly *abstracting* matter from its surface in place of introducing new.

"Exposed in this state to the focus of a camera with the glass towards the incident light, it became impressed with a remarkably well-defined negative picture, which was direct, or reversed, according as looked at from the front or the back. On pouring over this cautiously, by means of a pipette, a solution of hyposulphite of soda, the picture disappeared, but this was only while wet; for on washing in pure water and drying, it was restored, and assumed much the air of a daguerreotype when laid on a black ground, and still more so when smoked at the back, the silvered portions reflecting most light, so that its characters had, in fact, changed from negative to positive. From such a picture (of course before smoking) I have found it practicable to take photographic copies; and although I did not, in fact, succeed in attempting to thicken the film of silver, by connecting it, under a weak solution of that metal, with the reducing pole of a voltaic pile, the attempt afforded distinct indications of its practicability with patience and perseverance, as here and there, over some small portions of the surface, the lights had assumed a full metallic brilliancy under this process. I would only mention further, to those who may think this experiment worth repeating, that all my attempts to secure a good result by drying the nitrate in the film of chloride have failed, the crystallisation of the salt disturbing the uniformity of the coating. To obtain delicate pictures the plate must be exposed wet, and when withdrawn must immediately be plunged into water. The nitrate being thus abstracted, the plate may then be dried, in which state it is half fixed, and it is then ready for the hyposulphite. Such details of manipulation may appear minute, but they cannot be dispensed with in practice, and cost a great deal of time and trouble to discover.

"This mode of coating glass with films of precipitated argentine or other compounds, affords, it may be observed, the *only* effectual means of studying their habitudes on exposure to light, free from the powerful and ever-varying influence of the *size* in paper, and other materials used in its manufacture, and estimating their degree of sensibility and other particulars of their deportment under the influence of reagents. I find, for example, that glass so coated with the iodide of silver is much more sensitive than if similarly covered with the chloride, and that if both be washed with one and the same solution of nitrate, there is no comparison in respect of this valuable quality; the iodide being far superior, and of course to be adopted in preference, for the use of the camera. It is, however, more difficult to fix, the action of the hyposulphites on this compound of silver being comparatively slow and feeble.

"When the glass is coated with bromide of silver, the action, *per se*, is very slow, and the discoloration ultimately produced far short of blackness; but when moistened with nitrate of silver, sp. gr. 1·1, it is still more rapid than with the iodide, turning quite black in the course of a very few seconds' exposure to sunshine. Plates of glass thus coated may be easily preserved for the use of the camera, and have the advantage of being ready at a moment's notice, requiring nothing but a wash over with the nitrate of silver, which may be delayed until the image is actually thrown on the plate, and adjusted to the correct focus with all deliberation. The sensitive wash being then applied with a soft flat camel-hair brush, the box may be closed and the picture impressed, after which it only requires to be thrown into water, and dried in the dark, to be rendered comparatively insensible, and may be finally fixed with hyposulphite of soda, which must be applied hot, its solvent power on the bromide being even less than on the iodide."

Sir John Herschel suggested a trial of the fluoride of silver upon glass, which, he says, if proved to be decomposable by light, might possibly effect an etching on the glass, by the corroding property of the hydrofluoric acid.

The metallic fluorides have been found to be decomposable, and a very sensitive process on paper, called the fluorotype, will be described in the chapter on Miscellaneous Processes. I am not aware that any experiments have been made directly upon glass, but it is certainly worthy of a careful trial.

Herschel has remarked that we cannot allow the wash of nitrate to dry upon the coating of the chloride or iodide of silver. If, however, we dip a glass which has one film of chloride upon it into a solution of common salt, and then spread upon it some nitrate of silver, we may very materially thicken the coating, and thus produce more intense effects. Mr. Towson employed glass plates prepared in this manner with much success. The mode adopted by that gentleman was to have a box the exact size of the glass plate, in the bottom of which was a small hole; the glass was placed over the bottom, and the mixed solution, just strong enough to be milky, of the salt and silver poured in. As the fluid finds its way slowly around the edges of the glass, it filters out; the peculiar surface action of the solid glass plate, probably a modified form of cohesive force, separating the fine precipitate, which is left behind on the surface of the plate. By this means the operation of coating the glass is much quickened. Another method by which films of any of the salts of silver can be produced upon glass plates, is the following modification of the patent processes of Drayton and of Thompson for silvering glass.

Take a very clear plate of glass, and having put around it an edging of wax about half an inch in depth, pour into it a solution of nitrate of silver made alkaline by a few drops of ammonia, taking care that no oxide of silver is precipitated; mix with this a small quantity of spirits of wine, and then add a mixture of the oils of lavender and cassia, or, which is perhaps the best process, a solution of grape sugar. In a short time the glass will be covered with a very beautiful metallic coating. The solution is now poured off, the edging of wax removed, and the silver is exposed to the action of diluted chlorine, or to the vapour of iodine or bromine, until it is converted into a compound of one of these elements, after which we may proceed as recommended by Sir John Herschel.

Section II.—Albumen.

In the Technologiste for 1848, M. Niepce de Saint-Victor published his mode of applying *albumen* to glass plates. M. Blanquart Everard followed, and successively albumen, gelatine, and serum were employed. Messrs. Ross and Thomson, of Edinburgh, have been eminently successful operators with albumen on glass plates, many of their pictures leaving little to be desired. The manipulatory details of the albumen process will be found in the technical division of this work.

Section III.—Collodion.

The successful application of a solution of gun-cotton in ether, to form the film for receiving the sensitive surface on glass, appears to belong to Mr. Fry and Mr. Archer. There is some difficulty in fixing precisely this point, since the dates of actual publication are very uncertain. Mr. Fry certainly introduced the use of gutta percha and collodion.

The last novelty to which reference need be made is the *wax paper process* of M. Le Gray, which will be fully described.

CHAPTER VIII.

PORTRAITURE BY THE DAGUERREOTYPE.

When Daguerre published his process, a period of twenty minutes was required to obtain a good copy of any external object: hence this period was far too long to admit of its being employed for portraiture.

Mr. Towson, of Devonport, in a very valuable paper which appeared in the Philosophical Magazine in 1839, offered several suggestions on the use of large lenses, &c. which he supposed might lead to the use of the daguerreotype for the purposes of portraiture.

Dr. Draper, of New York, acting on the suggestions of Mr. Towson relative to the adjustment of the focus, succeeded in accelerating his process so far as to obtain portraits from the life. He published his process in the London and Edinburgh Philosophical Magazine for September 1840. From this paper I shall take the liberty of making copious extracts. It was first stated that it was necessary, to procure any impression of human features on the daguerreotype plate, to paint the face white, or dust it over with a white powder, it being thought that the light reflected from the flesh would not have sufficient power to change the iodized surface. This has been shown to be an error, for, even when the sun shines but dimly, there is no difficulty in obtaining a correct delineation of the features.

"When the sun, the sitter, and the camera, are situated in the same vertical plane, if a double convex non-achromatic lens of four inches diameter and fourteen inches focus be employed, perfect minatures can be procured in *the open air* in a period varying with the character of the light from 20 to 90 seconds. The dress also is admirably given, even if it should be black; the slight differences of illumination are sufficient to characterise it, as well as to show each button and button-hole, and every fold. Partly owing to the intensity of such light, which cannot be endured without a distortion of the features, but chiefly owing to the circumstance that the rays descend at too great an angle, such pictures have the disadvantage of not exhibiting the eyes with distinctness, the shadow from the eyebrows and forehead encroaching on them. To procure fine proofs, the best position is to have the line joining the head of the sitter and the camera so arranged as to make an angle with the incident rays of less than ten degrees, so that all the space beneath the eyebrows shall be illuminated, and a slight shadow cast from the nose. This involves, obviously, the use of reflecting mirrors to direct the ray. A single mirror would answer, and would economise time, but in practice it is often convenient to employ two; one placed, with a suitable mechanism, to direct the rays in vertical lines, and the second above it, to direct them in an invariable course towards the sitter.

"On a bright day, and with a sensitive plate, portraits can be obtained in the course of five or seven minutes, in the diffused day-light. The advantages, however, which might be supposed to accrue from the features being more composed, and of a natural aspect, are more than counterbalanced by the difficulty of retaining them so long in one constant mode of expression. But in the reflected sunshine, the eye cannot bear the effulgence of the rays. It is therefore absolutely necessary to pass them through some blue medium, which shall abstract from them their heat, and take away their offensive brilliancy. I have used for this purpose blue glass, and also ammoniaco-sulphate of copper, contained in a large trough of plate glass, the interstice being about an inch thick, and the fluid diluted to such a point, as to permit the eye to bear the light, and yet to intercept no more than was necessary. It is not requisite, when coloured glass is employed, to make use of a large surface; for if the camera operation be carried on until the proof *almost* solarizes, no traces can be seen in the portrait of its edges and boundaries; but if the process is stopped at an earlier interval, there will be commonly found a stain corresponding to the figure of the glass."

"The chair in which the sitter is placed has a staff at its back, terminating in an iron ring, that supports the head, so arranged as to have motion in directions to suit any stature and any attitude. By simply resting the back or side of the head against this ring, it may be kept sufficiently still to allow the minutest marks on the face to be copied. The hands should never rest upon the chest, for the motion of respiration disturbs them so much as to bring them out of a thick and clumsy appearance, destroying also the representation of the veins on the back, which, if they are held motionless, are copied with surprising beauty.

"It has already been stated, that certain pictorial advantages attend an arrangement in which the light is thrown upon the face at a small angle. This also allows us to get rid entirely of the shadow from the background, or to compose it more gracefully in the picture ; for this, it is well that the chair should be brought from the back-ground, from three to six feet.

"Those who undertake daguerreotype portraitures will of course arrange the back-grounds of their pictures according to their own tastes. When one that is quite uniform is required, a blanket, or a cloth of a drab colour, properly suspended, will be found to answer very well. Attention must be paid to the tint: white, reflecting too much light, would solarize upon the proof before the face had time to come out, and, owing to its reflecting all the rays, a blur or irradiation would appear on all edges, due to chromatic aberration.

"It will readily be understood, that if it be desired to introduce a vase, an urn, or other ornament, it must not be arranged against the back-ground, but brought forward until it appears perfectly distinct upon the obscured glass of the camera.

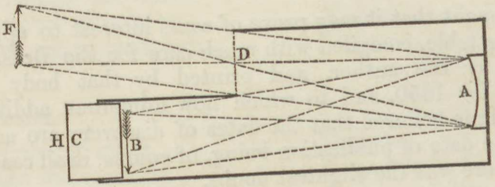
"Different parts of the dress, for the same reason, require intervals, differing considerably, to be fairly copied; the white parts of a costume passing on to solarization before the yellow or black tints have made any decisive representation. We have, therefore, to make use of temporary expedients. A person dressed in a black coat and open waistcoat of the same colour, must put on a temporary front of a drab or flesh colour, or, by the time that his face and the fine shadows of his woollen clothing are evolved, his shirt will be solarized, and be blue, or even black, with a white halo around it. Where, however, the white parts of the dress do not expose much surface, or expose it obliquely, these precautions are not essential; the white collar will scarcely solarize until the face is passing into the same condition.

"Precautions of the same kind are necessary in ladies' dresses, which should not be of tints contrasting strongly.

"It will now be readily understood, that the whole art of taking daguerreotype miniatures consists in directing an almost horizontal beam of light, through a blue-coloured medium, upon the face of the sitter, who is retained in an unconstrained posture by an appropriate but simple mechanism, at such a distance from the back-ground, or so arranged with respect to the camera, that his shadow shall not be copied as a part of his body."

Professor Draper used a camera having for its objective two double convex lenses, the united focus of which, for parallel rays, was only eight inches; they were four inches in diameter in the clear, and were mounted in a barrel, in front of which the aperture was narrowed down to three and a half inches, after the manner of Daguerre's. He also adopted the principle of bringing the plate forward out of the best visible focus, into the focus of the violet rays, as was first suggested by Mr. Towson, of Devonport, who also made many experiments, about the same period, with cameras having mirrors instead of lenses. A patent wast aken out by Mr. Woolcott, a philosophical instrument-maker of New York, for a camera for portraiture, with an elliptical mirror; which form of apparatus was also patented by Mr. Beard, in England, who having somewhat modified Dr. Draper's arrangements, succeeded still better in obtaining copies of "the human face divine."

A camera obscura of this description is constructed as follows.



12.

Fig. 12 is a sectional view of the apparatus. At one end of a box shaped as in the figure, and having an opening at D, is placed an elliptical mirror, A. The prepared plate B is fixed to the sliding frame C, by which it is adjusted to the best focus. The rays of light, radiating from a figure placed at F, will, it must be evident, pass through the opening at D, and fall on the mirror, as represented by the dotted lines, and will be thence reflected to the plate B.

The mirror has certainly the advantage of throwing a greater quantity of light upon the plate, but it has the great disadvantage of limiting the size of the picture. With a mirror of seven inches diameter, we only procure pictures which will be perfect over two square inches; whereas, with a lens of three inches diameter and fourteen inches focal length, pictures of a foot square may be worked. From this it will be seen that the mirror is only applicable where single objects are to be copied.

Eventually the sensibility of the surface of the plates was greatly increased. Mr. Goddard appears to have been the first to employ bromine in combination with iodine; and it was subsequently found by M. Claudet and others, that chlorine had an accelerating power, but not to the same extent as the bromine.

These discoveries led to that amazing degree of sensitiveness which now enables us, in good light, to take a picture in less than a second of time.

CHAPTER IX.

GENERAL SUMMARY OF THE HISTORY OF PHOTOGRAPHY.

It is thought that it may prove of some interest to append the following table, compiled with much care for the British Association, by the author, and printed by that body in their Reports for 1850, and to which now numerous additions are made. It is believed that the dates of discovery are accurately given, the date of publication being, of course, in all cases, taken where there was the slightest doubt.

Silver.

Nitrate of	Ritter	1801
—— (photographically employed)	Wedgwood & Davy	1802
—— with organic matter . . .	J. F. Herschel . .	1839
—— with salts of lead	J. F. Herschel . .	1839
Chloride of	C. W. Scheele . .	1777
—— (photographically employed)	Wedgwood . . .	1802
	Talbot	1839
—— darkened, and hydriodic salts	Fyfe, Lassaigne .	1839
Iodide of (photographically used)	Herschel . . .	1840
	Ryan	1840
—— with ferrocyanate of potash	Hunt	1841
—— with gallic acid (Calotype) .	Talbot	1841
—— with protosulphate of iron (Ferrotype)	Hunt	1844
—— with iodide of iron (Catalysotype)	Woods	1844
Bromide of	Bayard	1840
Fluoride of	Channing . . .	1842
Fluorotype	Hunt	1844
Oxide of	Davy	1803
—— with ammonia	Uncertain.	
Phosphate of	Fyfe	1839
Tartrate — Urate — Oxalate — Borate, &c.	Herschel . . .	1840

Silver—continued.

Benzoates of	Hunt	1844
Formiates of	Do.	1844
Fulminates of	Do.	1842

Silver Plate.

With vapour of iodine (Daguerreotype)	Daguerre	1839
With vapour of bromine	Goddard	1840
With chlorine and iodine	Claudet	1840
With vapour of sulphur	Niepce	1820
With vapour of phosphorus	Niepce	1820

Glass Plate.

Precipitates of silver	Herschel	1839
Albumen on	Niepce de St. Victor	1848
Collodion	Archer and Fry	1850

Gold.

Chloride of	Rumford Herschel	1798 1840
Etherial solution of	Rumford	1798
Etherial solution of, with percyanide of potassium	Hunt	1844
Etherial solution of, with protocyanide of potassium	Do.	1844
Chromate of	Do.	1844
Plate of gold and iodine vapour	Goddard	1842

Platinum.

Chloride of	Herschel	1840
Chloride of, in ether	Herschel	1840
Chloride of, with lime	Herschel	1832
Iodide of	Herschel	1840
Bromide of	Hunt	1844
Percyanate of	Do.	1844

Mercury.

Protoxide of	Uncertain.	
Peroxide of	Guibourt.	
Carbonate of	Hunt	1844

MERCURY—continued.

Chromate of	Hunt	1843
Deutiodide of	Do.	1843
Nitrate of	Herschel	1840
Protonitrate of	Herschel	1840
Chloride of	Boullay	1803
Bichloride of	Vogel	1806

IRON.

Protosulphate of	Hunt	1844
Persulphate of Ammonio-citrate of Tartrate of	Herschel	1840
Attention was first called to the very peculiar changes produced in the iron salts in general, by	Herschel	1845
Cyanic compounds of (Prussian blue)	Scheele Desmortiers	1786 1801
Ferrocyanates of	Fischer	1795
Iodide of	Hunt	1844
Oxalate of	Do.	1844
Chromate of	Do.	1844
Several of the above combined with mercury	Herschel	1843

COPPER.

Chromate of (Chromatype)	Hunt	1843
—— dissolved in ammonia	Do.	1844
Sulphate of	Do.	1844
Carbonate of	Do.	1844
Iodide of	Do.	1844
Copper-plate iodized	Talbot	1841

MANGANESE.

Permanganate of potash	Frommherz	1824
Deutoxide and cyanate of potassium	Hunt	1844
Muriate of	Do.	1844

LEAD.

Oxide of (the puce-coloured)	Davy	1802
Red lead and cyanide of potassium	Hunt	1844
Acetate of lead	Do.	1844

NICKEL.	
Nitrate of	Hunt 1844
—— with ferroprussiates . .	Hunt 1844
Iodide of	Hunt 1844
TIN	
Purple of cassius	Uncertain.
COBALT	Hunt 1844
Arsenic sulphuret of	Sage 1803
Arsenical salts of	
ANTIMONY	Hunt 1844
BISMUTH	Hunt 1844
CADMIUM	Hunt 1844
RHODIUM	Hunt 1844
CHROMIUM.	
Bichromate of potash	Mungo Ponton . . 1838
—— with iodide of starch . .	E. Becquerel . . . 1840
Metallic chromates (Chromatype)	Hunt 1843
CHLORINE AND HYDROGEN. . .	Gay-Lussac and Thénard 1809
Chlorine (tithonized)	Draper 1842
—— and ether	Cahours 1810
GLASS, manganese, reddened . .	Faraday 1823
CYANOGEN, solution of	Pelouse & Richardson 1838
METHYLE	Cahours 1846
Crystallisation of salts influenced by light	Petit 1722
	Chaptal 1788
	Dizé 1789
Phosphorus	Schulze 1727
	Ritter 1801
—— in nitrogen	Beckman 1800
Phosphorus and ammonia . .	Vogel 1806
Nitric acid decomposed by light	Scheele 1786

METHYLE—continued.

Fat matter	Vogel	1806
Development of pores in plants	Labillardière . . .	1801
Vitality of germs	Michellotti	1803
RESINOUS BODIES (*Heliography*)	Niepce	1814
Asphaltum	Niepce	1814
Resin of oil of lavender . . .	Niepce and Daguerre	1830
Guaiacum	Wollaston	1803
Bitumens all decomposed . .	Daguerre	1839
All residua of essential oils . .	Daguerre	1839
Flowers, colours of, expressed, and spread upon paper . .	Herschel	1842
Yellow wax bleached	Senebier	1791
Phosphorescent influences of solar rays	Licetas	1646
	Kircher	1646
	Canton	1768
	Biot	1840
	E. Becquerel . . .	1839
Vegetation in stagnant water .	Morren	1841
Influence of light on electrical phenomena	E. Becquerel . . .	1839

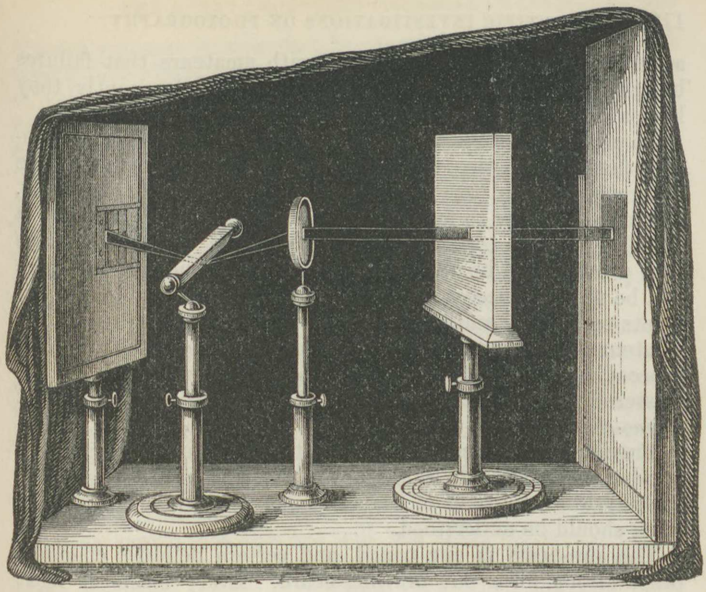
In the foregoing chapters every thing has been included which appeared necessary to the complete illustration of the history of the very beautiful art of Photography. It may appear to many that the manipulatory details included in this division should have been reserved for that which is more strictly technical. The difficulty of doing this without repeating in an unnecessary manner has led me to adopt what I consider to be the clearer course.

PART II.

SCIENTIFIC INVESTIGATIONS

ON

PHOTOGRAPHY.



CHAPTER I.

GENERAL REMARKS ON THE SOLAR AGENCY PRODUCING CHEMICAL CHANGE.

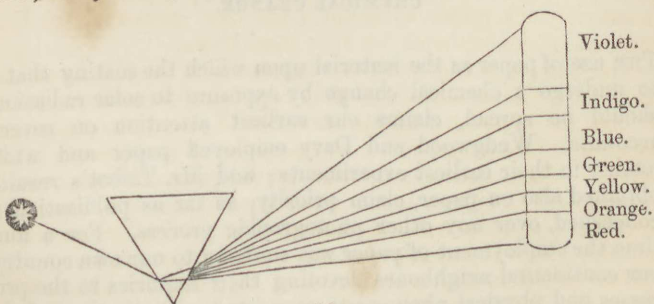
THE use of paper as the material upon which the coating that is to undergo a chemical change by exposure to solar radiations should be spread, claims our earliest attention on several accounts. Wedgwood and Davy employed paper and white leather in their earliest experiments; and Mr. Talbot's results, obtained also on paper, claim priority, as far as publication is concerned, over any other photographic process. For a long time the employment of paper was confined to our own country, our continental neighbours devoting their inquiries to the processes and physical phenomena connected with the use of the metallic plates constituting the tablets employed by Daguerre; but now they use the paper and glass processes in preference.

Notwithstanding the statements which have been too often repeated, to the effect that the practice of photography is exceedingly easy, that the manipulatory details of preparation present no difficulties, and that little more is necessary than to place a paper in a camera obscura, obtain a picture, and take it out again; it is a common complaint with amateurs that failures beset them at every stage of the process, and frequently they have abandoned the practice of photography in despair.

To pursue photography with success, it is essentially necessary that, by practice, the hand should be accustomed to the numerous manipulatory details; that, by repeated experiments, the causes leading to failure should be ascertained; and that a knowledge of the conditions under which the chemical changes take place should be obtained. This study, without which there will be no real success, is most favourably pursued by experiments on paper; and such are therefore recommended to the amateur when first he enters upon this interesting pursuit; proceeding only to the more delicate processes when he has mastered the rudimentary details of the more simple forms of *actino-chemistry*.

Previously, however, to explaining the practice of photography, to which a separate division is given, it appears important that the physical conditions of the elements with which we have to work should be understood.

The sun-beam is our pencil, and certain delicate chemical preparations form our drawing-board. Every beam of light which flows from its solar source is a bundle of rays, having each a very distinct character as to colour and its chemical functions. These rays are easily shown by allowing a pencil of sunlight to fall on one angle of a prism: it is bent out of its path, or *refracted*, and an elongated image is obtained, present-



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ing the various colours of which Light appears to be constituted—red, orange, yellow, green, blue, indigo, and violet. This coloured image is called the solar or the prismatic spectrum. The red ray, being the least refracted, is found at the lower edge, and the violet, being the most so, at the other extremity of this chromatic series. Below the ordinarily visible red, another ray of a deeper red, distinguished as the *extreme red*, or *crimson* ray, may be detected, by examining the whole through a deep blue glass; and, by throwing the spectrum upon a piece of yellow paper, another ray appears at the violet extremity, named by Sir John Herschel the lavender ray. Yet more recently, Mr. Stokes has proved a most remarkable extension of the luminous rays. By throwing a prismatic spectrum upon a solution of quinine in diluted sulphuric acid, or an infusion of the bark of the horse-chesnut tree, an extra spectral ray, situated far beyond the violet, makes its appearance, proving an extension of light over a space which has hitherto been thought incapable of producing any luminous phenomena.

The original spectrum of seven bands of colour was examined by Sir Isaac Newton, and that eminent philosopher determined that a given degree of refrangibility indicated a given colour; that the colour of a ray at once indicated its angle of refraction. Since the days of Newton, until our own time, this position had never been called in question; the seven rays were regarded as the primary colours of white light, and the law of Newton received as truth upon his authority. Sir David Brewster has, however, shown that this law will not stand the test of examination. He has proved that the prismatic spectrum consists of three chromatic spectra overlapping each other, and that those three colours—red, yellow, and blue—can be detected in every part of the image. Sir John Herschel has added two rays to the luminous or visible spectrum,—thus making the number nine instead of seven; but these can, equally with the others, be shown to be but combinations of the three primaries. There is, however, much reason to doubt if the new extra spectral blue rays can be comprehended within these three.

The colours of Light will be rendered most familiar by calling to memory the conditions of that very beautiful natural phenomenon, the rainbow. The primary bow is usually accompanied by a secondary image, in which the order of the colours is reversed. From close examination of the prismatic spectrum, I am disposed to believe that whenever we obtain this chromatic division of white light it is accompanied by a secondary spectrum, and that the real conditions of the colours are as follows:—

The *yellow* is the most luminous ray, and the illuminating power diminishes on either side of it; on one side it blends with the *blue*, to form the *green*, and on the other with the *red*, giving rise to the *orange* ray. The blue diminishing in intensity sinks towards blackness, and thus produces the *indigo*, the extreme edge of which represents the limit of the ordinary spectrum at that end; as the outer edge of the red forms its limits, as far as the human eye is concerned, on the other. Beyond the indigo we have the *violet* ray: this would appear to be the blending of the red of the supplementary spectrum with the blue of the ordinary one, the *lavender* ray resulting from the intercombination of the less luminous rays with the coloured surface upon which it is thrown. Then the *extreme red* or *crimson* ray will be seen to result from the blending of the extreme blue of the extraordinary with the red of the ordinary spectral image. This passage is still retained; but I have every reason to believe that it will before long require some modification, the discovery of Mr. Stokes materially altering the conditions.

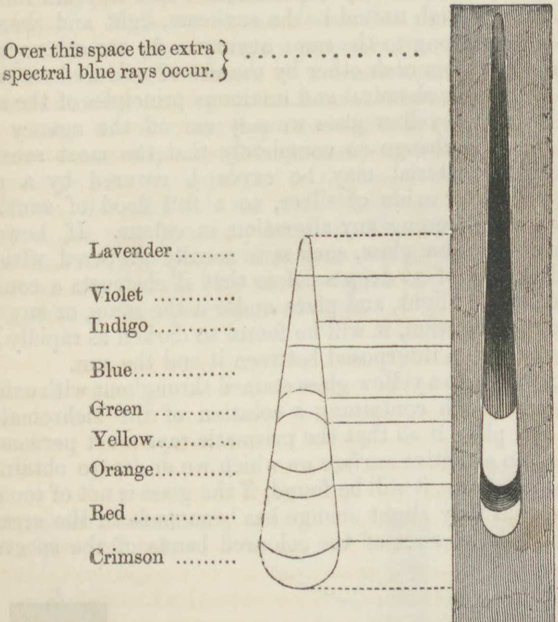
Sir William Herschel, and Sir Henry Englefield, determined the heating powers of these rays to be very varied. A thermometer was placed in each, and the following results obtained:—

In the blue ray, in	3′ the thermom.	rose from	55°	to 56°,	or	1°
" green "	3 "	"	54	" 58	"	4
" yellow "	3 "	"	56	" 62	"	6
" full red "	$2\frac{1}{2}$ "	"	56	" 72	"	16
" edge of red "	$2\frac{1}{2}$ "	"	58	" $73\frac{1}{2}$	"	$15\frac{1}{2}$
Quite out of visible light in	$2\frac{1}{2}$′	"	61	" 79	"	18

Sir John Herschel, by another form of experiment, has fully confirmed these results, and shown that the calorific or *heat*-producing radiations, being less refracted by the prism than the *light*-exciting rays, exist a considerable distance further from the visible rays than has been hitherto suspected. Light and heat have not, therefore, the same degrees of refrangibility; their influences are not coincident, their maxima in the solar spectrum are wide asunder. Melloni has shown that, by the use of coloured media, these agencies can be, to a considerable extent, separated from each other. Glass stained with oxide of copper, and washed on one side with a colourless solution of alum, admits the light rays most freely, but obstructs 95 per cent. of the heat rays. On the contrary, a slice of obsidian or black mica obstructs nearly all the light radiations, but offers no impediment to the passage of heat.

The chemical influences of the prismatic rays vary as their heating powers, but in the contrary direction.

If we place a piece of photographic paper in such a position that the spectrum falls upon it, it will be found to be very unequally impressed by the various rays. Some very extraordinary peculiarities have been observed by Sir John Herschel and myself; but it will be sufficient for our present purpose to state the general features of the impression under ordinary conditions. For some distance below the visible red ray, the paper will be found quite uncoloured; on the part where the red ray falls, a tinting of *red* or *pink* will be evident. The orange and yellow rays leave no stain, and the green in general but a faint one. In the place occupied by the blue ray, the first decided darkening is evident, which increases through the indigo and violet rays, and extends some distance beyond them. The shaded wood-engraving (Fig. 14) will serve



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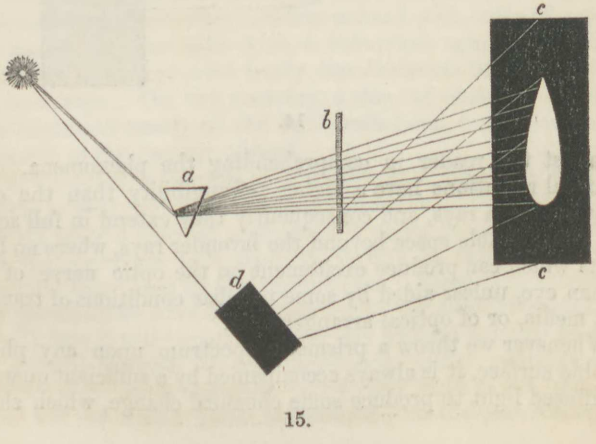
to assist the reader in comprehending the phenomena. The chemical radiations have a higher refrangibility than the ordinary luminous rays, and consequently they extend in full action to a considerable space beyond the lavender rays, where no light exists which can produce excitement on the optic nerve of the human eye, unless aided by some peculiar conditions of transparent media, or of optical arrangements.

Whenever we throw a prismatic spectrum upon any photographic surface, it is always accompanied by a sufficient quantity of diffused light to produce some chemical change, which shows itself in darkening, over the parts beyond the coloured image. However, there are two points where this change does not take place, and where the paper is preserved positively white; these are the points of maximum light and heat—the yellow and crimson rays. Here we have the evidence of the interference of these agencies with the chemical radiations. I have recently devised a more satisfactory experiment, which appears fully to prove that, although united in the sunbeam, light and chemical power do not belong to the same agency. As we can separate heat and light from each other by the use of coloured media, so can we isolate the chemical and luminous principles of the sun's rays. By a pure yellow glass we may cut off the agency producing chemical change so completely that the most sensitive photographic material may be exposed, covered by a glass stained yellow by oxide of silver, to a full flood of sunshine, without its undergoing any alteration in colour. If, however, we take a dark blue glass, such as is usually prepared with the oxide of cobalt, of so deep a colour that it obstructs a considerable quantity of light, and place under it the same, or any photographic preparation, it will be found to darken as rapidly as if no glass had been interposed between it and the sun.

Now, if we take a yellow glass stained throughout with oxide of silver, or a trough containing a solution of the bichromate of potash, and place it so that the prismatic rays must permeate it to reach the sensitive surface on which we desire to obtain the chemical spectrum, it will be found, if the glass is not of too deep a yellow, that very slight change has been made in the arrangement and relative sizes of the coloured bands of the spectrum.



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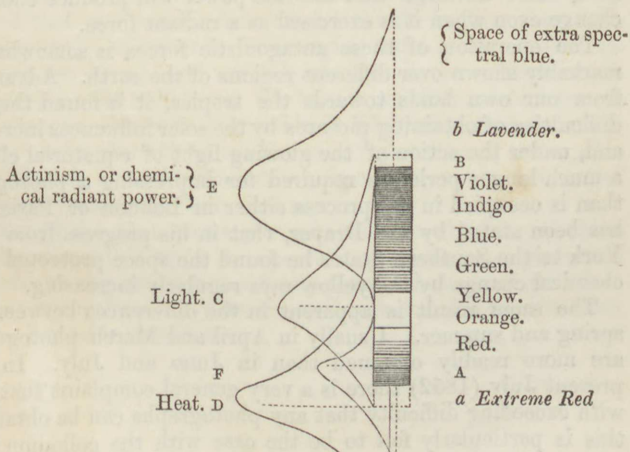
Notwithstanding the amount of light impinging along the line covered by the spectrum, no change whatever takes place on the paper. Preserving the prism *a*, Fig. 15, the yellow glass *b*, and the paper *c*, in the same positions, place a mirror at *d*, so that the sunbeam is strongly reflected on the paper: it will be blackened over every portion except that upon which the spectral image falls: along this line the paper will still be preserved white and unchanged. Thus we obtain conclusive proof that it is not LIGHT, *luminous power*, which produces the chemical change. That it is not HEAT is shown in the same manner by the protecting influence exerted by the maximum calorific rays; and therefore we are driven to the hypothesis of the existence of a new agency—a new imponderable element—or a novel form of force which is broadly distinguished from these principles or forces in its effects. To mark this the term ACTINISM has been proposed, and it is now very generally adopted. The word signifies nothing more than *ray power*, and therefore, as involving no theory, it is free from many of the objections which would apply to any other term adopted from preconceived ideas.



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Photography appears to be a misnomer, since the pictures so called are not drawn by light. It is, however, too firmly rooted in the public mind to admit of the hope that any other may be adopted. If I might venture a suggestion, I would advocate a return to the term introduced by Niepce, whose processes we have considered—HELIOGRAPHY, *Sun-drawing*, which most clearly expresses the fact, leaving the question of the particular agent effecting the chemical change still open for examination.

The annexed figure (16) shows the conditions as they are at present known. It was published many years since by me in a paper communicated to a periodical journal; and since it has been confirmed by all my subsequent researches, it appears desirable to give it a more permanent record.

From A to B exhibits the Newtonian spectrum, *a* and *b* being the rays which belonged to modern discovery previously to the recent observation that the peculiar blue rays seen in solution of quinine and some mineral oils belong to a yet higher order of refrangibility. The curves C, D, and E, represent the relative maxima of heat, light, and actinism, F being a second apparent maximum,—indicated in the red ray,—of the chemical powers. This may, however, be proved eventually to be a function of heat, since we know that calorific power will produce chemical change even when it is exercised as a radiant force.

The operation of these antagonistic forces is somewhat remarkably shown over different regions of the earth. Advancing from our own lands towards the tropics, it is found that the difficulties of obtaining pictures by the solar influences increase; and, under the action of the glowing light of equatorial climes, a much longer period is required for impressing a photograph than is occupied in the process either in London or Paris. It has been stated by Dr. Draper, that in his progress from New York to the Southern States he found the space protected from chemical change by the yellow rays regularly increasing.

The same result is apparent in the differences between the spring and summer. Usually in April and March photographs are more readily obtained than in June and July. In this present July (1852) there is a very general complaint that it is with exceeding difficulty that any photographs can be obtained: this is particularly felt to be the case with the collodion processes. It is very important to know that we may, by lowering the sensibility of the preparations, obviate these difficulties to a considerable extent.

It is worthy of notice, that the morning sun, between the hours of eight and twelve, produces much better effects than can be obtained after the hour of noon: this was observed at a very early period by Daguerre. For drawings by application, this is but slightly, if at all, felt, but with the camera it is of some consequence to attend to this fact. We are not yet in a position to record more than the fact,—the cause of the difference is not yet determined; probably it may be found to exist in a greater absorptive action of the atmosphere, caused by the elevation of aqueous vapour from the earth. But the experiments of M. Malaguti seem to imply the contrary, this philosopher having found that the chemical rays permeate water more readily than they do air: some experiments of my own, however, are not in accordance with M. Malaguti's results. In the neighbourhood of large towns it might be accounted for by the circumstance of the air becoming, during the day, more and more impregnated with coal smoke, &c., which offers very powerful interruption to the free passage of the chemical rays. This will, however, scarcely account for the same interference being found to exist in the open country, some miles from any town. Until our meteorological observers adopt a system of registering the variations of light and actinic power by means of some well-devised instrument, we cannot expect to arrive at any very definite results. The subject involves some matters of the first importance in photometry and meteorology, and it is to be desired that our public observatories should be furnished with the required instruments for carrying out a series of observations on the diurnal and monthly changes in the relative conditions of the solar radiations. We have now evidence which proves that changes, almost inappreciable, in the condition of the atmospheric media, through which the solar rays traverse, are capable of producing a most remarkable influence upon the colours of the spectrum and their chemical power.

Many of the phenomena of vegetable life will be found to be directly dependent upon the operation of these principles; and it would be important to mark any abnormal states of growth—such as not unfrequently occur—and to be enabled to refer them to peculiar solar conditions.

CHAPTER II.

CHEMICAL CHANGES ON SENSITIVE PREPARATIONS.

It is of some moment to the photographic artist that he is acquainted with the changes which occur in the several agents which he employs. A few of these are therefore selected.

Section I.—Nitrate of Silver.

1. The crystallised salt, in a pure state, should be procured. The commercial salt often contains nitrate of potash. The fused nitrate, which is sold in cylindrical sticks, is yet more liable to contamination. A preparation is sometimes sold for nitrate of silver, at from sixpence to ninepence the ounce less than the ordinary price, which may induce the unwary to purchase it. This reduction of price is effected by fusing with the salt of silver a proportion of some cupreous salt, generally the nitrate. This fraud is readily detected by observing if the salt becomes moist on exposure to the air,—a very small admixture of copper rendering the nitrate of silver deliquescent. The evils to the photographer are, want of sensibility upon exposure, and the perishability (even in the dark) of the finished drawing.

As all the silver salts are prepared from the nitrate, it is of consequence that its chemical character be clearly understood.

Section II.—Chloride of Silver.

Experiment 1.—Dry nitrate of silver, free of organic matter, will not blacken by sunshine; and, even when dissolved in perfectly pure distilled water, it may be exposed for a long time to solar influence without undergoing any visible change. Add, however, to the solution the smallest appreciable quantity of any organic matter, and it will almost immediately begin to blacken. This is so certain, that nitrate of silver is the most sensitive test that we have for the presence of organic matter in solution.

Experiment 2.—Place a stick of charcoal in pure water containing nitrate of silver, and expose to sunshine. Under the radiant influence, most beautiful crystals of silver will form around the charcoal, until all the metal is separated from the solution. We here see that carbonaceous matter has the power, under the influence of the solar rays, to effect the decomposition of the silver salt. In the first example, we have the metal precipitated as a black powder—oxide of silver; in the last, it is revived as a pure white metal, the crystals being of exceeding brilliancy. Thus we learn that the organic matter of the paper or the size is necessary to determine the change on which the photographic phenomena depend.

For the formation of the chloride of silver, any of the following salts may be employed; but the resulting colour varies curiously with each change, as will be noticed more fully presently.

2. Muriate of Soda (Common Salt).
3. ——— of Baryta.
4. ——— of Strontia.
5. ——— of Ammonia.
6. ——— of Peroxide of Iron.
7. ——— of Lime.

(Nos. 3–7: These salts have very remarkable colorific properties.)

8. Chloride of Potasium.
9. Chloride of Sodium.
10. Hydrochloric Acid (Spirits of Salts).
11. Solution of Chlorine in water.
12. Hydrochloric Ether.

All the above salts are necessary only for the purpose of giving a variety of colour to the artist's productions. This is a point of much interest, as the result of using these different materials as the mordant base determining the tone of the finished picture enables us to produce effects which are in accordance with the subject which we desire to represent.

A few experiments of an easy character will be instructive, as pointing out the character of those changes which sensitive surfaces undergo.

Experiment 3.—Pour some of the solution of common salt into the solution of nitrate of silver; immediately, a very copious white precipitate takes place. Pour off the supernatant liquor, and well wash it, by the dim light of a candle, with pure distilled water; then expose it to daylight: it will change colour very slowly, passing from white to grey. Drop a little nitrate of silver upon the white precipitate, it will darken much more rapidly than before; add a little organic matter, and the change occurs still quicker; and the degree of darkness which it eventually attains will be considerably deeper than before.

In this experiment we prove that, although the white salt of silver changes colour alone, the addition of nitrate of silver and organic matter considerably quickens the operation; therefore, in preparing the papers, it is always necessary for the nitrate of silver to be in excess.

Scheele, in his "*Experiments on Air and Fire*," has some experiments which are remarkably to the point. "I precipitated a solution of silver by sal ammoniac; then I edulcorated and dried the precipitate, and exposed it on a piece of paper to the beams of the sun for the space of two weeks, when the surface of the white powder grew black; after which I stirred the powder, and repeated the same several times. Hereupon I poured some caustic spirit of sal ammoniac on this, in all appearance, black powder, and set it by for digestion. This menstruum dissolved a quantity of *luna cornua* (horn silver), though some black powder remained undissolved. The powder having been washed, was for the greater part dissolved by a pure acid of nitre, which, by the operation, acquired volatility. This solution I precipitated again by means of sal ammoniac into horn silver. Hence it follows that the blackness which the *luna cornua* acquires is *silver by reduction*."

Experiment 4. *To determine the character of the change set up by sunshine.*—A solution, No. 1, is nitric acid and oxide of silver dissolved in water, and a solution, No. 2, is chlorine and sodium. These, when in solution, become hydrochloric (muriatic) acid, by the chlorine combining with the hydrogen of the water; and soda, by the sodium absorbing the oxygen from the same fluid. When these solutions are mixed, a white precipitate—*chloride of silver*—falls. The chlorine of the common salt seizes the silver, and as this is nearly insoluble, it is precipitated: the nitric acid combines at the same time with the soda, and this remains in solution. The chloride of silver being carefully washed, is placed in very pure distilled water, to which a minute portion of organic matter has been added, and then exposed to sunshine. After it has darkened, remove the water, and it will be found to contain chlorine; by adding some nitrate of silver, we shall obtain a fresh precipitate, and we may thus determine exactly the amount of decomposition which has taken place.

In the process, the strong affinity existing has been broken up. Metallic silver, in a state of very fine division, is produced; and the chlorine set free dissolves in the water, from which we can precipitate it by silver, and consequently readily ascertain its quantity.

It is necessary now to direct attention to the effects of organic matter in accelerating the blackening process. Sir John Herschel, whose researches in this branch of science are marked with his usual care, has given particular attention to this matter. As it is impossible to convey the valuable information that Sir John has published, more concisely than in his own language, I shall take the liberty of extracting rather freely from his memoir, published in the Philosophical Transactions.

"A great many experiments were made by precipitating organic liquids, both vegetable and animal, with solutions of lead; as also, after adding alum, with alkaline solutions. Both alumina and oxide of lead are well known to have an affinity to many of these fugitive organic compounds which cannot be concentrated by evaporation without injury,—an affinity sufficient to carry them down in combination, when precipitated, either as hydrates or as insoluble salts. Such precipitates, when collected, were applied, in the state of cream, on paper, and, when dry, were washed with the nitrate. It was here that the first prominently successful result was obtained. The precipitate thrown down from a liquid of this description by lead, was found to give a far higher degree of sensitiveness than any I had before obtained, receiving an equal depth of impression, when exposed, in comparison with mere nitrated paper, in less than a fifth of the time; and, moreover, acquiring a beautiful ruddy brown tint, almost amounting to crimson, with a peculiarly rich and velvety effect. Alumina, similarly precipitated from the same liquid, gave no such result. Struck by this difference, which manifestly referred itself to the precipitate, it now occurred to me to omit the organic matter (whose necessity I had never before thought of questioning), and to operate with an alkaline precipitant on a mere aqueous solution of nitrate of lead, so as to produce simply a hydrate of that metal. The result was instructive. A cream of this hydrate being applied and dried, acquired, when washed with nitrate of silver, a considerable increase of sensitiveness over what the nitrate alone would have given, though less than in the experiment where organised matter was present. The rich crimson hue also acquired in that case under the influence of light, was not now produced. Two peculiarities of action were thus brought into view; the one, that of the oxide of lead as a *mordant* (if we may use a term borrowed from the art of dyeing), the other, that of organic matter as a colorific agent.

"Paper washed with acetate of lead was impregnated with various insoluble salts of that metal—such as the sulphate, phosphate, muriate, hydriodate, borate, oxalate—and others, by washing with their appropriate neutral salts, and, when dry, applying the nitrate of silver as usual. The results, however, were in no way striking, as regards sensitiveness, in any case but in that of the muriatic applications. In all cases where such applications were used, a paper was produced infinitely more sensitive than any I had at that time made. And I may here observe, that in this respect the muriate of strontia appeared to have decided advantage."

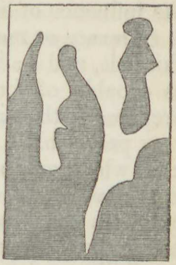
It would be tedious and useless to mention all the combinations of alkaline and earthy muriates which have been devised to vary the effect, or increase the sensitiveness, of the silver preparations: the very considerable differences produced through the influence of these salts will afford peculiarly interesting results to any inquirer, and furnish him with a curious collection of photographic specimens. As a general rule, the solutions of the muriate, and indeed all other salts, and of the silver washes, should be made in the combining proportions of the material used. With a scale of chemical equivalents at hand, the photographic experimentalist need not err, taking care that a slight excess of pure nitrate of silver prevails.

These changes being understood, we may proceed to the consideration of the preparation of the muriated papers employed for the ordinary processes.

Muriated paper is formed by producing a chloride of silver on the paper. This is done by washing the paper in the first place with the solution of muriate of soda, and then, when the paper is dry, with the silver solution, which it is sometimes necessary to apply twice.

In this process, which requires more care than may be at first conceived, we often suffer from the annoyances which arise from the unequal texture of the paper, and also from the want of uniformity in the distribution of the salts over the surface. It will not unfrequently be found that irregular patches, with sharply defined outlines, will appear on the paper, exhibiting a much lower degree of sensibility than the other parts of the sheet. These patches have been attributed by Sir John Herschel and Mr. Talbot to "the assumption of definite and different chemical states of the silver within and without their area." A few experiments will prove this to be the case.

Prepare a piece of the less sensitive paper, with only one wash of silver, and whilst wet expose it to the sunshine; in a few minutes it will exhibit the influence of light, by becoming very irregularly darkened, assuming such an appearance as that given in fig. 17, the light part being a pale blue, and the shaded portions a deep brown. In pursuing our inquiry into the cause of this singularity, it will be found that over the light parts a pure chloride of silver, or a chloride with the slight excess of the muriate of soda, is diffused; but over the dark parts the chloride of silver is united with an excess of the nitrate of silver. Where the rates of imbibition are different, this defect must follow, as a natural consequence, in very many cases; but it is found to occur frequently where we cannot detect any sufficient cause for the annoyance. Although we are acquainted with the proximate causes of the differences produced, yet the ultimate ones are involved in doubt. It is a remarkable fact, that the same irregular patches are formed *in the dark* on papers which have been kept a long time. Sir John Herschel suggested, as a means of preventing these troublesome occurrences, that the saline wash used should, prior to its application, be made to dissolve as much as possible of the chloride of silver, which it does to a considerable extent; and that the last wash of the nitrate of silver should be diluted with an equal quantity of water, and applied twice, instead of in one application. There can be no doubt but this evil is almost entirely overcome by operating in this way, but it is unfortunate that the process is somewhat injurious to the sensibility of the paper.



17.

Of the salts already named, some few of the effects should be noted.

Muriate of Soda.—This is usually employed, and the chloride of silver precipitated by it darkens to a fine chocolate brown, and by regulating the quantity of salt in solution, relatively to the strength of the nitrate of silver, a moderately high degree of sensibility may be obtained.

Muriate of Lime.—Not particularly sensitive, deepening to a brick-red in full sunshine, but is less liable to change in the fixing processes than almost any other preparation.

Muriate of Potash is scarcely in any respect different from the muriate of soda. The nitrate of potash, however, which is formed in the paper, is less liable to be affected by a humid atmosphere than the nitrate of soda.

Muriate of Ammonia, used in the proportion of two scruples to four ounces of water, and the silver solution in the proportion of sixty grains of the nitrate to one ounce of water, forms a very beautiful paper, equalling in sensibility the best kind prepared with the muriate of soda, at nearly one-half its expense. It darkens to a fine chocolate brown.

Muriate of Iron.—A solution of this salt appears in the first instance to answer remarkably well; but, unfortunately, the pictures formed perish slowly, however carefully guarded from the influence of light.

Chlorate of Potash.—Mr. Cooper recommends a solution of this salt, and a silver wash of sixty grains to the ounce of water, as capable of forming a good paper. Some of the specimens prepared with it are of exceeding beauty, the ground being of a very pretty blue, or rather lilac; but these papers cannot be used where any considerable degree of sensitiveness is desired.

Muriatic Acid.—A slightly acidulated solution of this acid produces a very tolerable paper, but it is extremely difficult to hit the best proportions for use. If too weak, the paper fails in sensibility, and a slight increase occasions a very injurious action on the paper, raising the *pile* like a down over the sheet. This kind of paper loses its sensitiveness with great rapidity: in about six or seven days, however carefully kept, it is scarcely susceptible to luminous influence. By washing the paper, after it is prepared, in pure water, it keeps much better; but, after being washed, light changes it to a rather disagreeable brick-red, prior to which the colour in general is a fine brown.

Dr. Schafhaeutl has proposed the use of the muriatic acid in a different way, to be noticed in a future chapter, and certainly his process has some advantages: when it is carefully attended to, the liability to spots or patches appears to be less than in any of the ordinary methods, and a very sensitive paper results, but it will not keep.

Aqueous Solution of Chlorine gives rise to a paper possessing in an eminent degree the merits of that prepared with muriatic acid, and it has the advantage of retaining its sensibility much longer.

Solutions of Chlorides of Zinc and Soda.—Either of these solutions may be used indiscriminately, provided the strength of the silver is regulated so as to give an excess of the nitrate over the chlorine in solution: the effects are not generally pleasing.

Section III.—Iodide of Silver.

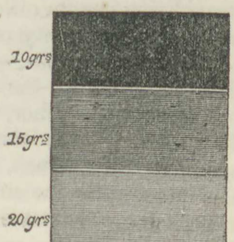
If iodide of silver is precipitated by mixing together solutions of iodide of potassium and nitrate of silver in a concentrated state, a heavy yellow powder falls, which will scarcely change in colour by an exposure of many days to sunshine. But if the solutions are infinitely diluted, so that on mixing they only become milky, and the light powder which occasions the opacity falls but slowly to the bottom of the vessel, it will be found that it is sensitive to the weakest solar radiations. There does not appear to be any chemical difference between the iodides thus obtained; but there are some remarkable physical peculiarities, and it is believed that attention to these will be found eventually to be of the utmost importance.

Section IV.—Bromide of Silver.

In many of the works on chemistry, it is stated that the chloride is the most sensitive to light of all the salts of silver; and, when they are exposed in a perfectly formed and pure state to solar influence, it will be found that this is nearly correct. Modern discovery has, however, shown that these salts may exist in peculiar conditions, in which the affinities are so delicately balanced as to be disturbed by the faintest gleam; and it is singular that, as it regards the chloride, iodide, and bromide of silver, when in this condition, the order of sensibility is reversed, and the most decided action is evident on the bromide before the eye can detect any change in the chloride.

The slight additional expense of the bromides is not worthy consideration, particularly as their use may be confined to papers for the camera obscura, the pictures on which are of course of the negative character, and the positive photographs can be formed by transfer on the chloridated papers of a highly sensitive kind. Since there has been some question as to the use of the iodide of silver without an infringement of patent, it is not a little surprising that the bromide has not been more generally employed.

It will be found that the bromide and iodide are much alike in the singular want of sensibility which they sometimes exhibit under the circumstances already alluded to, which are not easy of explanation.



18.

If a paper first washed with a solution of nitrate of silver has bromide of potassium applied to it in different proportions, say 20 grains, 15 grains, and 10 grains each, in two drachms of water, and, when dry, be again washed over with the silver solution, it will be found, unless, as is occasionally the case, some organic combination interferes, that the order of sensitiveness will begin with the weakest solution, the strongest being the least influenced by light. The different degrees of darkness induced are fairly represented in the margin (Fig. 18). As the different bromides give to photographic paper varieties which much resemble those enumerated under the muriates, I have thought it unnecessary to give an account of any of them. The paper prepared with the bromide of potassium is the kind I have adopted, after having tried upwards of two hundred combinations of silver with the other bromides.

To prepare a highly sensitive paper of this kind, select some sheets of very superior glazed post, and wash it on one side only with bromide of potassium—forty grains to one ounce of distilled water, over which, when dry, pass a solution of one hundred grains of nitrate of silver in the same quantity of water. The paper must be dried as quickly as possible without exposing it to too much heat; then again washed with the silver solution, and, when dry, carefully preserved for use.

It will be perceived that I adopt a slightly different manipulation from that recommended by Mr. Talbot. Instead of washing the paper with the solution of silver first, and applying the bromide or the muriate over this, and then the silver wash again, I use the alkaline salt first, and apply the metallic washes one on the other. I have been induced to this from observing that the photographic preparation penetrates less deeply into the paper than when laid on as originally prescribed, and, consequently, the sensibility of it is increased. It will be found that an addition of about one-twelfth of spirits of wine to the solution of silver will much increase the blackness of the paper when solarised; and I think we may safely say that the sensibility is also improved by it,—at all events it is not impaired.

M. Biot has expressed his opinion that it is not possible to find any substance more sensitive to light than the bromide of silver: this is true to a certain extent, but in combination with deoxidizing agents other preparations will be named which have a decided superiority over the pure bromide of silver.

Fluoride of Silver.—The use of this salt appears to have been first suggested by Sir John Herschel; it forms the basis of a process by the author, to be described in the chapter on Special Processes. It has lately been claimed as a new photographic agent by the French, but the date of publication determines this question in the author's favour.

Phosphate of Silver.—Dr. Fyfe appears to have been the first to suggest the use of the phosphate of silver as a photographic material, but I am obliged to confess it has not, in my hands, proved anything like so successful as, from Dr. Fyfe's description, it was in his own. Indeed, he himself observes, in speaking of its use in the camera obscura:—"Though representations may be got in this way, yet, so far as I have found, they have not the minute distinctness of those got by the method already mentioned (*i. e.* by application). Owing to the interference of the lens, the light does not act nearly so powerfully on the paper, as when it has to permeate merely a frame of glass."

For all practical purposes, the method which Dr. Fyfe has given of preparing these papers is, perhaps, the best:—"The paper is first soaked in the phosphate of soda, and then dried, after which the nitrate is spread over one side by a brush; the paper again dried, and afterwards again put through the salt, by which any excess of silver is converted to phosphate. As thus prepared, it acquires a yellow tinge, which becomes black by exposure to light." It will be evident from these directions, that what was formerly said about the necessity of having the nitrate of silver in excess, is here, according to Dr. Fyfe, objectionable. It certainly does not appear to be so essential in this preparation, that anything but pure phosphate of silver should be used; yet I cannot help fancying that a slight advantage is gained, even here, by allowing a little excess of nitrate. Dr. Fyfe has given a process for applying the phosphate of silver, mixed as a paint, on metal, glass, or paper. It, however, requires the skill of an artist to produce an even surface, and unless a uniform ground is given, the picture is deformed by waving lines of different shades. A method of precipitating argentine salts on smooth surfaces will be given in the following pages, by which means the most uniform face is procured, and many beautiful effects produced.

Papers prepared with other Salts of Silver.—With the exception of the carbonate, tartrate, acetate, citrate, oxalate, and one or two others, the salts of silver, besides those already described, do not appear to be sensibly influenced by light. Many have been mentioned by authors as absolutely insensible to its influence; but recent experiments have produced modifications of these salts, which are delicately sensitive to the solar ray. Amongst others, the chromate has been named, and certainly it has not yet been rendered sensitive to an exposure of some hours to daylight; but one experiment of mine has proved that the solar beam will, in a few days, produce a fine revival of metallic silver from its chromate; and another experiment with it has the most pleasing result of bringing within the range of probabilities the production of photographic pictures in their natural colours.

Researches having this object in view led to the discovery of the *chromatype;* but this beautiful salt (chromate of silver) has not yet been applied directly as the photographic agent. In the present state of our knowledge, we cannot venture to affirm that any salt of silver, or, indeed, of any of the other metals, exists, having an absolute insensibility to light, or in which the required unstable equilibrium may not be induced, so that the sun's beam might change the character of its combinations. I am, indeed, convinced that no body in nature is entirely uninfluenced by the action of the sun's rays. Papers washed with either of the alkaline carbonates, and then with a solution of nitrate of silver, resemble in their character those prepared with the muriates, but are not darkened so readily.

The tartrate of silver possesses some very extraordinary peculiarities. Papers may be prepared, either by spreading the tartrate at once over the surface, or better, by soaking the paper in a solution of Rochelle salt (the tartrate of potash and soda), and then applying two washes of the solution of nitrate of silver. The first action of light is very feeble, but there gradually comes on a stronger discolouration, which eventually proceeds with rapidity, and at length blackens to an extent beyond almost every other paper. This discolouration may be wonderfully accelerated by washing over the tartrated paper with a very dilute solution of the hydriodate of potash, during the process of darkening. It is not easy to use this when copying anything, but there are cases in which the extreme degree of darkness which this preparation acquires renders it valuable. The acetate of silver comports itself in the same manner as the tartrate. The citrate, oxalate, &c., are only interesting as forming part of the series of argentine preparations which exhibit decisive changes when exposed to light. The methods of rendering them available will be sufficiently understood from the foregoing details, and it would only be an unnecessary waste of words to give any more particular directions as it regards them.

Fulminate of Silver.—Notwithstanding the extraordinary degree of sensibility which has been given to paper and to the metallic plates by the industrious experiments of chemists, I am convinced that we may hope to obtain agents of far higher natural sensibility than those we now possess; and I look with much anxiety to some of the combinations of organic radicals with metallic bases. The fulminates and the ethyle compounds present a very promising line of inquiry. Mr. John Towson, of Devonport, who pursued, conjointly with myself, a most extensive series of researches on photographic agents, was endeavouring to form a solution of silver, in which the elements should be so delicately balanced as to be overturned by the action of the faintest light. To do this, he dissolved some very pure silver in nitric acid, to which spirits of wine was added somewhat suddenly in proportions equal to the acid used, and the precipitation of the fulminate prevented by a quick effusion of cold water, sufficient to bring the specific gravity of the solution to 1·17, and to this a few drops of ammonia were added. Pieces of Bank post paper dipped in this solution became, the instant they were presented to the declining light of an autumnal evening, a beautiful black having a purple tinge. This effect did not seem to come on gradually, but, as by a sudden impulse, at once. Both this gentleman and myself have often endeavoured to repeat this, but in no one instance have either of us succeeded in producing anything nearly so sensitive. It should be stated, that the solution prepared in the evening had become, by the following morning, only ordinarily sensitive, and that papers prepared with it were deliquescent and bad. In repeating any modification of this experiment, the greatest care should be taken, as explosions of considerable violence are otherwise likely to occur.

Another series of experiments on the fulminates of silver have produced very pleasing photographic results, but I am not enabled to specify any particular method of preparing them, which may be certain of reproducing the results to which I allude. Nothing can be more capricious than they are; the same salt darkening rapidly to-day, which will to-morrow appear to be absolutely insensible to radiation, and which will again, in a few days, recover its sensitiveness, to lose it as speedily as before.

The beautiful researches of Professor Frankland, of Owen's College, Manchester, however, most satisfactorily prove that a great many of the metals will combine with organic radicals in the sunshine which will not so combine in darkness.

We may sum up the amount of our knowledge of the chemical influences of the solar radiations as follows:—

1. The rays, having different illuminating or colorific powers, exhibit different degrees and kinds of chemical action.

2. The most luminous rays exhibit the least chemical action upon all inorganic matter. The least luminous and the non-luminous manifest very powerful chemical action on the same substances.

3. The most luminous rays influence all substances having an organic origin, particularly exciting vital power.

4. Thus, under modifications, chemical power is traced to every part of the prismatic spectrum; but in some cases this action is positive, *exciting;* in others negative, *depressing*.

5. The most luminous rays are proved to prevent all chemical

change upon inorganic bodies exposed, at the same time, to the influence of the chemical rays.

6. Hence actinism, regarded at present merely as a phenomenon different from light, stands in direct antagonism to light.

7. Heat radiations produce chemical change in virtue of some combined action not yet understood.

8. Actinism is necessary for the healthful germination of seed; light is required to excite the plant to decompose carbonic acid; caloric is required in developing and carrying out the reproductive functions of the plant.

9. Phosphorescence is due to actinism, and not to light.

10. Electrical phenomena are quickened by actinism, and retarded by light.

Numerous other points of minor importance will present themselves on studying the facts described. Without venturing to obtrude my own views, I now leave the subject for that full investigation which it will, I trust, receive, as promising beyond all others to enlighten us on those curious phenomena which appear to link together the organic and the inorganic worlds.

CHAPTER III.

THE THEORY OF THE DAGUERREOTYPE.

NUMEROUS speculations having been ventured as to the peculiar chemical changes which light produces on the iodidated silver tablets, I shall make no apology for introducing a few remarks on this very interesting subject.

Numerous experiments on plated copper, pure silver plates, and on silvered glass and paper, have convinced me that the first operations of polishing with nitric acid, &c., are essential to the production of the *most sensitive* surface. All who will take the trouble to examine the subject will soon be convinced that the acid softens the silver, bringing it to a state in which it is extremely susceptible of being either oxidized or iodized, according as the circumstance may occur of its exposure to the atmosphere or to iodine. The process, adopted, I believe, first in America, of producing a deposit of chemically pure silver on the plated metal, by means of the voltaic battery, which certainly gives rise to some peculiar conditions, appears to prove that the soft surface of silver is of advantage.

The sensitive surface is a combination of iodine, or of iodine and bromine, with the silver. When exposed to radiant influences in the camera, a molecular change is effected, and there is much doubt if any iodine or bromine is removed from the surface. Some have thought that the superficial film being decomposed, the iodine and bromine attack a lower surface of the plate; but experiments are still wanting.

I have discovered that all the rays of the prismatic spectrum act on the daguerreotype plate, except the yellow, and a circle of light of a peculiar and mysterious character, which *surrounds* the visible spectrum. The light acting on a prepared tablet, appears to decompose the film of *ioduret of silver* to different depths, according to the order of refrangibility of the rays: the violet ray and extra-spectral rays effecting the deepest decomposition, whilst the red acts to a depth inappreciably slight. Thus it is that the spectrum impressed on a daguerreotype plate reflects natural tints of the same kind as Sir Isaac Newton's thin films; the thickness of each film of reduced silver on the plate being in exact proportion to the chemical agency of the coloured ray by which it was decomposed.

On photographic papers, the decomposed argentine salt exists, in all probability, in a state of oxide, mixed with revived silver; but on the silver tablet the iodine is changed over all the parts on which the light acts, and pure silver in a state of extreme division results. The depth to which the decomposition has been effected being in exact relation to the intensity and *colour* of the light radiated from the object which we desire to copy, the mercurial vapour unites with different proportions of silver, and thus are formed the lights and middle tints of the picture. The shadows are produced by the unchanged silver from which the iodine is removed by the hyposulphite of soda.

Daguerre himself laid much stress upon the necessity of exposing the plate to receive the vapour of mercury at an angle of 45°. This, perhaps, is the most convenient position, as it enables the operator to view the plate distinctly, and watch the development of the design: but beyond this, I am satisfied there exists no real necessity for the angular position. Both horizontally and vertically, I have often produced equally effective daguerreotypes. Looking at a daguerreotype picture in such a position that the light is incident and reflected at a large angle, the drawing appears of the *negative* character; the silver in such a position appearing white, and the amalgam of mercury and silver a pale grey. View the plate in any position which admits of but a small angle of reflection, and we then see the design in all its exquisite beauty, correct in the arrangement of its lights and shades,—the silver appearing black, while the amalgam, by contrast in part, and partly in reality, appears nearly white. A very ingenious idea has been promulgated, that the light crystallizes the iodide of silver, and that the mercury adheres to one of the facets of each minute crystal. If this was the case, the picture could be seen distinctly in one position only, whereas in many different positions it is equally clear. There does not appear to be any more difficulty in explaining why the mercurial amalgam should vary in its tint with change of position, than in explaining why a common mirror, or a polished metal plate, should appear white when viewed at one angle, and black in another.

The cause leading to the uniform deposition of the mercurial vapour is far more difficult of solution. It does not appear to me that any one of the hypotheses put forth, satisfies all the conditions of this peculiar phenomenon.

Few papers have been published which so completely investigate the phenomena of the chemical change in the daguerreotype, as that of Mr. George Shaw, who pursued his experiments in association with Dr. Percy. As giving a large amount of valuable information, I transfer it from the Philosophical Magazine.

"It is well known that the impression produced by light on a plate of silver rendered sensitive by M. Daguerre's process, is wholly destroyed by a momentary exposure of the plate to the vapour of either iodine or bromine. Although this fact has long been known, the nature of the action by which so extraordinary an effect is produced has not yet been satisfactorily explained. In the hope of elucidating this subject, a series of experiments was instituted, the results of which are recorded in the following remarks.

"A silver plate prepared by exposure to iodine or its compounds with bromine, may be exposed to the vapour of mercury without being in any way affected by the exposure. If, however, the prepared plate be previously exposed to light, or made to receive the luminous image formed in the *camera obscura*, the mercurial vapour attacks it; forming, in the former case, a white film, and in the latter, a picture corresponding to the luminous image which had been allowed to fall on it.

"If a prepared plate, after receiving a vertical impression by light, be exposed to the vapour of iodine or bromine, it is found that the vapour of mercury no longer attacks it; or, in other words, the impression produced by light is destroyed.

"The first experiments made for the purpose of arriving at the cause of this phenomenon had reference to the relation between the time of the exposure to light and the time of exposure to the vapour of iodine or bromine necessary to destroy the effect produced by light. Prepared plates were exposed in the *camera obscura* for a length of time, which previous experiment had determined to be sufficient for a full development of the picture; some of those plates were exposed during two seconds to an atmosphere feebly charged with the vapour of bromine, while others were carefully preserved from contact with the vapours of iodine or bromine. The atmosphere of bromine employed was produced by adding thirty drops of a saturated solution of bromine in water to an ounce of water: the solution was poured into a glass vessel, and the plate was exposed to the vapour in the vessel during the time specified. The plates were then introduced into the mercury box, and by volatilizing the metal, pictures were developed on all those which had not been exposed to the vapour of bromine, while those which had been exposed to it exhibited no trace of a picture under the action of mercury.

"The same experiments were repeated with iodine, with exactly similar results.

"Prepared plates were exposed to diffused light in the shade, and others were exposed to the direct rays of the sun; the object being in both cases the production of a more intense impression than that produced by the feeble light of the *camera obscura*. Some of these plates were exposed to the vapour of bromine, and others to the vapour of iodine, while others were carefully preserved from the vapours of these substances. On subsequent exposure to the vapour of mercury, those plates which had not been exposed to iodine or bromine, exhibited, by the large quantity of mercury which condensed on them, the effects of exposure to intense light: while those which had been subjected to the action of either bromine or iodine were in no way affected by the vapour of mercury. Many repetitions of these experiments demonstrated that the effect of exposure to the most intense light was completely destroyed by the shortest exposure to the vapour of bromine or iodine.

"Experiments were now instituted for the purpose of ascertaining in what condition the prepared plate was left after having been first exposed to light and afterwards exposed to the vapour of bromine or iodine. In these experiments a method of treatment somewhat different from, and more convenient than that described, was resorted to, as in practising that method effects occasionally presented themselves which interfered with the results, and rendered it difficult to determine with certainty how far some of the appearances produced were due to the action of light. It is well known, that a prepared plate has a maximum of sensitiveness when the iodine and bromine are in a certain relation to each other; if there be a deficiency of bromine, the maximum sensitiveness is not obtained, and, if there be an excess, the plate is no longer sensitive to light; but when exposed to the vapour of mercury, *without having been exposed to light*, becomes white all over, by the condensation of mercury thereon; that is to say, it exhibits the appearance of a plate which had been *properly* prepared, and which *had* been exposed to light. From this it will be evident, that a plate properly prepared in the first instance, and then exposed to light, may, by subsequent exposure to the vapour of bromine, have the impression produced by light *wholly destroyed;* and yet, by the accumulation of bromine, may exhibit, on exposure to mercury, an appearance similar to that due to light. In other words, it is impossible (in the case supposed) to distinguish between an effect produced by light and an effect due to excess of bromine. By using iodine in the place of bromine, there is no risk of producing the appearance which accompanies excess of bromine; but, on the other hand, by augmenting the quantity of iodine, the sensitiveness of the plate is diminished. These difficulties were overcome by using a solution containing both iodine and bromine, in such proportions that the evaporation of each should take place in the proportion in which they produce on silver the most sensitive surface. The solution employed was made by adding alcoholic solution of iodine to a solution of chlorate of potash, until the latter would take up no more of the former; and to each ounce, by measure, of this solution, ten drops of a saturated solution of bromine in water were added. The solution of chlorate of potash was made by diluting one part of a saturated solution of the salt with ten parts of water. The use of the chlorate is simply as a solvent of iodine. In the subsequent experiments, the plate was exposed to the vapour of this mixture of iodine and bromine with precisely the same effect as when either was used separately, and without the inconvenience, or uncertainty, which attended their use.

"A number of preliminary experiments, the detail of which would be uninteresting, appeared to indicate, that not only is the effect of light on a daguerreotype plate destroyed by iodine or bromine, but that the plate is restored to its original condition; in other words, that its sensitiveness to light is restored. In order to determine this point, the following experiments were made.

"A prepared plate was exposed to light, and afterwards to the mixed vapour;[1] mercurial vapour produced no effect upon it after a long exposure; the plate on removal from the mercury box was a second time exposed to light, and again introduced into mercurial vapour. The appearance of the plate was very little changed, and it was concluded that no effect, or, if any, very little, was produced by the second exposure to light. This conclusion was, however, erroneous, as the following experiments proved:—

"A prepared plate was exposed to light, and afterwards to the mixed vapour: mercurial vapour was found to have no effect upon it; the plate was then partly covered with a metallic screen, fixed close to, but not in contact with it, and the whole was exposed to light. On placing the plate in the mercury box, a broad white band, nearly corresponding to the edge of the defended part, made its appearance; the whole of the defended part (excepting the band in question) was unaffected, and the

[1] "I shall hereafter call the mixed vapours of iodine and bromine produced in the way described in the last paragraph but one, *mixed vapour*, in order to avoid circumlocution.—G. S."

exposed part exhibited very little change. By a careful examination of the plate after it was removed from the mercury box, the white band in the middle appeared to be produced by the feeble light which had passed under the edge of the metal plate which had screened the light from part of the prepared surface; and the very dark, and apparently unaltered appearance of the exposed part, was occasioned by an excess of action, for mercury was found to have condensed on that part in large quantities, and to have produced the dark lead colour which is commonly called *solarisation;* but which effect, in the case in question, was so excessive, that the colour of the part on which mercury had condensed differed but very slightly from that on which no light had fallen. It was now evident that the apparent absence of effect in the last experiment was in reality occasioned by an excess of action; and by repeating that experiment, and making the time of the second exposure to light much shorter than before, the plate assumed, under the action of mercury, an intense and beautiful whiteness.

"From these experiments, then, it was perfectly clear that the impression produced by the light on a daguerreotype plate is wholly destroyed by the mixed vapour, and that *its sensitiveness to light is restored.*

"It now remained to discover to what extent the sensitiveness is restored by the treatment in question. It was not at first expected that the sensitiveness to light was as great after this treatment as after the original preparation of the plate; but experiments afterwards proved that the surface lost none of its sensitiveness by this treatment, nor even by numerous repetitions of it. A prepared plate was exposed to light; the impression was destroyed and sensitiveness restored by the mixed vapour; the plate was a second time exposed to light and a second time to bromine; still its sensitiveness appeared unimpaired, for a fourth or fifth exposure gave, on treatment with mercurial vapour, a vivid impression. In order to determine with the greatest accuracy if the sensitiveness of the prepared surface was at all impaired by these repeated exposures to light, the *camera obscura* was resorted to. A series of plates was prepared with the utmost attention to uniformity; some of these were exposed in the *camera obscura*, and pictures obtained by the subsequent exposure to vapour of mercury: the time requisite for the proper development of the picture was noted; others were first exposed to the direct rays of the sun, and afterwards to the mixed vapour, and these were exposed in the *camera obscura* for the same length of time as those which had not been exposed to light. On treatment with mercurial vapour, perfect pictures were produced, which could not be distinguished from those taken on plates prepared by the ordinary method. So completely does the mixed vapour restore the sensitiveness of prepared plates after exposure to light, that the most beautiful impressions were obtained in the *camera obscura* in two seconds on plates which had previously been *four* times exposed to the direct light of the sun, and after each such exposure treated with the mixed vapour.

"As the plates experimented on, to this stage of the inquiry, had been *wholly* exposed to the sun's light previous to exposure in the *camera obscura*, it was thought that possibly some slight effect was produced, which, from being the same on all parts of the plates, escaped observation; and in order to avoid the possibility of error from this cause, the impressions of light which it was intended to destroy by bromine were afterwards made in the *camera obscura*. Prepared plates were impressed with virtual images of different kinds, the *camera obscura* being pointed first at a house, afterwards to a bust, next to a tree, and finally to a living figure, the plates after each impression, excepting the last, being momentarily exposed to the mixed vapour. In every instance, the most perfect impressions of the objects to which the *camera obscura* was last directed were obtained, and no trace of the previous impressions was left.

"Experiments were next instituted for the purpose of ascertaining if the prepared surface, *after* the process of mercurialization, could be made to receive another impression by treatment with mixed vapour. Impressions were taken with the *camera obscura*, and after the full development of the picture by vapour of mercury, the plates were exposed to bromine and again placed in the *camera obscura*, the instrument being directed in different experiments to different objects: on exposure to mercurial vapour, other pictures made their appearance, and although confused from superposition on the first pictures, could be clearly traced, and were found perfect in every part. This production of picture upon picture was repeated, until, by the confusion of the superposed images, the effects of further exposure could be no longer distinguished.

"In all the experiments hitherto described, the destruction of the impressions by bromine was effected in the dark, the apparatus being situated in a room into which only a very feeble daylight was admitted. It remained to be discovered if the mixed vapour had the power of destroying the effect of light while the plate was still exposed to light, or if the vapour had the power of *suspending* or *preventing* the action of light on a daguerreotype plate. In order to determine this point, the apparatus was placed near the window of a well-lighted room, and so arranged that, during the whole time of the preparation of the plate, by exposure first to iodine and afterwards to bromine, it was exposed to full daylight, and by a mechanical arrangement, of too obvious a nature to render description necessary, the plate was withdrawn from the bromine vessel into a dark box; that is to say, it was withdrawn at the *same moment* from the influence of both light and bromine: on being placed in the *camera obscura*, plates so prepared received impressions which by mercurialization produced excellent pictures, and there was no trace of the action of any light save that of the *camera obscura*. It follows, then, that light is incapable of exerting any appreciable influence on daguerreotype plates during the time they are receiving their coatings of iodine and bromine.

"Although these experiments afford no information on the subject in reference to which they were originally undertaken, they are yet not without interest, both in their theoretical bearing and in their practical application. They demonstrate not only that the change (whatever it may be) effected by light on silver plates prepared by Daguerre's process is completely suspended in the presence of the vapour of either iodine or bromine, but that after that change has been produced the impression may be destroyed, and the plate restored to its original condition, by a momentary exposure to either of these vapours. In their practical application, these experiments show that all the care which has been taken to exclude light from daguerreotype plates during their preparation is unnecessary; that so far from a dark room being essential to the operations of the daguerreotype artist, the light of day may be allowed to fall on the plate during the whole time of its preparation; and that it is only necessary to withdraw it at the same moment from the action of bromine and light by sliding it from the bromine vessel into the dark box in which it is carried to the *camera obscura;* and where, from the situation or otherwise, there is a difficulty in observing the colour of the plate during the process of iodizing, it may be removed from the iodine vessel, and its colour examined by the direct light of the sun, without risk or injury: for when returned to the iodine or bromine vessel for a moment, the effect of light is wholly destroyed.

"Perhaps the most valuable practical application of these facts is in the use of the same plate for receiving several impressions. When, on taking the portrait or picture of any object liable to move, there is reason to suppose that the motion of the person or object has rendered the operation useless, it is not necessary to throw aside the plate on which the imperfect impression has been taken, and resort to the tedious process of cleaning and preparing another; it is only necessary to treat the plate in the manner already pointed out, and it is again equal in every respect to a newly-prepared plate; and this treatment may be repeated, until, by the slow accumulation of too thick a film of iodide of silver, the plate no longer possesses the same degree of sensitiveness to light."

The researches of M. Claudet are of considerable importance, particularly as the observation of a thoroughly practical photographic artist.

The phenomena which M. Claudet considers have not yet been satisfactorily explained, and of which he treats, are those referring to the following points:—

1. What is the action of light on the sensitive coating?

2. How does the mercurial vapour produce the daguerreotype image?

3. Which are the particular rays of light that impart to the chemical surface the affinity for mercury?

4. What is the cause of the difference in achromatic lenses between the visual and photogenic lenses? why do they constantly vary?

5. What are the means of measuring the photogenic rays, and of finding the true focus at which they produce the image?

At the meeting of the British Association at Swansea, M. Claudet expressed his opinion that the decomposition of the chemical surface of the daguerreotype plate, by the action of certain rays of light, produced on that surface a white precipitate, insoluble in the hyposulphite of soda, which, when examined by the microscope, had the appearance of crystals reflecting light, and which, when seen by the naked eye, were the cause of a positive daguerreotype image. These were probably particles of pure white silver.

The opinion of Daguerre himself, and other writers, was, that the action of light on the iodide of silver had only the effect of darkening the surface, and consequently of producing a negative image. But it escaped them, that, under the darkened iodide of silver, another action could take place after a continued exposure to light, and that the hyposulphite of soda washing could disclose a positive image. M. Claudet proved this fact in obtaining, by the action of light only, and without mercury, images having the same appearance as those developed under the action of mercurial vapour. This direct and immediate effect of light is certainly remarkable; but the daguerreotype process is not founded on that principle, on account of the slowness of its action; and it is fortunate that, long before light can produce the white precipitate alluded to, it operates another effect, which is the wonderful property of attracting the vapour of mercury. This vapour is condensed in the form of a white powder, having also, when examined by the microscope, the appearance of reflecting crystals.

It is probable that light exercises a two-fold action on the iodide of silver, whether it is combined or not with chlorine or bromine. By one, the iodide is decomposed, and the silver set free is precipitated on the surface in the form of a white powder or small crystals; by the other, which begins long before the former, the parts affected by light have been endowed with an affinity for mercurial vapour.

By means of his photographometer, this investigator has been able to ascertain that the pure light of the sun performs in about two or three seconds the decomposition of the bromo-iodide of silver, which is manifested by the white precipitate; while the same intensity of light determines the affinity for mercurial vapour in the short space of about $\frac{1}{1000}$th part of a second. So that the affinity for mercury is imparted by an intensity of light 3000 times less than that which produces the decomposition manifested by the white precipitate.

For this reason it is difficult to suppose that the two actions are the same. We must admit that they are different. Long before it can effect the decomposition of the surface, light imparts to the sensitive coating the affinity for mercurial vapour; and this appears to be the principle of the formation of the image in the daguerreotype process.

In a paper communicated to the Royal Society on the 17th of June, 1847, M. Claudet stated that the red, orange, and yellow rays were destroying the action of white light, and that the surface was recovering its former sensitiveness or unaffected state after having been submitted to the action of these rays. It was inferred from that curious fact that light could not have decomposed the surface; for if it had, it would be difficult to understand how the red, orange, or yellow rays could combine again, one with another, elements so volatile as bromine and iodine, after they had been once separated from the silver. These experiments have much in common with those of M. Edmond Becquerel, who has been led to a division of the spectrum into *exciting rays* and *continuating rays*. But he had not yet been able to ascertain that, when light has decomposed the bromo-iodide of silver, the red, orange, or yellow rays cannot restore the surface to its former state. The action of light, which can be destroyed by the red, orange, or yellow rays, does not determine the decomposition, which would require an intensity 3000 times greater; it is the kind of action produced by an intensity 3000 times less, giving the affinity for mercury, which is completely destroyed by the red, orange, or yellow rays. White light, or the chemical rays which accompany it, communicate to the surface the affinity for mercury; and the red, orange, or yellow rays withdraw it. This is in effect the same phenomenon as Dr. Wollaston observed with the tincture of gum guaiacum; one set of rays restoring the colour which another set had removed. A singular anomaly requires notice: viz. that when the sensitive surface is prepared only with iodine without bromine, the red, orange, or yellow rays, instead of destroying the action of white light, continue the effect of decomposition as well as that of affinity for mercury. Still there is a double compound of iodine which is far more sensitive than the simple compound, and on which the red, orange, or yellow rays exercise their destructive action as in the case of the bromo-iodide.

The phenomenon of the continuing action of the red, orange, or yellow rays, on the simple compound of iodide of silver, was discovered by M. Ed. Becquerel; and soon after M. Gaudin found, that not only those rays continue the action by which mercury is deposited, but that they develope without mercury an image having the same appearance as that produced by mercurial vapour.

M. Gaudin, not having observed the fact of the white precipitate, which is the result of the decomposition by the action of light, could not explain the cause of the image brought out under the influence of the yellow ray.

M. Claudet states that the iodide of silver without bromine is about 100 times more sensitive than the bromo-iodide to the action of the rays which produce the decomposition of the compound forming the white precipitate of silver, while it is 100 times less sensitive for the effect which gives the affinity for mercury. It may be that, in the case of the iodide of silver alone, the decomposition being more rapid, and the affinity for mercury slower than when bromine is added to the compound, the red, orange, or yellow rays having to act upon an incipient decomposition, have the power, by their own photogenic influence, of continuing the decomposition when it has begun. This may explain the development of the image under red, orange, or yellow glasses, according to M. Gaudin's discovery. But in the case of the bromo-iodide of silver, the red, orange, or yellow rays have to exert their action on the affinity for mercury, begun a long time before the decomposition of the compound; and they have the property of destroying that affinity.

So that it would appear that all the rays of light have the property of decomposing the iodide of silver in a longer or shorter time, as they have that of producing the affinity for mercury on the bromo-iodide of silver: with the difference, that on the former compound the separate actions of the several rays continue each other, and that on the second compound these separate actions destroy each other. We can understand that, in the first case, all the rays are capable of operating the same decomposition; and that in the second, the affinity for mercury when imparted by one ray is destroyed by another. This would explain the various phenomena of the formation of the two different deposits, and also the anomaly of the continuation of the action by the red, orange, or yellow rays, according to M. Ed. Becquerel's discoveries on the iodide of silver; and of the destruction of that action by the same rays, according to M. Claudet's observations on the bromo-iodide of silver.

The red, orange, and yellow rays, when acting on an unaffected surface, are considerably less capable than the most refrangible rays of imparting the affinity for mercurial vapour on both the iodide and bromo-iodide of silver; and they destroy that affinity when it has been produced on the bromo-iodide of silver by the photogenic rays. It follows from this fact, that when the red, orange, or yellow rays are more abundant in the light than the most refrangible rays, the photogenic effect is retarded in proportion to the excess of these antagonistic rays. This happens when there exist in the atmosphere some vapours which absorb the most refrangible rays. In these circumstances the light appears rather yellow; but it is very difficult to judge by the eye of the exact colour of the light, and of the proportion of photogenic rays existing in the atmosphere at any given moment.

The vapours of the atmosphere which render the light yellow, act as any other medium intercepting the blue rays, and those which have the same degree of refrangibility.

If we cover an engraving one-half with light yellow glass, and place it before a camera obscura, in order to represent the whole on a daguerreotype plate, we shall find that during the time which has been necessary to obtain the image of the half not covered, not the slightest effect has been produced on the half covered with the yellow glass.

Now, if we cover one-half with deep blue glass, and the other with the same light yellow glass, the engraving will be seen very distinctly through the yellow glass, and not at all through the blue. In representing the whole, as before, on the daguerreotype plate, the half which was clearly seen by the eye has produced no effect; and in the other, which could not be seen, is as fully represented, and in nearly as short a time, as when no blue glass had been interposed.

Thus we might construct a room lighted only through an inclosure of light yellow glass, in which light would be very dazzling to the eye, and in this room no photographic operation could be performed;[1] or a room inclosed by deep blue glass, which would appear very dark, and in which the photographic operation would be nearly as rapid as it would be in open air.

Thus we may conceive certain states of the atmosphere under which there will be an abundance of illuminating rays, and very few actinic rays; and some others, under which the reverse will take place. Considering how difficult it is to judge by the eye alone of the chemical state of light, we can understand why the photographer is constantly deceived in the effect he tries to produce, having no means to ascertain beforehand, with any degree of certainty, the intensity of light. For these reasons M. Claudet turned his attention to contrive an apparatus by which he could test at the same time the sensitiveness of the daguerreotype plate and the intensity of light. This instrument he called a Photographometer.

"By this instrument," says the inventor, "I have been able to discover at what degree of intensity of light the effect called solarization is produced: on well-prepared plates of bromo-iodide it does not begin under an intensity 512 times greater than that which determines the first effect of mercury; and also at what degree the decomposition producing the white precipitate without mercury manifests itself, both on iodide and on bromo-iodide of silver. On the first, it is 100 times quicker than on the bromo-iodide; and on the last it is produced by an intensity 3000 times greater than that which developes the first affinity for mercury.

"In the course of my experiments I noticed a curious fact, which proved very puzzling to me, until I succeeded in assigning a cause to it. I shall mention it here, because it may lead to some further discoveries. I observed that sometimes the spaces under the round holes, which had not been affected by light during the operation of the photographometer in a sufficient degree to determine the deposit of mercury, were, as was to be expected, quite black; while the spaces surrounding them were in an unaccountable manner slightly affected by mercury. At first I could not explain the phenomenon, except by supposing

[1] I have recently proved that this statement requires some modification; the rays permeating yellow glasses act powerfully on the sensitive surfaces of collodion and iodine.

that the whole plate had been previously by accident slightly affected by light, and that the exposure through the holes to another sort of light had destroyed the former effect. I was naturally led to that explanation, having before observed that one kind of light destroys the effect of another; as, for example, that the effect of the light from the north is destroyed by the light from the south, when certain vapours existing in the latter portion of the atmosphere impart a yellow tint to the light of the sun. But after repeated experiments, taking great care to protect the plate from the least exposure to light, and recollecting some experiments of M. Moser, (see Chapter on Thermography,) I found that the affinity for mercury had been imparted to the surface of the daguerreotype plate by the contact of the metallic plate having the round holes, while the space under the hole had received no similar action. But it must be observed that this phenomenon does not take place every time; some days it is frequent, and in some others it does not manifest itself at all. Considering that the plate furnished with round holes is of copper, and that the daguerreotype plate is of silver plated on copper, it is probable that the deposit of mercury is due to an electric or galvanic action determined by the contact of the two metals; and perhaps the circumstance that the action does not take place every time, will lead to the supposition that it is developed by some peculiar electric state of the ambient atmosphere; and by a degree of dampness in the air which would increase the electric current. May we not hope that the conditions being known in which the action is produced, and by availing ourselves of that property, it will be possible to increase on the daguerreotype plate the action of light? for it is not improbable that the affinity for mercury imparted to the plate is also due to some electrical influence of light. How could we otherwise explain that affinity for mercury given by some rays and withdrawn by some others, long before light has acted as a chemical agent?

"The question of the actinic focus is involved in another kind of mystery, which requires some attention. I have found that with the same lenses there exists a constant variation in the distance between the two foci. They are never in the same relation to each other: they are sometimes more or less separate; in some lights they are very distant, and in some others they are very near, and even coincide. For this reason I constantly try their position before I operate. I have not been able to discover the cause of that singular phenomenon, but I can state positively that it exists. At first, I thought that some variations in the density or dispersive power of the atmosphere might produce the alteration in the distance between the two foci; or that when the yellow rays were more or less abundant, the visual rays were refracted on different points on the axis of the foci, according to the mean refrangibility of the rays composing white light at the moment. But a new experiment has proved to me that these could not be the real causes of the variation. I generally employ two object-glasses; one of shorter focus for small pictures, and the other of longer focus for larger images. In both, the actinic focus is longer than the visual focus; but when they are much separated in one they are less so in the other: sometimes, when they coincide in one, they are very far apart in the other, and sometimes they both coincide. This I have tried every day during the last twelve months, and I have always found the same variations. The density of the atmosphere, or the colour of light, seems to have nothing to do with the phenomenon, otherwise the same cause would produce the same effect in both lenses. I must observe, that my daily experiments on my two object-glasses are made at the same moment and at the same distance for each, otherwise any alteration in the focal distance would disperse, more or less, the actinic rays, which is the case, as it is easy to prove. The lengthening or shortening the focus, according to the distance of the object to be represented, has for effect to modify the achromatism of the lenses. An optician, according to M. Lerebours' calculation, can at will, in the combination of the two glasses composing an achromatic lens, adapt such curvatures or angles in both that the visual focus shall coincide with the actinic focus; but he can obtain this result only for one length of focus. The moment the distance is altered, the two foci separate, because the visual and actinic rays must be refracted at different angles in coming out of the lens, in order to meet at the focus given for one distance of the object. If the distance is altered, the focus becomes longer or shorter; and as the angle at which different rays are refracted remains nearly the same, they cannot meet at the new focus, and they form two images. If the visual and actinic rays were refracted parallel to each other, in coming out of the lens they would always coincide for every focus; but this is not the case. It seems, therefore, impossible that lenses can be constructed in which the two foci will agree for all the various distances, until we have discovered two kinds of glasses in which the densities or the refractive power will be in the same ratio as the dispersive power."

The experiments of Mr. Stokes, to which reference has already been made, appear to prove a set of conditions, new to our knowledge, which promise to remove many of the anomalies with which M. Claudet and others have attempted the solution. The extension of the luminous image beyond the limit of the chemical spectrum, a set of new colours, which are with great difficulty made to permeate some media of apparently high transparency, are among the very important discoveries of this eminent analyst.

The author may be allowed to mention here, for the benefit of those who are disposed to pursue this class of researches, that he has just communicated (September, 1852) to the British Association at Belfast, some experiments on the chemical spectra, as obtained after the solar rays have been made to permeate coloured media. Some of the results are of a very remarkable kind, and promise to elucidate many points in connection with the chemical action of the sun's rays, which are at present involved in much obscurity.

CHAPTER IV.

ON THE PHOTOGRAPHIC REGISTRATION OF PHILOSOPHICAL INSTRUMENTS AND THE MEANS OF DETERMINING THE VARIATIONS OF ACTINIC POWER, AND FOR EXPERIMENTS ON THE CHEMICAL FOCUS.

SECTION I.—PHOTOGRAPHIC REGISTRATION.

THERE are so many advantages attendant on self-registration, as to make the perfection of it a matter of much interest to every scientific enquirer. The first who suggested the use of photographic paper for this purpose was Mr. T. B. Jordan, who brought the subject before a committee of the Royal Cornwall Polytechnic Society, on the 18th of February, 1839, and exhibited some photographic registers on the 21st of March of the same year. The plan this gentleman adopted was to furnish each instrument with one or two cylinders containing scrolls of photographic paper. These cylinders are made to revolve slowly by a very simple connection with a clock, so as to give the paper a progressive movement behind the index of the instrument, the place of which is registered by the representation of its own image.

The application of this principle to the barometer or thermometer is most simple; the scale of either of these instruments being perforated, the paper is made to revolve as close as possible to the glass, in order to obtain a well-defined image. The cylinder being made to revolve on its axis once in forty-eight hours, the paper is divided into forty-eight parts by vertical lines, which are figured in correspondence with the hour at which they respectively arrive at the tubes of the instruments. The graduations on the paper correspond to those on the dial of the barometer or scale of the thermometer, and may be printed on the paper from a copperplate, or, what is much better, may be printed by the light at the same time from opaque lines on the tube, which would of course leave a light impression on the paper: by this means we should have all that part of the paper above the mercury darkened, which would at the same time be graduated with white lines, distinctly marking the fluctuations in its height for every minute during daylight, and noting the time of every passing cloud.

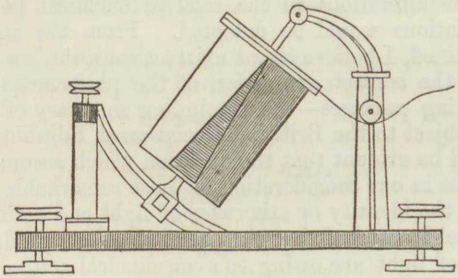
Mr. Jordan has also published an account of his very ingenious plan of applying the same kind of paper to the magnetometer or diurnal variation needle,[1] and several other philosophical instruments; but as these applications were not at the time entirely successful, owing principally to the difficulty of finding a suitable situation for so delicate an instrument, it is thought unnecessary to occupy these pages with any particular description of the arrangements adopted, which, however, were in all essential points similar to those employed by Mr. Ronalds, and adopted in some of our magnetic and meteorological observatories. Those of Mr. Brooks are of somewhat more refined a character, and require special notice.

A reflector is attached to the end of a delicately suspended magnet; this reflects a pencil of strong artificial light upon photographic paper placed between two cylinders of glass, which are kept in motion by a small clock arrangement. As the paper moves in a vertical direction whilst the magnet oscillates in a horizontal one, a zigzag line is marked on the paper; the extent of movement on either side of a fixed line showing the deviation of the magnet for every hour of the day. By means of this arrangement many most remarkable phenomena connected with terrestrial magnetism have been discovered, and since the methods of adjustment have been rendered more perfect, and the invention applied to a great variety of instruments, we may hope for yet more important results.

The registration of the ever-varying intensity of the light is so important a subject, that it has occupied the attention of several eminent scientific observers. Sir John Herschel and Dr. Daubeny have applied their talents to the inquiry, and devised instruments of much ingenuity for the purpose. The instrument constructed by Sir John Herschel, which he has named an *actinograph*, not only registers the *direct* effect of solar chemical radiation, but also the amount of general actinic power in the visible hemisphere; one portion of the apparatus being so arranged that a sheet of sensitive paper is slowly moved in such a direction, that the direct rays of the sun, when unobscured, may fall upon it through a small slit made in an outer cylinder or case, while the other is screened from the incident beam. The paper being fixed on a disc of brass, made to revolve by watch-work, is affected only by the light which "emanates from that definite circumpolar region of the sky to which it may be considered desirable to limit the observation," and which is admitted, as in the other case, through a fine slit in the cover of the instrument.

[1] See the Sixth Annual Report of the Royal Cornwall Polytechnic Society.

Mr. Jordan has devised an instrument for numerically registering the intensity of the incident beam, which appears to have some peculiar advantages; a description of which I shall take the liberty of transcribing. Figure 19 is an elevation of the instrument: it consists of two copper cylinders supported on a metal frame: the interior one is fixed to the axis and does not revolve, being merely the support of the prepared paper; the exterior cylinder is made to revolve about this once in



19.

twenty-four hours by a clock movement. It has a triangular aperture cut down its whole length, as shown in the figure, and it carries the scale of the instrument, which is made to spring closely against the prepared paper. This scale or screen is composed of a sheet of metal foil between two sheets of varnished paper, and is divided into one hundred parts longitudinally, every other part being cut out, so as to admit the light to the prepared paper without any transparent medium intervening. The lengths of the extreme divisions, measuring round the cylinder, are proportioned to each other as one to one hundred; consequently the lower division will be one hundred times longer passing over its own length than the upper one over its own length, and the lines of prepared paper upon these divisions will, of course, be exposed to the light for times bearing the same proportion to each other.

Now, as the sensitiveness of the paper can readily be adjusted, so that the most intense light will only just tint it through the upper division during *its passage* under the opening, and the most feeble light will produce a similar tint through the lower division during *its passage*, the number of lines marked on the paper at any given time will furnish a comparative measure of the intensity of solar light at that time, and may be registered as so many degrees of the *Heliograph*, the name Mr. Jordan has given his instrument, just as we now register the degrees of the thermometer.

An instrument of this kind was made by me for the British Association, and experiments carried on with it, at intervals, for some years. Many of the results were very curious, but the instrument being placed at the Observatory at Kew, the observations were unfortunately discontinued. It is believed that, with an instrument properly constructed, the details of the one employed were capable of much improvement; many very remarkable alterations in the relative chemical power of the solar radiations would be detected. From the indications I have obtained, I believe there exists a constant law of change, and that the correct expression of the phenomena is given in the following passages—the concluding summary of my Report on this subject to the British Association at Edinburgh:—

"It will be evident that the question which assumes the most prominence in our consideration of these remarkable phenomena is that of the identity or otherwise of light and actinism.

"Fresnel has stated that the chemical effects produced by the influence of light are owing to a mechanical action exerted by the molecules of æther on the atoms of bodies, so as to cause them to assume new states of equilibrium dependent on the nature and on the velocity of the vibrations to which they are subjected.

"Arago says, it is by no means proved that the photogenic modifications of sensitive surfaces result from the action of solar light itself. These modifications are perhaps engendered by invisible radiations mixed with light properly so called, proceeding with it, and being similarly refracted.

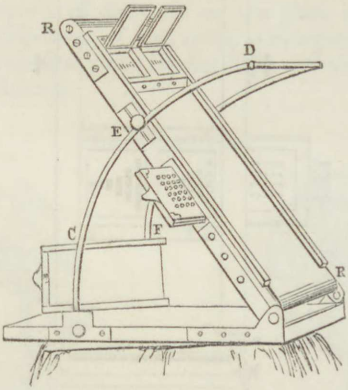
"These views fairly represent the condition in which the argument stands, and a yet more extensive set of experiments seems to be necessary before we can decide the question. It appears, however, important that we should dismiss, as completely as possible, from our minds, all preconceived hypotheses. The phenomena were all unknown when the theories of emission and of undulation were framed and accepted in explanation of luminous effects; and it will only retard the discovery of the truth, if we prosecute our researches over this new ground, with a determination to bend all our new facts to a theory which was framed to explain totally dissimilar phenomena."

SECTION II.—INSTRUMENTS FOR MEASURING ACTINIC VARIATIONS, &c.

THE PHOTOGRAPHOMETER.

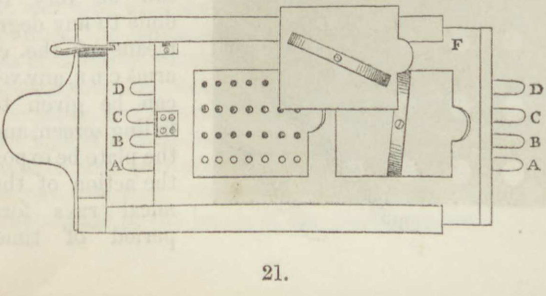
M. Claudet has devised the Photographometer and the Dynactinometer for measuring the intensity of the actinic radiations. These are both most ingenious instruments, the operations of which will be rendered intelligible by the following description:—

The accompanying figure (20) shews the photographometer complete. The sensitive plate or paper is placed in a dark box,



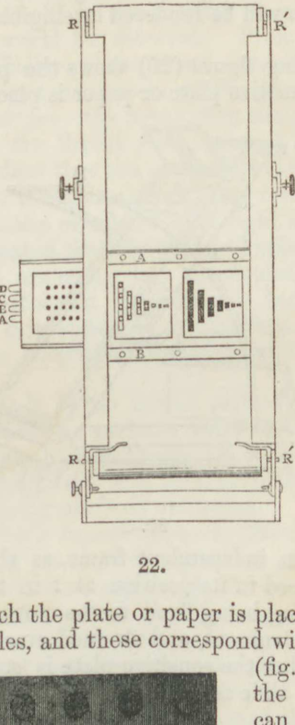
20.

which is fixed in an independent frame, as shewn in Figs. 21 and 22, and as placed in its position at F in the adjoining cut. A black silk webbing being fixed to the moveable plate seen at the head of the instrument, and strained over two rollers, R, R, it will be evident that the sensitive plate is screened from light until the moveable slide falling down the inclined plane passes



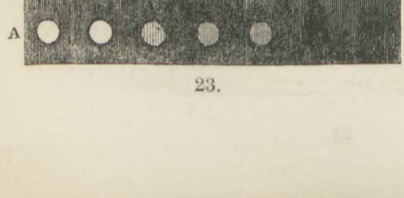
21.

over it. The openings in this moveable plate are parallel to each other. They are seven in number, each opening being one-half of the following one, and double that of the preceding one. Thus, after the operation of the light, we have seven separate images, the different intensities of which represent the action of light during the intervals of time in the geometric progression of—1 : 2 : 4 : 8 : 16 : 32 : 64.



22.

The box in which the plate or paper is placed for experiment, is pierced with holes, and these correspond with the slits in A B. (fig. 23). By inclining the instrument, which can be very readily done to any degree by means of the curved arms C D E, any velocity can be given to the falling screen, and thus the plate be exposed to the action of the chemical rays for any period of time we

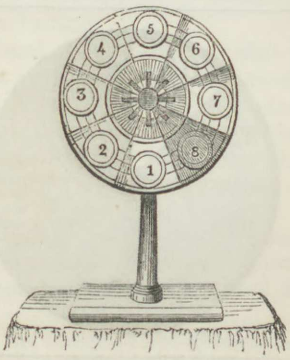


23.

please. Fig. 22 shows the result obtained on a plate by this instrument; the letters corresponding with the holes in the other woodcuts. In Fig 23 the screen with the vertical slits is shewn at the moment it is supposed to be passing over the holes A B C D. In this example the plate had been exposed to the vapour of iodine, in such a manner that one zone had attained the first coating of yellow colour; a second zone had reached the red; a third the blue and green; and a fourth having passed through all these tints, had obtained the second yellow coating. The number of white circular spots on each vertical zone indicates the degree of sensitiveness of the various coatings; the less sensitive being the first coating of yellow, D, and the most sensitive the second yellow coating, A. This is shewn by the deposit of mercury on the plate represented by the increased whiteness of the spots corresponding with the holes, each four vertical spots having been exposed for the same time to solar influence.

THE FOCIMETER.

24.

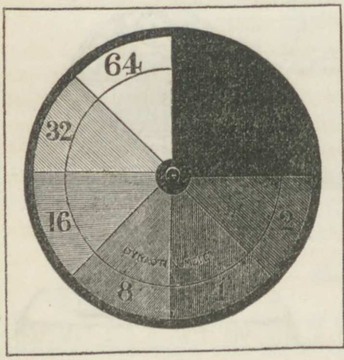


25.

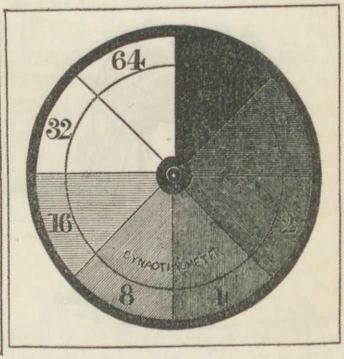
M. Claudet has also devised a very ingenious instrument for focusing, which he calls his Focimeter. (Fig. 24.) This it will be seen from the accompanying woodcut consists merely of segments of a circle, numbered and placed at fixed distances apart, upon a moveable axis. This is copied by the camera on a plate or paper, and the result is shewn in the annexed figure (25), in which it will be seen different degrees of effect are supposed to have been produced. These determine the best focal point for any lens very readily, and it is really a most useful piece of apparatus in the hands of the photographer.

THE DYNACTINOMETER.

The Dynactinometer is thus described by the inventor:—It consists of a thin metallic disc, perfectly black, having a slit extending from its centre to the circumference, fixed on an axis revolving through a permanent metallic disc, perfectly white. The white disc has also a slit from its centre of the exact length of the radius of the black disc; and by means of these two slits, which are so adjusted that the black disc can intersect the white disc, and by revolving, gradually cover the whole white area, the space of the white surface on which the black disc can be superposed forms itself a sort of dial, which is divided into any number of equal segments, all numbered. The inventor has adopted the number of twenty segments for a large circle inscribed on the dial, and of eight segments for a smaller circle, after the manner of the divisions of the Focimeter, but on the same plane. These eight segments are numbered in geometrical progression, 1, 2, 4, 8, 16, 32, 64.



26.



27.

The black disc may be made to revolve in such a manner that it shall cover a new segment of the large circle during each second, or any other equal fraction of time. By that means the last segment will have received eight times more light than the first, the black disc having moved over the whole in eight seconds.

The differences of photogenic intensities are hardly observable when they follow the arithmetical progression: the instrument is so constructed that it may indicate the intensities in the geometrical progression. The first segment remains always covered, in order to be represented black on the daguerreotype plate and mark the zero of intensity: the second is exposed to light during 1′, the third during 2″, the fourth during 4″, the fifth during 8″, the sixth during 16″, the seventh during 32″, and the eighth during 64″. This series, which could be extended by dividing the circle into a greater number of segments, is quite sufficient for all observations intended for practically measuring the intensity of the photogenic light, and for comparing the power of object-glasses.

The instrument is made to move by applying the hand on a handle fixed on the back at the extremity of the axis on which the disc revolves. An operator accustomed to count seconds by memory, or by following a seconds' beater, can perform the experiment with sufficient regularity; but in order to render the instrument more exact and more complete, it can be made to revolve by clock-work, which gives it at will either the arithmetical or the geometrical progression. This last movement presented some difficulty; but the inventor has been able to obtain it without much complication in the machinery, and the apparatus is within the reach of the greater number of operators having establishments on a complete footing.

For the instrument moving by hand, it is necessary that a second person should open and shut the object-glass at a given signal. But in adapting before the object-glass a flap connected with a cord and pulley, the operator, holding the cord in the left hand, can open the flap at the moment that with the right hand he makes the disc revolve, and shut the apparatus when the revolution is complete.

When the instrument acts by clock-work, the object-glass may be opened and shut by the same means, at the signal given by a bell which strikes at the commencement and at the end of the revolution.

If a daguerreotype plate receive the image of the dynactinometer during its revolution, it is obvious that each segment indicates an effect in proportion to the intensity of light and to the time that it has remained uncovered; also that the number of seconds marked on the first segment visible is the measure of the intensity of light at the moment of the experiment; the effect of each segment being in reality the degree of intensity which can be obtained during the corresponding time.

When we want to compare two object-glasses, they are adapted to two cameræ obscuræ placed before the dynactinometer. After having set the focus of the two apparatus, they are charged each with a daguerreotype plate or a photogenic paper. When all is ready, the flaps are opened at the moment that the dynactinometer commences its revolution, and they are shut when it is completed. The plates are removed and the images brought out. In comparing the result produced on each, it is easy to see which object-glass is the most rapid, and in what proportion. For instance, if the arithmetical progression has been followed, and on one of the plates or papers the number 4 of the great circle is the first visible, the conclusion is that it has been necessary for the intensity of the light at that moment to operate during four seconds in order to produce an effect in the camera obscura; and if, on the other plate or paper, the first seven segments have remained black, and the eighth segment is the first upon which the light has operated, the conclusion will be that the object-glass which has produced the effect on the first plate or paper has double the photogenic power of the other.

But if the geometrical progression has been followed, the same experiment will show the image of the segment No. 3 represented on one plate, and that of the segment No. 4 on the other, as having each the first degree of intensity: and we have to draw the same conclusion as regards the power of each object-glass.

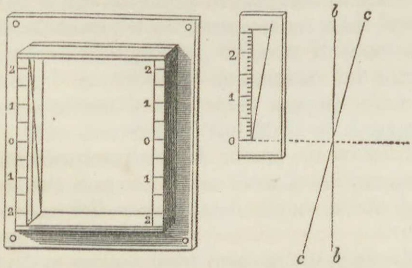
However, this conclusion would be exact only on the supposition that the two plates were endowed with the same degree of sensitiveness: for if they had not been prepared identically in the same manner, we could not have the exact measure of the comparative power of the two object-glasses. The difference might be due, not to any difference in the power of the object-glasses, but to the inequality in the sensitiveness of the two plates; although, in repeating the experiment several times, the mean result might be sufficiently conclusive. But this difficulty has not escaped the inventor, and he has tried to avoid it. Being able, by means of the photographometer, to compare the sensitiveness of two plates under the action of the same intensity of light, and during the same space of time, he availed himself of this instrument to determine beforehand the comparative sensitiveness of the plates which are to be used in the experiment with the dynactinometer. By this means we can try beforehand several couples of plates, and keep them as it were stamped with their degree of sensitiveness until we want to apply them to test the power of two lenses. The impression is made on one-half of the plate, leaving the other half for the image of the dynactinometer.

After having operated in the two cameræ obscuræ, each supplied with the lenses the power of which we wish to compare, we submit the two plates, each impressed with both the photographometer and dynactinometer, to the vapour of mercury, which developes the two images on each plate.

The number of spots given by the photographometer, Fig. 20, will indicate the sensitiveness of the plate; and in comparing the two images given by the dynactinometer, Fig. 26, 27, accounting for the difference of sensitiveness of each plate, if there is any, we are able at once to determine the comparative power of the two lenses.

For the practical investigation of this very important photographic question, Mr. Knight has devised an apparatus that will be most valuable as affording the means of adjusting readily to the best focal distance.

Mr. Knight's apparatus consists in a frame having two grooves; one vertical, in which he places the ground glass, and



28.

the other forming an angle with the first destined to receive the plate: the planes of the grooves intersect each other in the middle. After having set the focus upon the ground glass, this last is removed, and the plate is placed in the inclined groove. Now, if a newspaper, or any large printed sheet, is put before the camera, the image will be represented on the inclined plate; and it is obvious in its inclination the various points of the plate will meet a different focus. The centre of the plate will coincide with the visual focus; by its inclination it will in one direction meet the photogenic focus at a point more or less distant from the centre, if the photogenic focus is shorter than the visual focus, and in the other direction if it is longer. The frame is furnished with a scale of division, having the zero in the centre. When the image is represented on the daguerreotype, by applying against it another moveable scale of division similar to the other, the operator can find what is the division above or under zero, at which the image seems best defined; and after having removed from the camera the experiment frame, and set the focus as usual on the ground glass, he has only to move the tube of the object-glass by means of the rack and pinion, and to push it in or out; a space corresponding with the division of the scale indicating the deviation of the true photogenic focus: the tube of the object-glass is for that purpose marked with the same scale of division.

CHAPTER V.

THERMOGRAPHY.

The curious nature of the results obtained by heat radiations, associated as they are with the chemical action of the solar rays, induces me to introduce the subject in this treatise on Photography, merely reprinting my original communication on the subject, as the investigations have not been continued.

The Journal of the Academy of Sciences of Paris, for the 18th of July, 1842, contained a communication made by M. Regnault from M. Moser, of Königsberg, "Sur la Formation des Images Daguerriennes;"[1] in which he announced the fact, that "*when two bodies are sufficiently near, they impress their images upon each other.*" The Journal of the 29th of August contained a second communication from M. Moser, in which the results of his researches are summed up in twenty-six paragraphs. From these I select the following, which alone are to be considered on the present occasion:—

"9. All bodies radiate light even in complete darkness.

"10. This light does not appear to be allied to phosphorescence, for there is no difference perceived whether the bodies have been long in the dark, or whether they have been just exposed to daylight, or even to direct solar light.

"11. Two bodies constantly impress their images on each other, even in complete darkness.

"14. However, for the image to be appreciable, it is necessary, because of the divergence of the rays, that the distance of the bodies should not be very considerable.

"15. To render the image visible, the vapour of water, mercury, iodine, &c., may be used.

"17. There exists *latent light* as well as latent heat."

The announcement at a meeting of the British Association of these discoveries, naturally excited a more than ordinary degree of interest. A discovery of this kind, changing, as it did, the features, not only of the theories of light adopted by philosophers, but also the commonly received opinions of man-

[1] Comptes Rendus, tome xv., No. 3, folio 119.

kind, was more calculated to awaken attention than anything which has been brought before the public since the publication of Daguerre's beautiful photographic process. Having instituted a series of experiments, the results of which appear to prove that these phenomena are not produced by *latent light*, I am desirous of recording them.

I would not be understood as denying the absorption of light by bodies; of this I think we have abundant proof, and it is a matter well deserving attention. If we pluck a nastertium when the sun is shining brightly on the flower, and carry it into a dark room, we shall still be enabled to see it, by the light which it emits.

The human hand will sometimes exhibit the same phenomenon, and many other instances might be adduced in proof of the absorption of light; and I believe, indeed, of the principle that light is latent in bodies. I have only to show that the conclusions of M. Moser have been formed somewhat hastily, being led, no doubt, by the striking similarity which exists between the effects produced on the daguerreotype plates under the influence of light, and by the juxtaposition of bodies in the dark, to consider them as the work of the same element.

1. Dr. Draper, in the Philosophical Magazine for September 1840, mentions a fact which has been long known,—" That if a piece of very *cold* clear glass, or, what is better, a *cold* polished metallic reflector, has a little object, such as a piece of metal, laid on it, and the surface be breathed over once, the object being then carefully removed, as often as you breathe on it again, a spectral image of it may be seen, and this phenomenon may be exhibited for many days after the first trial is made." Several other similar experiments are mentioned, all of them going to show that some mysterious molecular change has taken place on the metallic surface, which occasions it to condense vapours unequally.

2. On repeating this simple experiment, I find that it is necessary for the production of a good effect to use dissimilar metals; for instance, a piece of gold or platina on a plate of copper or of silver will make a very decided image, whereas copper or silver on their respective plates gives but a very faint one, and bodies which are bad conductors of heat, placed on good conductors, make decidedly the strongest impressions when thus treated.

3. I placed upon a well-polished copper plate, a sovereign, a shilling, a large silver medal, and a penny. The plate was gently warmed, by passing a spirit-lamp along its under surface: when cold, the plate was exposed to the vapour of mercury:

each piece had made its impression, but those made by the gold and the large medal were more distinct; not only was the disc marked, but the lettering on each was copied.

4. A bronze medal was supported upon slips of wood, placed on the copper, one eighth of an inch above the plate. After mercurialisation, the space the medal covered was well marked, and, for a considerable distance around, the mercury was unequally deposited, giving a shaded border to the image; the spaces touched by the mercury [?] were thickly covered with the vapour.

5. The above coins and medals were all placed on the plate, and it was made too hot to be handled, and allowed to cool without their being removed; impressions were made on the plate in the following order of intensity,—gold, silver, bronze, copper. The mass of the metal was found to influence materially the result; a large piece of copper making a better image than a small piece of silver. When this plate was exposed to vapour, the results were as before. On rubbing off the vapour, it was found that the gold and silver had made permanent impressions on the copper.

6. The above being repeated with a still greater heat, the image of the copper coin was, as well as the others, most faithfully given, but the gold and silver only made permanent impressions.

7. A *silvered* copper plate was now tried with a moderate warmth. Mercurial vapours brought out good images of the gold and copper; the silver marked, but not well defined.

8. Having repeated the above experiments many times with the same results, I was desirous of ascertaining if electricity had any similar effect: powerful discharges were passed through and over the plate and discs, and it was subjected to a long-continued current without any effect. The silver had been cleaned off from the plate; it was now warmed with the coins and medals upon it, and submitted to discharges from a very large Leyden jar: on exposing it to mercurial vapour, the impressions were very prettily brought out, and, strange to say, spectral images of those which had been received on the plate when it was silvered. Thus proving, that the influence, whatever it may be, was exerted to some depth in the metal.

9. I placed upon a plate of copper, blue, red, and orange-coloured glasses, pieces of crown and flint glass, mica, and a square of tracing paper. These were allowed to remain in contact half an hour. The space occupied by the red glass was well marked; that covered by the orange was less distinct, but the blue glass left no impression; the shapes of the flint and crown

glass were well made out, and a remarkably strong impression where the crown glass rested on the tracing paper, but the mica had not made any impression.

10. The last experiment repeated. After the exposure to mercurial vapour, heat was again applied to dissipate it: the impression still remained.

11. The experiment repeated, but the vapour of iodine used instead of that of mercury. The impressions of the glasses appeared in the same order as before, but also a very beautiful image of the mica was developed, and the paper well marked out, showing some relation to exist between the substances used and the vapours applied.

12. Placed the glasses used above, with a piece of well-smoked glass, for half an hour, one twelfth of an inch below a polished plate of copper. The vapour of mercury brought out the image of smoked glass only.

13. All these glasses were placed on the copper, and slightly warmed: red and smoked glasses gave, after vaporisation, equally distinct images, the orange the next, the others left but faint marks of their forms; polishing with Tripoli and putty powder would not remove the images of the smoked and red glasses.

14. An etching, made upon a smoked etching ground on glass, the copper and glass being placed in contact. The image of the glass only could be brought out.

15. A design cut out in paper was pressed close to a copper plate by a piece of glass, and then exposed to a gentle heat; the impression was brought out by the vapour of mercury in beautiful distinctness. On endeavouring to rub off the vapour, it was found that all those parts which the paper covered amalgamated with mercury, which was rubbed from the rest of the plates: hence there resulted a perfectly white picture on a polished copper plate.

16. The coloured glasses before named were placed on a plate of copper, with a thick piece of charcoal, a copper coin, the mica, and the paper, and exposed to fervent sunshine. Mercurial vapour brought up the images in the following orders: smoked glass, crown glass, red glass, mica beatifully delineated, orange glass, paper, charcoal, the coin, blue glass: thus distinctly proving that the only rays which had any influence on the metal were the calorific rays. This experiment was repeated on different metals, and with various materials, the plate being exposed to steam, mercury, and iodine: I invariably found that those bodies which absorbed or permitted the permeation of the most heat gave the best images. The blue and violet rays

could not be detected to leave any evidence of action, and as spectra imprinted on photographic papers by light, which had permeated these glasses, gave evidence of the large quantity of the invisible rays which passed them freely, we may also consider those as entirely without the power of effecting any change on compact simple bodies.

17. In a paper which I published in the *Philosophical Magazine* for October 1840, I mentioned some instances in which I had copied printed paper and engravings on iodized paper by mere contact and exposure to the influence of calorific rays, or to artificial heat. I then, speculating on the probability of our being enabled, by some such process as the one I then named, to copy pictures and the like, proposed the name of THERMOGRAPHY, to distinguish it from Photography.

18. I now tried the effects of a print in close contact with a well-polished copper plate. When exposed to mercury, I found that the outline was very faithfully copied on the metal.

19. A paper ornament was pressed between two plates of glass, and warmed; the impression was brought out with tolerable distinctness on the under and warmest glass, but scarcely traceable on the other.

20. Rose leaves were faithfully copied on a piece of tin plate, exposed to the full influence of sunshine; but a much better impression was obtained by a prolonged exposure in the dark.

21. With a view of ascertaining the distance at which bodies might be copied, I placed upon a plate of polished copper a thick piece of plate-glass, over this a square of metal, and several other things, each being larger than the body beneath. These were all covered by a deal box, which was more than half an inch distant from the plate. Things were left in this position for a night. On exposing to the vapour of mercury, it was found that each article was copied, the bottom of the deal box more faithfully than any of the others, the grain of the wood being imaged on the plate.

22. Having found, by a series of experiments, that a blackened paper made a stronger image than a white one, I very anxiously tried to effect the copying of a printed page or a print. I was partially successful on several metals; but it was not until I used copper plates amalgamated on one surface, and the mercury brought to a very high polish, that I produced anything of good promise. By carefully preparing the amalgamated surface of the copper, I was at length enabled to copy from paper, line-engravings, woodcuts, and lithographs, with surprising accuracy. The first specimens produced exhibited a minuteness of detail and sharpness of outline quite equal to

the early daguerreotypes and the photographic copies prepared with the chloride of silver.

The following is the process adopted by me, which I consider far from perfect, but which affords us very delicate images:—

A well-polished plate of copper is rubbed over with the nitrate of mercury, and then well washed to remove any nitrate of copper which may be formed; when quite dry, a little mercury taken up on soft leather or linen is well rubbed over it, and the surface worked to a perfect mirror.

The sheet to be copied is placed smoothly over the mercurial surface, and a sheet or two of soft clean paper being placed upon it, is pressed into equal contact with the metal by a piece of glass, or flat board: in this state it is allowed to remain for an hour or two. The time may be considerably shortened by applying a very gentle heat for a few minutes to the under surface of the plate. The heat must on no account be so great as to volatilise the mercury. The next process is to place the plate of metal in a closed box, prepared for generating the vapour of mercury. The vapour is to be slowly evolved, and in a few seconds the picture will begin to appear; the vapour of mercury attacks those parts which correspond to the white parts of the printed page or engraving, and gives a very faithful but somewhat indistinct image. The plate is now removed from the mercurial box, and placed into one containing iodine, to the vapour of which it is exposed for a short time: it will soon be very evident that the iodine vapour attacks those parts which are free from mercurial vapour, blackening them. Hence there results a perfectly black picture, contrasted with the grey ground formed by the mercurial vapour. The picture being formed by the vapours of mercury and iodine, is of course in the same state as a daguerreotype picture, and is readily destroyed by rubbing. From the depth to which I find the impression made in the metal, I confidently hope to be enabled to give to these singular and beautiful productions a considerable degree of permanence, so that they may be used by engravers for working on.

It is a curious fact that the vapours of mercury and of iodine attack the plate differently; and I believe it will be found that vapours have some distinct relation to the chemical or thermo-electrical state of the bodies upon which they are received. Moser has observed this, and attributes the phenomena to the colours of the rays, which he supposes to become latent in the vapour on its passing from the solid into the more subtile form. I do not, however, think this explanation will agree with the results of experiments. I feel convinced that we have to do with some thermic influence, and that it will eventually be found that some purely calorific excitement produces a molecular change, or that a thermo-electric action is induced which effects some change in the polarities of the ultimate atoms of the solid.

These are matters which can only be decided by a series of well-conducted experiments; and, although the subject will not be laid aside by me, I hope the few curious and certainly important facts which I have brought before you will elicit the attention of those whose leisure and well-known experimental talents qualify them in the highest degree for the interesting research into the action of those secret agents which exert so powerful an influence over the laws of the material creation. Although attention was called to the singular manner in which vapours disposed themselves on plates of glass and copper, two years since, by Dr. Draper, Professor of Chemistry at New York, and about the same time to the calorific powers of the solar spectrum, by Sir John Herschel,[1] and to the influence of heat artificially applied, by myself, yet it is certainly due to M. Moser, of Königsberg, to acknowledge him to be the first who has forcibly called the attention of the scientific world to an inquiry which promises to be as important in its results as the discovery of the electropile by Volta.

As to the practical utility of this discovery, when we reflect on the astonishing progress made in the art of Photography since Mr. Fox Talbot published his first process, what may we not expect from Thermography, the first rude specimens of which exhibit far greater perfection than the early efforts of the sister art?

As a subject of purely scientific interest, thermography promises to develope some of those secret influences which operate in the mysterious arrangements of the atomic constituents of matter, to shew us the road into the yet hidden recesses of nature's works, and enable us to pierce the mists which at present envelope some of the most striking phenomena which the penetration and industry of a few "chosen minds" have brought before our obscured visions. In connection with photography, it has made us acquainted with subtile agencies working slowly but surely, and indicated physical powers beyond those which are already known to us, which may possibly belong to a more exalted class of elements, or powers, to which Light, Heat, and Electricity, are subsidiary in the great phenomena of Nature.

[1] Philosophical Transactions, Part I., 1840, p. 50.

CHAPTER VI.

ON THE POSSIBILITY OF PRODUCING PHOTOGRAPHS IN THEIR NATURAL COLOURS.

Few speculations are more replete with interest than that of the probability of our succeeding in the production of photographic images in their local colours. M. Biot, a great authority, says,—"Substances of the same tint may present, in the quantity, or the nature of the radiations which they reflect, as many diversities, or diversities of the same order, as substances of a different tint; inversely, they may be similar in their property of reflecting chemical radiations when they are dissimilar to the eye; so that the difference of tint which they present to the eye may entirely disappear in the chemical picture. These are the difficulties inherent in the formation of photographic pictures, and they show, I think, evidently, the illusion of the experimenters who hope to reconcile, not only the intensity, but the tints of the chemical impressions produced by radiation, with the colours of the objects from which these rays emanate." It may be remembered that two years since, Sir John Herschel succeeded in procuring upon photographic paper *a coloured image* of the solar spectrum; and that eminent inquirer has communicated to me a recent discovery of great interest, which I have his permission to publish. "I have got specimens of paper," says Sir John Herschel, "*long kept*, which give a considerably better representation of the spectrum in its *natural colours* than I had obtained at the date of my paper (February 1840), and that *light* on a *dark ground;* but at present I am not prepared to say that this will prove an available process for coloured photographs, *though it brings the hope nearer.*" Here we have the speculations of one philosopher representing the production of such pictures as hopeless, while the experiments of another prove these to be within the range of probabilities.

My own experiments have, in many instances, given me coloured pictures of the prismatic spectrum, *dark* upon *a light ground*, but the most beautiful I have yet obtained has been upon the daguerreotype iodidated tablets, on which the colours have, at the same time, had a peculiar softness and brilliancy. Daguerre himself has remarked, that when he has been copying any red brick or painted building, the photograph has assumed a tint of that character. I have often observed the same thing in each variety of photographic material, *i. e.*, where a salt of silver has been used. In the *Philosophical Magazine* for April 1840, will be found a paper,—" Experiments and Observations on Light which has permeated Coloured Media,"—in which I describe some curious results on some of those photographs which are prepared with the hydriodic salts exposed to luminous influence with coloured fluids superimposed; permitting, as distinctly isolated as possible, the permeation of the violet and blue, the green, the yellow, and the red rays, under each of which a complementary colour was induced. During January of the present year, I prepared some papers with the bichromate of potash and a very weak solution of nitrate of silver: a piece of this paper was exposed behind four coloured glasses, which admitted the passage respectively of, 1st, the violet, indigo, and blue rays; 2nd, the blue, the green, and a portion of the yellow rays; 3rd, the geeen, yellow, and orange rays; and, 4th, the orange and red rays. The weather being extremely foggy, the arrangement was unattended for two days, being allowed to lie upon a table opposite a window having a southern aspect. On examining it, it had, under the respective colours, become *tinted* of a blue, a green, and a red: beneath the yellow glass the change was uncertain, from the peculiar colour of the paper, and this without a single gleam of sunshine. My numerous engagements have prevented my repeating the observations I desire on this salt, which has hitherto been considered absolutely insensible to light.

The barytic salts have nearly all of them a peculiar calorific effect; the muriate, in particular, gives rise to some most rich and beautiful crimsons, particularly under the influence of light which has permeated the more delicate green leaves; and also in copying the more highly coloured flowers, a variety of tintings having been observed. We may always depend on producing a photographic copy of a leaf of a green colour by the following arrangement:—Having silvered a copper plate, place it in a shallow vessel, and lay thereon the leaf of which a copy is desired, maintaining it in its position by means of a piece of glass; pour upon it, so that the plate beneath the glass may be covered, a solution of the hydriodate of potash, containing a little free iodine: then expose the whole to sunshine. In about half an hour, one of the most beautiful photographic designs which can be conceived is produced, of a fine green yellow. The fluid is yellow, and cuts off nearly all the "chemical" rays, allowing only of the free passage of the less refrangible rays; the most abundant being the yellow. This retards the process of solarization, but it produces its complementary colour on the plate.

These facts will, I think, prove that the *possibility* of our being enabled to produce coloured photographs is decided, and that the *probability* of it is brought infinitely nearer, particularly by Sir John Herschel's very important discovery, than it was supposed to be.

M. Edmond Becquerel has recently succeeded in obtaining bright impressions of the spectrum in colours, and copying highly coloured drawings on metallic plates prepared with chlorine. Mr. Hill, of New York, announced that he had obtained more than fifty pictures from nature in all the beauty of native colouration. This process was not disclosed, but we were assured that it was a modification of the daguerreotype—one material, quite new, being introduced—and that as soon as the manipulatory details were perfected the whole was to be published. A very long time has elapsed, and we have no indication of any development of his method of operating, and I believe none of his specimens have reached England. The results of M. Niepce de St.-Victor have been of a far more satisfactory character: the main particulars thereof we select from a memoir entitled "Upon the Relation existing between the Colours of certain coloured Flames with the Heliographic Images coloured by Light."

When a plate of silver is plunged into a solution of sulphate of copper and chloride of sodium, at the same time that it is rendered electro-positive by means of the voltaic battery, the chloride formed becomes susceptible of colouration, when, having been withdrawn from the bath, it receives the influence of light.

M. Niepce de St.-Victor, from observing that when chloride of sodium (common salt) was employed the plate became more susceptible of receiving a yellow colour than any other, and knowing that it imparted a yellow colour to flame, was led to believe that a relation existed between the colour communicated by a body to flame, and the colour developed upon a plate of silver, which should have been chloridated with the particular body.

To avoid complexity, it may be briefly stated that the bath in which the sensitive surface is obtained is prepared with water, holding free chlorine in solution, to which has been added the salt which is essential to give a predominance to any particular colour.

It is well known that strontian gives a purple colour to flames in general, and to that of alcohol in particular. If we prepare a plate of silver and pass it into water saturated with chlorine to which is added some chloride of strontian, and when thus prepared we place *upon* it a coloured design of red and other colours, and then expose it to the sunshine, after six or seven minutes we shall perceive that the colours of the image are reproduced upon the plate, but the reds much more decidedly than the others. When we would produce successfully the other rays of the solar spectrum, we operate in the same manner as we have indicated for the red ray—employing for the orange the chloride of calcium, or that of uranium for the yellow, or the hypochlorite of soda, or the chlorides of sodium or potassium. Very fine yellows have been obtained with a bath composed of water slightly acidulated with muriatic acid and a salt of copper.

The green rays are obtained with boracic acid or the chloride of nickel; also with all the salts of copper. The blue and indigo rays are obtained with the double chloride of copper and ammonia. The violet rays are obtained with the chloride of strontian and sulphate of copper. Those substances which give white flames, as the chloride of antimony, the chlorate of lead, and the chloride of zinc, yield no colour by luminous action. All the colours of a picture have been produced by preparing a bath composed of the deuto-chloride of copper; and M. Niepce states that this salt thrown into burning alcohol produces a variegated flame according to the intensity of the fire, and it is nearly the same with all the salts of copper mixed with chlorine. Niepce says— "If we put a salt of copper in liquid chlorine we obtain a very sensitive surface by a single immersion in the bath; but the colorific result of this mixture is seldom good. I prefer a mixture of equal parts of chloride of copper and of chloride of iron, with three or four parts of water: the chloride of iron has, as those of copper, the property of being impressed on the plates of silver and of producing many colours, but they are infinitely more feeble, and the yellow always predominates; and this agrees with the yellow colour produced in flame by this salt."

It should be understood that when the plate of silver, being previously connected with a voltaic battery, is plunged into the bath and the circuit completed, it becomes covered with a dark coating, probably of a sub-chloride of silver mixed with the salt, on which the colour to be produced by solar radiation depends.

If we form a bath composed of all the substances which separately give a dominant colour, we obtain very lively colours; but the great difficulty is the mixing of the salts in such proportions as to give an equality to the tints, as it commonly happens that some colours are excluded by others. We cannot always depend upon obtaining the same results with the same materials, owing principally to the difficulty of preserving the solution at a uniform strength. Liquid chlorine is necessary—the application of dry chlorine will not produce the same results, and the volatile chlorine is continually escaping from the water.

Niepce de St.-Victor has made many experiments to produce the colours upon salts of silver and copper spread on paper, but without success; the metallic plate appears absolutely necessary, and the purer the silver the more perfect and intense is the impression. The following is recommended as the most effectual mode of manipulating. The silver plate is highly polished with the best tripoli powder and ammonia; being perfectly cleaned it is connected with the battery, and then plunged into the bath prepared in any of the ways stated. It is allowed to remain in the bath for some minutes, taken from it, washed in a large quantity of water, and dried over a spirit-lamp. The surface thus produced is of a dull neutral tint, often almost black; the sensibility of the plate appears to be increased by the action of heat, and when brought by the spirit-lamp to the cerise red colour it is in its most sensitive state. The sensibility, however, of the plates is low, two or three hours being requred to produce a decided effect in the camera obscura. The name of Heliochromes has been given to these naturally coloured photographs, some of which, the personal gift of the inventor to Mr. Malone, I have inspected. These, when I first saw them, were perfectly coloured in correspondence with the drawings of which they were copies; but the colours soon faded, and it does not appear as yet that any successful mode of fixing the colours has been discovered.

CHAPTER VII.

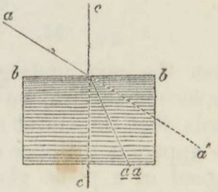
ON LENSES FOR THE PHOTOGRAPHIC CAMERA.

It is, to the photographic artist, a matter of considerable moment that he understands the principles upon which his instruments are constructed. It has, therefore, been thought advisable to add a short chapter which should give a sufficiently popular explanation of the dioptrical phenomena with which we have especially to deal.

Upon the refractive power of the media employed, depends the perfection of the results we obtain; therefore, some of the phenomena of refraction, or *breaking back*, as the term implies, should be clearly understood.

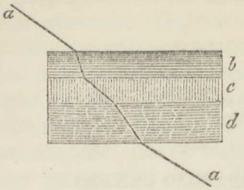
A ray of light passing through a vacuum progresses in a perfectly straight line, and we should, if we looked at a brilliantly illuminated point—were it possible—under such conditions, see it in its true position, the numerous rays coming undisturbed directly to the eye. But all matter, however attenuated it may be, has the property of refracting, or bending the ray of light; consequently we do not see the stars in their true position, owing to the refractive power of the atmosphere.

The most simple illustration of refraction is to allow a sunbeam *a*, passing through a small hole in the window-shutter of a dark room, to fall upon the surface of a fluid contained in a glass vessel, *b b*: instead of proceeding onward to *á*, it will be found to alter its course at the surface of the fluid, and pass along the line to *a a*. Every substance has different refractive powers in virtue of its physical constitution; but a ray of light incident perpendicularly on a refracting medium, as the ray *c*, (Fig. 29) suffers no refraction. If we float, one upon the other, fluids, *b*,*c*,*d*, having different powers of refraction, we shall then see the relative phenomena exhibited by the



29.

bending of the ray *a a*, in passing through them (Fig. 30).



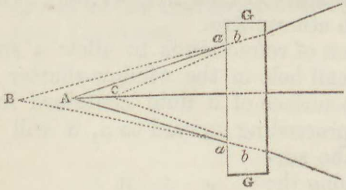
30.

It will be evident that no great difficulty exists in measuring the refractive powers of different transparent bodies: and that hence we are enabled to tabulate those which have the highest and lowest refractive indices. A few of the most important are given in the following table:—

Air	1·000294
Water.........................	1·336
Alcohol	1·372
Oil of cloves	1·535
Crown glass	1·534
Plate glass...................	1·542
Flint glass...................	1·830
Do. containing much lead	2·028
Diamond	2·439

This knowledge enables us to trace a ray of light through transparent bodies of any form, provided we can find the inclination of the incident ray to the surface, where it either enters or quits the body.

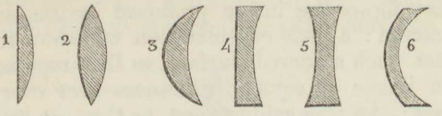
If parallel rays fall upon a plane surface G, of glass, they will retain their parallelism after passing through it as the ray A (Fig. 31). The rays diverging from the point A, will be refracted



31.

by the first surface into the directions *b b*, and by continuing *a a*, and *b b*, backwards, we shall find they meet at a point beyond A: so that supposing the eye to be placed within the body G, the point A would appear removed to B. But when the rays undergo a second refraction by passing out of the second surface, we shall find by continuing the lines backwards that they meet at C; therefore a plane glass diminishes the apparent distance of the point of the diverging rays. If, instead of a plane glass, we employ a piece equally curved, like a watch-glass, it produces very little change in the form and position of objects.

Lenses are glasses ground to different forms, their surfaces being segments of spheres, and it is in obedience to the refractory power of the surfaces so produced that their peculiarities belong. The adjoining figures represent the varieties.



32

1 is termed a plano-convex lens.

2 is a double convex lens.

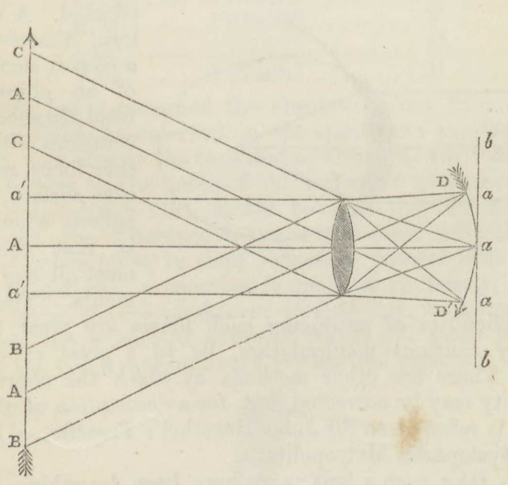
3 is formed of parts of two circles of different diameters, and is called a meniscus lens, or concavo-convex.

4 is a plano-concave lens.

5 is a double concave lens. And

6 is a concavo-convex lens, formed of parts of the inner surfaces of two dissimilar circles.

It is not necessary to examine the laws of refraction for all these forms; the phenomena will be fully understood by an examination of a few leading points. Whatever may be the form of a lens, the incident rays parallel to its axis pass through without suffering refraction, as A A A, *a a a*, Fig. 33,

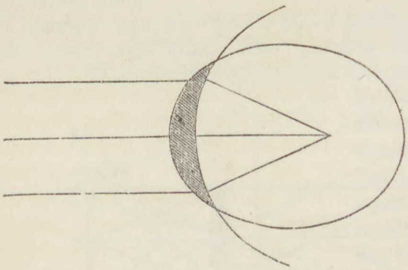


33.

All other rays must have a certain amount of obliquity, and these all consequently suffer refraction, as the rays *á á*. Now the rays B B, and the ray C C, are refracted, and meet at D D′; the line *b b* represents the focal image produced of the body from which the light proceeds.

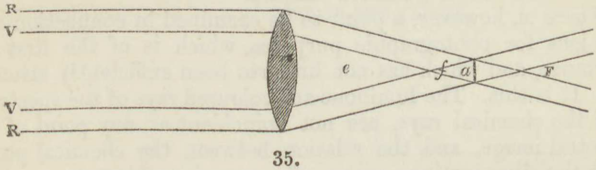
In the last figure the image produced by the lens is represented as curved: a little consideration will show that it is not possible that such a curved surface as that represented could produce an image of equal distinctness over every part of a plane surface: the rays cannot meet, as they are refracted from curved surfaces along any straight line, as F F F; and supposing we receive on the surface of a lens a bright circular image, it will be brilliant and well defined around the centre, the light becoming fainter towards the edge, and at length passing into a cloudy halo, exhibiting the prismatic colours. This is called *spherical aberration*, and to it is due that want of distinctness which commonly is found around the edges of pictures taken in the camera obscura.

It is therefore important, in the selection of lenses, that we look for *sharpness of definition over the whole of a perfectly flat field*. To manufacture a lens which shall effect this, is a task of some difficulty; but by attention to the two facts, that a lens, one surface of which is a section of an ellipse, and the other of a circle struck from the farthest of the two foci of that ellipse, as in Fig. 34, produces no aberration, much may be effected. A meniscus lens, therefore, with a convex surface, part of an ellipsoid, the focal distance of which coincides with its farther focus, and a concave surface, part of a sphere, whose centre is that focus, will meet all our requirements. The mechanical difficulties of producing such lenses are great, but they may, by cautious manipulation, be to a great extent overcome. There are other methods by which the aberration of sphericity may be corrected, but for a description of these the reader is referred to Sir John Herschel's *Treatise on Light*, in the Encyclopædia Metropolitana.



34.

If we take such a lens as we have been describing, and stop its centre with a blackened disc, leaving only a small portion of the edge for the light to pass through, and throw its image on a screen, we shall find it will be bordered with fringes of colour. At one distance *red* will prevail, at another *violet*. This is the result of *chromatic aberration*, and arises from the unequal refrangibility of the dissimilar rays. The red ray is less bent than the violet; consequently, supposing the rays R R to fall on the edge of a lens, they will converge to a point



35.

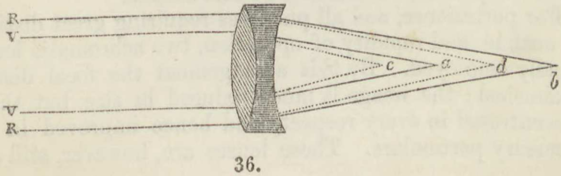
at F, whereas if the rays V V fall along the same circular line, they will, being more refracted, meet at *f*. Now if we place a disc at *e*, just the size of the cone of light, it will be edged with violet, but if we move it to *a*, the coloured border will be red.

The indices of refraction for the several rays have been most carefully determined by Fraunhofer, and for a standard medium, a flint glass prism, they are respectively

Red......	1·627749 dark line	B
Orange ..	1·629681	C
Yellow....	1·635026	D
Green	1·642024	E
Blue......	1·648260	F
Indigo	1·660285	G
Violet	1·671062	H

Fraunhofer has determined the absolute values from the fixed dark lines which he observed in the spectrum: they represent, however, very closely the rays distinguished by their colours.

By referring to the table of the refractive powers of transparent bodies (page 178), it will be seen that for a beam of white light, the difference between the most refractory flint glass and crown glass, in their refracting powers, is as 2·028 is to 1·534, and this proportion is maintained nearly, but not exactly, for all the coloured rays: if, therefore, we have a crown glass lens, the refractive power of which will place the focus at *a*, for the violet rays, and at *b*, for the red rays, and we grind



36.

to fit it a flint glass lens, the refractory power of which would place the foci of the rays at *c*, *d*, it will be seen that the result of such a combination would be the formation of a colourless image, at a mean point between them, by recombining the rays into white light. Such as is represented in the figure is the achromatic lens of a camera obscura.

There is, however, a point to be examined in connection with the lens for photographic purposes, which is of the first importance, and which has not hitherto been sufficiently attended to. It is this. The luminous and coloured rays of the spectrum, and the chemical rays, are not coincident at any point of the spectral image, and the relation between the chemical power, and the illuminating power, of a ray, is subject to constant variations.

It is often stated that the violet and blue rays are the chemical rays, and hence it is inferred, if the glass of a camera is corrected so as to make these rays, and the less refrangible red, to correspond, all is done which can be desired.

It must be distinctly understood that the colour of any particular ray has no direct relation to its chemical character. It is true, if the more refrangible rays are made to correspond with the more luminous rays, we approach the desired point, but we do not necessarily reach it. It has been said we may do so by overcorrecting a lens; but this is not the case, since beyond the limits of the chemical rays we have rays which have decidedly a protecting action, and if these are thrown into the field, the operation is retarded.

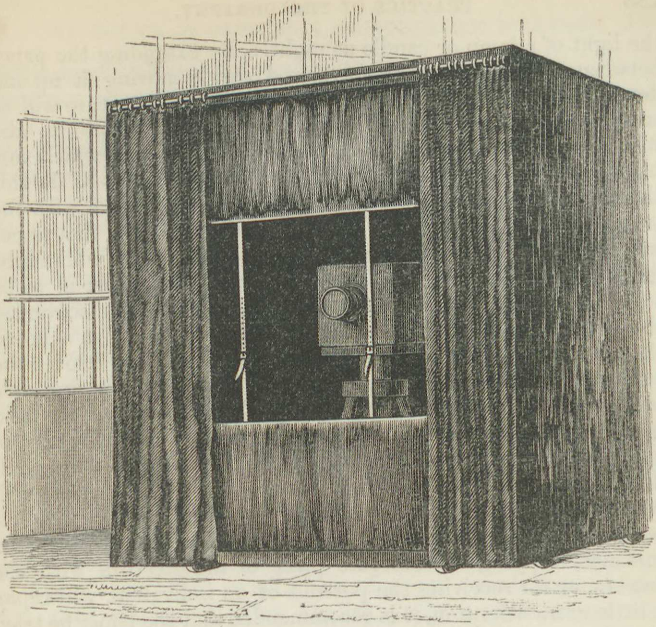
We commonly hear of a lens being slow or quick; this is purely accidental, arising entirely from the uncertainty in which all our optical instrument-makers remain as to the relation of the chemical and luminous forces to each other.

If the lenticular correction reaches and does not exceed the point of bringing the rays beyond Fraunhofer's line H, upon the field of vision, the lens will be a quick one, as it is called. On the contrary, if it does not reach, or if it goes beyond this, it will be slow in action, because either the *light* rays interfere, as is explained in a previous page, or those rays beyond the chemical spectrum to which attention has of late been directed by the very refined researches of Mr. Stokes.

For portraiture, and all purposes requiring great distinctness of outline and rapidity of operation, two achromatic lenses are usually employed. By this arrangement the focal distance is diminished; the image is much reduced in size, but then it is concentrated in every respect, and hence improved in all the necessary particulars. These lenses are, however, still open to the objection that they produce some distortion, which is only to be avoided by greatly reducing the size of the aperture through which the light falls on the lens, and this necessarily involves increased sensibility in the preparations we employ. The distortion is not to the extent which has been represented, but it may, by careful examination, be discovered in the finest photographic portraits to a greater or less extent.

PART III.

PRACTICE OF PHOTOGRAPHY.



CHAPTER I.

SELECTION OF PAPER FOR PHOTOGRAPHIC PURPOSES.

It is natural to suppose, that a process which involves the most delicate chemical changes requires more than ordinary care in the selection of the substance upon which preparations of a photographic character are to be spread. This becomes the more evident as we proceed in our experiments to produce improved states of sensitiveness. As the material, whatever it may be, is rendered more susceptible of solar influence, the greater is the difficulty of producing perfectly uniform surfaces, and with paper this is more particularly experienced than with metal or glass plates. Paper is, however, so convenient and so economical, that it is of the first importance to overcome the difficulties which stand in the way of its use, as the tablet on which the photographic picture is to be delineated.

The principal difficulty we have to contend with in using paper, is, the different rates of imbibition which we often meet with in different parts of the same sheet, arising from trifling inequalities in its texture and unequal sizing. This is, to a certain extent, to be overcome by a very careful examination of each sheet by the light of a lamp or candle at night. By extending the paper between the light and the eye, and slowly moving it up and down, and from left to right, the variations in its texture will be seen by the different quantities of light which permeate it; and it is always the safest course to reject every sheet in which any inequalities are detected. By day it is more difficult to do this than at night, owing to the interference of the refleced with the transmitted light. It will, however, often happen that paper which has been carefully selected by the above means will imbibe fluids very unequally. In all cases where the paper is to be soaked in saline solutions, we have another method of discovering those sources of annoyance. Having the solution in a broad shallow vessel, extend the paper, and gradually draw it over the surface of the fluid, taking care that it is wetted on one side only. A few trials will render this perfectly easy. As the fluid is absorbed, any irregularities are detected by the difference of appearance exhibited on the upper part, which will, over well-defined spaces, remain of a dull-white, whilst other portions will be shining with a reflective film of moisture. Where the importance of the use to which the paper is to be applied,—as, for instance, copying an elaborate piece of architecture with the camera, or for receiving the portrait of an individual, will repay a little extra attention, it is recommended that the paper be tried by this test with pure water, and dried, before it is submitted to the salting operation. It will be sometimes found that the paper contains minute fibres of thread, arising from the mass of which it is formed not having been reduced to a perfect pulp. Such paper should be rejected, and so also should those kinds which are found to have many brown or black specks, as they materially interfere with some of the processes. Some specimens of paper have an artificial substance given to them by sulphate of lime (plaster of Paris), but, as these are generally the cheaper kinds of demy, they are to be avoided by purchasing the better sorts. The plaster can be detected by fusing a sheet of the paper and examining the quantity of ash. Pure paper leaves less than ½ per cent. of ash. If plaster is present the ash will be much more considerable: the increase of weight is, however, sometimes due to kaolin. No really sensitive paper can be prepared when sulphate of lime is present; and it has the singular property of reversing the action of the hydriodic salts on the darkened chloride of silver, producing a negative in the place of a positive photograph. It is the custom for paper-makers to fix their names and the date on one leaf of the sheet of writing paper. It is wise to reject this leaf, or to select paper which is not so marked, as, in many of the photographic processes which will be described, these marks are brought out in most annoying distinctness. From the various kinds of size which the manufacturers use in their papers, it will be found that constantly varying effects will arise. A well-sized paper is by no means objectionable; on the contrary, organic combinations exalt the darkening property of the nitrate and muriate of silver. But unless we are careful always to use the same variety of paper for the same purpose, we shall be much perplexed by the constantly varying results which we shall obtain. No doubt, with the advancing importance of the art, the demand for paper for photographic purposes will increase; manufacturers will then find it worth the necessary care to prepare paper agreeably to the directions of scientific men. Several of our paper makers are now paying much attention to the preparation of photographic paper, and are considerably improving it. I have been most obligingly furnished by Mr. Sandford, of Paternoster Row, with specimens of a great variety of Foreign and English papers, and from the care that gentleman is bestowing on this subject the most important advantages may be expected. All who desire to make any progress in photography must take the necessary precautions, or be content to meet with repeated failures.

The photographic peculiarities of paper mainly depend upon the sizes employed. The English paper manufacturers very commonly employ gelatine, and this in very different conditions. The French, on the contrary, use starch, and this, from the strong affinity existing between starch iodine, appears to be one reason why the French paper is superior for the calotype in some of its forms.

Resin soap is largely employed as a size. The soap is applied to the bibulous paper, and then decomposed by an acid water, leaving a fine film of resin spread upon the surface, susceptible of the highest polish.

The following tables will exhibit the results of an extensive series of experiments, which were undertaken after the publication of Sir J. Herschel's memoir "On the Chemical Action of the Rays of the Solar Spectrum," in which he has given a table of results, obtained with different preparations on various kinds of paper; but as he has not established the influence of the paper, except in a few instances, independent of the preparation, it became desirable to do so; and the result of several years' experience has proved the correctness of the conclusions then arrived at.

In pursuing this inquiry, it was found that the same description of paper, from different manufacturers, gave rise to widely different effects; so that the most carefully conducted experiments, several times repeated, have only given approximations to the truth. The form of experiment was to select a number of specimens of paper,—prepare them with great care in precisely the same manner, and expose them to the same solar influences. They were partly covered with a piece of colourless glass,—the object of this being to determine whether under it the action was quicker or slower than when exposed uncovered. Sir John Herschel has shown that there are some peculiar differences in this respect; and this method offered a very correct mode of determining the relative effects.

I.—*Papers prepared with Muriate of Soda and Nitrate of Silver.*

a. Superfine satin post....	Considerable exalting effect.
b. Thick wove post	Depressing influence.
c. Superfine demy........	Slight exalting effect.
d. Bath drawing card	Changes slowly.
e. Thick post............	Slight exalting effect.
f. Common bank post	Ditto.
g. Thin post	Very tardy.
h. Tissue paper..........	Considerable exalting effect.

II.—*Papers prepared with Muriate of Barytes and Nitrate of Silver.*

a. Superfine satin post....	Slight exalting influence.
b. Thick wove post	Ditto, but stronger.
c. Superfine demy........	Similar to *a.*
d. Bath drawing card	Similar to *a.*
e. Thick post............	Considerable exalting influence.
f. Common bank post	Similar to *a.*
g. Thin post	Similar to *e.*
h. Tissue paper..........	Results uncertain.

III.—*Papers prepared with Muriate of Ammonia and Nitrate of Silver.*

a. Superfine satin post....	Strong exalting influence.
b. Thick wove post	Results uncertain—dependent on the size employed.
c. Superfine demy........	Slight exalting effect.
d. Bath drawing card	Results uncertain.
e. Thick post............	Ditto.
f. Common bank post	Very slow.
g. Thin post	Ditto.
h. Tissue paper..........	Strong exalting influence.

IV.—*Papers prepared with Iodide or Bromide of Potassium and Nitrate of Silver.*

a. Superfine satin post....	Darkens slowly.
b. Thick wove post	Results uncertain.
c. Superfine demy........	Strong exalting influence.
d. Bath drawing card	Very slowly changes.
e. Thick post............	Depressing influence.
f. Common bank post	Slight exalting effect.
g. Thin post	Ditto.
h. Tissue paper.........	Results uncertain.

Unsized paper has been recommended by some, but in no instance have I found it to answer so well as paper which has been sized. The principal thing to be attended to in preparing sensitive sheets, is to prevent, as far as it is possible, the absorption of the solutions into the body of the paper,—the materials should be retained as much as possible upon the *very surface.* Therefore the superficial roughness of unsized sheets, and the depth of the imbibitions, are serious objections to their use. It must not, however, be forgotten, that these objections apply in their force only to the silver preparations; in some modifications of the processes, with the bichromate of potash, the common bibulous paper, used for filtering liquids, has been found to answer remarkably well, on account of the facility with which it absorbs any size or varnish.

Great annoyance often arises from the rapid discolouration of the more sensitive kinds of photographic drawing paper, independent of the action of light, which appears to arise from the action of the nitrate of silver on the organic matters of the *size.* Unsized paper is less liable to this change. If we spread a pure chloride of silver over the paper, it may be kept for any length of time without any change of its whiteness taking place in the dark. Wash it over with a very weak solution of nitrate of silver, and, particularly if the paper is much sized, a very rapid change of colour will take place, however carefully we may screen it from the light. From this it is evident that the organic matter of the size is the principal cause of the spontaneous darkening of photographic papers prepared with the salts of silver.

The most curious part of the whole matter is, that in many cases this change is carried on to such an extent that a revival of metallic silver takes place, to all appearance in opposition to the force of affinity. This is very difficult to deal with. Chemistry has not yet made us acquainted with any organic body which would separate either chlorine or nitric acid from their metallic combinations. I can only view it in this light:—the nitric acid liberates a quantity of carbonaceous matter, which, acting by a function peculiarly its own, will at certain temperatures effect the revival of gold and silver, as proved by Dr. Schafheutl's and Count Rumford's experiments.

Having been informed that the paper-makers are in the habit of bleaching their papers with sulphur and sulphites, I have submitted a considerable quantity of the browned papers to careful examination. In all cases where the paper has *blackened*, I have detected the presence of sulphur. Consequently, when the darkening goes on rapidly, and terminates in blackness, we may, I think, correctly attribute it to the formation of a sulphuret of silver.

It is, however, certain that the slow action of organic matter is sufficient, under certain circumstances, to set up a chemical change which, once started, progresses slowly, but certainly, until the compound is reduced to its most simple form.

China clay—*kaolin*—has of late years been much used by the paper manufacturers, for the double purpose of giving weight to the paper, and of enabling them to produce a smooth surface upon all the finer varieties of paper; such as the "enamelled satin post." This compound of alumina and silica would not, if the finest varieties of clay were employed, be likely to do much mischief in the papers used for photography; but the less pure varieties of the Cornish clay are employed, and this commonly contains iron and other metals in a state of very fine division; and these, where they come to the surface, form little centres of action, from which dark circles spread in rather a curious manner. In France there has been manufactured a paper for this especial process; it is very thin, and of a tolerably uniform texture. It is said to answer exceedingly well with the modified forms of photographic manipulation employed in France, but it does not appear adapted, from some cause which is not clearly explained, to the English processes. Thin papers have been tried, and many varieties would answer exceedingly well, but that nearly every variety is found penetrated with small holes, which, though of minute dimensions, suffer light to pass freely, and consequently produce a spottiness on the resulting picture. Sir John Herschel found that this evil could be remedied by fastening two pieces of such paper together; but this method is troublesome and uncertain.

Returning to the consideration of *size* in the paper, the above-named authority—who employed the lead salts in some of his photographic processes—has the following remarks:—

"The paper with a basis of lead turns yellow by keeping in the dark, and the tint goes on gradually deepening to a dark brown.

But what is very singular, this change is not equally rapid upon all kinds of paper,—a difference depending, no doubt, on the size employed; which, it may be observed here once for all, is of the utmost influence in all photographic processes. In one sort of paper (known by the name of *blue wove post*) it is instantaneous, taking place the moment the nitrate (if abundant) is applied. And yet I find this paper to resist discolouration, by keeping, better than any other, when the mordant base is silver instead of lead. On the other hand, a paper of that kind called *smooth demy*, rendered sensitive by a combination of lead and silver, was found to acquire, by long keeping, a lead or slate colour, which increases to such a degree as might be supposed to render it useless. Yet, in this state, when it is impressed with a photographic image, the process of fixing with hyposulphite of soda destroys this colour completely, leaving the ground as white as when first prepared. This fortunate restoration, however, does not take place when the paper has been *browned* as above described. Some of the muriatic salts also are more apt to induce this discolouration than others, especially those with the earthy bases."

It will be evident from these remarks that it is of the utmost importance to secure a paper which shall be as chemically pure as possible. Experience has proved that recently-manufactured paper does not answer equally well with that which has been made for a year or two. It has been thought by many that this was an unfounded statement, but it is not so; and the causes operating to the improvement of paper by age are evident. The organic matter of the size is liable to a spontaneous change: this goes on for a considerable time, but at length the process becomes so exceedingly slow that it may, for all practical purposes, be said virtually to rest. Paper changes its colour by keeping from this cause, and I have found that such as I have selected from the shop-worn stocks of stationers has been generally superior to that which has been more recently manufactured.

Select, therefore, paper of a uniform texture, free from spots, and of equal transparency, choosing the oldest rather than the newest varieties.

Where the process is highly sensitive for which the paper is desired, it is important to treat it in the following manner:—Having a shallow dish sufficiently large to receive the sheets of paper without in any way crumpling them, it is to be filled with very clear filtered water, to which a sufficient quantity of nitric acid has been added to make it slightly sour to the taste. Taking a sheet of paper, it should be laid on a porcelain slab, and sponged with clean water on both sides, after which it should be placed in the acidulated water, and allowed to remain in it for several hours. Too many sheets should not be placed in the vessel at the same time. After a time they should be removed in mass, placed on the slab, and left for half an hour under gently flowing water,—this removes all the acid, and all those metallic and earthy matters which it has removed from the paper. After this it is to be dried, and it is then fit for photographic use.

This chapter has been deemed unnecessarily long; but, upon renewing many of the experiments, I have become so convinced of its importance in all particulars, that I could not induce myself to curtail it. All who aim at excellence in photography should repeat the experiments and closely observe the results.

CHAPTER II.

ON THE APPARATUS NECESSARY FOR THE PRACTICE OF PHOTOGRAPHY ON PAPER.

The most simple method of obtaining sun-pictures, is that of placing the object to be copied on a piece of prepared paper, pressing it close by a piece of glass, and exposing the arrangement to sunshine: all the parts exposed darken, while those covered are protected from change, the resulting picture being *white* upon a *dark ground.*

It should be here stated, once for all, that such pictures, howsoever obtained, are called *negative photographs;* and those which have their lights and shadows correct as in nature—dark upon a light ground, are *positive photographs.*

The accompanying woodcut, Fig. 37, represents a *negative* copy of a currant leaf, and Fig. 38, the *positive* copy obtained from it.

37.

38.

If a copy is made by means of the camera of any illuminated object, the picture being produced by the darkening of a white or yellow paper, it will be evident that the highest lights will be represented as dark portions, and the shadows as lights. Thus we obtain a *negative image.* The female figure in the adjoining woodcut, Fig. 39, is copied from a calotype *negative* portrait; and the negative being used by superposition on another prepared piece of paper, produces a *positive* in which the lights and shades are natural, as in the second figure, Fig. 40.

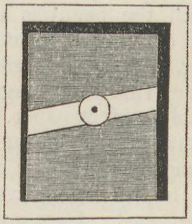

39.


40.

Let us commence by supposing the experimentalist to be supplied with paper prepared by some one acquainted with the manipulation, and that he is now to observe for the first time the effects produced.

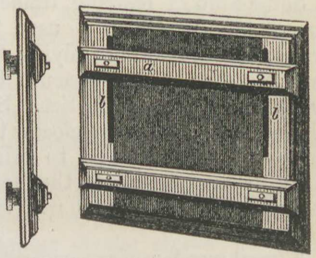
For the production of photographic drawings, it is necessary to be provided with a copying frame and glass, the most convenient size for which is something larger than a single leaf of quarto post writing paper. The glass must be of such a thickness as to resist some considerable pressure, and it should be selected as colourless as possible, great care being taken to avoid such glasses as have a tint of yellow or red, these colours preventing the permeation of the most efficient rays. Figures 41 and 42 represent such a frame in its most simple form; the first showing it in front, as it is employed in taking a copy of leaves, and the other the back, with its piece of stout tinned iron, or board, which presses on a cushion, securing the close contact of the paper with every part of the object to be copied, and its brass bar, which, when pressed into angular apertures in the sides of the frame, gives the required pressure to the paper. To copy leaves we proceed thus:—

41.



42.

Having placed the frame face downwards, carefully lay out, on the glass, the object to be copied, on which place the photographic paper very smoothly. Then cover this with the cushion, which may be either of flannel or velvet, fix the metal back, and adjust it by the bar, until every part of the object and paper are in the closest contact. For all ordinary uses, this frame answers exceedingly well; but a more convenient pressure frame is constructed in the manner represented by Fig. 43. This contains two bars, one of them moveable, and both of them may be fixed in any required position by binding screws.



43.

In arranging botanical specimens, the under surface of the leaves should be next the glass, their upper and smooth surface in contact with the paper. Although very beautiful copies may be taken of dried specimens, they bear no comparison with those from fresh-gathered leaves or recently collected plants, of which, with the most delicate gradations of shades, the veins of the leaves, and the down clothing the stems, are exhibited with incomparable fidelity. In the event of the plant having any thick roots or buds, it will be best to divide them with a sharp knife, for the purpose of equalizing the thickness in all parts, and ensuring close contact.

Engravings are to be placed with their faces to the prepared side of the photographic paper, and laid very smoothly on the glass, and then with the cushion and back pressed into the closest contact possible: the least difference in the contact, by permitting dispersion, occasions a cloudiness and want of sharpness in the photograph.

Of course, a copy of anything taken by means of the rays which have passed through it, must present all the defects as well as all the beauties of the article, whatever it may be. Thus, in copying a print, we have, besides the lines of the engraving, all the imperfections of the paper: this renders it necessary that those engravings should be selected which are on tolerably perfect paper. If the preservation of the engraving is not a matter of much moment, by washing it over the back with a varnish of Canada balsam and spirits of turpentine it is rendered highly transparent, and the resulting impression is much improved. Care must, however, be taken to use the varnish very thin, that it may not impart any yellow tinge to the paper. An exposure of a few minutes only is sufficient to produce strong and faithful copies during sunshine; but in diffused daylight a longer period is necessary.

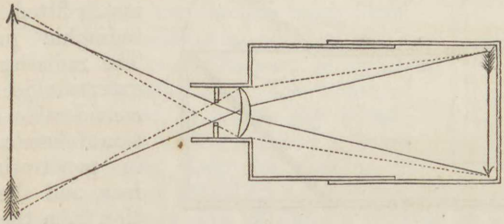
Some kind of copying frame is an indispensable requisite to the photographer: it is used for copying all small objects by transmission, and multiplying the original pictures obtained by means of the camera obscura from nature: it is, indeed, the printing-press of the artist. Some prefer two plates of stout plate-glass pressed very closely together with clamps and screws; but, as the intention is to bring the object to be copied and the sensitive paper into the closest possible contact, numerous mechanical contrivances will suggest themselves for this purpose.

A great number of experiments should be made with the copying frame before there is any attempt at using the *camera obscura.*

The Camera Obscura, or Darkened Chamber, was the invention of Baptista Porta, of Padua. Its principle will be best understood by the very simple experiment of darkening a room by closing the window-shutters and admitting a pencil of light through a small hole in them. If a piece of paper is held at a little distance from this hole, the figures of external objects will be seen delineated upon it; and, by putting a small lens over the hole, they are rendered much more evident, from the condensation of the rays by the spherical glass.

If, instead of a darkened room, we substitute a darkened box

(Fig. 44), the same effect will be seen. Suppose, in the first place, the box to be without the lens, the rays would pass from the external arrow in nearly right lines through the opening, refracted only in passing the solid edges of the hole, and form an image on the back of the dark box. The lens refracts the rays, and a smaller but a more perfectly defined picture is the result.



44.

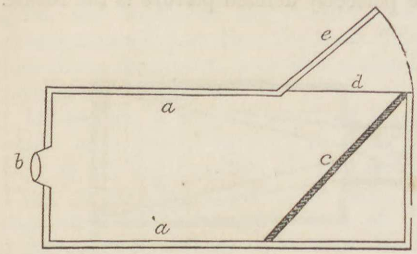
As in the phenomena of vision, so in the camera obscura, the image is produced by the radiations proceeding from the external object; and as these radiations progress from various parts, more or less illuminated, so are the high lights, the middle tints and shadows, most beautifully preserved in the spectral appearance. The colours, also, being in the first instance the effect of some physical modification of the primary cause, are repeated under the same influence; and the definition, the colour, and soft gradation of light and shadow, are so perfect, that few more beautiful optical effects can be produced than those of the camera obscura.

Now as every ray of light producing the coloured image is accompanied by the chemical principle *actinism*, and as this is regulated in action by the luminous intensity of the rays, the most luminous (*yellow*) producing the least chemical effect, while it increases with the diminishing illuminating power of the coloured rays of the radiating source, we have the impression made in accordance with the colour of the object we would copy, and not correct as to light and shadow. By referring to the frontispiece to the present volume, the effects produced by copying a coloured image will be seen. The yellows, reds, and those colours usually regarded as lights, are copied as shadows: hence the importance of attention to the colours of the dress, when a portrait is to be taken by any photographic process.

In the ordinary cameras used by artists for sketching, a mirror is introduced, which throws the image on a semitransparent table.

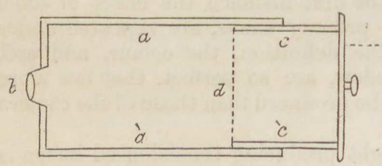
Fig. 45 is a section of one form of such an instrument: *a à* represents the box, in one end of which is fixed the lens *b*.

The lenticular image falls on the mirror *c*, placed at such an angle that it is reflected on the plate of ground-glass *d*. *e* is a screen to prevent the overpowering influence of daylight, which would render the picture almost invisible. This form of the apparatus, though very interesting as a philosophical toy, and extremely useful to the artist, is by no means fitted for photographic purposes. The radiations from external objects suffer considerable diminution of chemical power in penetrating the lens, and the reflection from the mirror so far reduces its intensity, that its action on photographic agents is slow. To obviate the objection of the reflected image, it is only necessary to place the photographic paper in the place of the mirror, but not in an angular position.



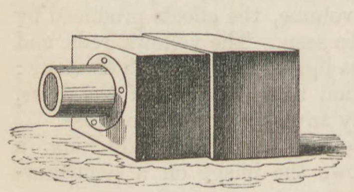
45.

Fig. 46 represents a photographic camera so constructed in its most simple form: *a à* is the outer box, in which is fixed the lens *b*, and *c c̀*, another box sliding within it, at the inner end of which is placed the prepared paper *d*: by sliding *c c̀* we are enabled to adjust the paper to the correct focus of the lens, the image being observed through a small hole at *e*.

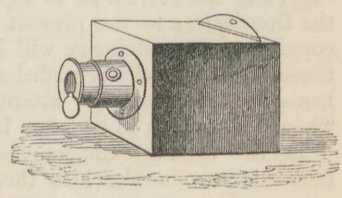


46.

A great variety of these instruments have been introduced to the notice of students of the art, many of them so unnecessarily expensive that they are beyond the reach of the humble amateur.

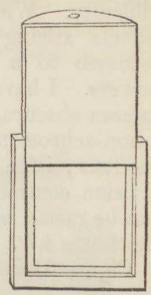


47.



48.

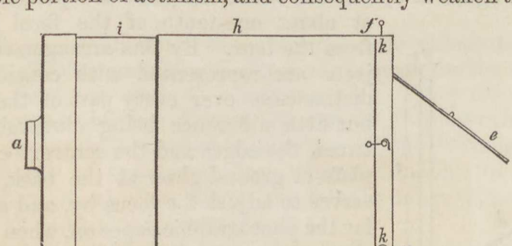
It is conceived that a few examples of mechanical contrivances by which the instrument is rendered portable, and in all respects convenient, will not be out of place. Fig. 47 represents one box sliding within the other for the purpose of adjusting the focus, the lens being fitted into a brass tube, which screws into the front of the camera. The woodcut (Fig. 48) is but one box, the lens being fitted into one brass tube sliding in another, like a telescope tube, the moveable part being adjusted by a screw and rack. The mouth of the tube is contracted, by which any adventitious radiations are obstructed, and a brass shade is adjusted to close the opening if required; the paper is placed in a case fitted with a glass front, as in Fig. 49, and a shutter, by which it is protected from the light until the moment it is required to throw the image upon it.



49.

In the first edition of this work, a form of camera was described, which possesses the advantages of extreme cheapness, and of being in most respects convenient. It is, therefore, here described in the language I employed in 1841:—

A photographic camera should possess, according to Sir John Herschel, "*the three qualities of a flat field, a sharp focus at great inclinations of the visual ray, and a perfect achromaticity.*" There can be no doubt but these qualifications are very essential,—the two first particularly are indispensable, and there is but one objection to the latter. We can only produce perfect achromaticity by a combination of glasses, and experiments prove that by increasing the thickness of the object-glass,* and the number of reflecting and refracting surfaces, we interrupt a considerable portion of actinism, and consequently weaken the action

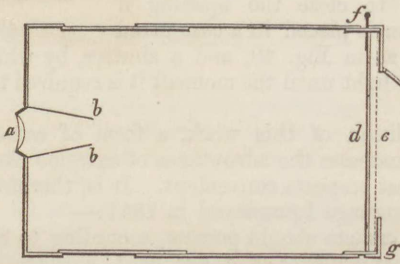


50.

* The recent experiments of the Rev. Mr. Stokes most fully confirm this view.

on the photographic material, whatever it may be; but our opticians have succeeded to a great extent in overcoming this difficulty. We may, to a considerable degree, get rid of the defects arising from chromatic dispersion, without having recourse to a combination of glasses of different refracting powers. I have long used myself, and constructed for others, a camera obscura, which appears to answer remarkably well, with a non-achromatic lens. Fig. 50 *a* represents the aperture of the lens; *i i′*, a box sliding into an outer case, *h h′*; *k k*, a third division, containing a ground glass at the back, and a door which can be raised or lowered by the screw *g*, the whole fitting into the frame *h h′*.

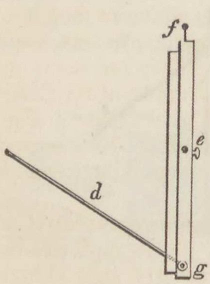
Figure 51 is a section of the camera. *a* is a lens of a peri-



51.

scopic form, whose radii of curvature are in the proportion of 2 to 1. This meniscus is placed with its convex surface towards the plane of representation, and with its concavity towards the object.

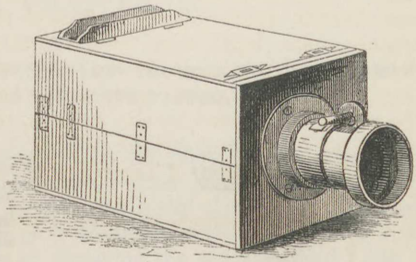
The aperture of the lens itself is made large, but the pencil of rays admitted is limited by a diaphragm, or stop, constructed as in the figure at *b*, between it and the plane of representation, at about one-tenth of the focal length from the lens. By this arrangement objects are represented with considerable distinctness over every part of the field, but little difference being observable between the edges and the centre. *c* is the plate of ground glass at the back, which serves to adjust the focus by, and also to lay the photographic paper on, when we desire to copy any object; *d*, a door to shut off the light from the paper or plate until the moment we desire to expose it to luminous agency. Fig. 52 represents this



52.

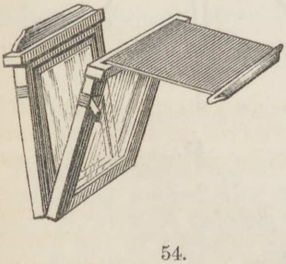
screen or door more perfectly, in the act of falling; *e* is a door at the back, through which the picture formed on the opaque glass is examined; *f*, a pin, keeping the door, *d*, in its place.

The following figures (Figs. 53, 54, 55) represent a more perfect arrangement. Its conveniences are those of folding, and thus packing into a very small compass, for the convenience of travellers. It is, however, only adapted for views, and not for portraits.

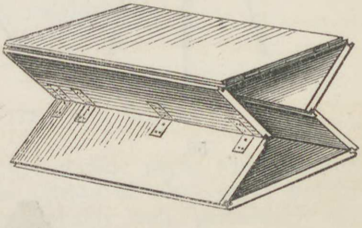


53.

With the camera obscura properly arranged, and the copying frame, the photographic student who confines his attention to the processes on paper has nearly all he requires. For the



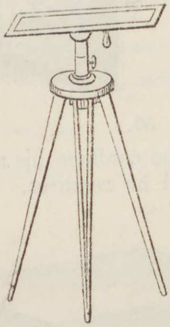
54.



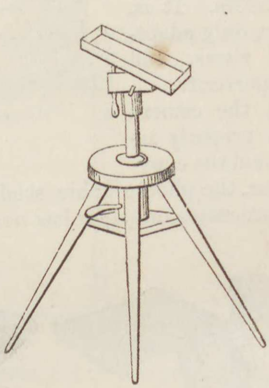
55.

convenience of adjusting the instrument to different heights, and to different angles of elevation, tripod stands are convenient, but not altogether indispensable. They are made in several ways; the two figures, 56 and 57, representing those which appear best adapted to the use of the traveller. The arrangement of compound legs shown in Fig. 56 ensures greater steadiness than the other; but the range of movement in Fig. 57 gives it some advantages.

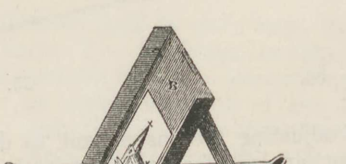
Beyond these things, a few dishes, such as are represented in Fig. 58, A A; and a frame B, upon which a photograph can be placed for the purpose of being washed, are the only things required for the practice of photography, except those pieces of apparatus which, belonging to special processes, will be found described in the chapters devoted to them. The object has been in this chapter to enumerate those only which are necessary for an amateur to make his rudimentary experiments.



56.



57.



58.

CHAPTER III.

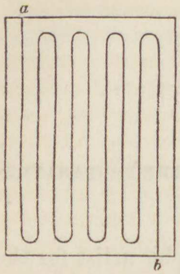
ON THE MODES OF MANIPULATION ADOPTED IN THE PREPARATION OF SENSITIVE PAPERS.

The only apparatus required by the photographic artist for the preparation of his papers, are,—some very soft sponge brushes and large camel-hair pencils (no metal should be employed in mounting the brushes, as it decomposes the silver salts), a wide shallow vessel capable of receiving the sheet without folds, and a few smooth planed boards, sufficiently large to stretch the paper upon, and a porcelain or glass slab. He must supply himself with a few sheets of good *white* blotting paper, and several pieces of soft linen, or cotton cloth; a box of pins; a glass rod or two; some porcelain capsules; and some beaker glasses, graduated measures, scales and weights.

Section I.—Nitrate of Silver.

The most simple kind of photographic paper which is prepared is that washed with the nitrate of silver only; and for many purposes it answers remarkably well, particularly for copying lace or feathers; and it has this advantage over every other kind, that it is perfectly fixed by well soaking in warm water.

The best proportions in which this salt can be used are 60 grs. of it dissolved in a fluid ounce of water. Care must be taken to apply it equally, with a quick but steady motion, over every part of the paper. It will be found the best practice to pin the sheet by its four corners to one of the flat boards above mentioned, and then, holding it with the left hand a little inclined, to sweep the brush, from the upper outside corner, over the whole of the sheet, removing it as seldom as possible. The lines in fig. 59 will represent the manner in which the brush should be moved over the paper, commencing at *a* and ending at *b*. On no account must the lines be brushed across, nor must we attempt to cover a spot which has not been wetted, by the application of fresh solution to the place, as it will, in darkening, become a well-defined space of a different shade from the rest of the sheet. The only plan is, when a space has escaped our attention in the first washing, to go over the whole sheet with a more dilute solution. It is, indeed, always the safest course to give the sheet two washings.


59.

The nitrated paper not being very sensitive to luminous agency, it is desirable to increase its power. This may be done to some extent by simple methods.

By soaking the paper in a solution of isinglass or parchment size, or by rubbing it over with the white of egg, and drying it prior to the application of the sensitive wash, it will be found to blacken much more readily, and assume different tones of colour, which may be varied at the taste of the operator.

By dissolving the nitrate of silver in common rectified spirits of wine, instead of water, we produce a tolerably sensitive nitrated paper, which darkens to a very beautiful chocolate brown; but this wash must not be used on any sheets prepared with isinglass, parchment, or albumen, as these substances are coagulated by alcohol.

The nitrate of silver is not sufficiently sensible to change readily in diffused light; consequently it is unfit for use in the camera obscura, and it is only in strong sunshine that a copy of an engraving can be taken with it.

Ammonio-Nitrate of Silver.—This is an exceedingly useful preparation for many purposes. It is prepared by adding ammonia to a solution of nitrate of silver: a deep olive precipitate of oxide of silver takes place; more ammonia should then be added, drop by drop, until this precipitate is redissolved, great care being taken care that more ammonia is not added than is necessary to do this. This solution is more sensitive than the nitrate, and may be used with advantage for copying by superposition; but it is not fitted for the camera obscura.

Section II.—Chloride of Silver.

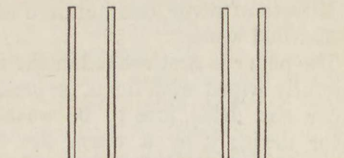
This is one of the most important salts employed in photography: it therefore demands especial attention.

Muriated Papers, as they are termed, are formed by producing a chloride of silver on their surface, by washing the paper with the solution of muriate of soda, or any other muriate, when the paper is dry, with the silver solution.

It is a very instructive practice to prepare small quantities of solutions of common salt and nitrate of silver of different strengths, to cover slips of paper with them in various ways, and then to expose them altogether to the same radiations. A curious variety in the degrees of sensibility, and in the intensity of colour, will be detected, showing the importance of a very close attention to proportions, and also to the mode of manipulating.

A knowledge of these preliminary but important points having been obtained, the preparation of the paper should be proceeded with; and the following method is recommended:—

Taking some flat deal boards, perfectly clean, pin upon them, by their four corners, the paper to be prepared; observing the two sides of the paper, and selecting that side to receive the preparation which presents the hardest and most uniform surface. Then, dipping one of the sponge brushes into the solution of muriate of soda, a sufficient quantity is taken up by it to moisten the surface of the paper without any hard rubbing; and this is to be applied with great regularity. The papers being "salted," are allowed to dry. A great number of these may be prepared at a time, and kept in a portfolio for use. To render these sensitive, the papers being pinned on the boards, or carefully laid upon folds of white blotting paper, are to be washed over with the nitrate of silver, applied by means of a camel-hair pencil, observing the instructions previously given as to the method of moving the brush upon the paper. After the first wash is applied, the paper is to be dried, and then subjected to a second application of the silver solution. Thus prepared, it will be sufficiently sensitive for all purposes of copying by application. The second wash is applied for the purpose of ensuring an excess of the nitrate of silver in combination, or, more properly speaking, *mixed* with the chloride. Mr. Cooper, with a view to the production of an uniform paper, recommends that it be *soaked* for a considerable length of time in the saline wash, and, after it is dried, that the sheet should, by an assistant, be *dipped* into the silver solution; while the operator moves over



60.

its surface a glass rod held in two bent pieces of glass, as in fig. 60; the object of which is to remove the small air-bubbles that form on the surface of the paper, and protect it from the action of the fluid. This process, however well it may answer in preparing paper for copying engravings, will yield paper not sufficiently sensitive for camera purposes; and it is objectionable on the score of economy, as a larger quantity of the silver solution is required to decompose the common salt than in the process described.

It may not be entirely useless or uninteresting, to state the more striking peculiarities of a few of the washes, on the study of which depends the possibility of our ever producing photographs in their natural colours, — a problem of the highest interest. It will be found that nearly every variety of paper exposed to the full action of the solar beams will pass through various shades of brown, and become at last of a deep olive colour: it must therefore be understood that the process of darkening is in all cases stopped short of this point.

Muriate of Soda.—Papers prepared with the muriate of soda have been more extensively used than any others for positive pictures, owing to the ease with which this material is always to be procured; and for most purposes it answers as well as any other, but it does not produce the most sensitive photographic ground.

The proportions in which this salt has been used are exceedingly various: in general, the solution has been made too strong; but several chemists have recommended washes that are as much too weak. For different uses, solutions of various qualities should be employed. It will be found well in practice to keep papers of three orders of sensitiveness prepared; the proportions of salt and silver for each being as follows:—

Sensitive Paper for the Camera Obscura.

Muriate of soda, thirty grains to an ounce of water.

Nitrate of silver, one hundred and twenty grains to an ounce of distilled water.

The paper is first soaked in the saline solution, and after being carefully wiped with linen, or pressed between folds of blotting paper and dried, it is to be washed twice with the solution of silver, drying it by a warm fire between each washing. This paper is very liable to become brown in the dark. Although images may be obtained in the camera on this paper by about half an hour's exposure, they are never very distinct, and may be regarded as rather curious than useful.

Less Sensitive Paper for Copies of Engravings—Botanical or Entomological Specimens.

Muriate of soda, twenty-five grains to an ounce of water.

Nitrate of silver, ninety-nine grains to an ounce of distilled water.

Applied as above directed.

Common Sensitive Paper, for Copying Lace-work, Feathers, Patterns of Watch-work, &c.

Muriate of soda, twenty grains to an ounce of water.

Nitrate of silver, sixty grains to an ounce of distilled water.

Applied as above directed.

This paper keeps tolerably well, and, if carefully prepared, may always be depended upon for darkening equally.

Section III.—Iodide of Silver.

This salt was employed very early by Talbot, Herschel, and others, and it enters as the principal agent into Mr. Talbot's calotype paper. Paper is washed with a solution of the iodide of potassium, and then with nitrate of silver. By this means papers may be prepared which are exquisitely sensitive to luminous influence, provided the right proportions are hit; but, at the same time, nothing can be more insensible to the same agency than the pure iodide of silver. A singular difference in precipitates to all appearance the same, led to the belief that more than one definite compound of iodine and silver existed; but it is now proved that pure iodide of silver will not change colour in the sunshine, and that the quantity of nitrate of silver in excess regulates the degree of sensibility. Experiment has proved that the blackening of one variety of iodidated paper, and the preservation of another, depends on the simple admixture of a very minute excess of the nitrate of silver. The papers prepared with the iodide of silver have all the peculiarities of those prepared with the chloride, and although, in some instances, they seem to exhibit a much higher order of sensitiveness, they cannot be recommended for general purposes with that confidence which experience has given to the chloride. It may, however, be proper to state the best proportions in which the iodidated papers can be prepared, and the most approved method of applying the solutions.

The finest kind of paper being chosen, it should be pinned by its four corners to a board, and carefully washed over with a solution of six grains of the nitrate of silver to half an ounce of water: when this is dry, it is to be washed with a solution of iodide of potassium, five grains in the same quantity of water, and dried by, but at some little distance from, the fire; then, some short period before the paper is required for use, it must be again washed with the silver solution, and quickly dried, with the same precaution as before. If this paper is warmed too much in drying, it changes from its delicate primrose colour to a bright pink or a rosy brown, which, although still sensitive, is not so much so as the parts which are not so altered. The peculiar property of this salt to change thus readily by calorific influence, and some other very remarkable effects produced on already darkened paper when washed with a hydriodic salt, and exposed to artificial heat, or the pure calorific rays of the spectrum, which will be hereafter noticed, appears to promise a process of drawing of a new and peculiar character.

The few simple directions here given will be sufficient to guide the young experimentalist in his earliest essays; and it is particularly recommended that the first experiments should be confined to the salts named in this chapter. The minute details required for the more highly sensitive processes are described in immediate connection with the process to which they refer.

CHAPTER IV.

ON FIXING THE PHOTOGRAPHIC PICTURES.

The power of destroying the susceptibility of a photographic agent to the further action of light, when the picture is completed by its influence, is absolutely necessary for the perfection of the art. Various plans have been suggested for accomplishing this, which have been attended with very different results; few, if any, of the materials used producing the required effect, and, at the same time, leaving the picture unimpaired. The hyposulphite of soda is decidedly superior to every other fixing material; but it will be interesting to name a few other preparations, which may be used with advantage in some instances.

The pictures formed on papers prepared with the nitrate of silver only, may be rendered permanent by washing them in very pure water. The water must be quite free from any muriates, as these salts attack the picture with considerable energy, and soon destroy it, by converting the darkened silver into a chloride, which changes upon exposure.

The great point to be aimed at in fixing any of the sun-pictures is the removal of all that portion of the preparation, whatever it may be, which has not undergone change, without disturbing those parts which have been altered in the slightest degree by the chemical radiations. When a picture has been obtained upon paper prepared with the nitrate of silver, or the ammonio-nitrate of silver, the best mode of proceeding is to wash it first with warm rain water, and then with a diluted solution of ammonia: if the ammonia is too strong, it dissolves the oxide of silver, which in these processes is formed in the fainter parts of the picture, and thus obliterates the more delicate portions. Herschel remarks—"If the paper be prepared with the simple nitrate, the water must be distilled, since the smallest quantity of any muriatic salt present attacks the picture impressed on such paper with singular energy, and speedily obliterates it, unless very dark. A solution containing only a thousandth part of its weight of common salt suffices to effect this in a few minutes in a picture of considerable strength."

Photographs on the muriated papers are not, however, so easily fixed. Well soaking these in water dissolves out the excess of nitrate of silver, and thus the sensibility is somewhat diminished; indeed, they may be considered as half fixed, and may in this state be kept for any convenient opportunity of completing the operation.

Muriate of soda (common salt) was recommended by Mr. Talbot as a fixing material, but it seldom is perfectly successful: as a cheap and easy method, it may be occasionally adopted, when the picture to be preserved is not of any particular consequence.

It may appear strange to many that the same material which is used to give sensitiveness to the paper should be applied to destroy it. This may be easily explained: In the first instance, it assists in the formation of the chloride of silver; in the other, it dissolves out a large portion of that salt from the paper, the chloride being soluble in a strong solution of muriate of soda. When common salt is used, the solution of it should be tolerably strong. The picture being first washed in water, is to be placed in the brine, and allowed to remain in it for some little time; then, being taken out, is to be well washed in water, and slowly dried. If the brine is used in a saturated state, the white parts of the photograph are changed to a pale blue—a tint which is not, in some cases, at all unpleasant.

I have in my possession some pictures which have been prepared more than eight years, which were then fixed with a strong brine, and subsequently washed with warm water. They have become slightly blue in the white portions, but otherwise they are very permanent; and they have lost but little of their original character.

The chloride of silver being soluble in solution of ammonia and some of its salts, they have been recommended for fixing photographs. The ammonia, however, attacks the oxide, which forms the darkened parts in some preparations, so rapidly, that there is great risk of its destroying the picture, or, at least, of impairing it considerably. It matters not whether the liquid ammonia or its carbonate be used, but it must be a very diluted solution. The only photographs on which I have used it with any success are those prepared with the phosphate of silver; and to these it imparts a red tinge, which is fatal to their use for transfers.

The ferrocyanate of potash, or, as it is more commonly called, the prussiate of potash, converts the chloride into a cyanide of silver, which is not susceptible of change by light; consequently this cheap salt has been employed as a fixing agent, but, most unfortunately, photographs which have been subjected to this preparation are slowly, but surely, obliterated in the dark.

The iodide of silver, which is readily formed by washing the photograph with a solution of the iodide of potassium, is scarcely sensitive to light; and this salt, used in the proportions of five or six grains to four or five ounces of water, answers tolerably well where transfers are not required. It tinges the white lights of the picture of a pale yellow,—a colour which is extremely active in absorbing the chemical rays of light, and is therefore quite inapplicable where any copies of the original photograph are required; and, in describing the hydriodated photographs, other objections will be noticed.

Of all the fixing agents, the hyposulphite of soda is decidedly the best. This was first pointed out by Sir John Herschel, who also recommended that it should be used warm in some cases, which was the plan adopted by Mr. Fox Talbot in the improvements of his calotype process.

To use the hyposulphite of soda with effect, there are several precautions necessary. In the first place, all the free nitrate of silver must be dissolved out of the paper by well washing; the photograph being spread on a plane surface, is to be washed over on both sides with a saturated solution of the hyposulphite of soda. The picture must then be washed, by allowing a small stream of water to flow over it, at the same time dabbing it with a piece of soft sponge, until the water passes off perfectly tasteless. This operation should be repeated twice, or, in particular cases, even three times. The hyposulphite of soda has the property of dissolving a large quantity of several of the salts of silver, but particularly of the chloride, with which it combines, forming a triple salt of an exceedingly sweet taste. This salt is liable to spontaneous decomposition, accompanied with separation of silver in the state of sulphuret: hence the necessity of freeing the paper, by washing, of every trace of it, the sulphuret of silver being of a dirty brown. It might appear that the use of warm water would more effectually cleanse the paper; so far from it, it occasions the immediate formation of the sulphuret of silver.

Some operators prefer leaving the picture in a bath of the hyposulphite of soda for some time, and then removing the salt by simple immersion in water, frequently changing it. The advantages of this appear to be, that the surface of the paper is not disturbed by any rubbing action or by the mechanical action of water flowing over the surface. For fixing the calotype pictures, Mr. Cundell, to whom we are much indebted for improvements in this particular process, recommends the following mode of manipulation:—

The picture, or as many of them as there may be, is to be soaked in warm water, but not warmer than may be borne by the finger; this water is to be changed once or twice, and the pictures are then to be well drained, and either dried altogether, or pressed in clean and dry blotting-paper, to prepare them to imbibe a solution of the hyposulphite of soda, which may be made by dissolving an ounce of that salt in a quart of water. Having poured a little of the solution into a flat dish, the pictures are to be introduced one by one; daylight will not now injure them: let them soak for two or three minutes, or even longer, if strongly printed, turning and moving them occasionally. The remaining unreduced salts of silver are thus thoroughly removed by soaking in water and pressing in clean blotting paper alternately; but if time can be allowed, soaking in water alone will have the effect in twelve or twenty-four hours, according to the thickness of the paper. It is essential to the success of the fixing process, that the paper be in the first place thoroughly penetrated by the hyposulphite, and the sensitive matter dissolved; and next, that the hyposulphite compounds be effectually removed. Unless these salts are completely washed out, they induce a destructive change upon the picture; they become opaque in the tissue of the paper, and unfit it for the operation of being copied.

Being desirous, not merely of describing all those processes which have passed into common use, but those even which have been suggested merely upon the strength of a few experiments, where these appear likely to lead to any improved practice, under any circumstances, in the art, the following process of Reuben Phillips is introduced.

Mr. Phillips found that the solvent power of any menstruum was increased by voltaic action. He therefore employed electrodes the size of the photographic picture to be fixed, and placing upon the under one a flannel wetted with the solvent—either common salt, ammonia, or hyposulphite of soda — he placed the impressed paper, wetted with the same solution, on it, and laid another wetted flannel upon it, covering the whole with the other electrode. Connection being made with a tolerably active battery, the metallic salt is rapidly removed to one pole, and thus the fixing process rendered comparatively short and easy, where a voltaic battery is at command.

The hyposulphite of soda has been used for almost every photographic process, from the facility it affords for removing the silver salts. The following is the process of Gustave le Gray, of Paris, which is valuable as being the directions of one who has produced most beautiful pictures: but it does not differ in any important particulars from the process already given:—

"Make in a bottle the following solution:—Filtered water, about a pint and a half; hyposulphite of soda, about three ounces; cover the bottom of a dish with this, and plunge in your negative proof, taking care to avoid air-bubbles: this dissolves the bromo-chloro-iodide of silver, but does not attack the gallo-nitrate of silver, which forms the blacks.

"Never put more than one proof at a time in the bath; but you may use it for several proofs one after the other.

"If you examine the proof as a transparency after it has remained some time in the bath, you may be tempted to think it is lost, as in some places spots will appear from the iodide of silver not being completely taken away; but if you wait until it is removed, which you will know by the disappearance of the yellow tint, you will be astonished at the whiteness and transparency of the paper, as well as at the beauty of the blacks in the image.

"It will require for this, to remain in the bath from half an hour to three quarters; you will then wash it in several waters, and leave it in a basin of clear water for three quarters of an hour; then let it dry spontaneously by hanging it up; the proof is then quite unalterable by light, as there remains nothing more in the paper than the gallo-nitrate of silver, which is black.

"Fixing by means of the bromide of potassium is not so durable, because it does not remove any of the materials used in preparing the paper. It may, nevertheless, be of great use in travelling, and when it is required to make several proofs one after the other; because then you avoid touching the hyposulphite in preparing the negative paper, which spots at the least contact with it.

"You may thus place the whole of your negative proofs together in this bath.

"Water, a pint and three quarters; bromide of potassium, 360 grains.

"In taking the proof out of the bath, you must wash it in several waters and dry it; it should be kept in the bath at least three quarters of an hour, but, if you leave it in two or three hours, it will not injure it."

Such is M. le Gray's statement, and so it is rendered by his English translator, Mr. Cousins; but I believe the quantity of the bromide of potassium to be by far too large, and that the pictures would sustain less injury by using a solution of one half the strength indicated. His process for fixing the positive pictures contains some important hints.

"Dissolve in a bottle hyposulphite of soda, 1500 grains;

"Filtered water, nearly a quart.

In another bottle dissolve 75 grains of nitrate of silver in a wine-glass or two of water; when well dissolved, you add to it a saturated solution of chloride of sodium, until the white precipitate ceases to fall; allow it to repose a short time, and then decant the clear liquor, and gather the precipitate of chloride of silver, which you dissolve in the other bottle of hyposulphite of soda; by means of this solution you obtain directly black tints upon the picture. The older the hyposulphite of soda is, the better; when it gets thick, you must add a fresh solution of hyposulphite alone, without the chloride of silver, the old containing an excess, which it has taken from the proofs already immersed in it. You must not filter it to take away the deposit, but only let it repose in a large bottle, and decant the clear liquid for use, leaving the sediment to be redissolved by fresh solution.

"By leaving the proofs a longer or shorter period in the bath, you can obtain all the tints from the red to the black, and clear yellow; with a little practice, you will be sure to get the tint you desire. You must not leave a proof less than an hour in the bath for it to be sufficiently fixed, and it can remain three or four days to obtain the sepia and yellow. By heating the hyposulphite of soda I accelerate the operation; but we must not then leave the proof for an instant to itself, as the rapidity of action is so great, that the picture might be completely effaced.

"By adding to the preceding solution about one fluid ounce of liquid ammonia, I obtain pretty bister tints, and very pure whites. The English paper is exceedingly good for these tints.

"I obtain also fine velvet-like tints by putting the photograph (when taken out of the hyposulphite of soda) upon a bath of a salt of gold, using 15 grains of the chlorine of gold to one pint and a half of distilled water.

"Fine yellow tints are obtained by placing the proof (if too vigorous) first in a bath of hyposulphite, and then in a bath composed of one pint and a half of water, and one fluidounce and a half of hydrochloric acid; washing it perfectly in water. Liquid ammonia, employed in the same quantity as last mentioned, gives remarkably fine tints.

"When the proof is the colour you desire, wash it in several waters, and leave it two or three hours in a basin of water, until, touching it with the tongue, you perceive no sweet taste which indicates the presence of hyposulphite of silver; then dry it by hanging it up, and it is finished. The bath may contain as many proofs as can be conveniently placed in it."

The following fixing processes are rather more curious than useful: they were first indicated by Sir John Herschel, from whose memoir on the "Chemical Agency of the Rays of the Solar Spectrum" I quote:—

"By far the most remarkable fixing process with which I am acquainted, however, consists in washing over the picture with a weak solution of corrosive sublimate, and then laying it for a few moments in water. This at once and completely *obliterates* the picture, reducing it to the state of perfectly white paper, on which the nicest examination (if the process be perfectly executed) can detect no trace, and in which it may be used for any other purpose, as drawing, writing, &c., being completely insensible to light. Nevertheless, the picture, though invisible, is only dormant, and may be instantly revived in all its force by merely brushing it over with a solution of a neutral hyposulphite, after which, however, it remains as insensible as before to the action of light. And thus it may be successively obliterated and revived as often as we please. It hardly requires mention that the property in question furnishes a means of painting in mezzotinto (*i. e.* of commencing on black paper and working in the lights), as also a mode of secret writing, and a variety of similar applications.

"There is a remark which ought not to be omitted in regard to this part of our subject—viz., that it makes a great difference, in respect of the injury done to a photographic picture by the fixing process, whether that picture have been impressed by the long-continued action of a feeble light, or by the quick and vivid one of a bright sun. Even supposing the pictures originally of equal intensity, the half-tints are much less powerfully corroded or washed out in fixing in the latter case than in the former."

CHAPTER V.

THE TALBOTYPE AS NOW PRACTISED, AND ITS MODIFICATIONS.

In the historical section the description of the *calotype*, as published by Mr. Fox Talbot, is given. While these sheets have been passing through the press, Mr. Henry Fox Talbot has announced his intention of making the country a free gift of all his patents, reserving only the right of taking portraits for sale. Since the name of Daguerre has been given to the process invented by him, it appears but just that the name of Talbot should be employed to designate the process which he introduced, and which is now so universally employed. This claim of Mr. Talbot's no one can dispute. He first communicated it to the public on the 5th and 19th of February, 1841, in the Literary Gazette; and on the 10th of June in the same year Mr. Talbot communicated his process to the Royal Society. It has, however, been so materially improved, and admits of so many variations, that the present mode of working demands our separate consideration.

Section I.—Mr. Cundell's Process.

The first important published improvement on the calotype was due to Mr. Cundell, whose process was published in the Philosophical Magazine for May 1844, from which we extract the following:—

1. To produce a calotype picture, there are five distinct processes, all of which, except the third, must be performed by candle-light: they are all very simple, but, at the same time, they all require care and caution. The first and not the least important is—

2. **The Iodizing of the Paper.**—Much depends upon the paper selected for the purpose; it must be of a compact and uniform texture, smooth and transparent, and of not less than medium thickness. The best I have met with is a fine satin post paper, made by "R. Turner, Chafford Mill." Having selected a half-sheet without flaw or water-mark, and free from even the

minutest black specks, the object is to spread over its surface a perfectly uniform coating of the iodide of silver, by the mutual decomposition of two salts, nitrate of silver and iodide of potassium. There is a considerable latitude in the degree of dilution in which these salts may be used, and also in the manner and order of their application; but as the thickness and regularity of the coating depend upon the solution of nitrate of silver, and upon the manner in which it is applied, I think it ought by all means to be applied first, before the surface of the paper is disturbed. I use a solution of the strength of seventeen grains to the ounce of distilled water.

3. The paper may be pinned by its two upper corners to a clean dry board a little larger than itself; and, holding this nearly upright in the left hand, and commencing at the top, apply a wash of the nitrate of silver *thoroughly*, *evenly*, and *smoothly*, with a large soft brush, taking care that every part of the surface be thoroughly wetted, and that nothing remain unabsorbed in the nature of free or running solution. Let the paper now hang loose from the board into the air to dry, and by using several boards time will be saved.

4. The nitrate of silver spread upon the paper is now to be saturated with iodine, by bringing it in contact with a solution of the iodide of potassium: the iodine goes to the silver, and the nitric acid to the potash.

5. Take a solution of the iodide of potassium of the strength of 400 grains to a pint of water, to which it is an improvement, analogous to that of M. Claudet in the daguerreotype, to add 100 grains of common salt. He found that the chlorinated iodide of silver is infinitely more sensitive than the simple iodide; and by this addition of common salt, a similar, though a less remarkable, modification is obtained of the sensitive compound. Pour the solution into a shallow flat-bottomed dish, sufficiently large to admit the paper, and let the bottom of the vessel be covered to the depth of an eighth of an inch. The prepared side of the paper, having been previously marked, is to be brought in contact with the surface of the solution, and, as it is desirable to keep the other side clean and dry, it will be found convenient, before putting it in the iodine, to fold upwards a narrow margin along the two opposite edges. Holding by the upturned margin, the paper is to be gently drawn along the surface of the liquid until its lower face be thoroughly wetted on every part; it will become plastic, and in that state may be suffered to repose for a few moments in contact with the liquid: it ought not, however, to be exposed in the iodine dish for more than a minute altogether, as the new compound, just formed upon the paper,

upon further exposure, would gradually be redissolved. The paper is therefore to be removed, and, after dripping, it may be placed upon any clean surface with the wet side uppermost until about half dry, by which time the iodine solution will have thoroughly penetrated the paper, and have found out and saturated every particle of the silver, which it is quite indispensable it should do, as the smallest portion of undecomposed nitrate of silver would become a black stain in a subsequent part of the process.

6. The paper is now covered with a coating of the iodide of silver; but it is also covered, and indeed saturated, with saltpetre and the iodide of potassium, both of which it is indispensable should be completely removed. To effect the removal of these salts, it is by no means sufficient to "dip the paper in water;" neither is it a good plan to wash the paper with any considerable motion, as the iodide of silver, having but little adhesion to it, is apt to be washed off. But the margin of the paper being still upturned, and the unprepared side of it kept dry, it will be found that by setting it afloat on a dish of clean water, and allowing it to remain for five or ten minutes, drawing it gently now and then along the surface to assist in removing the soluble salts, these will separate by their own gravity, and (the iodide of silver being insoluble in water) nothing will remain upon the paper but a beautifully perfect coating of the kind required.

7. The paper is now to be dried; but, while wet, do not on any account touch or disturb the prepared surface with blotting-paper, or with anything else. Let it merely be suspended in the air; and, in the absence of a better expedient, it may be pinned across a string by one of its corners. When dry, it may be smoothed by pressure. It is now "iodized" and ready for use, and in this state it will keep for any length of time if protected from the light. The second process is that of exciting or

8. **Preparing the Paper for the Camera.**—For this purpose are required the two solutions described by Mr. Talbot; namely, a saturated solution of crystallized gallic acid in cold distilled water, and a solution of the nitrate of silver of the strength of 50 grains to the ounce of distilled water, to which is added one-sixth part of its volume of glacial acetic acid. For many purposes these solutions are unnecessarily strong, and, unless skilfully handled, they are apt to stain or embrown the paper: where extreme sensitiveness, therefore, is not required, they may with advantage be diluted to half the strength, in which state they are more manageable and nearly as effective. The gallic acid solution will not keep for more than a few days, and only a small quantity, therefore, should be prepared at a time. When

these solutions are about to be applied to the iodized paper, they are to be mixed together, in equal volumes, by means of a graduated drachm tube. This mixture is called "the gallo-nitrate of silver." As it speedily changes, and will not keep for more than a few minutes, it must be used without delay, and it ought not to be prepared until the operator is quite ready to apply it.

9. The application of this "gallo-nitrate" to the paper is a matter of some nicety. It will be found best to apply it in the following manner :—Pour out the solution upon a clean slab of plate-glass, diffusing it over the surface to a size corresponding to that of the paper. Holding the paper by a narrow upturned margin, the sensitive side is to be applied to the liquid upon the slab, and brought in contact with it by passing the fingers gently over the back of the paper, which must not be touched with the solution.

10. As soon as the paper is *wetted* with the gallo-nitrate, it ought instantly to be removed into a dish of water; five or ten seconds at the most is as long as it is safe at this stage to leave the paper to be acted upon by the gallo-nitrate; in that space of time it absorbs sufficient to render it exquisitively sensitive. The excess of gallo-nitrate must immediately be washed off by drawing the paper gently several times under the surface of water, which must be perfectly clean; and being thus washed, it is finished by drawing it through fresh water, two or three times, once more. It is now to be dried in the dark, in the manner described in § 7; and, when surface-dry, it may either be placed, while still damp, in the camera, or in a portfolio, among blotting-paper, for use. If properly prepared, it will keep perfectly well for four-and-twenty hours at least, preserving all its whiteness and sensibility.

11. The light of a single candle will not injure the paper at a moderate distance; but the less the paper, or the exciting solution, is unnecessarily exposed, even to a feeble candle-light, the better. Common river or spring water answers perfectly to *wash* the paper, distilled water being required for the silver solutions only.

Stains of "gallo-nitrate," while recent, may be removed from the fingers by a little strong ammonia, or by the cyanide of potassium.

The third process is that of

12. **The Exposure in the Camera**, for which, as the operator must be guided by his own judgment, few directions can be given, and few are required. He must choose or design his own subject; he must determine upon the aperture to be used, and

judge of the time required, which will vary from a few seconds to three or four minutes. The subject ought, if possible, to have a strong and decided effect; but extreme lights, or light-coloured bodies, in masses, are by all means to be avoided. When the paper is taken from the camera, very little, or more commonly no trace whatever, of a picture is visible until it has been subjected to the fourth process, which is

13. **The Bringing-out of the Picture**, which is effected by again applying the "gallo-nitrate" in the manner directed in § 9. As soon as the paper is wetted all over, unless the picture appear immediately, it is to be exposed to the radiant heat from an iron, or any similar body, held within an inch or two by an assistant. It ought to be held vertically, as well as the paper; and the latter ought to be moved, so as to prevent any one part of it becoming dry before the rest.

As soon as the picture is sufficiently brought out, wash it immediately in clean water to remove the gallo-nitrate, as directed in § 10; it may then be placed in a dish by itself, *under* water, until you are ready to fix it. The most perfect pictures are those which "come out" before any part of the paper becomes dry, which they will do if sufficiently impressed in the camera. If the paper be allowed to dry before washing off the gallo-nitrate, the lights sink and become opaque; and if exposed in the dry state to heat, the paper will embrown; the drying, therefore, ought to be *retarded*, by wetting the back of the paper, or the picture may be brought out by the vapour from hot water, or, what is better, a horizontal jet of steam. The fifth and last process is

14. **The Fixing of the Picture**, which is accomplished by removing the sensitive matter from the paper. The picture, or as many of them as there may be, is to be soaked in warm water, but not warmer than may be borne by the finger; this water is to be changed once or twice, and the pictures are then to be well drained, and either dried altogether, or pressed in clean and dry blotting-paper, to prepare them to imbibe a solution of the hyposulphite of soda, which may be made by dissolving an ounce of that salt in a quart (forty ounces) of water. Having poured a little of the solution into a flat dish, the pictures are to be introduced into it one by one; daylight will not now injure them; let them soak for two or three minutes, or even longer if strongly printed, turning and moving them occasionally. The remaining unreduced salts of silver are thus thoroughly dissolved, and may now, with the hyposulphite, be entirely removed by soaking in water and *pressing* in clean white blotting-paper alternately: but if time can be allowed, soaking in water alone will have the

effect in twelve or twenty-four hours, according to the thickness of the paper. It is essential to the success of the fixing processs that the paper be in the first place thoroughly penetrated by the hyposulphite, and the sensitive matter dissolved; and next, that the hyposulphite compounds be effectually removed. Unless these salts are completely removed, they induce a destructive change upon the picture; they become opaque in the tissue of the paper, and entirely unfit it for the next, which is

15. **The Printing Process.**—The picture being thus fixed, it has merely to be dried and smoothed, when it will undergo no further change. It is, however, a *negative* picture, and if it have cost some trouble to produce it, that trouble ought not to be grudged, considering that you are now possessed of a matrix which is capable of yielding a vast number of beautiful impressions. I have had as many as fifty printed from one, and I have no doubt that as many more might be obtained from it.

16. The manner of obtaining these impressions have been so often described, and there are so many different modes of proceeding, that it may be sufficient to notice very briefly the best process with which I am acquainted. Photography is indebted for it to Dr. Alfred Taylor. His solution is made by dissolving one part of nitrate of silver in twelve of distilled water, and gradually adding strong liquid ammonia until the precipitate at first produced is at length *just* redissolved.

17. Some paper is to be met with, containing traces of bleaching chlorides, which does not require any previous preparation; but in general it will be found necessary to prepare the paper by slightly impregnating it with a minute quantity of common salt. This may be done by dipping it in a solution in which the salt can barely be tasted, or of the strength of from thirty to forty grains to a pint of water. The paper, after being pressed in clean blotting-paper, has merely to be dried and smoothed, when it will be fit for use.

18. The ammonio-nitrate of silver is applied to the paper in the manner described in § 3; and, when perfectly dry, the negative picture to be copied is to be applied to it, with its face in contact with the sensitive side. The back of the negative picture being uppermost, they are to be pressed into close contact by means of a plate of glass; and, thus secured, they are to be exposed to the light of the sun and sky. The exposed parts of the sensitive paper will speedily change to lilac, slate-blue, deepening towards black; and the light, gradually penetrating through the semi-transparent negative picture, will imprint upon the sensitive paper beneath a *positive* impression. The negative picture, or matrix, being slightly tacked to the

sensitive paper by two mere particles of wafer, the progress of the operation may from time to time be observed, and stopped at the moment when the picture is finished.

19. It ought then, as soon as possible, to be soaked in warm water, and fixed in the manner described in § 14.

20. In these pictures there is a curious and beautiful variety in the tints of colour they will occasionally assume, varying from a rich golden orange to purple and black. This effect depends in a great degree npon the paper itself; but it is modified considerably by the strength of the hyposulphite, the length of the time exposed to it, by the capacity of the paper to imbibe it, and partly, perhaps, by the nature of the light. Warm sepia-coloured pictures may generally be obtained by drying the paper, by pressure, and making it imbibe the hyposulphite supplied in liberal quantity.

The paper of "I. Whatman, Turkey Mill," seems to give pictures of the finest colour, and, upon the whole, to answer best for the purpose.

If the chemical agents employed be pure, the operator, who keeps in view the *intention* of each separate process, and either adopting the manipulation recommended, or improving upon it from his own resources, may rely with confidence upon a satisfactory result.

This calotype paper is so exceedingly sensitive to the influence of light, that very beautiful photogenic copies of lace, feathers, leaves, and such like articles, may be made by the light of a common coal-gas flame, or an Argand lamp. The mode of proceeding is precisely that described for obtaining the ordinary photogenic drawings by daylight, only substituting the calotype paper, which should be damp, for the common photogenic.

When exposing the prepared paper to the light, it should be held about four or five inches from the flame, and the time required will be about three minutes.

Section II.—Modified Processes.

But little remains to be added to this very clear and satisfactory description of the Talbotype process,—to which, indeed, is mainly due the perfection to which it has arrived both at home and abroad.

There are, however, a few modifications which must be noticed, as tending to simplify the details in some cases, and to improve the general effects in others. In the main, however, it will be found that Mr. Cundell's process of manipulation is almost as good as any that can be adopted: and that gentleman certainly merits the thanks of the patentee, and of all photographic artists.

Many modifications of Mr. Talbot's mode of manipulating have been introduced with very variable advantages. I have, however, found that nearly every variety of paper requires some peculiar method to excite it to its maximum degree of sensibility. A few of the published methods may be noticed, as under different circumstances they may prove useful.

Mr. Robert Bingham, who has operated with such success, adopts the following process:—

Apply to the paper a solution of nitrate of silver, containing 100 grains of that salt to 1 ounce of distilled water. When nearly, but not quite dry, dip it into a solution of iodide of potassium, of the strength of 25 grains of the salt to 1 ounce of distilled water, drain it, wash it, and then allow it to dry. Now brush it over with aceto-nitrate of silver, made by dissolving 50 grains of nitrate of silver in one ounce of distilled water, to which is added one-sixth its volume of strong acetic acid. Dry it with bibulous paper, and it is now ready for receiving the image. When the impression has been received, it must be washed with a saturated solution of gallic acid, and exposed to a steam heat, a jet of steam from the spout of a tea-kettle, or any convenient vessel. The image will be gradually brought out, and may be fixed with hyposulphite of soda. It will be observed that in this process the solutions of nitrate of silver and of gallic acid are not mixed before application to the paper, as in Mr. Talbot's process.

Mr. Channing, of Boston, very much simplified the calotype process. He directs that the paper should be first washed over with 60 grains of crystallized nitrate of silver, dissolved in 1 ounce of distilled water, and when dry, with a solution of ten grains of the iodide of potassium in one ounce of water: it is then to be washed with water, and dried between folds of blotting paper: the sensibility of the paper is said, and correctly, to be much improved by combining a little chloride of sodium with the iodide of potassium: 5 grains of the latter salt, and rather less than this of the former, in an ounce of water, may be employed advantageously.

To use this paper of Mr. Channing's, where time is an object, it is necessary to wash it, immediately before it is placed in the camera obscura, with a weak solution of nitrate of silver, to which a drop or two only of gallic acid has been added. The picture is subsequently developed by the gallo-nitrate of silver, as already described.

Blanquart Everard, Sagnez, and some others, have recommended that in the preparation of the highly sensitive photographic papers no brushes should be employed. They pursue the following plan: the solutions are poured upon a perfectly flat piece of glass, and the paper carefully drawn over it, and, if necessary, pressed closer by another plate of glass.

A plan of iodizing paper has been proposed by Mr. Jordan, which offers many advantages. Iodide of silver is precipitated from the solution of the nitrate by iodide of potassium, and this precipitate being lightly washed, is redissolved in a strong solution of the latter salt. This solution is applied to the paper, and the paper allowed to dry; after this it is placed face downwards upon some clean water; the iodide of potassium is removed by this, and a pure iodide of silver left on the paper.

If the paper carefully and properly iodized is washed with a very dilute solution of the aceto-nitrate of silver, that is to say, with a solution composed of 10 grains of nitrate of silver to 1 fluid ounce of distilled water, and 10 drops of a concentrated solution of gallic acid be added to another ounce of distilled water, and the two mixed, it will keep for three weeks or a month. It may be used dry in the camera, and afterwards developed with the gallo-nitrate in the usual manner. It will, however, require an exposure in the camera of from ten to twenty minutes, and is, therefore, only useful for still objects; but for buildings, landscapes, foliage, and the like, nothing can be more beautiful.

Le Gray recommends as a highly sensitive paper for portraits the following:—

Distilled water	6200 grains.
Iodide of potassium	300 „
Cyanide of potassium . . .	30 „
Fluoride of potassium . . .	1 „

Papers are washed with this, and then with his strong solution of aceto-nitrate of silver, which is described in the section devoted to the wax paper process.

Section III.—M. Martin's Calotype Process.

M. A. Martin, who is aided by the Imperial Academy of Sciences of Vienna in his endeavours to improve the photographic processes, and render them available to the purposes of art, has published the following as the best proportions in which the solutions should be made, and the order of their application.

For the negative picture—

First.	Iodide of potassium	½ oz.
	Distilled water	10 fluid oz.
	Concentrated solution of cyanide of potassium	7 drops.
Second.	Nitrate of silver	7 drachms.
	Distilled water	10 fluid oz.
	Strong acetic acid	2 drachms.
Third.	A concentrated solution of gallic acid.	
Fourth.	Good spirits of wine.	
Fifth.	Hyposulphite of soda	1 oz.
	Distilled water	10 fluid oz.

For the positive pictures—

First.	Chloride of sodium	168 grains.
	Distilled water	10 oz.
Second.	Nitrate of silver	1 oz.
	Distilled water	10 oz.
Third.	Hyposulphite of soda . . .	1 oz.
	Distilled water	40 oz.

Nitrate of silver 30 grains, dissolved in ½ oz. of distilled water, to be poured into the solution, in a small stream, while it is constantly stirred with a glass rod.

Martin particularly recommends the application of the iodine salt first to the paper, drying this, then applying the argentine solution, and drying rapidly. I have urged the necessity of this on several occasions: the advantages are, that the iodide of silver is left on the very surface of the paper ready for the influence of the slightest chemical radiation.

The use of organic matter in facilitating the change of the silver salts very early engaged the attention of Sir John Herschel; and from time to time, following his suggestions, others have employed various organic matters, albumen and gelatine being the favourite substances. These have been principally used for the purpose of spreading photographic preparations on glass—which we shall have particularly to describe: at the same time they are stated to have been employed with much advantage on paper by some photographists. For the negative pictures, Gustave Le Gray gives us the following directions and particular information:—

First Operation.—Dissolve three hundred grains of isinglass in one pint and three quarters of distilled water (for this purpose use a water bath).

Take one half of this preparation while warm, and add to it as under:—

Iodide of Potassium	200 grains.
Bromide of ditto	60 „
Chloride of Sodium	34 „

Let these salts be well dissolved, then filter the solution through a piece of linen, put it, still warm, in a large dish, and plunge in your paper completely, leaf by leaf, one on the other, taking care to prevent the air-bubbles from adhering to the paper.

Put about twenty leaves at a time into the dish, then turn the whole, those at the top to the bottom, then take them out one by one, and hang them by one corner with a pin bent like the letter S, to dry spontaneously.

When hung up, attach to the opposite corner a piece of bibulous paper, which will facilitate the drying.

When the paper is dry cut it the size required, and preserve it in a folio for use; this paper may be made in the day-time, as it is not sensitive to light in this state.

The bromide does not, in this case, act as an accelerator, as it does on the silver plates of the Daguerreotype, because, instead of quickening, it retards the operation a little; its action is to preserve from the gallic acid the white of the paper, which would blacken more rapidly if you employed the iodide of potassium alone.

Second Operation.—Prepare, by the light of a taper, the following solution in a stoppered bottle: distilled water, 6 fluid ounces, crystallized nitrate of silver, 250 grains.

When the nitrate is dissolved, add 1 ounce of crystallizable acetic acid: be careful to exclude this bottle from the light, by covering it with black paper. This solution will keep good until the whole is used.

When you wish to operate, pour the solution upon a porcelain or glass slab, surrounded with a glass or paper border to keep the liquid from running off. I usually take the solution out of the bottle by means of a pipette, so as to prevent the distribution of any pellicle of dust or other impurity over the glass slab.

Take a sheet of the iodized paper by two of the corners, holding them perpendicularly, and gently lower the middle of the paper upon the centre of the slab; gradually depress until the sheet is equally spread; repeat this operation several times until the air-bubbles disappear; take also the precaution to keep the upper side of the paper dry.

In order to prevent the fingers from spotting the paper, pass a bone paper knife under the corner of the sheet, to lift it from the slab between that and the thumb.

Let the sheet remain upon the slab until the formation of the chloro-bromo-iodide of silver is perfect.

This may be known by the disappearance of the violet colour which the back of the paper at first presented; it must not be left longer, otherwise it would lose its sensitiveness.

The time required to effect this chemical change is from one to five minutes, depending upon the quality of the paper.

Spread upon a glass, fitted to the frame of the camera, a piece of white paper well soaked in water; upon this place the prepared sheet, the sensitive side upwards.

The paper which you place underneath must be free from spots of iron and other impurities.

It is also necessary to mark the side of the glass which ought to be at the bottom of the camera, and to keep it always inclined in that direction when the papers are applied; if this precaution is neglected, the liquid collected at the bottom, in falling over the prepared paper, would not fail to produce spots. The paper thus applied to the glass will remain there for an hour without falling off, and can be placed within that time in the camera.

When I am going to take a proof at a distance, I moisten the sheet of lining paper with a thick solution of gum arabic, and can thus preserve for a longer time its humidity and adhesion. I can also in this case make use of two glasses between which the paper is placed, according to the direction of M. Blanquart Everard; but it is necessary to take great care that the plates of glass are perfectly clean, and to have them re-polished if scratched.

I employ for this purpose, blotting-paper to clean them, as well as my plates; it is much superior to linen, and absorbs liquids and impurities that adhere to it. I never spare the blotting paper, for I would rather use a leaf too much than be uncertain about the cleanness of my glass.

When the sheet of lining paper adheres well to the glass, it should not be removed, but only moistened afresh with water, after which you may apply another sheet of the sensitive paper.

In preparing several sheets of the sensitive paper at a time, it is not necessary to wash the slab for each sheet; you need only draw over it a piece of white paper to remove any dust or pellicle formed.

When your operations are finished, you may pour back the aceto-nitrate of silver into a bottle, and reserve it for another time.

The necessity of employing M. Gray's papers in a wet state is their most objectionable quality, but certainly the results obtained by strict attention to his directions are often exceedingly beautiful. For developing the image the following is recommended, which does not, however, differ essentially from the developing processes already described.

Make about a pint bottle of saturated solution of gallic acid, having acid in excess, and using distilled water; decant a portion into a smaller bottle for general use, and fill up the other bottle; you will thus always have a clear saturated solution.

Pour upon a slab of glass, kept horizontal, a little of this liquid, spreading it equally with a slip of paper, then apply the paper which has been exposed in the same manner as described for the negative paper, being careful to keep the back dry. Watch its development, which is easily observed through the back of the paper; you may leave it thus as long as the back of the image does not begin to spot.

When it is rendered very vigorous, remove it quickly to another clean slab, and well wash it in several waters, occasionally turning it, and gently passing the finger over the back; by this means you remove any crystals of gallic acid which might spot the picture.

The appearance of the image at the end of this process will enable you to judge if it was exposed in the camera the proper time.

If it becomes a blueish grey all over, the paper has been exposed too long; if the strongest lights in the object, which should be very black in the negative, are not deeper than the half tints, it has still been too long exposed; if, on the contrary, it has been exposed too short a time, the lights are but slightly marked in black.

If the time has been just right, you will obtain a proof which will exhibit well-defined contrasts of black and white, and the light parts very transparent. The operation is sometimes accelerated by heating the gallic acid, and by this process the dark parts of the picture are rendered very black.

To fix these negative proofs, a very strong solution of hyposulphite of soda, about 1 ounce of the hyposulphite of soda to 8 fluid ounces of water, is employed, and the picture is allowed to remain in it until every trace of yellowness is removed from the paper.

Section IV.—Calotype Process on Waxed Paper.

The most successful operator with waxed paper has been M. Le Gray, to whom we are indebted for this and several other improvements. In a work lately published by this photographer, he has entered into the question of the physical agencies which are active in producing the chemical changes on the various preparations employed. Throughout the essay, he evidently labours under an entire misconception of the whole of the phenomena, to which, indeed, it is clear he cannot have directed his attention. His manipulatory details are very perfect, but his scientific explanations are not to be received as correct expressions of the facts.

First Process: To Wax the Paper.—This process divides itself into several parts, waxing the paper being the first. For this purpose he takes the paper prepared by Lacroix d'Angoulême, or, that of Canson brothers of Annonay. A large plate of silvered copper, such as is employed for the daguerreotype, is obtained and placed upon a tripod, with a lamp underneath it, or, upon a balneum mariæ. The sheet of paper is spread upon the silver plate, and a piece of pure white wax is passed to and fro upon it until, being melted by the heat, it is seen that the paper has uniformly absorbed the melted wax. When this has thoroughly taken place, the paper is to be placed between some folds of blotting paper, and then an iron, moderately hot, being passed over it, the bibulous paper removes any excess of wax, and we obtain a paper of perfect transparency.

Second Process: To Prepare the Negative Paper. — In a vessel of porcelain or earthenware capable of holding 5 pints and a quarter of distilled water, put about 4000 grains of rice, and allow them to steep until the grains are but slightly broken, so that the water contains only the glutinous portion. In a little less than a quart of the rice solution thus obtained dissolve:—

Sugar of Milk	620 grains.
Iodide of Potassium	225 "
Cyanide of Potassium . . .	12 "
Fluoride of Potassium . . .	7 "

The liquid, when filtered, will keep for a long time without alteration.

When you would prepare the paper, some of this solution is put into a large dish, and the waxed paper, sheet by sheet, is plunged into it, one over the other, removing any air-bubbles which may form. Fifteen or twenty sheets being placed in the bath they are allowed to soak for half an hour, or an hour, according to the thickness of the paper. Turning over the whole mass, commence by removing the first sheet immersed, and hooking it up by one corner with a pin bent in the shape of the letter S, fix it on a line to dry, and remove the drop from the lower angle by a little bundle of blotting-paper. M. Le Gray then remarks that French and English paper should never be mixed in the same bath, but prepared separately, as the "English paper contains a free acid which immediately precipitates an iodide of starch in the French papers and gives to them a violet tint." The paper being dry is to be preserved for use in a portfolio; even in this state it is not absolutely insensible.

Third Process: To render the Waxed Paper Sensitive.—Make a solution of

Distilled water	2325 grains.
Crystallized nitrate of silver . .	77½ "

and when this is dissolved add of

Crystallized acetic acid . . .	186 grains.

Papers prepared with this solution will keep well for a few days. M. Le Gray, however, recommends for his waxed paper, and for portraits, that the quantity of nitrate of silver be increased to 155 grains: the paper must be used moist.

The method of preparing these papers is to float upon an horizontal plate of glass either of the above solutions, and taking a piece of the iodized paper, to carefully place it upon the fluid, taking great care that no air-bubbles interpose. The paper must remain a short time in contact with this sensitive fluid until chemical combination is effected. Four or five minutes are required for some papers, and eight or ten seconds are sufficient for other kinds. When a violet tint appears this should be removed.

For those papers which it is desirable to keep for some time, as during a journey, it is recommended that into one vessel of porcelain you put about five or six millilitres of the strong aceto-nitrate above described, and into another some distilled water: you plunge completely both sides of the waxed and iodized paper in the first fluid, and allow it to remain about four or five minutes; withdraw it, and plunge it immediately into the bath of distilled water, in which let it soak for not less than four minutes. When these papers are carefully dried they may be preserved for some time for use, and by lessening the dose of nitrate of silver this period may be considerably prolonged. It will of course be understood by all who have followed the processes described up to this point, that the papers which are prepared for keeping are not those which are the most sensitive; hence it is necessary to expose such a much longer time in the camera than those prepared by the stronger solution of silver. The more sensitive variety, under ordinary circumstances of light, will require an exposure in the camera of about twenty seconds, the less sensitive demanding about 10 or 15 minutes, according to the circumstances of light.

Fourth Process: The Development of the Image.—The picture is developed by the aid of gallic-acid dissolved in distilled water. Le Gray finds the following to be the best proportions:—

Distilled water	40 fluid ozs.
Gallic acid	60 grains.

The paper is to be plunged into this solution, and allowed to remain until it is fully developed. The time will vary from ten minutes to two hours or more, according to the intensity of the rays incident on the paper when in the camera. The development of the image is much accelerated by the addition of 15 or 20 drops of the aceto-nitrate of silver.

Fifth Process: Fixing.—It is found convenient often, when on a journey, to give a temporary fixedness to the pictures obtained, and to complete the process with the hyposulphite at any time on your return home. A wash of 360 grains of bromide of potassium to two quarts of water is the strength which should be employed. The process of fixing with hyposulphite consists, as in other preparations, simply in soaking the paper until the yellow tint of the iodide has disappeared: the details are particularly given at page 216, in the chapter on Fixing Photographs.

Section V.—M. Flacheron's Process.

The productions of M. Flacheron, which were seen in the Great Exhibition, excited much interest, and the process by which these were obtained in the Eternal City was eagerly sought for by photographic amateurs. In the Art Journal for May, Mr. Thomas has communicated the process by which the photographers of Rome produce their best effects; and as this is very important, as being useful in hot climates, a sufficient portion of that communication is transferred to these pages.

"1st. Select old and thin English paper—I prefer Whatman's: cut it in such a manner that the sheet shall be the sixteenth of an inch smaller than the glass of the paper-holder on every side, and leave two ends at diagonal corners to the sheet by which to handle it.

"2ndly. Prepare the following solution:

"Saturated solution of iodide of potassium 2½ fluid drachms: pure iodide 9 grains: dissolve.

"Then add, distilled water 11½ ounces, iodide of potassium 4 drachms, bromide of potassium 10 grains, and mix. Now, filter this solution into a shallow porcelain vessel somewhat larger than the sheet of paper to be prepared. Take a piece by the two diagonal ends, and gently place the end of the marked side nearest to you, upon the surface of the bath; then carefully incline the surface of the sheet to the liquid, and allow it to rest two minutes; if French paper, one minute, or until the back of the paper (not wetted) becomes tinted uniformly by the action of the dark-coloured solution. Raise it up by means of the two ends occasionally, in order to chase away any air-bubbles, which would be indicated by white spots on the back, showing that the solution in these parts has not been absorbed. Hold the paper by one of the ends for a minute or so, in order that the superfluous moisture may run off, then hang up to dry, by pinning the one end to a string run across a room, and let the excess drop off at the diagonal corner. When dry the paper is ready for use, and quite tinted with iodine on both sides. It will keep any length of time, and is much improved by age.

"3rdly. I will presume that four sheets are to be excited for the camera, and that the operator has two double paper-holders, made without a wooden partition, the interior capacity of which is sufficiently large to admit of three glasses, all moveable. The third, as will be seen, is to prevent the two pieces of excited paper coming in contact with each other.

"Prepare the following solution:

"Take nitrate of silver 2½ drachms; acetic-acid 4½ drachms; distilled water 3½ ounces: mix and dissolve.

"Now take four of the glasses of the paper-holders perfectly clean, and place each upon a piece of common blotting-paper to absorb any little excess of liquid. Pour about 1½ drachms, or rather more of the solution just prepared, into a small glass funnel, into which a filter of white bibulous paper has been placed, and let the solution filter drop by drop upon glass No. 1, until about 1½ drachms have been filtered in detached drops, regularly placed upon its surface; then, with a slip of paper, cause the liquid to be diffused over the whole surface of the glass. Take a piece of prepared paper, and place it marked, side downwards, upon a glass just prepared, beginning at the end nearest you, and thus chasing out the air. Draw it up once or twice by its two diagonal corners; allow it to rest, and prepare glass No. 2 in a similar manner. Now look at glass No. 1, and it will be perceived that the violet tint of the paper has become mottled with patches of white, which gradually spread, and in a few seconds the paper resumes its original whiteness, which is an indication that it is ready for the camera. It will be found to adhere firmly to the glass. Do not remove it; but hold the glass up to allow the excess of fluid to run off at one corner. It must not be touched with blotting-paper, but replaced flat on the table. Serve Nos. 2, 3, and 4, in like manner. Take four pieces of common white paper, not too much sized, free from iron spots, and cut a trifle smaller than the prepared sheet; soak them in distilled water; draw out one piece, hold it up by the fingers to drain off superfluous moisture, and place it gently upon the back of the prepared paper. With another piece of glass kept for the purpose, having the edge rounded, and large enough to act uniformly upon the paper, scrape off gently the excess of liquid, beginning at the top of the sheet, and removing with the rounded edge of the scraper, the liquid to one of the corners. Repeat this operation twice. Both the excited and superimposed paper are thus fixed to the glass. Two glasses and papers being thus prepared, take the clean glass No. 5, and place upon No. 1: press gently: the moist paper will cause it to adhere. Take up the two glasses thus affixed and place them upon glass No. 2, in such a manner that the supernumerary glass No. 5 shall be in the centre. The whole will form a compact body, and having polished the surfaces and wiped the edges, may at once be put in the paper-holders. * * *

"4thly. With a Ross's, Chevalier's, or Lerebours' single lens, three inches diameter, and half an inch diaphragm, the object to be copied, well lighted by the sun, the paper will require from four to six minutes' exposure.

"5thly. Take out the three glasses, which will still firmly adhere, separate them gently, and remove the piece of moistened paper, which must not be used again. Now lift up the prepared paper by one corner to the extent of half the glass, and pour into the centre about one drachm of a saturated solution of gallic acid, which will immediately diffuse itself. Raise also the other corner to facilitate its extension; and serve the others in like manner. The image takes generally from ten to twenty minutes to develope. Hold up the glass to a candle to watch its intensity. When sufficiently developed remove the negative from the glass. Wash it in two or three waters for a few hours, dry with blotting-paper, and immerse each separately for ten minutes in a bath of the following solution: then wash and dry.

"The iodide may be removed by means of hyposulphite of soda in the usual way; twelve months afterwards, or when convenient. If," says Mr. Thomas, "the process has been carefully conducted, four beautiful negatives must be the result. I was ten days working incessantly at Pompeii, and scarcely ever knew what a failure was."

Section VI.—Mr. Muller's Process.

This gentleman has been practising photography with great success at Patna, in the East Indies. His process is as follows:—

A solution of hydriodate of iron is made in the proportions of eight or ten grains of iodide of iron to one ounce of water; this solution is prepared in the ordinary way, with iodine, iron turnings, and water. The ordinary paper employed in photography is washed on one side with a solution of nitrate of lead (15 grains of the salt to 1 ounce of water); when dry, this paper is iodized either by immersing it completely in the solution of the hydriodate of iron, or by floating the leaded surface on the solution. It is removed after a minute or two, and lightly dried with blotting-paper. The paper now contains iodide of lead and proto-nitrate of iron: while still moist it is rendered sensitive by a solution of nitrate of silver (100 grains to the onnce of water) and placed in the camera. After the ordinary exposure it may be removed to a dark room; if the image is not already developed, it will be found speedily to appear in great sharpness *without any further application.* It may then be fixed with the hyposulphite of soda in the usual manner.

CHAPTER VI.

THE DAGUERREOTYPE.

In the first division of this work, Chapter IV. page 35, all the details of the original processes are given with considerable minuteness, and the vignette heading to that section exhibits all the apparatus required for even the improved modern practice.

Section I.—Daguerre's Improved Manipulation.

The following remarks by M. Daguerre on polishing and preparing the plates, from the Comptes Rendus of March 13, 1843, should be carefully attended to, as the preliminary process upon which the success of every subsequent state depends.

"Since the publication of my process, I have not been able to occupy myself much with it. The investigations to which I devoted myself have been in an entirely new direction, and the experiments which they required were analogous with the preceding ones, only inasmuch as they were made on a metallic plate. However, I have lately been so much struck with the unequal results which the impressions generally present—even those of persons who are especially occupied with them—that I determined to seek some means of remedying this serious inconvenience, which I attribute to two principal causes.

"The first relates to the operation of polishing, which it is physically impossible to effect without leaving on the surface of the plate traces of the liquid and of the other substances used in this operation: the cotton alone which is employed, however clean it may be, is sufficient to leave a film of dirt on the silver. This first cause constitutes a very great obstacle to the success of the impression, because it retards the photogenic action by preventing the iodine from coming in direct contact with the silver.

"The second consists in the alterations of the temperature of the air with which the plate is in contact, from the first operations to the mercurial operations. It is known that when a cold body is surrounded with warmer air it condenses its moisture. To this effect must be attributed the difficulty which is experienced in operating in a humid medium, especially when we come to the mercurial operation, which requires, to raise a suitable vapour, a temperature of 122° F.

"This vapour, which first heats the air contained in the apparatus, produces on the metal a dew which weakens the image. It is very evident that this humid layer is very injurious; since if, for example, the plate, on leaving the camera obscura, be breathed on two or three times, the mercurial vapour can no longer cause the impression to appear.

"The water which is condensed, *even at the slightest difference of temperature* between the surface of a body and the surrounding air, contains in solution, or in suspension, a non-volatile substance, which might be called atmospheric dust; and as soon as the equilibrium of temperature is established between the air and the surface of the body, the humid vapour which was condensed on it is volatilised, and depositing on it the dust which it contains, goes on to be re-saturated in the air with a fresh quantity of this impure substance.

"In order as much as possible to neutralise this effect, the temperature of the plate may be kept higher than that of the surrounding air, during each of the operations. But it is impossible to cause this heat to reach to 122° F., in order for it to be of the same temperature as the vapour of mercury, since, if the plate be exposed to that degree of heat after the operation of light in the camera obscura, the image will be altered.

"I first tried to absorb the humidity of the air in the mercurial box by the usual means, such as lime, &c.; but these means are insufficient, and only complicate the process, without giving a good result. Another means which has been proposed consists in vapourising the mercury under the pneumatic machine; by this process, truly, the dew on the plate is avoided, but the pressure of the air, which is indispensable to the impression, is suppressed. The results thus obtained, also, are always wanting in purity.

"The following is the process at which I have stopped, because it is very simple, and because it obviates the two inconveniences above mentioned; that is to say, it frees the silver as much as possible from all dirt or dust, and neutralises the humidity produced by the elevation of temperature in the mercurial box. By the first of these two effects it increases the promptitude, and by the second it renders the lights much whiter (especially by the application of M. Fizeau's chloride of gold): these two effects are always certain. The promptitude given by this process is to that hitherto obtained as 3 to 8: this proportion is accurate.

"This process consists in covering the plate, after having polished it, with a layer of very pure water, and heating it very strongly with a spirit-lamp, and in afterwards pouring off this layer of water in such a manner that its upper part, where the dust which it has raised floats, does not touch the plate.

"It is necessary to have a frame of iron wire of the size of the plate, having at one of its angles a handle, and in the middle, on the two opposite sides, two small cramp-irons, to retain the plate when it is inclined. After having placed this frame on a horizontal plane, the plate is placed on it, which is covered with a layer of very pure water, and putting as much water as the surface can retain. The bottom of the plate is afterwards very strongly heated, and very small bubbles are formed at the surface. By degrees these bubbles become larger, and finally disappear; the heat must be continued to ebullition, and then the water must be poured off. The operator should commence by placing the lamp under the angle of the frame where the handle is; but, before removing the frame, this angle must be very powerfully heated, and then, by gradually removing it by means of the handle, the water immediately begins to run off. It must be done in such a way that the lamp shall follow, under the plate, the sheet of water in its progress, and it must be only gradually inclined, and just sufficient for the layer of water, in retiring, not to lose in thickness; for, if the water were dried up, there would remain small isolated drops, which, not being able to flow off, would leave on the silver the dust which they contain. After that, the plate must not be rubbed: very pure water does not destroy its polish.

"This operation should be performed only just before iodising the plate. Whilst it is yet warm, it is placed in the iodising box, and, without allowing it to cool, it is submitted to the vapour of the accelerating substances. Plates thus prepared may be kept one or two days (although the sensibility diminishes a little), provided that several plates be placed opposite to one another, at a very short distance apart, and carefully enveloped to prevent change of air between the plates.

"The plates cannot be too well polished. It is one of the most important points to obtain a fine polish; but the purity often disappears when substances which adhere to the surface of the silver are used,—such as the peroxide of iron, which has been very generally made use of for giving the last polish. This substance, indeed, seems to burnish the silver, and to give it a more perfect polish; but this polish is factitious, since it does not really exist on the silver, but in fact on a very fine layer of oxide of iron. It is for this reason that there is required for polishing them a substance which does not adhere to the silver; pumice, which I recommended at the commencement, leaves less residue.

"As regards the liquid to be employed: in the first operations nitric acid of five degrees must be employed, as I stated in the first instance; but for the last operations it must be reduced to one degree.

"The polishing with oil and the heating may be suppressed.

"I take the opportunity afforded by this communication to lay before the Academy the following observations, which I owe to experience:—

"The layer produced by the descending vapours of the iodine and of the accelerating substances forms with silver a more sensible compound than is obtained with the ascending vapours. I make this observation only to lay down a fact, for it would be difficult to employ descending vapours, on account of the dust which might fall during the operation, and from stains.

"The resistance which light experiences in passing through a white glass is well known. This resistance is even greater than it appears, and may be attributed not only to the dust which is left on the glazing in cleaning it, but also to that which is naturally deposited on it. The object-glass of the camera obscura is certainly in the same case. To ascertain this, I put the object-glass in cold water, which I boiled; I knew that it was impossible to remove it without the sides. This operation had, therefore, no other object than to raise the temperature of the glass to 212° F. C., and I then immediately poured on the two sides of the object-glass very pure boiling water to remove the dust. By operating directly with the object-glass, thus cleansed, I still further increased the promptitude. This means presents too many difficulties to be put in practice; only care should be taken to clean the object-glass every day.[1]

"The atmospheric dust, which is the scourge of the photogenic images, is, on the contrary, favourable to images which are obtained by contact or at a very short distance. To be convinced of this, we have only to clean the two bodies which we wish to put in contact with the boiling water, as I have just indicated, and to keep them both at the same temperature as the air; there will then be no impression, which evidently proves that these images have no relation with the radiation which gives photographic images."

[1] Professor Stokes has recently confirmed the truth of this by some very conclusive experiments.

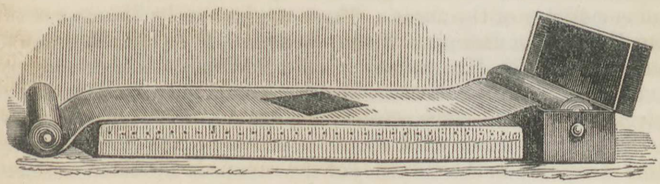
Section II.—Polishing the Plate.

Upon this subject but little remains to be added to what is stated in Daguerre's earliest form of manipulation, and the few remarks just quoted from the Comptes Rendus.

It is of the utmost importance that a very perfect mirror surface should be produced, and to ensure the utmost freedom from all organic matter during the polishing, the plate-holder represented in two positions by *e e*, in Fig. 66, has been devised. The plate-holder is secured to a table by a clamp, and the plate to be polished is fixed upon the horizontal surface of the plate-holder by means of four binding-screws placed at its corners. The plate having undergone the preliminary rubbing, which, as being a comparatively coarse operation, need not be further detailed than it is in the earlier section, and having been fixed on the holder, the last polish is to be given to it. The hand-buff, *i*, in Fig. 66, is to be dusted over with animal charcoal, and moistened with a little spirits of wine: some operators employ tripoli in a state of impalpable powder mixed with essential oil of lavender. If, however, any essential oil is used, it must be ascertained to be quite free from castor oil,—with which it is very commonly adulterated,—by placing a drop on a piece of paper: if it is a pure essential oil, it will, when warmed, entirely evaporate, but if not, a greasy spot will remain.

In M. Claudet's establishment, where, from long experience, the best modes of manipulation are introduced, the last buffing is effected in a somewhat different manner.

In a box on a roller, to which there is a handle, Fig. 61, is



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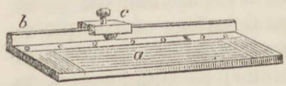
placed a long piece of drab-coloured velvet, which can be drawn out and extended, by means of a second roller, upon the perfectly flat table. The first foot or two, for example, is drawn out: the plate, which has already received its preliminary polishing, is placed face downwards, and being pressed close with the fingers, a rapid circular motion is given to it, and in a few minutes it receives its highest lustre. As the velvet becomes blackened by use it is rolled off, the portion remaining in the box being always perfectly clean, and ready for use. The plate is now ready for receiving its sensitive coating, and, to avoid the chance of the surface touching any other object, M. Claudet adopts the simple but most effective mode of pushing it from the buff into a spherical wooden bowl, in which the plate rests by its four corners in perfect security.

As the edges of the metallic plates are generally sharp, they would often cut the buffs, were that accident not prevented by a suitable precaution. Fig. 62 represents an apparatus called a *plate-bender*. The surface *a* is perfectly horizontal, and has a steel border near the bar *b*: upon the bar *b* runs a press that carries a steel knife edge so rounded as to be able to bend a plate but not to cut it. The silver plate that is to buffed is placed on this apparatus with an edge close to the back bar, and the press is then run along it from end to end, by which means the edge of the silver plate is bent downwards in a very slight degree, but sufficient to prevent any cutting action on the buffs. All the four edges of each plate are bent in the same manner.



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Section III.—To Give the Sensitive Surface to the Plate.

Various compounds, called accelerating liquors, have been introduced, in all of which we have combinations in various proportions of either bromine and iodine, or chlorine and iodine, and sometimes of the three. These are known by the names of Eau Bromeé, or Bromine Water, Bromide of Iodine, Redman's Sensitive Solution, Hungarian Liquid, and Woolcott's Accelerating American Fluid. In all cases, bromine, combined sometimes with chlorine and iodine, is the accelerating agent. They all require to be diluted with water until about the colour of pale sherry. The plate is exposed to the influence of the vapour in the same manner as with the iodine, the iodine being applied first by the method directed by Daguerre, but the colour to be attained differs according to the solution employed. An iodizing box is shown at *c*, Fig. 66: at the bottom of this some iodine is strewed, and in general it is covered with a little sand or a card;—this is to avoid the irregular action on any part of the plate: the box being adjusted with a cover, the iodine is preserved from evaporation and lasts a long time. When the plate has assumed its fine straw yellow it is removed to the action of the accelerating agents, liquid or otherwise, as the case may be. The following rules will guide the experimenter in using the different liquids. If bromide of iodine be used as the accelerating agent, the plate should remain over the iodine until it is of a pure yellow tint, and over the bromine till of a deep rose colour. By observing the time of exposure necessary to render a plate sensitive, any number of plates may be prepared exactly alike, provided that the same quantity of the solution, always of an uniform strength, be put into the pan. By using a much weaker solution a longer exposure is then necessary, but the plate becomes more evenly covered, and there is less danger of having too much or too little of the accelerator upon it. The same remark may apply to other accelerating solutions. If Redman's solution, or the Hungarian liquid, a pale yellow and light rose will be found most sensitive. As a general rule, if the yellow colour produced by the iodine be pale, the red should be pale also; if deep, the red must incline to violet. When several plates are to be prepared at one time, the same solution will serve for all; but it seldom answers to preserve the mixture for any time; and its use, after keeping, is one great cause of the failures which so annoy amateurs. The bromine contained in these solutions is very subtile, and escapes, leaving little else but iodine remaining, which will, after some little time, give a red colour to the plate, without rendering it sensitive, entirely disappointing the expectations of the operator. Eau bromée, or bromine water, which is very easily prepared, is extensively used on the Continent, and is simple in its use. If a certain quantity of an uniform solution be placed in the pan, for each plate prepared one observation will suffice to determine the time of exposure; if not, the colour must guide the operator, varying according to the degree of colour obtained over the iodine: thus, if the first colour obtained be a light yellow, the plate should attain a full golden tint over the iodine, and may then be retained over the bromine until it acquires a rose colour. If iodized of a golden yellow, then, in the second operation, it is taken to a pale rose, and in the third to a deep rose. If in the first of a full red, in the second to a deep red, and lastly to a grey; if the first to a deep red, in the second to a light blue, and in the third, to a white, or nearly the absence of all colour.

Experience, however, must invariably guide the operator, as scarcely any two solutions, though professedly the same in character, possess the same properties.

In a pamphlet published by M. Fizeau, bromine-water is recommended to be prepared as follows:—" To prepare a solution of bromine, of a fixed proportion and convenient strength to operate with, I, in the first place, make a saturated solntion of bromine in water; this is prepared by putting into a bottle of pure water a great excess of bromine, agitating strongly for some minutes, and before using allowing the bromine to separate. Now, a definite quantity of this saturated water is to be mixed with a definite quantity of plain water, which will give a solution of bromine always of the same strength: this mixture is conveniently made in the following manner:—The apparatus necessary is a *dropping tube*, which is also required for another part of the process, capable of holding a small definite quantity, and a bottle having a mark to indicate a capacity equal to thirty times that of the dropping tube: fill the bottle with pure water to the mark, then add, by means of the dropping tube, the proper quantity of the saturated solution of bromine.

"The purity of the water is of some importance: the foregoing proportions refer to the pure distilled water, and it is well known that the water of rivers and springs is not pure; but these different varieties can be used as absolutely pure water by adding a few drops of nitric acid till they taste slightly acid; two or three drops to the pint is generally sufficient.

"The liquid produced, which is of a bright yellow colour, ought to be kept in a well-stopped bottle; it is the normal solution, and I shall call it simply bromine water, to distinguish it from the saturated solution.

"**Bromine Box.**—The box I employ for subjecting the plate to the vapour of the bromine water is constructed in the following manner:—It consists of a box lined with a varnish, which is not acted on by bromine; its height is about four inches; the other dimensions are regulated by the size of the plate, which ought to be at least half an inch all round, short of the sides of the box; it is composed of three separate portions—the cover, which is the frame holding the plate, the body of the box, and the bottom, upon which is placed the vessel for the bromine; this moveable bottom is slightly hollowed, so that the bromine vessel may always be placed in exactly the same position."

Few men have done more for photography than Fizeau, and in nearly all his suggestions he has been exceedingly happy: the bromine water thus prepared is used with the best effect by our most eminent daguerreotype artists.

Bromide of iodine is best prepared by the method of M. de Valicours, which is as follows:—"Into a bottle of the capacity of about two ounces, pour thirty or forty drops of bromine, the precise quantity not being of importance. Then add, grain by grain, as much iodine as the bromine will dissolve till quite saturated. This point is ascertained when some grains of the iodine remain undissolved. They may remain in the bottle, as they will not interfere with the success of the preparation.

"The bromide of iodine thus prepared, from its occupying so small a space, can very easily be carried, but in this state it is much too concentrated to be used. When it is to be employed, pour a small quantity, say fifteen drops, by means of a dropping-tube, into a bottle containing about half an ounce of filtered river water. It will easily be understood that the bromide of iodine can be used with a greater or less quantity of water without altering the proportion which exists between the bromine and iodine."

Chloride of iodine was first employed by M. Claudet, and is prepared by merely placing iodine in an atmosphere of chlorine. Chloride of bromine is made by mixing two drachms of a saturated solution of bromine with fifteen drops of strong muriatic acid and about nine or ten ounces of water. The Hungarian mixture appears to be a similar compound to this.

For the following exceedingly convenient preparations we are indebted to Mr. R. J. Bingham, who has for some time, with much success, devoted his attention to the improvement of photographic processes. The following extracts are from the Philosophical Magazine for October 1846:—

"*An Improvement in the Daguerreotype Process by the application of some new compounds of bromine, chlorine, and iodine, with lime.*—All persons who have practised the daguerreotype must have remarked that in warm weather a considerable deposition of moisture takes place upon the glass or slate cover used to confine the vapour in the bromine or accelerating pan. This moisture must also necessarily condense upon the cold metallic surface of the plate during the time it is exposed to the bromine vapour. In fact, I have been informed by a number of professional daguerreotypists (and I have experienced the difficulty myself), that they were unable to obtain perfect pictures during the excessive heat of the late season; and a very clever and enterprising operator, who last year made a tour on the Continent, and brought home some of the finest proofs I have ever seen, entirely failed this season in obtaining clear and perfect pictures, from the constant appearance of a mist or cloud over the prepared surface. This appears to be caused by the deposition of moisture upon the plate, arising from the water in which the bromine is dissolved. To obviate this, some have recommended the pan to be kept at a low temperature in a freezing mixture; and M. Daguerre, in a communication to the French Academy of Sciences, recommends the plate to be heated: but in practice both these are found to be unsuccessful. (See Lerebours' *Traité de Photographie.*)

"It appeared to me, that if we could avoid the use of water altogether in the accelerating mixture, not only would the difficulty I have mentioned be avoided, but a much more sensitive surface would be obtained on the plate. With this view I endeavoured to combine bromine with lime, so as to form a compound analogous to bleaching powder. In this I was successful, and find that bromine, chloride of iodine, and iodine, may be united with lime, forming compounds having properties similar to the *so-called* chloride of lime.

"The bromide of lime[1] may be produced by allowing bromine vapour to act upon hydrate of lime for some hours: the most convenient method of doing this is to place some of the hydrate at the bottom of a flask, and then put some bromine into a glass capsule supported a little above the lime. As heat is developed during the combination, it is better to place the lower part of the flask in water at the temperature of about 50° Fah.: the lime gradually assumes a beautiful scarlet colour, and acquires an appearance very similar to that of the red iodide of mercury. The chloroiodide of lime may be formed in the same manner: it has a deep brown colour. Both these compounds, when the vapour arising from them is not too intense, have an odour analogous to that of bleaching powder, and quite distinguishable from chlorine, bromine, or iodine alone.

"Those daguerreotypists who use chlorine in combination with bromine, as in Woolcott's American mixture, or M. Guérin's Hungarian solution, which is a compound of bromine, chlorine, and iodine, may obtain similar substances in the solid state, which may be used with great advantage. By passing chlorine over bromine, and condensing the vapours into a liquid, and then allowing the vapour of this to act upon lime, a solid may be obtained having all the properties of the American

[1] "I call this substance bromide of lime, although there is a difficulty as to the composition of bleaching powder, and which would also apply to the compounds I describe. Some chemists regard the *chloride of lime* to be a compound of lime, water, and chlorine. Balard thinks it is a mixture of hypochlorite of lime and chloride of calcium; and the view of Millon and Prof. Graham is, that it is a peroxide of lime, in which one equivalent of oxygen is replaced by one of chlorine."

accelerator; or by combining the chloro-iodide of lime with a little of the bromide, a mixture similar to that of M. Guérin's may be produced: but I greatly prefer, and would recommend, the pure bromide of lime, it being, as I believe, the quickest accelerating substance at present known. By slightly colouring the plate with the chloro-iodide, and then exposing it for a proper time over the bromide, proofs may be obtained in a fraction of a second, even late in the afternoon. A yellow colour should be given by the use of the first substance; and the proper time over the bromide is readily obtained by one or two trials.[1] With about a drachm of the substance in a shallow pan, I give the plate ten seconds the whole of the first day of using the preparation, and add about three seconds for every succeeding one. The compound should be evenly strewed over the bottom of the pan, and will last, with care, about a fortnight.

"The great advantage of this compound is, that it may be used continuously for a fortnight without renewal; and, unlike bromine water, its action is unaffected by the ordinary changes of temperature."

The advantages of employing a dry material are so great that the bromide of lime is now commonly employed.

By the employment of these agents a sensitive coating is produced, upon which actinic changes are almost instantly made. The modes of proceeding to prepare the plates are similar to those already named.

The time necessary for the plate to be exposed to the action of the bromine water, if it be used, must be determined by experiment, for it will vary according to the size of the box and the quantity of liquid used. It is ordinarily between thirty and sixty seconds, the time varying with the temperature of the atmosphere: when once determined, it will be constant with the same box, the same strength of solution, and the same temperature.

The method of coating the plate which is most approved is as follows:—Place the pan upon a table, fill the pipette with bromine water, draw out a little way the glass slide, and allow the bromine water to run into the pan, and again close the vessel: the liquid must cover evenly the bottom of the pan;

1 "It is better to count time both over the iodine and the bromide of lime: the exposure of the plate to the iodine, after it has received its proportion of bromine, should be one-third of the time it took to give it the first coating of iodine. We have found that if less iodine than this be allowed to the plate it will not take up so much mercury, neither will the picture produced be so bold and distinct."

if not level, it must be adjusted: the level will be easily seen through the glass slide. When everything is thus arranged, the plate, previously iodized, is to be placed in its frame over the pan, the slide withdrawn, and the necessary time counted; after this has elapsed, the slide should be shut, and the plate immediately placed in the dark box of the camera.

For a second operation, this bromine water must be thrown away, and a fresh quantity used. The bottle containing the bromine water should be kept away from the direct light of the sun, and care should be taken that no organic matter fall into the bottle, such as grease, chips of cork, &c. These enter into new combinations with the bromine, and lead to error as to its amount in solution.

Daguerre himself introduced some very considerable improvements in the process of iodising. He avoids the use of metal strips, and gives some curious experiments on the action of edges, grooves, &c., in determining the deposition of vapour. M. Daguerre then states that, but for the difficulty of fixing them, the bands might be very much reduced in size; for it is sufficient for them to produce their effect that there be a solution of continuity between them; and this is proved by the fact that nearly the same result is obtained by engraving at the $\frac{1}{8}$th of an inch from the edge of the plate a line deep enough to reach the copper. The objections to this are, that during the polishing process the engraving is filled with dust, and it retains water, which sometimes occasions stains. He then proposes, as a very great simplification of this process, that the plate be laid flat in a shallow box containing two grooves, one to receive the plate, and the other a board saturated with iodine. Around the plate he places a border of either powdered starch or lime, and the iodine *descends* from the board to the tablet. The starch or lime absorbs the iodine with avidity, and thus prevents its attacking the edges of the silver, and the vapour is diffused with perfect evenness over it. Another advantage is, that the saturated board may be used for several days in succession, without being at all renovated.

M. Seguier somewhat modifies even this process. A box of hard wood, varnished internally with gum lac, contains a lump of soft wood, furnished with a card of cotton sprinkled with iodine. Upon this is placed a plate covered with card-board on each of its faces. One of these card-boards furnishes, by radiation, to the metal the vapour of iodine, while the other returns to the cotton that which it had lost. It suffices to turn the plate from time to time, in order that the operation may go on with equal rapidity. A plate of glass is placed upon the upper card-board, where it is not operated on. The plate is sustained a little above the charged cotton by frames of hard wood varnished with gum lac. By increasing the distance between the cotton and the plate, or the contrary, we are enabled to suit the arrangement to the temperature of the season, and thus always operate with facility and promptitude. M. Seguier also states, that a single scouring with tripoli, moistened with acidulated water, is sufficient to cleanse the plates thoroughly, and does away with the tedious process of scouring with oil, and afterwards the operation of heating the tablet over a spirit lamp. M. Soliel has proposed the use of the chloride of silver to determine the time required to produce a good impression on the iodated plate in the camera. His method is to fix at the bottom of a tube, blackened within, a piece of card, on which chloride of silver, mixed with gum or dextrine, is spread. The tube thus disposed is turned towards the object of which we wish to take the image, and the time that the chloride of silver takes to become of a grayish slate colour will be the time required for the radiations in the camera to produce a good effect on the iodated silver.

These remarks have been introduced as supplementary to the generally approved modes, as they are suggestive in themselves of still further improvements.

Section IV.—To Develope the Image formed on the Plate.

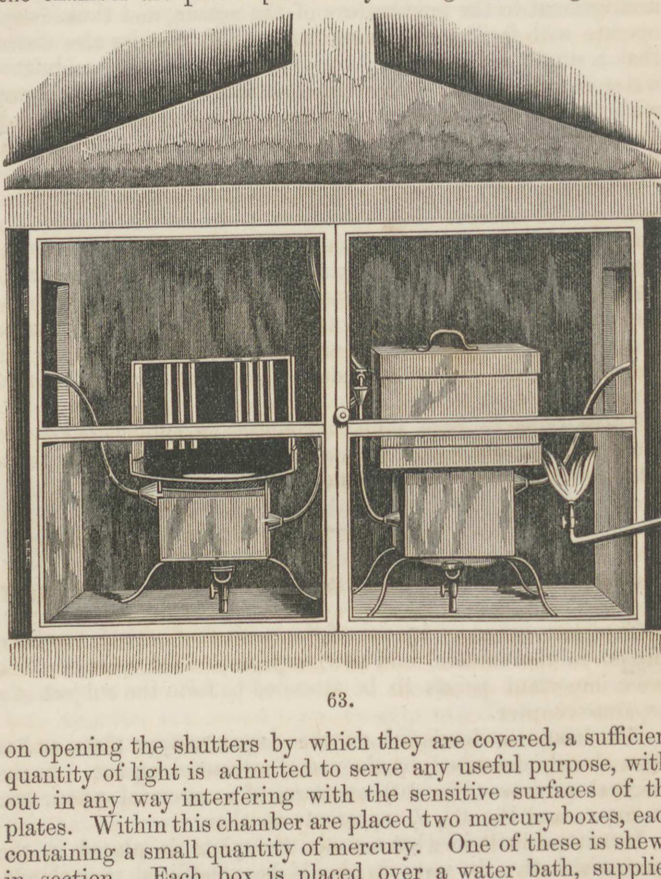
The plate, prepared by one of the methods directed, has been placed in the camera, and the image impressed upon it. The more important points to be attended to form the subject of a separate chapter.

The image is developed on the daguerreotype plate, as has been already described, by the use of mercurial vapour. In the original process (Fig. 10) one form of a mercurial vapour box is given; and Fig. 66, *d*, represents another.

It matters little in what manner the plate is placed in the mercurial bath; the mercury should be volatilized very slowly, and the image allowed to have its full development before it is removed from the box. Care should be taken that the operator avoids as much as possible contact with the mercurial vapour, since continued exposure to its influence might lead to serious inconvenience.

M. Claudet has adopted a most admirable arrangement in this respect, as is shewn in the woodcut on the following page.

Fig. 63 represents a small dark chamber fixed outside the apartment in which the operations are carried on, but opening into it by means of sliding glass doors. On either side of the chamber are placed pieces of yellow glass, through which,



63.

on opening the shutters by which they are covered, a sufficient quantity of light is admitted to serve any useful purpose, without in any way interfering with the sensitive surfaces of the plates. Within this chamber are placed two mercury boxes, each containing a small quantity of mercury. One of these is shewn in section. Each box is placed over a water bath, supplied by means of a pipe with water from a cistern above, and a small sand bath is placed between the mercury box and the water bath. By means of the gas-burner beneath the box, the water is heated, and the mercury volatilized slowly and deposited on the plates, which are fixed on the grooves shown on the sides of the box in section. The windows being closed, any mercurial vapours which may escape from the box may pass out into the air through proper ventilators, and the operator is thus protected from the injurious effects of the mercury.

Section V.—Fixing the Daguerreotype Image.

It has already been stated that the solution of hyposulphite of soda is the most effective agent for removing all the unchanged iodide of silver, after the application of, and the development of the image by, the mercurial vapour.

This being effected, greater permanence is given by the application of a solution of gold.

The process, as described by M. Fizeau, to whom we are indebted for its introduction, is as follows :—

"Dissolve eight grains of chloride of gold in sixteen ounces of water, and thirty-two grains of hyposulphite of soda in four ounces of water: pour the solution of gold into that of the soda, a little by little, agitating between each addition. The mixture, at first slightly yellow, becomes afterwards perfectly limpid. This liquid now contains a double hyposulphite of soda and gold.

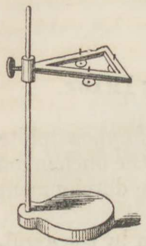
"To use this salt of gold, the surface of the plate should be perfectly free from any foreign substance, especially dust; consequently it ought to be washed with some precautions which might be neglected if it was to be finished by the ordinary mode of washing.

"The following manner generally succeeds the best: the plate being yet iodized, and perfectly free from grease on its two surfaces and sides, should have some drops of alcohol poured on the iodized surface; when the alcohol has wetted all the surface, plunge the plate into a basin of water, and after that into a solution of hyposulphite of soda.

"This solution ought to be changed for each experiment, and to consist of about one part of the salt to fifteen of the water: the rest of the washing is done in the ordinary way, only taking care that the water should be as free as possible from dust.

"The use of the alcohol is simply to make the water adhere perfectly all over the surface of the plate, and prevent it from quitting the sides at each separate immersion, which would infallibly produce stains.

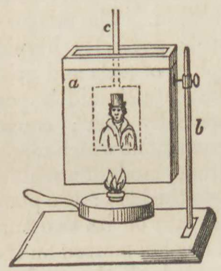
"When a picture has been washed, with these precautions, the treatment with the salt of gold is very simple. It is sufficient to place the plate on a support, fig. 64, or fig. 66, *g*, and pour upon its surface a sufficient quantity of the salt of gold that it may be entirely covered, and heat it with a strong spirit-lamp; the picture will be seen to brighten, and become, in a minute or two, of great force. When this effect is produced, the liquid should be poured off, and the plate washed and dried.



64.

"In this operation the silver is dissolved, and the gold precipitated upon the silver and mercury, but with very different results: in effect, the silver, which, by its reflection, forms the shades of the picture, is in some way darkened by the thin film of gold which covers it, from which results a strengthening of all the dark parts. The mercury, on the contrary, which, in the state of an infinite number of small globules, forms the lights, is augmented in its solidity and brightness by its union with the gold, from which results a great degree of permanency, and a remarkable increase in the lights of the picture."

The plates are then washed by means of an arrangement of this order. The apparatus represented in fig. 65 may be employed.



65.

a is a vessel sufficiently large to take the plate, and not more than half an inch wide: this is filled with distilled water, which is heated by means of a spirit-lamp; *b* is a stand supporting the trough, and *c* a holder for the plate. After the plate has been immersed for a few minutes, it is to be drawn out slowly, and by blowing on it the water is removed, and the warm metal rapidly dried. Such are the principal processes which have been adopted in the daguerreotype manipulation. Other modes for giving permanency to the daguerrean image have been adopted, but none of them have been so thoroughly successful.

It appears advantageous to quote a few of the modified forms of proceeding for fixing these pictures, when obtained, which have from time to time been recommended.

Extract of a Letter from M. Preschot to M. Arago.

In one of the sittings of last month you mentioned a process for fixing photogenic images on metal. Knowing, as I do, the interest you take in the beautiful discovery of the daguerreotype, I hope you will excuse the liberty I take in troubling you with results which I obtained in experiments made a few months ago.

Photogenic images, obtained by M. Daguerre's process, may be fixed by treating them with a solution of hydrosulphate of ammonia. For this purpose, a concentrated solution of this fluid is mixed with three or four volumes of pure water, which is poured into a flat vessel, in sufficient quantity that the plate may be steeped in it horizontally, and just covered with the fluid. When, by the action of the fluid, the tints of the drawing are sufficiently changed, which occurs in less than a minute, the plate is to be withdrawn and put into a flat vessel containing water: it is afterwards taken out and dried. By this process the polished parts of the metal are tinged grey by the sulphuret, and the amalgamated parts are not attacked,—or, at least, but very little. The tints may be varied by the concentration of the fluid or the duration of the immersion: however, too long an action turns the lights yellow. Photogenic images, treated in this manner, bear rubbing with the finger without losing any of their details.

M. Choiselat proposed a plan which has been rarely acted upon, but which is well deserving of all attention.

Chloride, and particularly iodide, of silver, dissolved in hyposulphite of soda, may be advantageously employed for fixing the images of the daguerreotype. Steeped in these solutions, they are under the electro-chemical influence exerted by the copper on the dissolved silver, and thus became ineffaceable.

Instead of the hyposulphite, a mixture of iodide, bromide, &c., of potassa may be employed, holding the silver salt in solution.

The iodide of silver best adapted for this operation is that which is obtained by treating, with the aid of heat, a plate of this metal by the iodide precipitated from alcohol by water, afterwards dissolving the iodide formed and adhering to the plate in the hyposulphite.

Dr. Berres, of Vienna, assisted by Mr. F. Kratochwila, has succeeded by another process, bearing some analogy to that of M. Fizeau, in fixing the daguerreotype designs. He takes the photograph produced in the usual manner by the process of Daguerre, holds it for a few minutes over a moderately warmed nitric acid vapour, and then lays it in nitric acid of 13° or 14° Réaumur (61¼° or 63½° Fahrenheit), in which a considerable quantity of copper or silver, or both together, has been previously dissolved. Shortly after having been placed therein, a precipitate of metal is formed, and can be changed to any degree of intensity. The photographic picture coated with metal is now removed, washed in water, cleaned, and dried; it is then polished with chalk or magnesia, and a dry soft cloth or leather, after which the coating will become clean, clear, and transparent, so that the picture, with all its properties, can again be seen.

SECTION VI.—SIMPLIFICATION OF THE DAGUERREOTYPE.

The following experiments for the simplification of the daguerreotype processes, which were made by me many years since, do not appear to be entirely uninstructive; the original paper is therefore retained, with a few verbal alterations only.

The extreme expense of the apparatus and plates, as supplied by the patentee, induced me, in the very first stage of my experiments, to endeavour to construct for myself a set which should be equally as effective, and less expensive.

I was soon satisfied that all the arrangements might be much simplified.

My apparatus consisted of a deal box the size of my plates, and three inches deep, with a thin loose board in the bottom. This board is well saturated with the tincture of iodine; the spirit is allowed partially to evaporate, and then, being put in its place, the plate is adjusted at a proper height above it, varying the height according to the temperature: the box being closed, the operation is completed in about three minutes. Another deal box, having a glass in one side, and a bottom of sheet iron, which is slightly concaved to contain mercury, with grooves upon which the plate may rest at the proper angles, serves to mercurialize the plates. My camera, which I use for every photographic process, is described in a former chapter. It is sometimes convenient, particularly when travelling, to use a piece of amalgamated copper, which may be prepared, when wanted, by rubbing it with some nitrate of mercury. The expense of the plates may be very much reduced: instead of using copper *plated* with silver, I would recommend the use of silvered copper, which every one can prepare for himself at a very small expense. The following is the best method of proceeding:—

Procure a well-planished copper plate of the required size, and well polish it, first with pumice stone and water, then with snake stone, and bring it up to a mirror surface with either rotten-stone or jewellers' rouge. Plates can be purchased in a high state of preparation from the engravers. Having prepared the copper plate, well rub it with salt and water, and then with the silvering powder. No kind answers better than that used by clock-makers to silver dial-plates. It is composed of one part of well-washed chloride of silver, five parts of cream of tartar, and four parts of table salt. This powder must be kept in a dark vessel, and in a dry place. For a plate six inches by five, as much of this composition as can be taken up on a shilling is sufficient. It is to be laid in the centre of the copper, and the fingers being wetted, to be quickly rubbed over every part of the plate, adding occasionally a little damp salt. The copper being covered with the silvering, it is to be speedily well washed in water, in which a little soda is dissolved, and as soon as the surface is of a fine silvery whiteness it is to be dried with a very clean warm cloth. In this state the plates may be kept for use. The first process is to expose the plate to the heat of a spirit flame, until the silvered surface becomes of a well-defined golden-yellow colour; then, when the plate is cold, take a piece of cotton, dipped in very dilute nitric acid, and rub lightly over it until the white hue is restored, and dry it with very soft clean cloths. A weak solution of the hydriodate of potash, in which a small portion of iodine is dissolved, is now passed over the plate with a wide camel's hair brush. The silver is thus converted, over its surface, into an ioduret of silver; and in this state it is exposed to light, which blackens it. When dry it is to be again polished, either with dilute acid or a solution of carbonate of soda, and afterwards with dry cotton, and the smallest possible portion of prepared chalk; by this means a surface of the highest polish is produced. The *rationale* of this process is, in the first place, the heat applied drives off any adhering acid, and effects more perfect union between the copper and silver, so as to enable it to bear the subsequent processes. The first yellow surface appears to be an oxide of silver, with, possibly, a minute quantity of copper in combination, which being removed leaves a surface chemically pure. Copper plates may also be very beautifully silvered by galvanic agency, by which we are enabled to increase the thickness of the silver to any extent, and the necessity for the heating process is removed, the silver being absolutely pure. The best and simplest mode with which I am acquainted is to divide an earthenware vessel with a diaphragm: one side should be filled with a very dilute solution of sulphuric acid, and the other with either a solution of ferroprussiate of potash, or muriate of soda, saturated with chloride of silver. The copper plate, varnished on one side, is united, by means of a copper wire, with a plate of zinc. The zinc plate being immersed in the acid, and the copper in the salt, a weak electric current is generated, which precipitates the silver in a very uniform manner over the entire surface.

At a very early stage of my inquiries I found that the influence of all the rays, excepting the yellow, was to loosen the adhesion of the iodidated surface, and the under layer of unaffected silver. When this changed film was removed by rubbing, the silver beneath always exhibited the most perfect lustre, and I have hence invariably adopted this mode of polishing my daguerreotype plates. The required surface is thus produced with one-third the labour, and a very great saving of time; besides which, the silver is in a much more susceptible state for receiving the vapour of the iodine. The plate being thus prepared, we proceed in the manner before directed.

It is somewhat singular, that on the first notice of Daguerre's pictures, long before the publication of his process, when I learnt that they were on "hard polished tablets," I entertained the idea that plates of copper thus silvered were oxidised, and then acted on by iodine. I applied the iodine both in solution and vapour; but, of course, as the mercury was not used, I failed to effect any perfect pictures. It is, however, worthy of remark, that on one occasion, having placed a piece of silvered copper in a trough containing a weak solution of iodine, with some leaves of hemlock superimposed, these being kept close by means of a piece of glass, over all the exposed portions the silver was completely removed, and the copper abraded to a considerable extent, while beneath the leaves the silver was scarcely affected. I thus procured a very beautiful etching, the figures being in high relief. This was frequently repeated with success; but other inquiries having drawn off my attention, the process has been long neglected, although I am convinced it is capable of being turned to much useful account.

In November 1839, I pursued a series of experiments with bromine, but no very definite advantage was obtained. Some curious effects which I noticed at that time are worthy of notice. I copy the remarks made in my memorandum-book at the time.

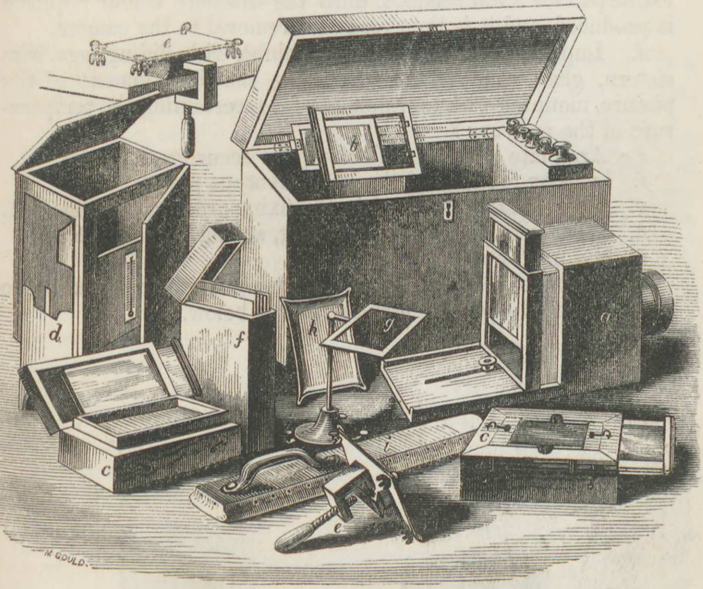
4. Exposed a plate to the vapour of bromine: it assumed a leaden-grey colour, which blackened by light very readily. Exposed this to mercury without much improving the effect or altering the lights. Upon immersing this plate in a solution of the muriate of soda, the parts unacted on by light became a jet black, whilst the parts on which light had acted were dissolved off, leaving a clean coating of silver. The effect was most decisive—*a black picture on a white ground.*

8. Allowed three plates to assume—the first a straw-yellow, the second a steel-blue, and the third a dull blue, and examined their sensitiveness; the plate which had arrived at the dull blue colour appeared to be the most sensitive.

These experiments, which were then pursued with a view to produce more permanent pictures—to fix the mercury, or to engrave the plate—were, however, abandoned, and have not yet been resumed, although it is desirable that some one should turn his attention to this point. On one occasion, after having prepared a picture according to the process prescribed by

Daguerre, I placed it, without removing the iodine, in a vessel of chlorine; the picture was obliterated, and very speedily *blackened*. On exposing this *black* plate to light, it almost instantaneously *whitened*. This is mentioned to show the extent of curious subjects which photography opens out for examination.

The apparatus for the Daguerreotype shown in the vignette, may be enumerated with advantage.



66.

a. Is the camera obscura, with the screen upon which the image is seen, and by which the focus is adjusted, partly raised; and when this is accurately determined a screw is shown by which it is secured.

b. Silver plate and edges for the same.

c c. Are bromide and iodine boxes of walnut, enclosing each a stout porcelain pan: each pan is furnished with an air-tight glass cover. On the upper edge of each box is a groove for holding the plate. On withdrawing the glass cover of the iodine pan, the plate is exposed to its action, and the colour produced is observed by holding a sheet of white paper in such a position that its reflection may be seen on the plate, which enables the operator to judge of the progress of the operation. When the plate has obtained the required colour, the glass cover is pushed in, so as to cover the iodine pan, and the cover over the bromine pan is withdrawn. The plate is now removed from the iodine box and placed over the bromine box, and the colour observed as before. When the plate has received the proper amount of bromine, which is perceptible by the colour, the cover of the bromine pan is pushed in, and the plate is again placed over the iodine pan for a few seconds, until the ultimate colour required is produced, and it is then ready for removal to the camera.

d. Improved Mercury Box, of walnut, with sliding legs, iron cistern, glass windows for inspecting the development of the picture, mounted with thermometer for ascertaining the temperature of the mercury ?

e e Are plate holders, with clamp for securing the same.

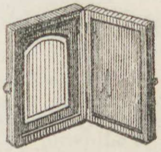
f. Is a box for holding the daguerreotype plates.

g. A levelling stand, used in the fixing process, see page 251.

h. A flat peculiar dish for washing, see fig. 1, page 14.

i. Is a hand-buff.

The pictures being completed, they are mounted in morocco or ornamented cases, such as are shown below.



67.

68.

CHAPTER VII.

THE COLLODION PROCESS.

WITH the advance of this beautiful art, there appears to be a progressively increasing desire to produce more artistic results; and numerous improvements have recently been introduced.

Collodion, as the basis of the photographic agents, beyond all other preparations, offers, in its exceeding sensibility, beauty of details in the finished pictures, and ease of operating, so very many decided advantages, that a separate chapter has been devoted to its consideration.

Collodion is a peculiar preparation, formed by dissolving gun-cotton in ether. It is a very mucilaginous solution of a volatile character, and the ether evaporating leaves a film of the utmost transparency behind. It is not all kinds of gun-cotton which dissolve equally well in ether. According to my experience the most easily soluble is prepared by soaking good cotton in a saturated solution of nitrate of potash for some time; it is then, in a moist state, plunged into sulphuric acid with which but a small quantity of nitric acid has been mixed: after remaining in the acid for about a minute, it is well washed with water until no trace of an acid taste is discovered, and then dried at a temperature but very slightly elevated above that of the apartment.

Mr. Archer, to whom, in conjunction with Mr. Fry, we are mainly indebted for the introduction of this preparation as a photographic agent, gives the following as his processes for preparing gun-cotton.

"There are two receipts for making gun-cotton, from either of which a good dissolving cotton may be obtained. Several others have been described, but I should only be confusing the subject to attempt to give the whole; and it would be foreign to the limited purpose of this work to do so. The results, however, vary so much with the strength and proportion of the acids used, as to render it extremely difficult to name any one in particular which would entirely succeed under all circumstances. In all cases it is more easy to prepare a cotton which will explode readily, and yet *not be at all soluble*, than one which will entirely dissolve in rectified sulphuric ether.

Take of dry nitre in powder,	40 parts	
Sulphuric acid . .	60	"
Cotton	2	"

"The nitre, sulphuric acid, and cotton, are weighed in the above proportions, and placed near at hand within reach of the operator, to prevent delay in mixing when the operator has commenced. Then pour the proportion of sulphuric acid into the powdered nitre, stirring them well together for a few seconds with a strong glass rod. Immediately the two are mixed, add the cotton, having previously pulled out the fibres, and mix them well together with two glass rods, in order that the whole of the cotton may come in contact with the nitric acid vapour, which is being rapidly generated from the mixture. This action must be continued for about two minutes; then quickly remove the cotton with the adhering nitre and sulphuric acid from the basin, with the glass rods, and plunge it into a large quantity of water; it is to be well washed in repeated changes of water until all the acid and nitre are washed away. The cotton is then collected together, and first pressed between the hands to drain off the water, and then still further dried by pressure in a cloth; the fibres of cotton can now be carefully separated, and hung up with pins to the edge of a shelf, or any other convenient place, to dry. There is no necessity to use artificial heat, as the small quantity requisite for a few ounces of solution can easily be dried without it.

"The next receipt is by certain proportions of nitric and sulphuric acids:

Take 1 oz. by measure of nitric acid, sp. gr. 1·450
1 oz. " sulphuric ditto ordinary
80 grs. by weight of cotton.

"The fibres of cotton must be well separated as in the preceding mode. The two acids are first mixed, and the requisite proportion of cotton added as quickly as possible, and well stirred with two glass rods for not more than fifteen seconds: the gun-cotton is removed from the acids, and plunged into water to undergo the same washings, &c. as in the former recipe.

"It will be seen that the cotton is not exposed to the action of the mixed acids, in this last mode, longer than is necessary to saturate the cotton; should the action be continued further, the solubility of the cotton is entirely lost.

"Water must not be spared in washing the cotton, for not a trace of acid should be left; the collodion would be injured by any remaining."

To Prepare the Collodion.—Thirty grains of gun-cotton prepared as described should be taken and placed in 18 fluid ounces of ether, and then 2 ounces of alcohol should be added; making thus an imperial pint of the solution. The cotton, if properly made, will dissolve almost entirely; any small fibres which may be floating about should be allowed to deposit, and the clear solution poured off previously to the process of iodizing it.

To Iodize the Collodion.—Mr. Archer's method is as follows; and I believe no better course can be pursued.

Prepare a saturated solution of iodide of potassium in alcohol, say 1 oz., and add to it as much iodide of silver as it will take up. Or to 1 oz. of alcohol add an excess both of iodide of potassium and iodide of silver; after a day or two, and with repeated shaking at intervals to facilitate the operation, a saturated solution of the two salts will be obtained, and if this is filtered off into another bottle it will always be found ready for use. The first bottle can be kept as a stock bottle, to obtain a still further supply by replenishing it with alcohol, and adding now and then small additional quantities of the two salts. The iodide of silver can be readily obtained by precipitation. For instance, take 1 oz. of solution of nitrate of silver used in the process, 30 grs. of nitrate of silver to 1 oz. of water, and add to it sufficient of a solution of iodide of potassium in water as will throw down the whole of the nitrate of silver as an iodide. When this precipitated iodide of silver has settled, which it very readily does, the liquid above must be poured off, and fresh water added, repeating this washing several times. The iodide of silver after this is dried, and then put into a bottle with a small quantity of alcohol, just sufficient to keep it moistened. The quantity of the solution of iodide of silver which can be added to 1 oz. of collodion must depend upon the quantity of alcohol in the collodion. The collodion process now resolves itself into

1st. **Cleaning the Glass plate.**—By far the most successful general manipulator in the ordinary forms of the collodion process is Mr. Horne; and that gentleman having most obligingly furnished me with the proof sheets intended for the manual published by his firm, I have great pleasure in being enabled to give his most recent improvements. A variety of substances, such as tripoli, nitric acid, spirits of wine, &c., have been recommended for cleaning the glass: but all these Mr. Horne thinks are quite superfluous; the only articles actually necessary being a clean cloth or two, and a wash leather that has been well and thoroughly rinsed through several changes of clean water, to deprive it as much as possible of the dressing which a new one contains, and a little liquid ammonia, not strong, but the ordinary *liquor ammoniæ* of the shops. If this is not at hand, a little caustic potash or soda will answer as well, the purport of it being to remove any greasy matter attached to the surface, as glass is frequently marked with soap; and although it might appear at first sight that clean water must thoroughly remove this article, the operator will be certain of spoiling many of his pictures if he depend upon water alone.

The plan Mr. Horne recommends is as follows:—Pour upon the plate a few drops of ammonia, rub it well over both surfaces, and thoroughly rinse through two waters, allowing the water to flow over the plate either by pouring from a vessel or holding under a tap; now, with a clean cloth wipe perfectly dry, and finally well rub with a leather. Simple as this may appear, there is much more in it than will be at first imagined, for unless the glass is free from stains it is quite impossible to be successful. The plate may be washed perfectly clean, but the surface not thoroughly dried. Then, again, some hands are very warm, and if the plate is allowed to rest too much upon any one part, or held too long in the fingers at any one particular spot, that will become warmer than the surrounding part, from the glass being a bad conductor of heat. The cloth and leather should therefore be sufficiently large, that the plate may be as it were insulated as much as possible from the hands, that no unnecessary heat shall be applied. At the same time the employment of a warm cloth is very useful, for the heat is then equally diffused over the plate, and, what is very essential, the surface perfectly and quickly dried.

Coating the Plate.—It has already been pointed out how necessary it is to handle the plate as little as possible in cleaning; we therefore suppose the operator to have the plate in a clean dry leather, from which it is taken to receive the collodio-iodide of silver. The plate must be held by the left hand perfectly horizontal, and then with the right a sufficient quantity of collodio-iodide should be poured into the centre, so as to diffuse itself equally over the surface. This should be done coolly and steadily, allowing it to flow to each corner in succession, taking care that the edges are all well covered. Then gently tilt the plate, that the superfluous fluid may return to the bottle from the opposite corner to that by which the plate is held. At this moment the plate should be brought into a vertical position, when the diagonal lines caused by the fluid running to the corner will fall one into the other and give a clear flat surface. To do this neatly and effectually, some little practice is necessary, as in most things, but the operator should by no means hurry the operation, but do it systematically and quietly, at the same time not being longer over it than is actually necessary, for collodion being an ethereal compound evaporates very rapidly. Many operators waste their collodion by imagining it is necessary to perform this operation in great haste; but such is not the case, for an even coating can seldom be obtained if the fluid is poured on and off again too rapidly; it is better to do it steadily, and submit to a small loss from evaporation. If the collodion becomes too thick, thin it with the addition of a little fresh and good ether.

Exciting the Plate.—Previous to the last operation it is necessary to have the bath ready, which is made as follows:—

Nitrate of silver	30 grains.
Distilled water	1 ounce.

Dissolve and filter.

The quantity of this fluid *necessary* to be made must depend upon the *form of trough to be used*, whether horizontal or vertical, and also upon the *size* of plate. The kind used by Mr. Horne is the vertical, though many still prefer the former, and attach, as before described, a piece of Indian rubber to the back of the plate as a handle whilst applying the collodion, and to keep the fingers from the solution whilst dipping in the bath. With the vertical troughs a glass dipper is provided, upon which the plate rests, preventing the necessity of any handle or the fingers going into the liquid. If, however, the glass used is a little larger than is required, this is not necessary. Having then obtained one or other of these two, and filtered the liquid, previously free from any particles of dust, &c., the plate is to be *immersed steadily and without hesitation*, for if a pause should be made at any part a line is sure to be formed, which will print in a subsequent part of the process.

The plate being immersed, must be kept there a sufficient time for the liquid to act freely upon the surface, particularly if a negative picture is to be obtained. *As a general rule it will take about two minutes, but this will vary with the temperature of the air at the time of operating, and the condition of the collodion.* In very cold weather, or indeed anything below 50° Fahrenheit, the bath should be placed in a warm situation, or a proper decomposition is not obtained under a very long time. Above 60° the plate will be certain to have obtained its maximum of sensibility by two minutes' immersion, but below this temperature it is better to give it a little extra time.

To facilitate the action, let the temperature be what it may, the plate must be lifted out of the liquid two or three times, which also assists in getting rid of the ether from the surface, for without this is thoroughly done a uniform coating cannot be obtained; *but on no account should it be removed until the plate has been immersed about half a minute,* as marks are apt to be produced if removed sooner.

Having obtained the desired coating, the plate is then extremely sensitive, and, therefore, we presume the operator has taken every precaution to exclude ordinary day-light.

The room must be closed against any portion of day-light, and candle alone employed, placed at a distance from the operator to give the requisite light.

The plate thus rendered sensitive must then be lifted from the solution and held over the trough, that as much liquid as possible may drain off previous to being placed in the frame of the camera, and the more effectually this is done the better, or the action in camera will not be equal over the whole surface; at the same time it must not be allowed to dry, but, in short, to obtain its full maximum of sensibility, it should be damp without superfluous moisture.

The question, says Mr. Horne, is often asked, how soon after coating the plate with collodio-iodide should it be immersed in the nitrate bath? Now, this is a difficult question to answer. We have said the time of *immersion* is dependent upon the temperature and quality of the collodion; so likewise must we be governed as to time *before immersion.* To make collodio-iodide or xylo-iodide, for, chemically speaking, there is no difference in the two, it is necessary that the ether should contain a certain quantity of alcohol, or the different articles are not soluble: therefore, if we take a fresh bottle, and coat the plate from this, it contains its full dose of ether, and with the thermometer ranging between 60° and 70° the evaporation of this article will be very rapid, and consequently a tough film soon formed. If on the other hand we are using a solution which has been in use some time, and many plates, perhaps, coated, the proportion of alcohol is much greater, and not being of so volatile a nature, it will necessarily take a longer time to acquire the requisite firmness for immersion. If, for instance, after coating a plate, we find on immersion it does not colour freely, we have then reason to suppose the plate has not been immersed sufficiently quick, but if on the other hand we find the film very tender, and upon drying it cracks, then we have reason to know that plates prepared from that bottle must not be immersed quite so soon. *The larger the proportion of alcohol the more sensitive will be the plates, and the quicker and more even will be the action of bath.* but a longer period must be allowed for the sensitive film to harden before immersion.

The next question also often asked is, how long must be the exposure in camera ? a question more difficult to answer than the last, without knowing something of the character of the lens and the intensity of light. Practice alone can determine, combined with close observation of those parts which should be the shadows of a picture. If, for instance, in developing we find those parts less exposed to the light than others developing immediately the solution is applied, then we have reason to suppose the exposure has been too long; but if on the contrary they develope very slowly we have proof the time allowed has not been sufficient to produce the necessary action. In a good picture we should see first the whites of a dress appear, then the forehead, after which we shall find, if the light has been pretty equally diffused, the whole of the face and then the dress.

The Development of Image.—To effect this it must be taken again into the room, and with care removed from the slide to the levelling stand.

It will be well also to caution the operator respecting the removal of the plate. Glass, as before observed, is a bad conductor of heat; therefore, if in taking it out we allow it to rest on the fingers at any one spot too long, that portion will be warmed through to the face, and as this is not done until the developing solution is ready to go over, the action will be more energetic at those parts than at others, and consequently destroy the evenness of the picture. We should, therefore, handle the plate with care, as if it already possessed too much heat to be comfortable to the fingers, and that we must therefore get it on the stand as soon as possible.

Having then got it there, we must next cover the face with the developing solution.

This should be made as follows:—

Pyrogallic acid	5 grains.
Distilled water	10 oz.
Glacial acetic acid . . .	40 minims.

Dissolve and filter.

Now, in developing a plate, the quantity of liquid taken must be in proportion to its size. A plate measuring 5 inches by 4 will require half an ounce; less may be used, but it is at the risk of stains; therefore we would recommend that half an ounce of the above be measured out into *a perfectly clean measure*, and to this from 8 to 12 drops of a 50 grain solution of nitrate of silver added.

Pour this quickly over the surface, taking care not to hold the measure too high, and not to pour all at one spot, but having taken the measure properly in the fingers, begin at one end, and carry the hand forward; immediately blow upon the face of the plate, which has the effect not only of diffusing it over the surface, but causes the solution to combine more equally with the damp surface of the plate: it also has the effect of keeping any deposit that may form in motion, which, if allowed to settle, causes the picture to come out mottled. A piece of white paper may now be held under the plate, to observe the development of the picture, if the light of the room is adapted for viewing it in this manner well; if not, a light must be held below, but in either case arrangements should be made to view the plate easily whilst under this operation, a successful result depending so much upon obtaining sufficient development without carrying it too far.

As soon as the necessary development has been obtained, the liquor must be poured off, and the surface washed with a little water, which is easily done by holding the plate over a dish and pouring water on it, taking care, both in this and a subsequent part of the process, to hold the plate horizontally, and not vertically, so as to prevent the coating being torn by the force and weight of the water.

Fixing of Image.—This is simply the removal of iodine from the surface of the plate, and is effected by pouring over it, after the water, a solution of hyposulphite of soda, made of the strength of 4 oz. to a pint of water. At this point daylight may be admited into the room; and, indeed, we cannot judge well of its removal without it. We then see, by tilting the plate to and fro, the iodide gradually dissolve away, and the different parts left more or less transparent, according to the action of light upon them.

It then only remains to thoroughly wash away every trace of hyposulphite, for, should any of the salt be left, it gradually destroys the picture. The plate should, therefore, either be immersed with great care in a vessel of clean water, or, what is better, water poured gently and carefully over the surface.

After this it must be stood up to dry, or held before a fire.

We have now carried the operator carefully through every stage of the process, from the cleaning of plate to the fixing of image; but our remarks have reference to collodio-iodide alone; that is, gun-cotton dissolved in ether, charged with an iodide of silver. We cannot, however, consider our task finished without mentioning the addition of gutta percha to the collodion. This valuable discovery was made by Mr. P. W. Fry, to which gentleman belongs some of the most important steps made in the art.

The sensibility of the plates appears to be more materially increased by the addition of the gutta percha; indeed, pictures by superposition may be obtained with absolute instantaneity, and in the camera obscura in less than a second of time.

The plan of proceeding to obtain this extreme sensibility, as recommended by Mr. Fry, is to obtain a thick and strongly charged collodio-iodide, and to two parts of this add one of a saturated ethereal solution of gutta percha, allowing it to stand a day or two to clear itself, previous to being used.

The plate is then coated in the usual manner. As the ether evaporates a peculiar white film comes over, at which time it is ready for immersion in the bath. This must be conducted as previously described, and, from its extreme sensibility, with, if possible, greater precaution than before.

For the development of negative pictures, Mr. Fry recommends the pyrogallic solution, rather stronger than that previously given, about one grain to the ounce, with the addition of an extra portion of acetic acid, and the plate *re-dipped in the nitrate bath*, in preference to adding silver solution to the pyrogallic acid.

In fixing the image after development it is necessary to keep the hyposulphite on longer than with the ordinary collodion, as the iodide is held with greater tenacity. In other respects the method of proceeding is precisely the same.

Having, by the foregoing means, obtained and fixed a negative photographic image on glass, and which is capable of producing positives upon paper by the ordinary photographic means, it is as well, previous to obtaining these, to render the tender film of collodion less liable to injury.

This can be accomplished by means of a varnish, of which there are different kinds that may be used.

By far the best kind of varnish which can be employed is one for which we are indebted to Dr. Diamond, of the Surrey Lunatic Asylum. This varnish is made by powdering some amber and putting it into chloroform. In a few days a perfect solution takes place. This varnish flows readily over the plate, and dries in a few minutes, leaving a beautifully transparent hard glaze upon the picture.

It was shown by Mr. Horne in the early days of collodion that the negative images could be converted into positive ones by mixing with the pyrogallic solution a very small quantity of nitric acid; but it has since been shown by Mr. Fry, and others, that a better result may be obtained by the use of proto-sulphate and proto-nitrate of iron.

The former salt is readily obtained, and in a very pure form. It should be used as follows:—

Proto-sulphate of iron	10 grains.
Distilled water	1 oz.
Nitric acid	2 drops.

To develope the image pour the above over the plate, taking care not to carry the development too far.

The proto-nitrate may be obtained by double decomposition, as recommended by Dr. Diamond: 600 grains of proto-sulphate of iron are dissolved in one ounce of water, and the same quantity of nitrate of baryta in six ounces of water; these being mixed together, proto-nitrate of iron and sulphate of baryta are formed by double decomposition; also, by dissolving sulphuret of iron in dilute nitric acid, as recommended by Mr. Ellis, who proceeds as follows:—

To one ounce of nitric acid and seven of water, add a small quantity of sulphuret of iron broken into fragments. Stand the vessel aside, that the sulphuretted hydrogen may escape, and the acid become saturated with iron. Pour off the liquid, and filter. Then boil in a florence flask, to get rid of the sulphur, and again filter, when a dark green liquid will be obtained, which is the proto-nitrate of iron. This should be kept in well-stopped bottles, and protected from the air as much as possible, to prevent its changing into a pernitrate, in which state is is quite useless as a photographic agent.

To develope the picture mix one part of the above proto-nitrate with three of water, and apply it to the plate in the ordinary way, when a most beautiful clear image can be obtained.

The negative image being developed, a mixture of pyro-gallic and hypo-sulphite of soda, which has undergone partial decomposition, is poured over the plate, and then it is gently warmed. Upon this the darkened parts are rendered brilliantly white by the formation of metallic silver. This picture being backed up with black velvet assumes the air of a fine daguerreotype, without any of the disadvantages arising from the reflection of light from the polished silver surface. For this beautiful result photography is indebted to Dr. Diamond, who is still pursuing the subject with much zeal. We have also seen a similar effect produced by Mr. Fry and Mr. Berger, by the use of the proto-sulphate of iron solution and pyrogallic acid. The image is first developed by the iron and the solution poured off; immediately another of pyrogallic acid is poured on, and the effect is produced.

The pictures are fixed with the hyposulphite in the usual method.

A peculiar whitening process was introduced by Mr. Archer, which is as follows:—

The picture being thoroughly washed in plenty of water, after fixing with hypo-sulphite of soda, is treated in the following manner.

Prepare a saturated solution of bi-chloride of mercury in muriatic acid. Add one part of this solution to six of water. Pour a small quantity of it over the picture at one corner, and allow it to run evenly over the glass. It will be found immediately to deepen the tones of the picture considerably, and the positive image will almost disappear; presently, a peculiar whitening will come over it, and in a short time a beautifully delicate white picture will be brought out.

The negative character of the drawing will be entirely destroyed, the white positive alone remaining. This picture, after being well washed and dried, can be varnished and preserved as a positive; but nevertheless, even after this bleaching, it can be changed into a deep-toned negative, many shades darker than it was originally, by immersing it, after a thorough washing, in a weak solution of hypo-sulphite of soda, or a weak solution of ammonia. The white picture will vanish, and a black negative will be the result.

It is very singular that the picture can be alternately changed from a white positive to a black negative many times in succession, and very often with improvement.

Thus, by the above process, a most perfect white positive or a deep black negative is produced, quite distinct from each other.

In the first part of this after-process it will be observed that the effect of this bi-chloride of mercury solution is to deepen the shades of the picture, and this peculiarity can be made available to strengthen a faint image, by taking the precaution of using the solution weaker, in order that the first change may be completed before the whitening effect comes on.

The progress of the change can be stopped at this point by the simple application of water.

The author first pointed out the remarkable action of corrosive sublimate, in his paper, published by the Royal Society, on the Daguerreotype process on paper.

M. Adolphe Martin has published some remarks on the collodion in the Comptes Rendus of 5th July, 1852.

The collodion he employs is made of—

30 grains of Cotton.
750 grains of Nitrate of Potash.
1500 grains of Sulphuric Acid.

This is well washed and dissolved in 10 volumes of ether and 1 volume of alcohol: by this, 15 grains of gun-cotton are dissolved in 1860 grains of ether, and 930 grains of alcohol: add then to this collodion, 15 grains of nitrate of silver transformed into iodide, and dissolved in 20 grains of alcohol by means of an alkaline iodide. M. Adolphe Martin prefers iodide of ammonium.

The plate is next plunged into a bath of 1 part distilled water, 1 $\frac{1}{12}$th nitrate of silver, and 1 $\frac{1}{20}$th nitric acid. The image is developed by proto-sulphate of iron, and he effects the change from negative to positive by a bath of double cyanide of silver and potash consisting of about 2 quarts of water, in which are dissolved 375 grains of cyanide of potassium, and 60 grains of nitrate of silver. The pictures thus produced are remarkable for their intense whiteness.

We must allow Mr. Archer to give his own description of a very ingeniously constructed camera, which he has devised for working out of doors.

Description of the Camera for the Collodion.—" I will proceed to give a general description of the camera I have constructed, premising that it admits of being made as a very light folding camera, if thought necessary.

" It is a wooden box, 18 inches long, 12 inches wide, and 12 inches deep, and is capable of taking a picture 10 inches square. Externally it may be thus described:—In front it has a sliding door, with a circular opening in it, to admit the lens: this sliding door enables the operator to lower, or raise, the lens, and consequently the image formed by it, on the ground glass, as the view may require. The two sides of the camera have openings cut in them, into which sleeves of India rubber cloth are fixed, to admit the hands of the operator; and are furnished with India rubber bands at the lower ends, which press against the wrists. and prevent the admission of light.

" The back of the camera has a hinged door fitted at its upper part with an opening of just sufficient size for the eyes, and shaped so as to fit close to the face. A black cloth is tied round this end of the camera, to prevent any ray of light penetrating at this opening. In the top of the camera near the front is inserted a piece of yellow glass, to admit a small quantity of yellow light, and is closed with a hinged door, to regulate the quantity of light required.

" The interior of the box is furnished with a sliding frame, to support the ground glass or the bath and the prepared plate; and it has a stop, by means of which any focus from 3 inches to 15 inches can easily be obtained.

" The bottom of the camera is furnished with a gutta percha tray, about 1 inch deep, to hold the washings, &c., when the camera is in operation.

" Also, the bottom of the camera at the back has an opening cut in it, extending nearly the whole width of the camera, and as far in as the edge of the gutta percha tray.

"This opening is intended to admit, when the camera is in use, a light wooden case containing the glass bath, focusing frame, stock of glass, and paper required in the process.

"There are various other little contrivances which I have not specified; such as a drawer for the pictures, a shelf for bottles, &c.

"This form of camera will admit of the following manipulation. Having placed it upon a stand pointing to the object to be taken, the hinged door at the back is opened, and the bath is three parts filled with the solution of nitrate of silver; a plate of glass is then taken from the cell, and cleaned if necessary.

"The collodion is poured on in the manner previously described; when the film has set a little it is immersed in the nitrate of silver bath, and the lid of the bath is closed down upon it. The next step is to obtain the focus with the ground glass: this can be done whilst the collodion is becoming iodized.

"After adjusting the sliding frame to the proper focal distance, the camera must be closed, and the rest of the process conducted by passing the hands through the sleeves, and placing the eyes close to the aperture in the back of the camera, and drawing the black cloth over the front of the head.

"By the aid of the yellow light admitted from the top, the operator can carry on the rest of the process. The plate is now ready for the action of light, and is taken from the bath; or the bath itself, with the plate in it, is placed in the sliding frame. The refracted image is at once thrown upon the sensitive plate. After the requisite exposure, the plate is taken from the bath, and the picture is developed with the solution previously described. The progress of this operation can be seen by aid of the yellow light, keeping the eyes close to the aperture behind.

"When, from experience, the picture is sufficiently brought out, a little water is poured on the glass to wash off the developing solution, and the drawing is partially fixed by the application of a small quantity of a solution of common salt.

"The drawing may now be removed from the camera without fear of being injured by light, and the remainder of the operations can be conducted outside the camera.

"If the film is sufficiently strong to bear removal from the glass, the following procedure is adopted. The plate of glass is placed horizontally upon the back lid of the camera, which is hung so as to form a temporary table, and the film is loosened from the edge of the glass with a flat strip of glass; a sheet of damp paper is then placed flat on the drawing, and rather within its upper edge; the film is turned over the edge of the paper, and a glass rod is placed just within the edge. The sheet of paper with the collodion in contact with it is now raised from the glass, and rolled up on the glass rod. When the drawing is entirely enclosed in the paper, the rod is removed, and the delicate film thus encased is put away into its proper receptacle, to be finally fixed and mounted at leisure.

"The drawing thus rolled up can be preserved for months without injury, provided it is kept slightly damp; and if each drawing is enclosed in another sheet of paper, its preservation is still further secured.

"The advantages of a camera of this kind may be thus enumerated.

"It allows the preparation on the spot of the most sensitive surfaces; their immediate use whilst the sensibility is at its maximum; the ready development of the image, and after fixing.

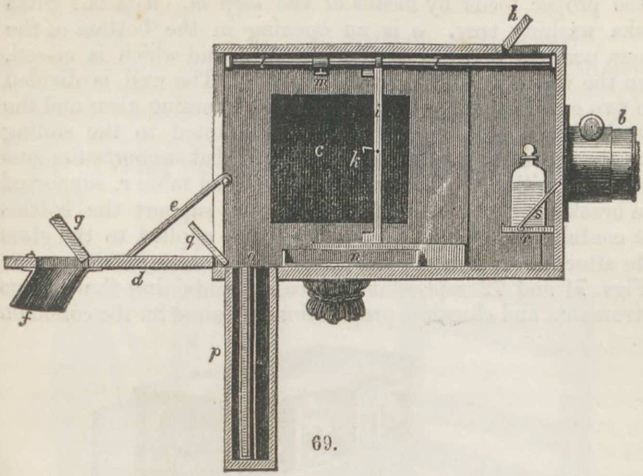
"All these operations being carried on consecutively, the operator can, after the first trial, see what results the progress of his labours is likely to produce.

"It gives him the power of shading off any portions of the view during the action of the light, by holding in front of the prepared plate and near the lens a moveable screen, or any flat piece of wood, as the case may require; thereby preventing the too rapid action and consequent solarisation of the distant portions of the scene. The spire of a church, for instance, pointing upwards into a bright sky, often requires this precaution to prevent its being entirely lost. Other instances of this effect will readily suggest themselves to those at all acquainted with the art."

"The camera can be made, with slight modifications, applicable to any other process on paper or glass, and of course obviates the necessity of any kind of portable tent."—*Archer, F.S., Manual of the Collodion Photographic Process.*

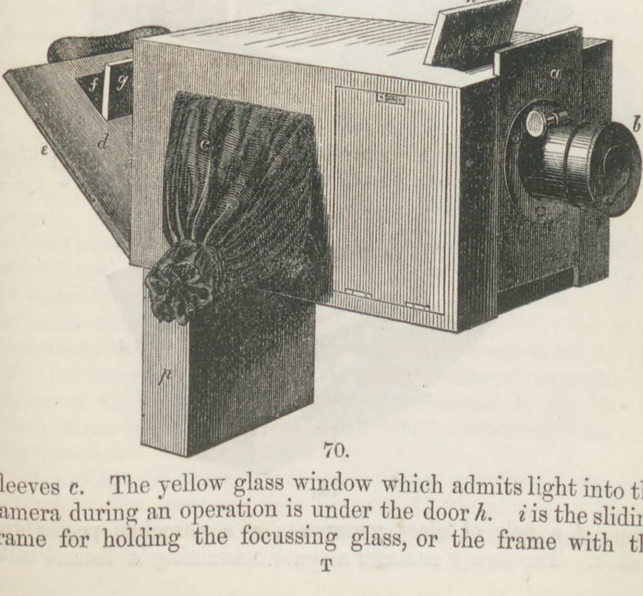
The following figures represent Mr. Archer's Camera, as constructed by Mr. Griffin:—

The figure 69 is a section of the camera, and 70 its external form, which, with a view to portability, is constructed so as to serve as a packing case for the entire apparatus represented by figs. 69 to 76. *a* is the sliding door that supports the lens *b*. *c c* are the side openings fitted with cloth sleeves to admit the operator's arms. *d* is a hinged door at the back of the camera, which can be supported like a table by the hook *e*. *f* is the opening for looking into the camera during an operation.



69.

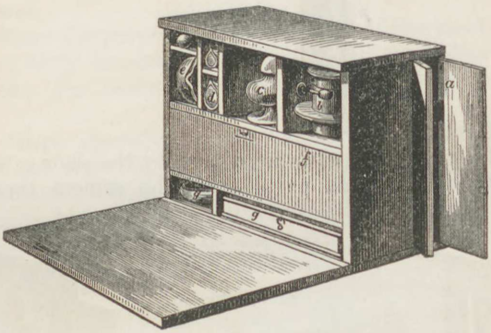
This opening is closed, when necessary, by the door *g*, which can be opened by the hand passed into the camera through the



70.

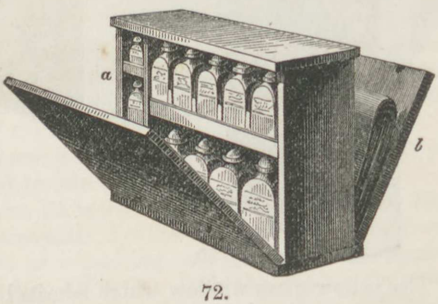
sleeves *c*. The yellow glass window which admits light into the camera during an operation is under the door *h*. *i* is the sliding frame for holding the focussing glass, or the frame with the prepared glass, either of which is fastened to the sliding frame by the check *k*. The frame slides along the rod *l*, *l*, and can be fixed at the proper focus by means of the step *m*. *n* is the gutta percha washing tray. *o* is an opening in the bottom of the camera near the door, to admit the well *p*, and which is closed, when the well is removed, by the door *q*. The well is divided into two cells, one of which contains the focussing glass and the other the glass trough, each in a frame adapted to the sliding frame *i*. On each side of the sliding door that supports the lens *a*, there is, within the camera, a small hinged table *r*, supported by a bracket *s*. These two tables serve to support the bottles that contain the solutions necessary to be applied to the glass plate after its exposure to the lens.

Figs. 71 and 72 represent two cases, containing the various instruments and chemical preparations required for the collodion



71.

process. *a*, fig. 71, is a grooved cell for a series of glass plates. *b* is a receptacle for the lens of the camera. *c* contains a spirit

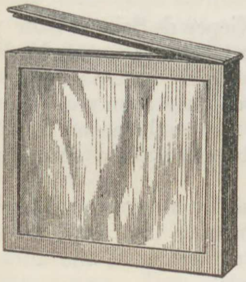


72.

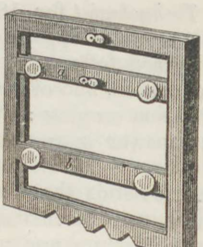
lamp; *d*, a pair of glass measures; *e*, a porcelain pestle and mortar. The door *f* encloses a space containing a funnel with filter papers, and silks and leathers for cleaning the plates. *g* contains a small retort stand, a porcelain capsule, and a box with scales and weights.

The case, fig. 72, is divided into two compartments. One side, *a*, contains twelve stoppered glass bottles, with the various chemical preparations required by the operator. The other side, which can be closed by the door *b*, contains a supply of photographic paper, both for negative and positive pictures.

Fig. 73 is the glass trough for holding the nitrate of silver solution.



73.

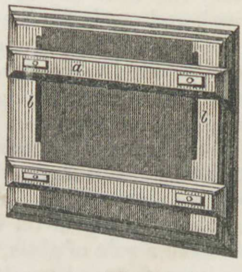


74.

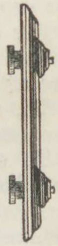
Fig. 74 is a frame for fixing in the camera such plates of glass as do not require to be exposed to the lens while still in the glass trough.

Fig. 75 is a pressure frame for the preparation of positive from negative photographs.

Fig. 76 is a section of this frame.



75.



76.

Both of these frames, figs. 74 and 75, are so contrived as to be suitable for plates of many different sizes. In the frame represented by fig. 74, the bars *a* and *b* are both moveable, to permit the fixing of the plate in the camera directly opposite the centre of the lens. In the frame represented by fig. 75, the bar *a* alone is moveable, and is fastened by screws that move in the slits *b*, *b*.

The whole of these boxes and frames can be conveniently packed in the camera. The box, fig. 71, is passed in by the side-door; the well, *p*, and all the other cases and frames, by the door *d*; and the camera, thus loaded for transport, is put into a strong leather case.

CHAPTER VIII.

THE USE OF ALBUMEN ON GLASS PLATES AND ON PAPER, &c.

SECTION I.—ALBUMEN ON GLASS.

IN the *Technologist* for 1848, M. Niepce de Saint Victor published his mode of applying albumen to glass plates. M. Blanquart Everard followed; and successively albumen, gelatine, serum, collodion, and other substances, have been recommended for application on glass: but few of these substances have been found to answer so perfectly as albumen applied according to the directions of M. Le Gray.

He recommends that the whites of fresh eggs equal to about five fluid ounces be mixed with not more than 100 grains of iodide of potassium, and about twenty grains of the bromide, and half that quantity of common salt.

He then directs you to beat this mixture in a large dish with a wooden fork, until it forms a thick white froth; to let it repose all night, and the next day to decant the viscous liquid which has deposited, and use it for the preparation of your glasses.

For this purpose take thin glass, or, what is much better, *ground glass, on which the adherence is more perfect;* cut it the size of your camera frame, and grind the edges.

The success of the proof is, in a great measure, due to the evenness of the coat of albumen.

To obtain this, place one of your glasses horizontally, the unpolished side above (if you use ground glass, which I think preferable), and then pour on it an abundant quantity of the albumen. Take a rule of glass, very straight, upon the ends of which have been fastened two bands of stout paper steeped in white wax: hold this with the fingers in such a manner that they will overlap the sides of the glass plate about one-eighth of an inch. You then draw the rule over the glass with one sweep, so as to take off the excess of albumen. The object of the slip of paper is to keep the glass rule from the surface of the plate, and ensure a thin but even coating of the albuminous mixture.

Thus, in making the paper band more or less thick, you vary the thickness of the coating. Or you may arrive at the same result by passing two narrow bands of paper on the sides of the plate, and passing simply the rule down. I prefer the first means, because, with the second, one is almost sure to soil the glass in sticking on the paper.

You must never go the second time over the glass with the rule, or you will make air-bubbles. When thus prepared, permit the plate to dry spontaneously, keeping it in an horizontal position and free from dust. When the coat of albumen is well dried, submit your glasses to the temperature of 160° to 180° Fahrenheit; this you may do either before a quick fire, or by shutting them up in an iron saucepan well tinned, with a cover; you then place the saucepan in a bath of boiling water: the action of the heat hardens the albumen; it becomes perfectly insoluble, and ready to receive the aceto-nitrate of silver.

The glass thus prepared may be kept for any length of time. I prepare the first coat also by saturating the former mixture with gallic acid, which gives it more consistency and greater sensitiveness.

When you wish to make a proof, (by using the preparation moist,) you plunge the glass thus prepared in a bath of aceto-nitrate of silver, described in the second operation of the negative paper. This operation is very delicate, because the least stoppage in its immersion in the bath will operate on the sensitive coating, and cause irregularities which nothing can remedy.

To obtain this instantaneous and regular immersion, I make a box with glass sides, a trifle larger than the plate, and about half an inch wide, with wooden grooves, similar to those in the daguerreotype plate box: into this I pour the aceto-nitrate, and let the prepared glass fall into it with a single movement, leaving it to soak four or five minutes in the bath; then remove it, wash well with distilled water, and expose it in the camera while moist. The time will vary from two to thirty minutes, or nearly double that time if the glass is dry.

When you wish to operate with the glasses dry instead of moist, it is proper to dip them in a bath of gallic acid a quarter of an hour after they are taken out of the aceto-nitrate bath; then well wash them with distilled water, and dry them as directed.

When you take the plate out of the camera, you develop the image in the same way as the negative on paper, by putting it into a bath of saturated gallic acid: when it is well developed, fix it by the same method indicated for the paper.

To obtain a positive proof, it is sufficient to apply on the negative proof a sheet of common positive paper, or, better still, a sheet of positive albuminized paper, which is described hereafter.

You then put it in the pressure frame, placing above it a piece of black cloth pasted on one side of a thick sheet of glass; then shut the frame, giving to the proof a slight pressure; after which, expose it to the light. In order to follow its action you may just raise it by one corner of the glass, to judge of the tint which the image takes: when you think it sufficiently exposed, take it out of the frame, and fix it the same as the positive paper.

Niepce de Saint Victor has recently published a process in which he employs starch instead of albumen on the glass plates. The main features of this process are as follows:—About 70 grains of starch are rubbed down with the same quantity of distilled water, and then mixed with three or four ounces more water; to this is added $5\frac{1}{2}$ grains of iodide of potassium dissolved in a very small quantity of water, and the whole is boiled until the starch is properly dissolved. With this the glass plates are carefully covered, and then placed to dry on a perfectly horizontal table. When thoroughly dried, the aceto-nitrate of silver is applied by wetting a piece of paper, placing this on the starch, and over it another piece of paper wetted with distilled water. This mode of preparation furnishes, it is said, tablets of great sensibility; but the starch is liable to break off from the glass, and there is much difficulty in spreading it uniformly in the first instance.

Section II.—Mr. Malone's Process.

Some very ingenious experiments have been made by Mr. Malone, from whose communication the following remarks are quoted:—

"To the white of an egg its own bulk of water is to be added; the mixture, beaten with a fork, is then strained through a piece of linen cloth, and preserved for use in a glass stoppered bottle; then a piece of plate glass, cleaned with a solution of caustic potash, or any other alkali, is to be washed with water and dried with a cloth. When the glass is about to be used, breathe on it, and rub its surface with clean new blotting paper; then, to remove the dust and fibres which remain, use cotton-wool or a piece of new linen. Unless this latter, and, indeed, every other precaution, is taken to prevent the presence of dust, the picture will be full of spots, produced by a greater absorption of iodine (in a subsequent process) in those than in the surrounding parts.

"On the clear glass pour the albumen, inclining the plate from side to side until it is covered; allow the excess to run off at one end of the corners, keeping the plate inclined, but nearly vertical. As soon as the albumen ceases to drop rapidly, breathe on or warm the lower half of the plate; the warmth and moisture of the breath will soon cause it to part with more of its albumen, which has now become more fluid: of course, care must be taken to warm only the lower half. Wiping the edges constantly hastens the operation. Until this plan was adopted, the coatings were seldom uniform; the upper half of the plate retained less than the lower. When no more albumen runs down, dry the plate by a lamp, or by a common fire, if the dust that it is inclined to impart be avoided.

"The next operation is to iodize the plate. Dilute pure iodine with dry white sand in a mortar, using about equal parts of each; put this mixture into a square vessel, and place over it the albuminized plate, previously heated to about 100° Fah. As soon as the film has become yellow in colour, resembling beautifully stained glass, remove the plate into a room lighted by a candle, or through any yellow transparent substance, yellow calico for instance, and plunge it vertically and rapidly into a deep narrow vessel containing a solution of one hundred grains of nitrate of silver to fifty minims of glacial acetic acid, diluted with five ounces of distilled water. Allow it to remain until the transparent yellow tint disappears, to be succeeded by a milky-looking film of iodide of silver. Washing with distilled water leaves the plate ready for the camera.

"It may be here noted that the plate is heated in iodizing for the purpose of accelerating the absorption of the iodine: an exposure to the vapour for ten minutes, with a few seconds' immersion in the silver solution, has been found to be sufficient."

Hydrochloric acid, chlorine or bromine, may be used with the iodine to give increased sensibility to the plate.

The plate is removed from the camera, and we pour over it a saturated solution of gallic acid. A negative Talbotype image is the result. At this point previous experimentalists have stopped. We have gone further, and find that by pouring upon the surface of the reddish brown negative image, during its development, a strong solution of nitrate of silver, a remarkable effect is produced. The brown image deepens in intensity until it becomes black. Another change commences—the image begins to grow lighter; and finally, by perfectly natural magic, black is converted into white, presenting the curious phenomenon of the change of a Talbotype *negative* into apparently a positive Daguerreotype, the positive still retaining its negative properties when viewed by transmitted light.

To fix the picture, a solution of one part of hyposulphite of soda in sixteen parts of water is poured upon the plate, and left for several minutes, until the iodide of silver has been dissolved. Washing in water completes the process.

"The phenomenon of the Daguerreotype," says Mr. Malone, "is in this case produced by very opposite agency, no mercury being present; metallic silver here producing the lights, while in the Daguerreotype it produces the shadows of the picture. We at first hesitated about assigning a cause for the dull white granular deposit which forms the image, judging it to be due simply to molecular arrangement. Later experiments, however, have given us continuous films of bright metallic silver, and we find the dull deposit becomes brilliant and metallic when burnished. It should be observed that the positive image we speak of is on glass, strictly analogous to the Daguerreotype. It is positive when viewed at any angle but that which enables it to reflect the light of the ray. This is one of its characteristics. It must not be confounded with the continuous film image which is seen properly only at one angle; the angle at which the other ceases to exist. It is also curious to observe the details of the image, absent when the plate is viewed negatively by transmitted light, appear when viewed positively by reflected light."

Section III.—Mr. Mayall's Process.

Mr. Mayall has recently published a form of process, employed by M. Martin, which differs in no essential particular from those already described; but as involving some niceties of manipulation, on which, the writer says, depends the perfection of his finished pictures, it is thought advisable to quote it.

"First. The albumen of a *fresh* egg must be beaten into a snow-like mass with a bunch of quills, dropping into it ten drops of a saturated solution of iodide of potassium; allow it to stand six hours in a place free from dust, and moderately warm,—say 60°.

"Second. A piece of hand-plate glass, eight inches by six, with the edges ground smooth, must be cleaned as follows: with a piece of cotton wool rub over both sides with concentrated nitric acid, then rinse well with water, and dry. Stick a wafer on that side which I will now call the back, to mark it; pounce upon the face a moderate quantity of fine tripoli, moistened with a few drops of a concentrated solution of carbonate of potash; then with a piece of cotton wool rub the surface briskly in circles for about five minutes; then with dry tripoli; then with clean cotton to clear away all the dusty particles.

"Third. To the centre of the back stick a gutta percha ball, as a handle: strain the prepared albumen through clean linen; pour it gently into the centre of the cleaned side of the glass, keep it moving until the surface is entirely covered, run it into the corners, and finally pour off any excess at the four corners; disengage the gutta percha handle, and place the glass on another slab, that has been levelled by a spirit level, in a place perfectly free from dust, and moderately warm. I will call this my *iodo-albuminized glass;* it will keep for any length of time, and may be prepared in daylight.

"Fourth. To excite (a yellow shaded light only being used), dissolve 50 grains of nitrate of silver in 1 ounce of distilled water and 120 grains of strong acetic acid; pour the whole of this solution into a *cuvette,* or shallow porcelain dish, a little larger than the glass plate; place one end of the iodo-albuminized glass in the solution; with a piece of quill support the upper end of the glass, and let it fall suddenly on to the solution, lifting it up and down for ten seconds; take it out and place it face upwards in another dish, half filled with distilled water; allow the water to pass over the surface twice; take out the glass, rear it up to dry; it is ready for the camera, and will keep in this state ten days,—of course, shut up from daylight, in a moderately warm place, but never moist. The solution may be filtered into a black bottle, and will do again by now and then adding a few drops of acetic acid, and keeping it in the dark. Expose in the camera from four to ten minutes, according to the amount of light and the aperture of the lens. Suppose I say a lens of three inches diameter, sixteen in focus for parallel rays, a one inch diaphragm placed three inches in front of the lens (one of Ross's photographic lenses is just the thing), the exposure would be in good light about five minutes.

"Fifth. Develop as follows. Place the glass, face upwards, on a stand with adjusting screws to make it level; pour a concentrated solution of gallic acid over the surface; the image will be from half an hour to two hours in coming out. It is best to apply a gentle heat, not more than 10° above the temperature of the room, it being 60°. Should the image still be feeble, pour off the gallic acid, rinse the proof with water, and pour on to it equal quantities of aceto-nitrate of silver and gallic acid reduced one half with water. The image will now quickly develop; arrest it in four or five minutes, wash it well in three waters, and fix with hyposulphite of soda as follows:—

"Sixth. Three drachms of hyposulphite of soda to one ounce of water. Allow the proof to remain in this solution until all the yellow iodide disappears, wash it well, rear up to dry, and it is finished.

"Success is sure to attend any one practising this method, provided the *eggs are fresh* and the *glass is clean:* if the glass is not clean, or the eggs are stale, the albumen will split off in fixing.

"*Caution.*—Wash all the vessels, as soon as done with, with nitric acid, and then with water. Every precaution should be used to avoid dust. The albumen of a duck's egg is more sensitive than that of a hen; and from an experiment of to-day, I am almost certain that of a goose is more sensitive than either."—*Athenæum,* No. 1220.

Section IV.—Miscellaneous Modified Processes.

Several other preparations have been employed, with variable success, and recommended for procuring an absorbent film upon glass plates—amongst others the serum of milk has been used by M. Blanquart Everard; others combine with their albumen or gelatine, grape sugar and honey; the object of these being to quicken the process, which they appear to do in virtue of their power of precipitating the metals from their solutions.

Blanquart Everard has lately communicated the following to the Paris Academy of Sciences, as an instantaneous process:—"Fluoride of potassium added to iodide of potassium, in the preparation of the negative proof, produces instantaneous images on exposure in the camera. To assure myself of the extreme sensibility of the fluoride, I have made some experiments on the slowest preparations employed in photography—that of plates of glass covered with albumen and iodide, requiring exposure of at least sixty times longer than the same preparation on paper. On adding the fluoride to the albumen and iodide, and substituting for the washing of the glass in distilled water after treatment with the aceto-nitrate of silver, washing in fluoride of potassium the image immediately on exposure in the camera obscura, I have indeed obtained this result (but under conditions less powerful in their action) without the addition of the fluoride to the albumen, and by the immersion only of the glass plate in a bath of fluoride after its passage through the aceto-nitrate of silver. This property of the fluorides is calculated to give very valuable results, and will probably cause, in this branch of photographic art, a change equally as radical as that effected by the use of bromine on the iodized silver plates of Daguerre." A process published in the author's Researches on Light, in 1844, and named the Fluorotype, sufficiently establishes my claim to priority in the use of the fluorides.

Messrs. Ross and Thompson, of Edinburgh, at the meeting of the British Association in that city, exhibited some positive images on glass plates: these were backed up with plaster of Paris, for the purpose of exalting the effects, which were exceedingly delicate and beautiful.

Messrs. Langenheim, of Philadelphia, have, however, recently introduced into this country specimens, which they term Hyalotypes. These are positive pictures, copied on glass from negatives, obtained upon the same material. Their peculiarity is the adaptation of them for magic-lantern sliders. The process by which they are produced is not published, but judging from the effects obtained, the probability is that a very slight variation only from the processes described has been made. The idea is an exceedingly happy one, as by magnifying those images which are of the utmost delicacy and the strictest fidelity, perfect reflexes of nature are obtained.

There can be no doubt but other means of coating glass with sensitive materials may be employed. Certainly the use of albumen is a ready method, but this medium appears to interfere with the sensibility which it is so desirable to obtain. As stated, by using combinations of iodide and fluoride salts, there is no doubt but the sensibility may be most materially improved, and we find many of the continental photographers using honey and grape sugar with much advantage.

I would, however, venture to suggest that films of silver precipitated from the solution of the nitrate by grape sugar, aldehyde, or gun-cotton dissolved in caustic alkali, upon which any change could be afterwards produced, appear to promise many important advantages.

Section V.—Positive Photographs from Etchings on Glass Plates.

A very easy method of producing any number of positive photographs from an original design is in the power of every one having some slight artistic talent. The merit of having suggested the process I am about to describe has been claimed by Messrs. Havell and Wellmore, and also by Mr. Talbot; indeed, there appears no reason to doubt the originality of either of these gentlemen, Mr. Havell having prosecuted his experiment in ignorance of the fact that Mr. Talbot had used the same means to diversify his photographic specimens. Mr. Talbot proposes that a plate of warmed glass be evenly covered with a common etching ground, and blackened by the smoke of a candle. The design is then to be made, by carefully removing from the glass all those parts which should represent the *lines* and *shadows*, and shading out the middle tints. It will be evident that the light passing through the uncovered parts of the glass, and being obstructed by the covered portions, will impress on the white photographic papers a correct picture, having the appearance of a spirited ink drawing.

Mr. Havell's method was to place a thin plate of glass on the subject to be copied, upon which the high lights were painted with a mixture of white lead and copal varnish, the proportion of varnish being increased for the darker shading of the picture. The next day, Mr. Havell removed, with the point of a pen-knife, the white ground, to represent the dark etched lines of the original. A sheet of prepared paper having been placed behind the glass, and thus exposed to light, a tolerable impression was produced; the half tints had, however, absorbed too much of the violet rays, an imperfection which was remedied by painting the parts over with black on the other side of the glass; if allowed to remain too long exposed to the sun's rays, the middle tints became too dark, and destroyed the effect of the sketch. Another method employed by Mr. Havell was to spread a ground composed of white lead, sugar of lead, and copal varnish, over a plate of glass, and having transferred a pencil drawing in the usual manner, to work it out with the etching point.

Various modifications of these processes have been introduced by different artists, and they evidently admit of many very beautiful applications. When the etching is executed by an engraver, the photograph has all the finish of a delicate copper-plate engraving. The only thing which detracts from this method of photography is, that the great merit of self-acting power is abandoned.

Section VI.—Albuminized Paper.

M. Le Gray gives the following as the improved proportions in which he recommended an albuminous mixture to be made for paper.

White of Eggs, 2 fluid ounces and a half.

Iodide of Potassium	. . .	56 grains.
Bromide of Potassium	. . .	15½ „
Chloride of Sodium	. . .	4 „

M. Le Gray, in his memoir, gives the following general directions:—

Pour the solution into a dish placed horizontally, taking care that there is no froth; then take the paper that you have chosen, and wet it on one side only, beginning at the edge of the dish which is nearest to you, and the largest side of the sheet, placing the right angle on the liquid, and inclining it towards you; advance it in such a manner as to exercise a pressure which will remove the air-bubbles. Place before you a light, so as to be able to perceive the bubbles, and to push them out if they remain.

Let the leaf imbibe for a minute at most, without touching it; then take it up gently, but at once, with a very regular movement, and hang it up by the corner to dry.

You prepare thus as many leaves as you wish in the same bath, taking care that there is always about a quarter of an inch in depth of the solution in the dish; then place your sheets (thus prepared and dried) one on the other between two leaves of white paper, and pass over them several times a very hot iron, taking out a leaf each time: you will thus render the albumen insoluble.

The iron should be as hot as it can be without scorching the paper.

Then make use of this negative paper exactly like the first paper named; only great attention must be observed that the immersion in the aceto-nitrate bath is instantaneous, and that the air-bubbles are immediately driven out; for every time you stop you will make stains the same as on glass. It is also necessary to heat moderately the gallic acid.

One of the best services rendered by the albumen to photography is, without doubt, its application to the preparation of the positive paper, to which it gives a brilliancy and vigour difficult to obtain by any other method; which is prepared thus:—

Take white of eggs, to which add the fifth part by volume of saturated solution of chloride of sodium; then beat it into a froth, and decant the clear liquid after it has settled for one night.

With this the paper is first washed, and then with a strong solution of nitrate of silver.

M. Blanquart Everard published a process as his own, in France, and received the compliments of the Academy of Sciences for it, which in no respect differed from Mr. Talbot's: this, therefore, requires no further notice; but a modification of M. Niepce de St. Victor, and his own application of albumen, must not be neglected.

Method of preparing paper with albumen, so that it may be employed dry.—The paper prepared by means of albumen possesses properties analogous to those prepared by means of serum, but in a much less degree: the former, like the latter, may be kept for an indefinite time after its preparation with the iodide of potassium, but after having been submitted to the action of the aceto-nitrate of silver it will not keep good beyond the next day. The impressions obtained by means of the following preparation are admirable: though not so well defined as those on glass, yet they are more beautiful, as the outline is less harsh, and they possess more harmony and softness. We consider this to be quite a triumph for those who exercise themselves in the photographic art.

Beat into a froth the whites of eggs, to which a saturated solution of iodide of potassium and bromide of potassium has been added, in the proportion of thirty drops of the former and two drops of the latter for the white of each egg; let the mixture stand until the froth returns to a liquid state, filter through clear muslin, and collect the albumen in a large flat vessel. On this lay the paper to be prepared, and allow it to remain there some minutes. When it has imbibed the albumen, lift it up by one of its corners; let it drain, and lastly dry, by suspending it with pins to a line or cord across the room. The subsequent preparation with the aceto-nitrate of silver is in every respect similar to that above described for the paper prepared with serum; care being taken not to dry it between the two folds of blotting-paper until it has become perfectly transparent. The exposure of the prepared paper to the light in the camera is done in the same way, and the same treatment with gallic acid is followed: it will, however, be found that the time required for exposure will generally be four or five minutes.

Preparation of albuminous paper for receiving a positive image.—The positive paper prepared with albumen gives impressions somewhat shining, but of a very rich tone, well defined, and of perfect transparency; it is prepared in the following manner:—To any quantity of white of eggs add 25 per cent. by weight of water, saturated with chloride of sodium; beat into a froth, and filter as in the previous operation,—only in this case leave the paper in contact with the albumen for only half a minute hang it up to dry, which it usually does in six to eight minutes; then lay it on a vessel containing a solution of 25 parts of nitrate of silver in 100 parts of water. Leave the paper on the solution for at least six minutes, then place it on a plate to dry.

The serum of milk has also been employed on paper as a quickening agent, and some of the French authorities speak highly of it; but I am not enabled from my own experience to speak of its advantages.

CHAPTER IX.

ON THE PRODUCTION OF POSITIVE PHOTOGRAPHS BY THE USE OF THE HYDRIODIC SALTS.

A VERY short time after the publication of Mr. Talbot's processes, which I anxiously repeated with various modifications, I discovered a singular property in the hydriodate of potash of again whitening the paper darkened by exposure, and also, that the bleaching process was very much accelerated by the influence of light. Early in the year 1839, Lassaigne, Mr. Talbot, Sir John Herschel, and Dr. Fyfe, appear to have fallen on the same discovery.

As this process, giving by one operation pictures with their lights, correct, is of much interest, I gave it for a very considerable time my undivided attention. The most extraordinary character of the hydriodic salts is, that a very slight difference in the strength of the solutions, in the composition of the photographic paper, or in the character of the incident light, produces totally opposite effects; in one case the paper is rapidly whitened, in the other a deep blackness is produced almost as rapidly. Sometimes these opposing actions are in equilibrium, and then the paper continues for a long time perfectly insensible.

I am inclined to hope these researches have reduced to certainty their somewhat inconstant effects, and rendered this method of producing photographs one of the most easy, as it is the most beautiful. That the various positions I wish to establish may be completely understood, and to ensure the same results in other hands, it will be necessary to enter into a somewhat detailed account of the various kinds of paper used, and to give tolerably full directions for successfully using them, either in the camera, or for drawings by application,—to examine attentively the effects of different organic and inorganic preparations on the paper, and to analyse the influence of the different rays upon it. See also Part I. Chapter VI. Section VII. page 88.

These particulars will be copied chiefly from my paper, "On the Use of the Hydriodic Salts as Photographic Agents," published in the London and Edinburgh Philosophical Magazine for September and October 1840, to which will be added the results of my experiments since that time.

The variable texture of the finest kinds of paper occasioning irregularities of imbibition, is a constant source of annoyance, deforming the drawings with dark patches, which are very difficult to remove: consequently my first endeavours were directed to the formation of a surface on which the photographic preparations might be spread with perfect uniformity.

A variety of sizes were used with very uncertain results. Nearly all the animal glutens appear to possess a colorific property, which may render them available in many of the negative processes; but they all seem to protect the darkened silver from the action of the hydriodic solutions. The gums are acted on by the nitrate of silver, and browned, independent of light, which browning considerably mars the effect of the finished picture. It is a singular fact, that the tragacanth and acacia gums render the gums much less permanent. I therefore found it necessary for general practice to abandon the use of all sizes, except such as enter into the composition of the paper in the manufacture. It occurred to me that it might be possible to saturate the paper with a metallic solution, which should be of itself entirely uninfluenced by light, on which the silver coating might be spread without suffering any material chemical change. The results being curious, and illustrative of some of the peculiarities of the hydriodic salts, it will be interesting to study a few of them.

Sulphate and Muriate of Iron.—These salts, when used in small proportions, appeared to overcome many of the first difficulties, but all the drawings on papers thus prepared faded out in the dark. If, after these photographs have faded entirely out, they are soaked for a short time in a solution of the ferro-cyanate of potash, and then are exposed to the light, the picture is revived, but with reversed lights and shadows.

Acetate and Nitrate of Lead.—These salts have been much used by Sir John Herschel, both in the negative and positive processes, and, it appears, with considerable success. I found a tolerably good result when I used a *saturated* solution; but papers thus prepared required a stronger light than other kinds. When I used weaker solutions, the drawings were covered with black patches. On these a little further explanation is required. When the strong solution has been used, the hydriodate acid which has not been expended in forming the iodide of silver—which forms the lights of the picture—goes to form the iodide of lead. This iodide is soluble in boiling water, and is easily removed from the paper. When the weaker solution of lead has been used, instead of the formation of an iodide the hydriodate exerts one of its peculiar functions in producing an oxide of the metal.

Muriate and Nitrate of Copper.—These salts, in any quantities, render the action of the hydriodates very quick; and, when used in moderate proportions, they appeared to promise at first much assistance in quickening the process. I have obtained, with papers into the preparation of which nitrate of copper has entered, perfect camera views in ten minutes; but experience has proved their inapplicability, the edges of the parts in shadow being destroyed by chemical action.

Chlorides of Gold and Platinum act similarly to each other. They remain inactive until the picture is formed; then a rapid oxidation of these metals takes place, and all the bright parts of the picture are darkened.

An extensive variety of preparations, metallic and non-metallic, was used with like effects, and I am convinced that the only plan of obtaining a perfectly equal surface, without impairing the sensitiveness of the paper, is careful manipulation with the ordinary muriates and silver solutions.

By attention to the directions given at page 88, which are simple in their character, but arrived at by a long series of inquiries, any one may prepare photographic papers on which the hydriodic solutions shall act with perfect uniformity.

Hydriodates of Potash and Soda.—The former of these salts being more easily procured than any of the hydriodates, is the one generally employed. The strength of the solution of these salts best adapted for the general kinds of paper is thirty grains to an ounce of water. The following results will exhibit the different energies manifested by these solutions at several strengths, as tried on the same paper by the same light:—

120	grains of the salt to an ounce of water took to whiten the paper				12	minutes.
100	do.	do.	to	do.	10	do.
80	do.	do.	to	do.	9	do.
60	do.	do.	to	do.	7	do.
40	do.	do.	to	do.	6	do.
30	do.	do.	to	do.	4	do.
20	do.	do.	to	do.	6	do.
10	do.	do.	to	do.	12	do.

The other hydriodic salts correspond nearly with these in their action; a certain point of dilution being necessary with all.

Hydriodate of Ammonia, if used on unsized paper, has some advantage as to quickness over the salts either of potash or of soda. This preparation is, however, so readily decomposed, that the size of the paper occasions a liberation of iodine, and the consequent formation of brown-spots.

Hydriodide of Iron.—This metallic hydriodide acts with rapidity on the darkened paper; but even in the shade its chemical energy is too great, destroying the sharpness of outline, and impairing the middle tints of the drawing. It also renders the paper very yellow.

Hydriodate of Manganese answers remarkably well when it can be procured absolutely free of iron. When the manganesic solution contains iron, even in the smallest quantities, light and dark spots are formed over the picture, which give it a curious speckled appearance.

Hydriodate of Baryta possesses advantages over every other *simple* hydriodic solution, both as regards quickness of action and the sharpness of outline. A solution may, however, be made still superior to it, by combining a portion of iron with it. Forty grains of the hydriodate of baryta being dissolved in one ounce of distilled water, five grains of very pure sulphate of iron should be added to it, and allowed to dissolve slowly. Sulphate of baryta is precipitated, which should be separated by filtration, when the solution is composed of hydriodate of baryta and iron. By now adding a drop or two of diluted sulphuric acid, more baryta is precipitated, and a portion of hydriodic acid set free. The solution must be allowed to stand until it is clear, and then carefully decanted off from the sediment, as filtering paper decomposes the acid, and free iodine is liberated. By this means we procure a photographic solution of every active character. It should be prepared in small quantities, as it suffers decomposition under the influences of the atmosphere and light.

Hydriodic Acid, if used on paper which will not decompose its aqueous solution, which is rather difficult to find, acts very readily on the darkened silver. A portion of this acid, free in any of the solutions, most materially quickens the action. From the barytic solution it is always easy to set free the required portion, by precipitating the barytes by sulphuric acid. As the hydriodate of barytes is rarely kept by the retail chemist, it may be useful to give an easy method of preparing the solution of the required strength.

Put into a Florence flask one ounce of iodine, and cover it with one fluid ounce and a half of distilled water; to this add half a drachm of phosphorus cut into small pieces; apply a very gentle heat until they unite, and the liquid becomes colourless;

then add another fluid ounce and a half of water. It is now a solution of hydriodic acid and phosphoric acid. By adding carbonate of barytes to it, a phosphate of barytes is formed, which, being insoluble, falls to the bottom, whilst the soluble hydriodate of barytes remains dissolved. Make up the quantity of the solution to nine ounces with distilled water, and carefully preserve it in a green glass stoppered bottle.

For drawings by application, less care is required than for the camera obscura. With a very soft flat brush apply the hydriodic solution on both sides of the prepared paper, until it appears equally absorbed; place it in close contact with the object to be copied, and expose it to sunshine. The exposure should continue until the parts of the paper exposed to uninterrupted light, which first change to a pale yellow, are seen to *brown* a little. The observance of this simple rule will be found of very great advantage in practice. Immersion for a short time in soft water removes the brown hue, and renders the bright parts of the picture clearer than they would otherwise have been.

Engravings to be copied by this process,—which they are most beautifully,—should be soaked in water and superimposed on the photographic papers, quite wet. If the paper is intended to be used in the camera, it is best to soak it in the hydriodic solution until a slight change is apparent, from chemical action on the silver: it is then to be stretched on a slight frame of wood, which is made to fit the camera, and not allowed to touch in any part but at the edges; placed in the dark chamber of the camera at the proper focus, and pointed to the object of which a copy is required, which with good sunshine is effected in about twenty minutes, varying of course with the degree of sensibility manifested by the paper. If the wetted paper is placed upon any porous body, it will be found, owing to the capillary communication established between different points, that the solution is removed from some parts to others, and different states of sensitiveness induced. Another advantage of the frame is, the paper being by the moisture rendered semi-transparent, the light penetrates and acts to a greater depth; thus cutting out fine lines which would otherwise be lost. However, if the camera is large, there is an objection to the frame; the solution is apt to gather into drops, and act intensely on small spots, to the injury of the general effect. When using a large sheet, the safest course is to spread it out when wetted upon a piece of very clean *wet* glass, great care being taken that the paper and glass are in close contact. The picture is not formed so quickly when the glass is used, as when the paper is extended on a frame, owing to the evaporation being slightly retarded. The additional time required—about one-sixth longer—is, however, in most cases, of little consequence.

The picture being formed by the influence of light, it is required, to render it unchangeable by any further action of the luminous fluid, not only that the hydriodic salt be entirely removed from the paper, but that the iodide of silver which is formed be also dissolved out of the drawing.

By well washing the drawing in warm water, the hydriodate is removed, and the pictures thus prepared have been stated to be permanent; and if they are kept in a portfolio, and only occasionally exposed, they are really so: for I shall show presently, that they have the property of *being restored in the dark to the state in which they were prior to the destructive action of light.* A drawing which I executed in June, 1839, which has often been exposed for days successively to the action of sunshine, and has altogether been very little cared for, continues to this date (October 1852), as perfect as at first. These photographs will not, however, bear *long-continued* exposure without injury—about three months in summer, or six weeks in winter, being sufficient to destroy them. As this gradual decay involves some very curious and interesting chemical phenomena, I shall make no excuse for dwelling on the subject a little.

The drawing fades first in the dark parts, and as they are perceived to lose their définedness, the lights are seen to darken, until at last the contrast between light and shadow is very weak.

If a dark paper is washed with an hydriodate and exposed to sunshine, it is first bleached, becoming yellow; then the light again darkens it. If, when quite dry, it is carefully kept from the light, it will be found in a few days to be again restored to its original yellow colour, which may be again darkened by exposure, and the yellow colour be again restored in the dark. The sensitiveness to the influence of light diminishes after each exposure, but I have not been enabled to arrive at the point at which this entirely ceases. If a dark paper, bleached by an hydriodate and light, be again darkened, and then placed in a bottle of water, the yellow is much more quickly restored, and bubbles of gas will escape freely, which will be found to be oxygen. By enclosing pieces of hydriodated paper in a tube to darken, we discover, as might have been expected, some hydrogen is set free. If the paper is then well dried, and carefully shut up in a warm dry tube, it remains dark; moisten the tube or the paper, and the yellowness is speedily restored.

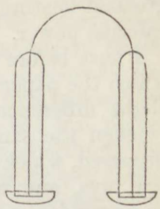
Take a photograph thus formed, and place it in a vessel of water: in *a few days* it will fade out, and bubbles of oxygen will gather around the sides. If the water is examined there will be found no trace of either silver or iodine. Thus it is evident the action has been confined to the paper.

We see that the iodide of silver has the power of separating hydrogen from its combinations. I cannot regard this singular salt of silver as a definite compound: it appears to me to combine with iodine in uncertain proportions. In the process of darkening, the liberation of hydrogen is certain; but I have not in any one instance been enabled to detect free iodine: of course it must exist, either in the darkened surface, or in combination with the unaffected under layer: possibly this may be the iodide of silver, with iodine in simple mixture, which, when light acts no longer on the preparation, is liberated, combines with the hydrogen of that portion of moisture which the hygrometric nature of the paper is sure to furnish, and as an hydriodate again attacks the darkened surface, restoring thus the iodide of silver. This is strikingly illustrative of the fading of the photograph.

The picture is formed of iodide of silver in its light parts, and oxide of silver in its shadows. As the yellow salt darkens under the influence of light, it parts with its iodine, which immediately attacks the dark oxide, and gradually converts it into an iodide. The *modus operandi* of the restoration which takes place in the dark is not quite so apparent. It is possible that the active agent being quiescent, the play of affinities comes undisturbed into operation; that the dark parts of the picture absorb oxygen from the atmosphere, and restore to the lighter portions the iodine it has before robbed them of. A series of experiments on the iodide of silver in its pure state will still more strikingly exhibit this very remarkable peculiarity.

Precipitate with any hydriodate, silver, from its nitrate in solution, and expose the vessel containing it, liquid and all, to sunshine; the exposed surfaces of the iodide will blacken: remove the vessel into the dark, and, *after a few hours*, all the blackness will have disappeared. We may thus continually restore and remove the blackness at pleasure. If we wash and then well dry the precipitate, it blackens with difficulty, and if kept quite dry it continues dark; but moisten it, and the yellow is restored after a little time. In a watch-glass, or any capsule, place a little solution of silver; in another, some solution of any hydriodic salt; connect the two with a filament of cotton, and make up an electric circuit with a piece of platina wire: expose this little arrangement to the light, and it will be seen, in a very short time, that iodine is liberated in one vessel, and the yellow iodide of silver formed in the other, which blackens as quickly as it is formed.

Place a similar arrangement in the dark; iodine is slowly liberated. *No iodide of silver is formed*, but around the wire a beautiful cyrstallization of metallic silver. Seal a piece of platina wire into two small glass tubes; these, when filled, the one with hydriodate of potash in solution, and the other with a solution of the nitrate of silver, reverse into two watch-glasses, containing the same solutions; the glasses being connected with a piece of cotton. An exposure during a few hours to daylight will occasion the hydriodic solution in the tube to become quite brown with liberated iodine: a small portion of the iodide of silver will form along the cotton, and at the end dipping in the salt of silver. During the night the hydriodic liquid will become again colourless and transparent, and the dark salt along the cotton will resume its native yellow hue.



77.

From this it is evident that absolute permanence will not be given to these photographs until we succeed in removing from the paper all the iodide of silver formed. The hyposulphites dissolve iodide of silver; therefore it might have been expected, *à priori*, they would have been successful on these drawings. If they are washed over with the hyposulphite of soda, and then quickly rinsed in plenty of cold water, the drawing is improved, but no better fixed than with cold water alone. If we persevere in using the hyposulphite, the iodide is darkened by combining with a portion of sulphur, and the lights become of a dingy yellow, which is not at all pleasant.

No plan of fixing will be found more efficacious with this variety of photographic drawings, than soaking them for some hours in cold water, and then well washing them in hot water.

It often happens that a picture, when taken from the camera, is less distinct than could be desired: it should not, however, be rejected on that account. All the details exist, although not visible. In many cases the soaking is sufficient to call them into sight; if they cannot be so evoked, a wash of weak ammonia or muriatic acid seldom fails to bring them up. Care, however, must be taken not to use these preparations too strong, and the picture must be washed on the instant, to remove the acid or alkali.

One very singular property of these photographs is, that when first prepared, and after the washing, they are not fixed or otherwise; but when exposed to sunshine, they change in their dark parts from a red to a black. This peculiarity will be found by experiment to be entirely dependent on the influence of the red rays, or that portion of the sunbeam which appears to have the greatest heating power: hence regarded as the seat of greatest calorific power.

I have before mentioned the peculiar state of equilibrium in which the paper is when wetted with the hydriodate, and that a slight difference in the incident light will either bleach or blacken the same sheet. If four glasses, or coloured fluids, be prepared, which admit respectively the blue, green, yellow and red rays, and we place them over an hydriodated paper, having an engraving superposed, it will be bleached under the influence of the blue light, and a perfect picture produced; while, under the rays transmitted by the green glass, the drawing will be a negative one, the paper having assumed, in the parts which represent the lights, a very defined blackness. The yellow light, if pure, will produce the same effect, and the red light not only induces a like change, but occasions the dark parts of the engraving to be represented in strong lights: this last peculiarity is dependent on the heating rays, and opens a wide field for inquiry. My point now, however, is only to show that the darkening of the finished photograph is occasioned by the *least* refrangible rays of light; whereas its preparation is effected by the *most* refrangible.

I know not of any other process which shows, in a way at once so decided and beautiful, the wonderful constitution of every sunbeam which reaches us. Yet this is but one of numerous results of an analogous character, produced by these opposite powers, necessary to the constitution of that solar beam, which is poured over the earth, and effects those various changes which give to it diversified beauty, and renders it conducive to the well-being of animated creatures.

Before quiting this branch of the art, it will be interesting to examine the modifications which have been introduced by some continental inquirers.

M. Lassaigne, who has claimed priority in the use of the iodide of potassium, saturated his paper with a sub-chloride of silver, which was allowed to assume a violet-brown colour, and it was then impregnated with the iodidated solution.

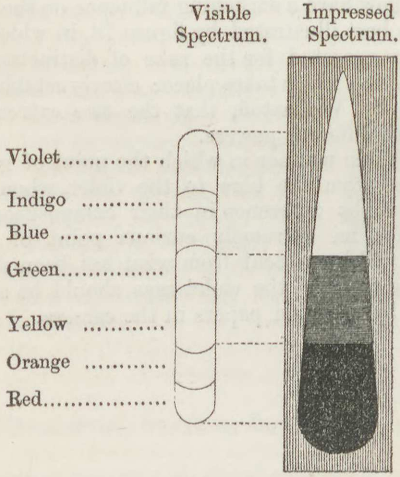
M. Bayard simply allowed ordinary letter paper, prepared according to Mr. Talbot's method, to blacken by light. He then steeped it for some seconds in a solution of iodide of potassium, and laying it on a slate he placed it in the camera.

M. Verignon introduced a somewhat more complicated process. His directions are,—White paper should first be washed with water acidulated by hydrochloric (muriatic) acid;

then, after being well dried, steeped in the following solution :—Water fourteen parts, with one part of a compound formed of two parts of muriate of ammonia, two parts of bromide of sodium, and one of chloride of strontium. The paper dried again is passed into a very weak solution of nitrate of silver. There is thus formed, by double decomposition, a chloride and bromide of silver, which is made to turn black by exposing the paper to the light for about half an hour. To use this paper, it is steeped in a very weak solution of the iodide of sodium, and placed, quite wet, into the camera obscura, at the proper focus. In fine weather, M. Verignon states, the effect is produced in twelve minutes. I have, however, never produced a good picture by this process in less than thirty minutes. A great objection to this mode of preparation is the very rapid deterioration of the paper: every day it will become less and less sensitive to light, and at the end of a fortnight it is useless.

The papers recommended for use in the former pages have the advantage of keeping well, provided ordinary care is taken with them. It is necessary to exclude them from the light, to keep them very dry, and, as much as possible, they should be protected from the action of the air. I have kept papers, prepared with the muriate of ammonia, baryta, and strontia, for twelve months, and have found them but very little impaired.

Dr. Schafhaeutl allows paper prepared in the way mentioned at a former page to darken in a bright sun light. It is then



78.

macerated for at least half an hour, in a liquid prepared by mixing one part of the already described acid nitrate of mercury, with nine or ten parts of alcohol. A bright lemon yellow precipitate of basic hyponitrate of the protoxide of quicksilver falls, and the clear liquor is preserved for use. The macerated paper is removed from the alcoholic solution, and quickly drawn over the surface of diluted muriatic acid (one part strong acid to seven or ten of water), then quickly washed in water, and slightly and carefully dried at a heat not exceeding 212° of Fahr. The paper is now ready for being bleached by the rays of the sun; and in order to fix the drawing nothing more is required than to steep the paper a few minutes in alcohol, which dissolves the free bichloride of mercury. I must confess, however, that in my hands the process has not been so successful as it is described to have been by the author of it

It is perhaps necessary to remark, that we cannot multiply designs from an original hydriodated photograph. The yellow colour of the paper is of itself fatal to transfers, and independently of this, the wet hydriodic solution would immediately destroy any superposed photograph.

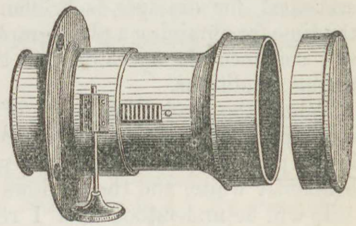
We have seen in a former chapter that the white photographic papers are darkened by the blue, indigo, and violet rays. On the dark papers washed with the hydriodic salts in solution, the bleaching is effected most energetically by the violet rays: it proceeds with lessening intensity to the blue, while all the rays below the yellow have a darkening influence on the paper. This effect will be best illustrated by figure 78, in which is shown—somewhat exaggerated for the sake of distinctness—the very remarkable action which takes place; clearly establishing the fact first noticed by Wollaston, that the two extremities of the spectrum have different powers.

The remarkable manner in which the point of greatest intensity is shifted from the blue to the violet, when papers have but a very slight difference in their composition or mode of preparation, is an extremely curious point of philosophical inquiry. It will be evident from what has been said, that it is necessary the focus of the violet rays should be always chosen in using the hydriodated papers in the camera.

CHAPTER X.

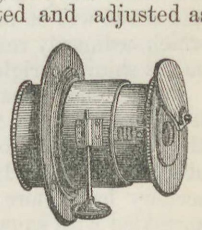
GENERAL REMARKS ON THE USE OF THE CAMERA OBSCURA.

These remarks will apply with equal force to all the processes by which views of external objects can be obtained; but they have more especial reference to those highly sensitive ones, the Daguerreotype, the Talbotype, and the Collodion processes.



79.

It has already been stated that a single achromatic lens, producing a large image, should be employed for motionless objects, where time is not of consequence. For a building, a statue, or the like, it is not of much consequence whether one minute or ten may be consumed in the operation of obtaining its impression. With the human figure and animals the case is very different: the utmost concentration of the solar radiations is therefore required to ensure rapidity of action. This is effected by the double combination of lenses, which are usually mounted and adjusted as shewn in the above figure, 79. In Fig. 80, the single lens arrangement is shewn.



80.

It is often of the utmost importance, to obtain definition of the objects, that all extraneous rays should be cut off; this is effected by means of a diaphragm of stops, which can be obtained to fit any lens. With this adjustment any sized aperture can be obtained.

Section I.—Buildings, Statues, Landscapes, and Foliage.

The great defect in nearly all the photographic pictures which are obtained is the extreme contrast between the high lights and the shadows, and in many an entire absence of the middle tones of the picture.

In the very beautiful production of Mr. Buckle, of Peterborough, which we displayed in the Great Exhibition, there was a very remarkable degree of fine definition, united with a beautiful blending of the respective parts which constituted the picture. There was no glaring contrast between the lights. Those parts which were the most brilliantly illuminated were softened into the middle tones of the picture, and those again faded gradually into the deep shadows. In the works of M. Martin and M. Flacheron, whose processes I have given, the same harmonising of lights and shadows was generally found to exist.

The usual mistake with amateurs is that of selecting bright sunshine as the period for operating. It is thought, when a cathedral, for example, is brilliantly lighted up by sunshine, is the time for obtaining a photographic copy of it. A little reflection will convince the operator that this is the case only under particular conditions.

When the projecting parts of the building are flooded with sunshine, they cast the deepest possible shadows; consequently, in the photographic picture the prominent points would appear brilliantly white, and the shadows intensely dark.

It will be understood that I refer always to the *positive*, or completed picture.

A clear blue sky, reflecting its light upon a similar structure, produces less prominent illumination of the bold ornamental parts, and gives more light to those parts on which the shadows are cast. A photograph taken under such conditions of light and shade will be far more beautiful than the spotted productions which ordinarily result from the practice of operating when the sun is shining brightly on the object.

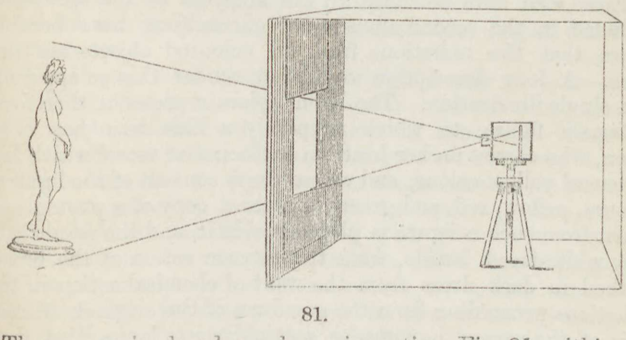
In the same manner, when the sun shines brightly on the leaves of trees, a very large quantity of light is reflected from their surfaces, the other parts appearing by contrast in almost absolute shadow. Hence, nearly all photographic views of forest scenery have more the appearance of scenes which have been sprinkled with snow than foliage glowing with sunshine.

An artist studies in his productions the most effective disposition of the lights and shadows, and it is by the harmonious, disposition of these that he succeeds in giving a peculiar charm to his productions. Nearly all photographic pictures, although they have the merit of strict truthfulness, appear to want this great beauty of art. This has mainly arisen from the circumstance that intense illumination has been sought for under the idea of producing the sharpest picture; and it is true that thus we do obtain a very perfect definition of outline. Many productions are remarkable for this, and, indeed, reproduce with unnatural exactness all the minute details of the objects copied; whereas the human eye never sees this extraordinary sharpness of outline in nature; upon the edge of every object there are fringes of light which soften off their outlines, and subdue the general tone of objects, blending all harmoniously. Perhaps there is more than ordinary difficulty in producing this in a representation of nature which is effected by means of a lens. The artist may, however, do much: all times, even of bright illumination, are not fitted for producing a picturesque photograph. Nature should therefore be looked at with an artist's eye, and the happy moment chosen when the arrangements of light and shade give the most picturesque effects, and when these are in a condition to be correctly reproduced according to the laws by which actinic influences are regulated.

Section II.—Portraits from the Life.

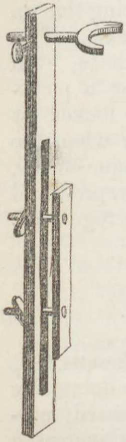
It is important for the production of a correct likeness that as small an aperture as possible should be used. By doing this there is great loss of light, and consequently the necessarily prolonged time must be compensated for by greatly increased sensibility in the plates.

It is also important that arrangements should be made to cut off from the lens all light proceeding from extraneous objects: this is best effected by the modes adopted by M. Claudet.



81.

The camera is placed, as shewn in section, Fig. 81, within an arrangement of curtains which, as will be seen in the vignette heading to this part, page 187, is capable of adjustment, so as to have any required opening in front of the camera. The whole of this screen being mounted on rollers is easily moved; therefore the operator has it in his power to adjust the opening, and to shut off all adventitious radiations, thus securing the effectiveness of the rays proceeding directly from the sitter, or the object to be copied.



82.

The sitter should be placed in the easiest possible position compatible with the arrangement of the body as nearly as is possible in a vertical plane. This is necessary, as the parts which are nearest the glass suffer a very considerable degree of distortion and enlargement. Of course great steadiness is required on the part of the sitter during the few seconds he submits to the operation of the photographer. It is usual to support the head by a rest fastened to the back of the seat, as shewn in fig. 82; but where the person can maintain a steady position without this, the result is generally the most satisfactory, the "rest" not unfrequently giving an air of stiffness to the sitter. In a great number of portraits a dark and unnatural shade is thrown under the eyes: this arises from the employment of a "top light." The light falling vertically produces the shadow of the brow over the eye, and gives a sombre character to the face. This is objectionable also, as being annoying to the sitter, who assumes in consequence a somewhat painful expression.

Those who have attended to the analyses of the spectrum, included in the second division of our subject, have become aware that the radiations from all coloured objects are not alike. A long description would not render this so apparent as a single illustration. The Frontispiece represents, therefore, a female figure, to which purposely a blue face has been given, who carries on her head an earthenware vessel which has a general yellow colour, and whose dress consists of the lightest colours, yellow, red, and green; an exact copy of a photograph taken from such a figure is placed beside it, and the result is, a very white-faced female, from the intense action of the blues, clothed in dark dress from the want of chemical action in the radiations proceeding from the gay dress of the original. Hence it is of the utmost importance, particularly to ladies, that they should be directed to avoid in their dresses, when about to sit for their portraits, such colours as would produce darks for lights, and the contrary.

CHAPTER XI.

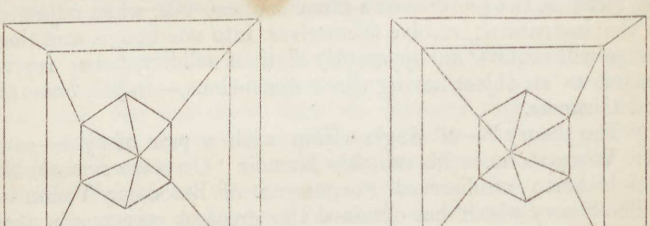
THE STEREOSCOPE.

From the interest which this very interesting optical instrument has excited, and the very intimate relation which exists between it and photography, since it is only practical to produce images suited for the instrument by the agency of the camera obscura, it is thought advisable to devote a short chapter to some notice of it. It is not intended that any examination of the phenomena of vision, or of the application of the stereoscope to the explanation of single vision with a pair of eyes, shall be attempted; these questions would be somewhat out of place in the present manual, and would occupy too large a space if properly dealt with.

The stereoscope is before the world: a simple description, therefore, of the forms under which it may be constructed, and a sufficient explanation of its principles, is all that can here with propriety find a place. The name is compounded from two Greek words, signifying *solid*, and *I see*, and adopted from the fact that two pictures on a plane surface, will, when adjusted in the instrument, resolve themselves into one image, and that image will acquire an apparently distinct solidity, being represented as an object having three dimensions,—*length*, *breadth*, and *thickness*.

" The theory "—of single vision with a pair of eyes—says Mr. Wheatstone, in his valuable Memoir ' On some remarkable and hitherto unobserved Phenomena of Binocular Vision'—" The theory which has obtained the greatest currency is that which assumes that an object is seen single because its pictures fall on corresponding points of the two retinæ; that is, on points which are similarly situated with respect to the two centres, both in distance and position. This theory supposes that the pictures projected on the retinæ are exactly similar to each other, corresponding points of the two pictures falling on corresponding points of the two retinæ." Leonardo da Vinci, in his Treatise on Painting, has some remarks on the peculiarity of vision, which bear in a singular manner on the phenomena of the stereoscope, to the effect, that a painting, though conducted with the greatest art and finish to the last perfection, both with regard to its contours, its lights, its shadows, and its colours, can never show a relievo equal to that of natural objects, unless these be viewed at a distance, and with a single eye; for if an object, as an orange, be viewed by a single eye, all objects in that space behind it, which we may suppose to be included in its shadow, are invisible to that eye; but open the other eye without moving the head, and a portion of these becomes visible: those only are hid from sight which are included in the space covered by the two shadows formed by two candles supposed to be placed in the positions of the eyes. The hidden space is so much the shorter according to the smallness of the object, and its proximity to the eyes. Upon this Mr. Wheatstone remarks:—"Had Leonardo da Vinci taken, instead of a sphere, a less simple figure for the purpose of his illustrations—a cube for instance—he would not only have perceived that the object obscured from each eye a different part of the more distant field of view, but the fact would also have been forced upon his attention,—that the object itself presented a different appearance to each eye."

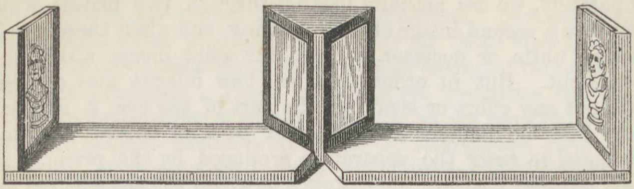
If any of my readers will be at the trouble to look at a simple solid form, keeping the head perfectly steady, with a single eye, and make an outline drawing of the image as seen—say, first with the left eye, and then with the right eye—it will be found that two dissimilar forms will be obtained analogous to those represented in the following diagram.



83.

By a little effort, it is easy, by squinting, to resolve these two figures into one, when it will be found that an apparently solid image is formed from these dissimilar outlines of a solid.

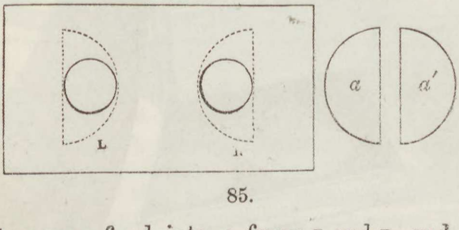
The stereoscope of Professor Wheatstone is arranged to produce this in a more effective manner. The instrument, fig. 84, consists of two plane mirrors, so adjusted that their backs form an angle of ninety degrees with each other. These mirrors are fixed by their common edge upon an horizontal board, in



84.

such a manner that, upon bringing it close to the face, each eye sees the image reflected from the two ends of the instrument in a different mirror; at each end of the board are panels in which the drawings are placed. The two reflected images coincide at the intersection of the optic axes, and form an image of the same apparent magnitude as each of the component pictures. This instrument is called the reflecting stereoscope; and as it will admit of being made of any size, so as to allow of the introduction of large pictures, it offers many advantages. Mr. Wheatstone suggested in his memoir, already quoted, the use of an instrument constructed with prisms, which is analogous to the beautifully portable lenticular stereoscope of Sir David Brewster, described by him in the Philosophical Magazine.

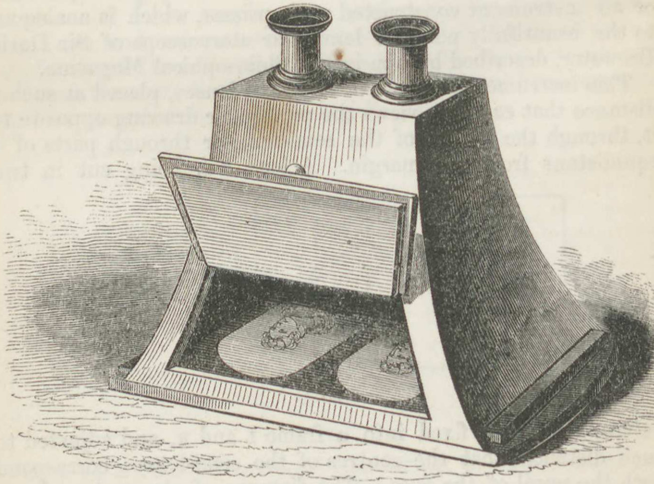
This instrument consists of two semi-lenses, placed at such a distance that each eye views the picture or drawing opposite to it, through the margin of the semi-lens, or through parts of it equidistant from the margin. A lens, *a á*, being cut in two



85.

halves, these are fixed into a frame L and R, and adjusted to such distances that the centres of the semi-lenses correspond with the pupil of the eyes. The distance of the centre of one pupil from the other is at an average 2½ inches, and to this the semi-lenses may be adjusted; but if the instrument is provided with the means of effecting a little change in this respect, it will often be found to be of considerable advantage.

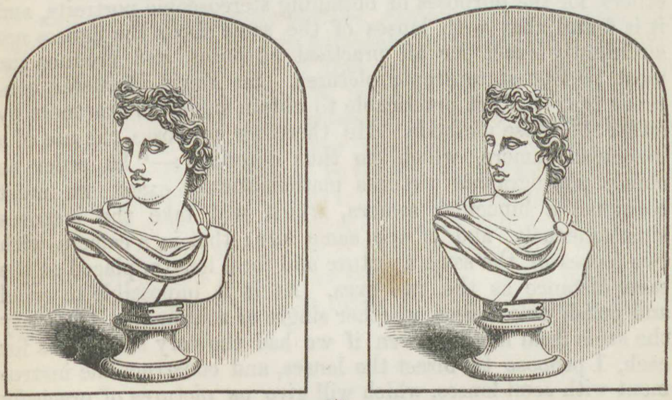
"When we thus view," says Sir David Brewster, "two dissimilar drawings of a solid object, as it is seen by each eye separately, we are actually looking through two prisms, which produce a second image of each drawing, and when these second images unite, or coalesce, we see the solid image which they represent. But in order that the two images may coalesce, without any effort or strain on the part of the eye, it is necessary that the distance of the similar parts of the two drawings be equal to *twice* the separation produced by the prism. For this purpose measure the distance at which the semi-lenses give the most distinct view of the drawings; and having ascertained, by using one eye, the amount of the refraction produced at that distance, or the quantity by which the image of one of the drawings is displaced, place the drawings at a distance equal to twice that quantity; that is, place the drawings so that the average distance of similar parts in each is equal to twice that quantity. If this is not correctly done, the eye of the observer will correct the error by making the images coalesce without being sensible that it is making any such effort. When the dissimilar drawings are thus united, the solid will appear standing, as it were, in relief, between the two plane representations."



86.

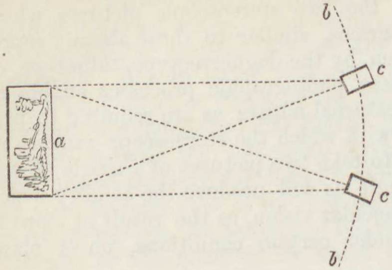
The lenticular instrument, fitted for use, is shewn in figure 86: it consists of a frame of wood or metal; the two semi-lenses are fixed in brass tubes which are capable of being adjusted to accommodate the differences of sight in different individuals. At the bottom of the box, as seen through the opening, are placed the two stereoscopic pictures, which may consist either of diagrams, similar to those already represented, or of images taken by the daguerreotype, talbotype, or collodion processes. These photographic processes enable us to obtain such copies of external nature as are required to produce the magical results with which the stereoscope renders us familiar. It is required to take two pictures of a single object, at such a difference of angle as will produce the solidity which is evident in ordinary binocular vision, as the result of viewing two dissimilar images, under certain conditions, on a plane surface.

The two accompanying figures represent a bust as viewed by each of the two eyes singly. If the experiment is tried upon a



87.

bust or statue, it will be found that one eye will see surfaces which are invisible to the other. Thus in these examples it will be quite apparent, upon examination, that the line of the cheek is more distant from the line of the nose in one than in the other image, and that a similar inequality exists in several other parts. By a little practice, any reader may, by squinting, resolve these two images into one, and thus produce the stereoscopic effect. Now the object is to place the camera in the position of the eyes, and thus obtain the representation of two images, as viewed by each eye separately. This may be effected with a single camera, by adjusting it at a certain measured distance from the object to be copied, and having obtained one picture, move it round about twenty degrees, and take the second image. *a* may represent the object to be copied, *b* being the distance at which the camera *c* is placed, which is, say 100 feet from the point *a*: the picture from this point being taken, the camera is moved round, still preserving the same distance from the object by means of a cord attached to the camera obscura, or by measuring the space. Two cameras with lenses of the same focal length



88.

may be employed, and are indeed employed, by M. Claudet and others, for the purposes of obtaining stereoscopic portraits, and it is found that with lenses of the same focus the figures are sufficiently exact for all practical purposes, and produce the most perfect stereoscopic pictures. Sir David Brewster contends that it is not practicable to obtain sufficient exactness by either of these methods. He therefore proposes the use of a binocular camera, which he thus describes:—"In order to obtain photographic pictures mathematically exact, we must construct a binocular camera, which will take the pictures simultaneously, and of the same size; that is, a camera with two lenses of the same aperture and focal length, placed at the same distance as the two eyes. As it is impossible to grind and polish two lenses, whether single or achromatic, of exactly the same focal lengths, even if we had the very same glass for each, I propose to bisect the lenses, and construct the instrument with semi-lenses, which will give us pictures of precisely the same size and definition. These lenses should be placed with their diameters of bisection parallel to one another, and at a distance of $2\frac{1}{2}$ inches, which is the average distance of the eyes in man; and when fixed in a box of sufficient size, will form a binocular camera, which will give us, at the same instant, with the same lights and shadows, and of the same size, such dissimilar pictures of statues, buildings, landscapes, and living objects, as will reproduce them in relief in the stereoscope."

There appears but one objection to the binocular camera of Sir David Brewster, and that is one arising from the circumstance of employing really the very worst portion of the lens; *i.e.*, the two sides. This, however, in practice, is not found to be of any disadvantage; the images are sufficiently perfect, although not so absolutely correct as those formed by the centre of the lens, and they are certain of being resolvable into a distinct image of three dimensions.

With the single camera, taking the precaution named, with two lenses of the same focal length, or with the semi-lenses, stereoscopic pictures may be obtained without difficulty.

The magic result of the resolution of two plain pictures into one, possessing to the eye the most positive solidity, is so striking when witnessed for the first time, that it appears to be a deception of the senses. Even when fully accustomed to the phenomena of the stereoscope, there is an indescribable charm in the beautiful pictures, that they are gazed at again and again with increasing admiration. Living forms appear to stand out in all the roundness of life; and where colours have been judiciously applied to the daguerreotype or calotype portrait, it is not possible to conceive a more perfect realization of the human form than that which stands forth, prominently, from the back ground of the stereoscopic picture. Statues, in like manner, are almost realized again in their miniature representations. Architectural piles are seen in all that exactness of proportion and gradation of distance, which is, in their minute reproduction, singularly interesting; and in landscapes, the stereoscope gives us a reformation of every image in apparently the most perfect solidity and truth of distance. In the stereoscope we have at once an instrument which enables us to study many of the phenomena of vision, and to reproduce loved and beautiful objects, or interesting scenes, through the agency of those rays by which they were illuminated, in that strange perfection which, in its mimicry of visible external nature, almost baffles the examination of human sense.

APPENDIX.

The following correspondence, important in the history of photography, appeared in the Times newspaper of August 13, 1852.

THE PHOTOGRAPHIC PATENT RIGHT.

We have been requested to publish the following correspondence between the Presidents of the Royal Society and the Royal Academy, and the patentee of the art of photography upon paper, with the view of definitively settling a question of considerable interest to artists and amateurs of photography in general:—

No. 1.

London, July, 1852.

Dear Sir,—In addressing to you this letter, we believe that we speak the sentiments of many persons eminent for their love of science and art.

The art of photography upon paper, of which you are the inventor, has arrived at such a degree of perfection that it must soon become of national importance; and we are anxious that, as the art itself originated in England, it should also receive its further perfection and development in this country. At present, however, although England continues to take the lead in some branches of the art, yet in others the French are unquestionably making more rapid progress than we are.

It is very desirable that we should not be left behind by the nations of the continent in the improvement and development of a purely British invention; and, as you are the possessor of a patent right in this invention, which will continue for some years, and which may, perhaps, be renewed, we beg to call your attention to the subject, and to inquire whether it may not be possible for you, by making some alteration in the exercise of your patent rights, to obviate most of the difficulties which now appear to hinder the progress of the art in England. Many of the finest applications of the invention will, probably, require the co-operation of men of science and skilful artists. But it is evident that the more freely they can use the resources of the art, the more probable it is that their efforts will be attended with eminent success.

As we feel no doubt that some such judicious alteration would give great satisfaction, and be the means of rapidly improving this beautiful art, we beg to make this friendly communication to you, in the full confidence that you will receive it in the same spirit—the improvement of art and science being our common object.

ROSSE.
C. L. EASTLAKE.

To H. F. Talbot, Esq., F.R.S., &c.
Lacock Abbey, Wilts.

No. 2.

Lacock Abbey, July 30.

My Dear Lord Rosse,—I have had the honour of receiving a letter from yourself and Sir C. Eastlake respecting my photographic invention, to which I have now the pleasure of replying.

Ever since the Great Exhibition I have felt that a new era has commenced for photography, as it has for so many other useful arts and inventions. Thousands of persons have now become acquainted with the art, and, from having seen such beautiful specimens of it produced both in England and France, have naturally felt a wish to practise it themselves. A variety of new applications of it have been imagined, and doubtless many more remain to be discovered.

I am unable myself to pursue all these numerous branches of the invention in a manner that can even attempt to do justice to them, and moreover I believe it to be no longer necessary, for the art has now taken a firm root both in England and France, and may safely be left to take its natural development. I am as desirous as any one of the lovers of science and art, whose wishes you have kindly undertaken to represent, that our country should continue to take the lead in this newly-discovered branch of the fine arts; and, after much consideration, I think that the best thing I can do, and the most likely to stimulate to further improvements in photography, will be to invite the emulation and competition of our artists and amateurs, by relaxing the patent right which I possess in this invention. I therefore beg to reply to your kind letter by offering the patent (with the exception of the single point hereafter mentioned) as a free present to the public, together with my other patents for improvements in the same art, one of which has been very recently granted to me, and has still thirteen years unexpired. The exception to which I refer, and which I am desirous of still keeping in the hands of my own licensees, is the application of the invention to taking photographic portraits for sale to the public. This is a branch of the art which must necessarily be in comparatively few hands, because it requires a house to be built or altered on purpose, having an apartment lighted by a skylight, &c., otherwise the portraits cannot be taken indoors, generally speaking, without great difficulty.

With this exception, then, I present my invention to the country, and trust that it may realize our hopes of its future utility.

Believe me to remain, my dear Lord Rosse,

Your obliged and faithful servant,

H. F. TALBOT.

The Earl of Rosse, Connaught Place, London.

CORRESPONDENCE OF ENGLISH AND FRENCH WEIGHTS AND MEASURES.

English Weights.	English Grains.	French Grammes.	
2·2055 Pounds Avoirdupois } 2·6803 — Troy }	15438·	1000·	= 1 Kilogramme
1 Pound Avoirdupois	7000·	453·4	
1 — Troy	5760·	373·096	
1 Ounce Troy	480·	31·091	
1 — Avoirdupois	437·5	28·338	
1 Drachm Apothecaries	60·	3·8864	
1 — Avoirdupois	27·344	1·7711	
1 Imperial Grain	1·	0·065	
	15·438	1·	= 1 Gramme
	1·5438	0·1	= 1 Decigramme
	·1544	0·01	= 1 Centigramme
	·0154	0·001	= 1 Milligramme

English Imperial Measures.	French Litres.	
1 Gallon	4·5455	
1 Pint = 20 fluid ounces	0·5682	
1 Decigallon = 16 fluid ounces	0·4545	
1 Fluid ounce, being the bulk of an avoirdupois ounce of water at 62° Fahr.	0·2841	
1 Fluid drachm	0·0355	
1 Septem, being the bulk of 7 grains of water at 62° Fahr. or the $\frac{1}{10000}$ of a gallon	0·000455	
0·22 Gallon } 1·76 Pint } 2·20 Decigallon }	1·000	
2·2 Septems } 15·4 Grains of water at 62° Fahr. }	0·001	= 1 Centimetre Cube

INDEX.

THE END.

WILSON AND OGILVY, SKINNER STREET, SNOWHILL, LONDON.

JANUARY 1853.

PHOTOGRAPHIC APPARATUS.

MESSRS. GRIFFIN AND CO. have for sale all the varieties of PHOTOGRAPHIC APPARATUS described in PROFESSOR HUNT'S "*Manual of Photography.*" The principal articles of their stock are described in No. 7 of their SCIENTIFIC CIRCULAR. The following are Additions and Corrections to that List. All other Photographic Apparatus and Pure Chemicals can be supplied, though not here enumerated.

GUARANTEE OF THE GOODNESS OF PHOTOGRAPHIC LENSES.

It frequently happens that Amateurs do not succeed in immediately producing Photographic Pictures equal to those obtained by Experienced Artists. In such cases the fault is sometimes hastily and erroneously charged to the Lenses. To prevent complaints on this head, Messrs. GRIFFIN AND CO. have arranged with a competent Photographer to try every set of Lenses which they Import; and a Collodion Picture, produced by each set of Lenses, will be sold with it, to show the purchaser what the Lenses can effect. The cost of the experiments, and of the Collodion Picture given as a guarantee, will add 10s. 6d. to the prices of the Lenses quoted in the Circular,—for which cost the purchaser is ensured against the receipt of Lenses not properly adjusted.

1. IMPROVED CAMERA for the COLLODION PROCESS, as described in HUNT'S "*Manual of Photography,*" page 273, figures 69 to 75.—French-polished Mahogany Camera, 2½ inch Achromatic Lens, adapted for taking Views, all the necessary Apparatus and Chemicals, with a strong leather case and strap, £16. 16s.
2. STAND suitable for the above Camera, 20s.

GLASS DIPPING BATHS FOR NITRATE OF SILVER.

To take Plates of the following sizes:—

		s.	d.
3.	3¼ inches by 2¾ inches	5	0
4.	3¼ — 4¼ —	7	0
5.	6⅜ — 4¾ —	8	6
6.	8½ — 6¾ —	10	6

FLAT GLASS PANS USED FOR WASHING PLATES.

For Plates of the following sizes:—

		s.	d.
7.	3½ inches by 4½ inches	4	6
8.	4½ — 5½ —	6	0
9.	5 — 6¾ —	7	6
10.	9 — 7 —	10	6

SILVER PLATES FOR DAGUERREOTYPES. See No. 2778.

An additional size, with BOXES and PASSE PARTOUTS to match.

11. Plates, 5 inches by 4 inches, £1. 2s. per dozen.
12. WALNUT BOX, with Grooves for 12 Plates of this size, 3s. 6d.
13. PASSE PARTOUT (same as No. 2753), for this size, 1s. 2d. each.

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14. ORNAMENTAL PASSE PARTOUTS. A great variety of elegant French Patterns, suitable for the six sizes of Silver Plates.
For Common Passe Partouts, see CIRCULAR, No. 2753-2757.

15. MOROCCO LEATHER CASES FOR DAGUERREOTYPES. A great variety of SIZES, QUALITIES, and STYLE of ORNAMENT, in addition to those described in the CIRCULAR, No. 2750-2752.

EMBOSSED FRAMES FOR PASSE PARTOUTS.

Adapted for Passe Partouts that contain Plates of the following dimensions:—

						s.	d.
16.	$2\frac{1}{8}$ inches	by	$2\frac{7}{8}$ inches		. . . . . .	0	9
17.	$2\frac{3}{4}$	—	$3\frac{1}{4}$	—	. . . .	0	10
18.	$3\frac{1}{4}$	—	$4\frac{1}{4}$	—	. . . .	1	0
19.	4	—	5	—	. . . .	1	6
20.	$4\frac{3}{4}$	—	$6\frac{3}{4}$	—	. . . .	1	9

21. THERMOMETER for the MERCURY BOX, with Scale after FAHRENHEIT to 212°. Three sizes, each 3s. 6d.

COLOURS FOR PAINTING DAGUERREOTYPES.

22. Box, containing 10 Colours in Glass Tubes, with a Cup of Silver, a Cup of Gold, and a set of Brushes, 10s. 6d.
23. Single Colours, in Tubes, 1s. each.
24. Cup of Silver, 6d.
25. Cup of Gold, 8d.

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26. STEREOSCOPE, Mahogany, complete, with a Dozen Lithographs, 21s.
27. Daguerreotype Pictures for ditto.
28. Lithographic Pictures for ditto.
29. Silver Plates for Daguerreotype Pictures.
30. Passe Partouts for ditto, 9d.

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31. PURE CHEMICALS REQUIRED FOR THE PROCESSES WITH COLLODION AND WAXED PAPER:—

		s.	d.
Ammonia, Muriate	per oz.	0	3
Barium, Chloride	—	0	3
Barytes, Nitrate	—	0	6
Ether, Sulphuric	—	0	6
Mercury, Bichloride	—	1	0
Potash, Carbonate	—	0	9
Potash, Nitrate	—	0	2
Silver, Iodide	—	10	0
Sugar of Milk	—	0	4
White Wax	—	0	3

GRIFFIN'S SCIENTIFIC CIRCULAR.

No. 7. MARCH, 1852. PRICE 2D.

A DESCRIPTIVE AND ILLUSTRATED CATALOGUE OF

PHOTOGRAPHIC APPARATUS, MICROSCOPES, TOOL CHESTS, CABINETS OF MINERALS, ETC.

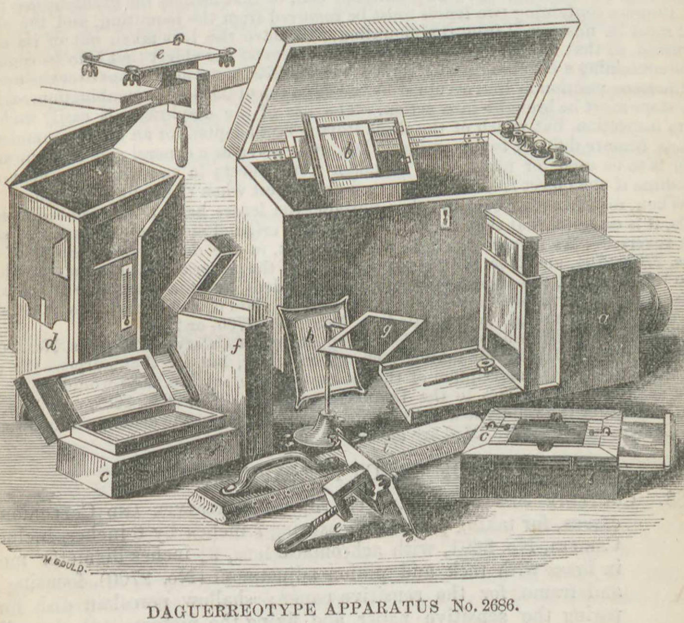
OFFERED FOR SALE AT THE AFFIXED PRICES BY

JOHN JOSEPH GRIFFIN AND COMPANY,

Chemical Museum, 53, Baker Street, Portman Square, London;

AND

RICHARD GRIFFIN & Co., GLASGOW.



DAGUERREOTYPE APPARATUS No. 2686.

The Apparatus is in all cases catalogued at the lowest cash prices. The expense of packing cases and Packing Materials is charged in addition. We employ very careful and experienced persons to pack the goods securely; but we do not hold ourselves responsible for any breakage that may take place during the carriage of the goods to their places of destination. The packing cases being charged at the cost price, and often being made expressly to fit the goods, and never having been received in a state fit to use again when returned to us empty by carriers, &c., we beg to intimate, that we cannot take them back, nor make any allowance for them.

As the Articles in this Catalogue commence with No. 2683, it is necessary to mention, that the Articles Nos. 1 to 2682 are contained in our GENERAL DESCRIPTIVE CATALOGUE OF CHEMICAL AND PHILOSOPHICAL APPARATUS, the last edition of which, including the first Six Parts of the SCIENTIFIC CIRCULAR, was published in December, 1851, in octavo, illustrated by 1200 woodcuts, price 2*s.*, or post free, 2*s.* 6*d.*

PHOTOGRAPHIC APPARATUS.

The Cameras No. 2689, 2691, 2695, are intended for taking views, landscapes, copying pictures, and other inanimate objects, the lens with which each is fitted being mounted so that a portion of the external rays is cut off by a stop placed in front of the lens. This corrects the aberration of the rays of light passing through those parts of the lens nearest the edge. This stop gives a degree of sharpness to the pictures which cannot be produced by the double combination of lenses, and hence its general adoption for taking inanimate objects. For portraits taken from life, however, where rapidity of action is a great desideratum, the single lens is nearly useless; as the amount of light admitted by the stop is so limited that a long time is required to take a portrait, and it is difficult to keep a sitter in the same position for the necessary period. Consequently, if a Camera for portraits is required, it is necessary to select it from Nos. 2690, 2692, or 2696, or if a Camera for both portraits and views is required, then the choice must be made from Nos. 2690, 2692, or 2696; but in the latter case, the double combination of lenses must be altered for views as follows:—The posterior cell, or that nearest the ground-glass plate of the Camera containing two lenses must be removed from the mounting, and the anterior cell must be unscrewed from the mounting, and have the lens taken out of its cell and reversed, so that its plane side shall be placed nearest the object that is to be copied. A tube containing a Diaphragm with three stops, No. 2706, must now be put over the mounting in the same position as that occupied by the brass cap of the double combination, and one of the stops must be brought into action. The use of the diaphragm is easily understood from inspection, but which of the three stops is best adapted for an object intended to be taken, is more difficult to determine. It may be given as a general rule that the smallest stop is to be used for pictures to be taken from objects in sunshine—the next during sunshine if the object is in the shade, and the largest when the light is limited.

When, for the above, or any other purpose, the lenses have been removed from their cells, it is essential that they be replaced in their original position, and that the sides be not reversed. As a guide, we may mention that, in the double combination of lenses, Nos. 2703, 2704, and 2705, the least convex side of the posterior lens (or that which passes into the Camera), the concave side of the second lens, and the plane side of the anterior lens, must be all turned towards the ground-glass plate of the Camera, as must also the convex side of the single achromatic lens, Nos. 2698, 2700, or 2702.

The Camera and Lenses of the Sets of Apparatus for Calotype Processes, Nos. 2683 and 2684, are also adapted for taking pictures on silver, but for that purpose the articles enumerated after the description of the Camera in the set No. 2686 would be required. The same remark applies to the Daguerreotype sets, Nos. 2686, 2687, and 2688, which can be used for the Calotype and Collodion Processes, when the articles enumerated after the Camera in the set No. 2683 are added.

SETS OF CALOTYPE APPARATUS.

2683. COMPLETE SET OF APPARATUS FOR THE CALOTYPE AND COLLODION PROCESSES, for taking pictures measuring 7 inches by 6 inches, including a Camera, No. 2691, with achromatic lens, 2¼ inches diameter mounted in brass with rack and pinion adjustment (No. 2700), focusing glass, and frame for the sensitive paper; shallow porcelain dish for preparing the sensitive paper, and fixing the picture; two camel's-hair brushes; one quire photographic paper; one quire blotting paper; pressure frame for producing positive pictures; oil lamp, with yellow glass shade; balance, with a set of weights, and two glass capsules to contain the substance to be weighed; glass measure, and the following chemicals in stoppered bottles: acetic acid, gallic acid, ammonia, iodide of potas-

SETS OF CALOTYPE APPARATUS (*continued*).

sium, nitrate of silver, hyposulphite of soda, and bottles for solutions; the whole packed in a coloured deal case, with lock, key, and handles, 6*l.* 16*s.* 6*d.*

The Camera of this Set is equally suitable for Processes with Paper, Glass, and Silver.

2684. A similar Set of Apparatus, but of larger size, including the Camera, No. 2695, adapted to produce pictures up to 10 inches by 8 inches, 10*l.* 10*s.*

2685. Complete Set of Calotype Apparatus for obtaining pictures on paper, 7 inches by 6 inches, including a Portable Folding Camera, *figs.* 2693 and 2693 *a*, mounted with achromatic lens, in massive brass front, with rack and pinion adjustment; focusing glass in frame, and frame for holding two pieces of sensitive paper; porcelain dish for preparing the paper and fixing the pictures; camel's-hair brushes; one quire photographic paper; one quire fine blotting paper; pressure frame for producing positive pictures; oil lamp, with yellow glass shade; balance, with set of weights, and two glass capsules for holding the substances to be weighed; glass measure, and a full supply of chemicals for the Calotype Process, including acetic acid, nitrate of silver, iodide of potassium, hyposulphite of soda, gallic acid, and ammonia, in strong glass bottles, with extra bottles for solutions. The whole packed in a neat coloured deal case, adapted for travelling, 7*l.* 10*s.*

The Portable Folding Camera is suitable for Landscapes only, because the focus cannot be conveniently adjusted for Portraits.

Sets of Calotype Apparatus of any other size made to order.

SETS OF DAGUERREOTYPE APPARATUS.

In the following sets, the silvered plates on which the pictures are obtained are not included in the price. The quantity of each size required must be ordered separately. *See No.* 2778, *page* 105.

2686. Complete Set of Daguerreotype Apparatus for pictures on plates up to 4¼ by 3¼ inches, with best sliding camera; double combination of achromatic lenses, mounted in brass, with rack and pinion adjustment, No. 2703; three dark frames; a focusing glass; iodine and bromine apparatus; two plate boxes; two plate holders; polishing buffs; mercury box with thermometer; washing tray; spirit lamp; pliers; fixing stand, and iodine, bromide of lime, hyposulphite of soda, chloride of gold, tripoli, charcoal, mercury and naphtha, in stoppered bottles. The whole packed in two boxes, with lock, key, and handles. 8*l.* 8*s.*

2687. The same apparatus for larger plates, up to 6⅝ inches by 4¾ inches, complete, in cases. 14*l.* 14*s.*

2688. The same apparatus for larger plates, up to 8½ inches by 6⅝ inches, complete, in cases, 26*l.*

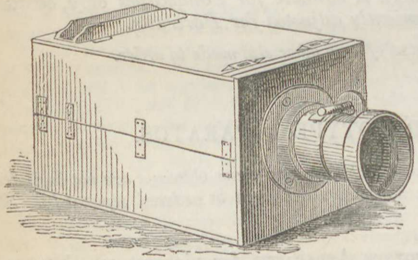
PHOTOGRAPHIC CAMERAS.

2689. PHOTOGRAPHIC CAMERAS, *fig.* 2686 *a*, so constructed as to be capable of being employed for the Daguerreotype, Calotype, and Collodion Processes. With sliding body to adapt it to lenses of different foci; focusing glass in frame; two frames for the prepared Calotype paper—and three frames for holding the glass plates, No. 2783, for use in the Collodion Process, and for the silvered plates, Nos. 2778, 2779 and 2780 in the Daguerreotype Process, fitted with achromatic lens, $1\frac{3}{4}$ in. diameter, mounted in brass, with rack and pinion adjustment, No. 2698, capable of producing pictures, 5 inches square, 2*l*. 17*s*. 6*d*.

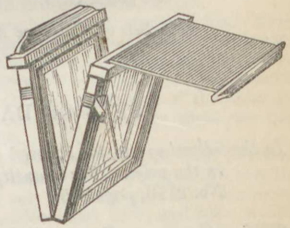
2690. The same Camera, with double combination of achromatic lenses, No. 2703, 3*l*. 12*s*. 6*d*.

2691. PHOTOGRAPHIC CAMERA, *fig.* 2686 *a*, so constructed as to be capable of being employed for the Daguerreotype, Calotype, and Collodion Processes, with sliding body to adapt it to lenses of different foci; focusing glass in frame; two frames for holding the prepared Calotype paper; three frames for containing the glass plates, Nos. 2783, and 2784 for use in the Collodion Process; and the plates, Nos. 2779, 2780 and 2781, in the Daguerreotype process; fitted with achromatic lens, $2\frac{1}{4}$ in. in diameter, mounted in brass with rack and pinion adjustment, No. 2699; capable of producing pictures 7 inches by 6 inches, 3*l*. 15*s*.

2692. The same Camera, with double combination of achromatic lenses, No. 2704, 5*l*. 7*s*. 6*d*.



2693.



2693 *a*.

2693. PORTABLE CALOTYPE CAMERA FOR TRAVELLERS, which packs up into a very small compass, *figs.* 2693 and 2693 *a*, consisting of a walnut-box, the sides of which are hinged to fold inwards; ground focusing glass, and an improved dark frame, capable of holding the sensitive paper for taking two pictures, fitted with an achromatic lens, $2\frac{1}{4}$ inches diameter, mounted in the best manner, with rack and pinion adjustment, No. 2699, capable of producing a picture 7 inches by 6 inches, 4*l*. 4*s*.

The Portable Folding Camera is suitable for Landscapes only.

2694. PHOTOGRAPHIC CAMERA, adapted for the Calotype Process, fitted with a meniscus lens $1\frac{3}{4}$ inch in diameter, mounted in brass, with sliding adjustment, ground focusing glass in frame, and frame for the prepared paper, capable of producing pictures, 5 inches square, 1*l*. 15*s*.

2695. Photographic Camera, *fig.* 2686 *a*, so constructed as to be employed for the Daguerreotype, Calotype, and Collodion Processes, with sliding body to adapt it to lenses of different foci ; focusing glass in frame, two frames for holding the prepared Calotype paper ; three frames for holding the glass plates, No. 2783, 2784 and 2785, for use in the Collodion Process, and the plates 2780, 2781 and 2782, in the Daguerreotype Process, fitted with achromatic lens, 2½ inches in diameter, mounted in brass with rack and pinion adjustment, No. 2702; capable of producing pictures 10 inches by 8 inches, 5*l.* 5*s.*

2696. The same Camera, with the double combination of achromatic lenses, No. 2705, 11*l.* 15*s.*

SINGLE ACHROMATIC LENSES.

These lenses are well adapted for the plate or paper process, where time is no object (as in taking views, inanimate objects, pictures, &c.), but for taking portraits, when a more rapid action is required, the double combination of Achromatic Lenses must be employed.

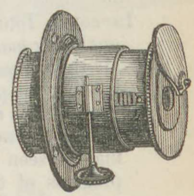
2697. Single Achromatic Lens, 1¾ inch in diameter, 7-inch focus. Price 9*s.*

2698. Ditto, mounted in brass, with rack and pinion adjustment. Price 1*l.* 5*s.*

2699. Single Achromatic Lens, 2¼ inches in diameter, 10-inch focus. Price 14*s.*

2700. Ditto, mounted in brass, with rack and pinion adjustment. Price 1*l.* 17*s.* 6*d.*

2701. Single Achromatic Lens, 2½ inches in diameter, 14-inch focus. Price 1*l.*



2698.

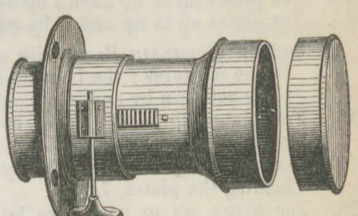
2702. Ditto, mounted in brass, with rack and pinion adjustment. Price 2*l.* 10*s.*

DOUBLE COMBINATION OF ACHROMATIC LENSES.

The Double Lenses are adapted for taking portraits, figures, groups, &c., as they admit a great quantity of light, and consequently produce a picture in less time than a single lens.

2703. A Double Combination of Achromatic Lenses, 1·7 inches in diameter, having a combined focus of about 4 inches, mounted in brass, with rack and pinion adjustment, producing a picture 4¼ inches by 3¼ inches. Price 2*l.*

2704. A Double Combination of Achromatic Lenses, 2·4 in. in diameter, having a combined focus of about 7 inches, mounted in brass, with rack and pinion adjustment, producing a picture 6⅜ inches by 4¾ inches. Price 3*l.* 10*s.*



2703.

2705. A Double Combination of Achromatic Lenses, 3·2 inches in diameter, having a combined focus of about 10 inches, mounted in brass, with rack and pinion adjustment, producing a picture 8½ inches by 6⅜ inches. Price 9*l.*

2706. A Diaphragm of stops fitted to either of the above sets of Lenses, 15*s.*

The use of this Diaphragm is given in the explanatory note at page 98.

The focus of the Combination is measured from the back lens to the ground-glass, the image being received from some distant object.

MISCELLANEOUS PHOTOGRAPHIC APPARATUS.

IMPROVED MERCURY BOX (*fig.* 2686 *d*), of walnut, with sliding legs, iron cistern, glass windows for inspecting the development of the picture, mounted with thermometer for ascertaining the temperature of the mercury, 3 sizes :—

2707. With three frames for plates up to $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, 18*s*.
2708. With three frames for plates, up to $6\frac{3}{8}$ inches by $4\frac{3}{4}$ inches, 1*l*. 4*s*.
2709. With three frames for plates, up to $8\frac{1}{2}$ inches by $6\frac{3}{8}$ inches, 1*l*. 12*s*. 6*d*.

2710. MERCURY BOTTLE, of box-wood, for holding the mercury necessary for use with the mercury box, 2*s*. each.

2711. DAGUERREOTYPE SPIRIT LAMP, with screw cap, japanned tin, for heating the mercury box, 2*s*.

2712. THERMOMETER for the mercury box, 5*s*.

IMPROVED IODINE AND BROMINE BOX, in pairs (*fig.* 2686 *c c*), of walnut, enclosing each a stout porcelain pan: each pan is furnished with an air-tight glass cover. On the upper edge of each box is a groove for holding the plate. On withdrawing the glass cover of the iodine pan, the plate is exposed to its action, and the colour produced is observed by holding a sheet of white paper in such a position that its reflection may be seen on the plate, which enables the operator to judge of the progress of the operation. When the plate has obtained the required colour, the glass cover is pushed in, so as to cover the iodine pan, and the cover over the bromine pan is withdrawn. The plate is now removed from the iodine box and placed over the bromine box, and the colour observed as before. When the plate has received the proper amount of bromine, which is perceptible by the colour, the cover of the bromine pan is pushed in, and the plate is again placed over the iodine pan for a few seconds, until the ultimate colour required is produced, and it is then ready for removal to the camera, 3 sizes :—

2713. For plates up to $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, 1*l*. 5*s*. per pair.
2714. For plates up to $6\frac{3}{8}$ inches by $4\frac{3}{4}$ inches, 1*l*. 16*s*. per pair.
2715. For plates up to $8\frac{1}{2}$ inches by $6\frac{3}{8}$ inches, 2*l*. 16*s*. per pair.

SQUARE PORCELAIN PANS, with air-tight glass cover, for either bromine or iodine mixtures; the body and glaze firm and compact, and not liable to be acted on by any photographic compound, 3 sizes :—

2716. For plates up to $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, with three plate-frames for holding the plates, 6*s*.
2717. For plates up to $6\frac{3}{8}$ inches by $4\frac{3}{4}$ inches, with three plate-frames for holding the plates, 7*s*. 6*d*.
2718. For plates up to $8\frac{1}{2}$ inches by $6\frac{3}{8}$ inches, with three plate-frames for holding the plates, 10*s*. 6*d*.

2719. GRADUATED GLASS PIPETTE, for dosing the bromine, 3*s*. 6*d*.

WALNUT BOXES, fitted with grooves for holding 12 plates, *fig.* 2686 *f*.

2720. For holding the No. 2778 plates, 2*s*. 6*d*. each.
2721. For holding the No. 2779 plates, 2*s*. 6*d*. each.
2722. For holding the No. 2780 plates, 3*s*. each.
2723. For holding the No. 2781 plates, 4*s*. each.
2724. For holding the No. 2782 plates, 5*s*. 6*d*. each.

2725. Apparatus for Resilvering Daguerreotype Plates by Electro-plating, consisting of a Smee's Battery, glass decomposition cell and connecting wire, with the requisite binding-screws :—for silvering plates of any size up to 4¼ inches by 3¼ inches. Price 12*s.* 6*d.*

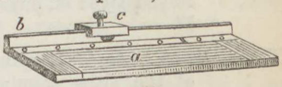
2726. Silver solution, for electro-plating Daguerreotype plates, per oz. 2*s.*

Two ounces of this solution, diluted with 18 *ounces of water, form a pint of solution of the proper strength for electro-plating.*

Full instructions for Electro-Plating, &c., will be found in Napier's Electro-Metallurgy, just published, forming Vol. XIV. of the new edition of the "Encyclopædia Metropolitana." Price 3*s.* 6*d.*

2727. Plate-holder, French pattern, for securing the plates firmly and conveniently (*fig.* 2686 *e e*), with clamp, for No. 2778 plates, 3*s.* 6*d.*

2728. Plate-holder, for No. 2779 plates, 3*s.* 6*d.*
2729. Plate-holder, for No. 2780 plates, 3*s.* 6*d.*
2730. Plate-holder, for No. 2781 plates, 5*s.*
2731. Plate-holder, for No. 2782 plates, 6*s.*



2732.

2732. Apparatus for bending the edges of Daguerreotype plates, so as to prevent the sharp edges cutting the buffers in buffing. Price 9*s.*

2733. Hand-buffs, covered with leather or velvet, small size (*fig.* 2686 *i*), per pair, in box, 9*s.*

2734. Hand-buffs, full size (*fig.* 2686 *i*), per pair, in box, 12*s.*

2735. Finely-carded Cotton-wool, freed from grease, &c., price 3*d.* per oz.

2736. Fixing Stand, with iron foot and levelling screws, for supporting the plates while fixing (*fig.* 2686 *g*), for plates up to 4¼ inches by 3¼ inches, 5*s.* 6*d.*

2737. Ditto for plates up to 8½ inches by 6⅝ inches, 6*s.*

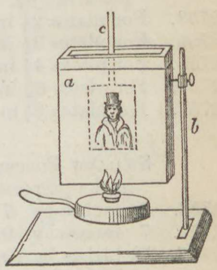
Apparatus for drying Daguerreotype Plates, consisting of a flat-shaped copper vessel, tinned inside; a holder for the plate, and a support (*fig.* 2738), 3 sizes :—

2738. For plates up to 4¼ inches by 3¼ inches, 7*s.*
2739. For plates up to 6⅝ inches by 4¾ inches, 9*s.*
2740. For plates up to 8½ inches by 6⅝ inches, 10*s.* 6*d.*

2741. Glass Funnel, for filtering the fixing solution, 2 inches in diameter, 4*d.*

2742. Circular Filters to suit the funnel, cut ready for use. The packet of 100, 7*d.*

2743. Steel Pliers for holding the plates whilst drying off, 2*s.*



2738.

Parallel Mirror, mounted in brass, for attaching to the front of the lenses, when portraits, views, &c., are required to be taken in direct instead of reversed positions by the Daguerreotype process, 2 sizes :—

2744. Mirror, 2¼ inches by 3 inches, mounted in brass, 2*l.*
2745. Mirror, 4 inches by 3 inches, mounted in brass, 3*l.*

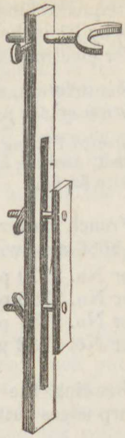
PHOTOGRAPHIC APPARATUS (*continued*).

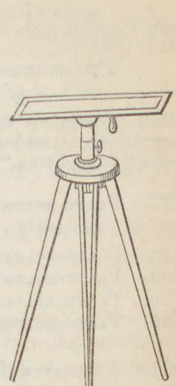
2746. Stand for supporting the Camera in taking portraits and views, &c., for the Photographic Cameras (Nos. 2693 and 2689, *fig.* 2746), 16*s.*

2747. Ditto for the Camera (No. 2691), 1*l.*

2748. Stand for supporting the Camera of the travelling Photographist; it folds up into a small compass, is very firm in use, and can be employed on uneven ground, 1*l.*

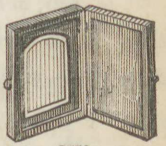
2749. HEAD REST, for keeping the head of the sitter steady whilst a portrait is being taken. The rest is intended to be fixed to the back of a chair (*fig.* 2749), 7*s.* 6*d.*


2749.


2746.

MOROCCO LEATHER CASE, lined with silk velvet, fitted with oval or square gilt matt, glass, and cover (*fig.* 2750).

2750. For plates, $2\frac{7}{8}$ inches by $2\frac{1}{8}$ inches, 15*s.* per dozen.
2751. For plates, $3\frac{1}{4}$ inches by $2\frac{3}{4}$ inches, 1*l.* 4*s.* per dozen.
2752. For plates, $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, 1*l.* 10*s.* per dozen.


2750.

PASSE-PARTOUT, or cardboard frames and glasses, elegantly ornamented, for holding Daguerreotype pictures (*fig.* 2753).

2753. For plates $2\frac{1}{8}$ inches by $2\frac{7}{8}$ inches, 7*s.* per dozen.
2754. For plates $3\frac{1}{4}$ inches by $2\frac{3}{4}$ inches, 8*s.* 6*d.* per dozen.
2755. For plates $4\frac{1}{4}$ inches by $3\frac{1}{4}$ inches, 9*s.* per dozen.
2756. For plates $6\frac{3}{8}$ inches by $4\frac{3}{4}$ inches, 1*s.* 6*d.* each.
2757. For plates $8\frac{1}{2}$ inches by $6\frac{3}{8}$ inches, 2*s.* 6*d.* each.


2753.

SHALLOW PORCELAIN DISHES, with flat bottom, for containing the solutions in the preparation of paper for the Calotype Process, &c. (*fig.* 2686 *h.*)

2758. 5 inches by 7 inches, 1*s.* 6*d.*
2759. 7 inches by 9 inches, 2*s.*
2760. $7\frac{1}{2}$ inches by 10 inches, 2*s.* 6*d.*
2761. 11 inches by 14 inches, 4*s.* 6*d.*

CAMEL'S-HAIR PENCILS for photographic purposes :—

2762. $1\frac{1}{2}$ inches wide, 1*s.* 6*d.* each.
2763. 2 inches wide, 2*s.* 6*d.* each.

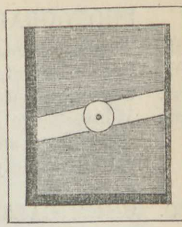
2764. GRADUATED GLASS MEASURE for measuring drachms, in making the Gallo-nitrate of Silver, 1*s.* 6*d.*

PRESSURE FRAMES, for producing Positive Pictures, copying Botanical Specimens, Flowers, &c. (*fig.* 2765).

2765. For pictures 6 inches by 5 inches, 7*s.* 6*d.*
2766. For pictures 8½ inches by 6½ inches, 9*s.*
2767. For pictures 12 inches by 10 inches, 12*s.*

PRESSURE FRAME, so constructed that the development of the picture may be ascertained without shifting the paper.

2768. For pictures 8½ inches by 6½ inches, 12*s.*
2769. For pictures 12 inches by 10 inches, 16*s.*



2765.

2770. PRESSURE FRAME, IMPROVED, for copying Negative Collodion Pictures on glass, and adapted also for producing Positives of the Calotype process; size for glass plates up to 6⅜ inches by 4¾ inches, 8*s.*

2771. Ditto for plates up to the full size, 12*s.*

2772. STEAM APPARATUS FOR DEVELOPING THE PHOTOGRAPHIC PICTURE by a jet of steam, 6*s.*

The employment of this apparatus prevents the browning of the picture which sometimes takes place when a dry heat is employed.

2773. OIL LAMP, with yellow glass shade, for viewing the development of the Daguerreotype Picture, preparing paper for the Calotype, &c., 3*s.* 6*d.*

2774. BALANCE, and set of weights, with brass pans, in oak box, 3*s.*

2775. BALANCE, and set of weights, with steel beam of superior make, and glass pans, in mahogany box, 10*s.* 6*d.*

2776. DISTILLING APPARATUS for preparing pure water; a tin-plate still of one gallon capacity, with a worm-tub, complete, 16*s.*

2777. Stoneware Water Bottle, with stopcock, 1-gallon size, for holding distilled water, 4*s.*

SILVER PLATES FOR DAGUERREOTYPES, of a superior manufacture :—

2778. Size, 2⅛ inches by 2⅞ inches, 6*s.* 6*d.* per dozen.
2779. Size, 2¾ inches by 3¼ inches, 10*s.* per dozen.
2780. Size, 3¼ inches by 4¼ inches, 14*s.* per dozen.
2781. Size, 4¾ inches by 6⅝ inches, 1*l.* 10*s.* per dozen.
2782. Size, 6⅝ inches by 8½ inches, 2*l.* 12*s.* 6*d.* per dozen.

[*For Boxes to hold the Plates, see Nos.* 2720-2724.]

Daguerreotype plates sometimes contain so thin a layer of silver, that even with the greatest care the copper will show itself after the plate has been used to obtain two or three pictures. The plates above enumerated are of a superior description, containing one-thirtieth of silver.

GLASS PLATES for the COLLODION PROCESS. Best plate-glass, free from scratches, &c., with ground and polished edges :—

2783. 4¼ inches by 3¼ inches, 4*s.* per dozen.
2784. 6⅜ inches by 4¾ inches, 6*s.* 6*d.* per dozen.
2785. 8½ inches by 6⅝ inches, 14*s.* per dozen.

PHOTOGRAPHIC PAPERS:—

2786. Turner's Photographic Paper, for Negative Pictures, 3*s.* per quire.
2787. Canson's Photographic Paper, for Negative Pictures, 3*s.* per quire.
2788. Canson's Photographic Paper, for Positive Pictures, 4*s.* per quire.
2789. White Wove Filtering Paper, prepared with the greatest care, perfectly free from smalt, chlorine, lime, iron, and other common impurities, filters rapidly, and is highly absorbent, 1*s.* 3*d.* per quire.

2790. CHEMICALS FOR DAGUERREOTYPE, CALOTYPE, &c., perfectly pure, at the following prices :—

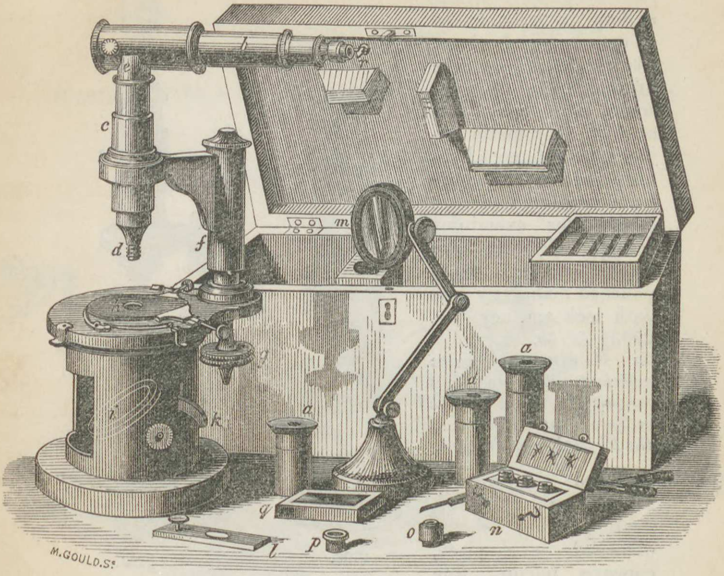
Acid, Acetic, crystallisable, sp. gr. 1·07, 8*d.* per oz.
,, Gallic, 3*s.* 6*d.* per oz.
,, Pyro-Gallic, 1*l.* 8*s.* per oz., 1*s.* per bottle.
,, Nitric, 1*s.* 6*d.* per lb., 2*d.* per oz.
,, Succinic, 4*s.* per oz.
,, Sulphuric, 1*s.* 6*d.* per lb., 2*d.* per oz.
Ammonia, pure, 2*d.* per oz.
,, Iodide of, 4*s.* 6*d.* per oz.
,, Acetate, 4*d.* per oz.
Bromide of Lime, 2*s.* per bottle.
Bromine, 3*s.* 6*d.* per oz.
,, Chloride, 3*s.* per oz.
,, Water, 4*d.* per oz.
Charcoal, fine, prepared for buffing, 1*s.* per bottle.
Collodion, 1*s.* per oz.
Collodio-Iodide of Silver, 2 ozs. in bottle, 2*s.* 6*d.*
Copper, Sulphate, cryst., 2*d.* per oz.
Gold, Chloride, cryst., 3*s.* per 15 grains in bottle.
,, Salt of—(Sel d'Or), 5*s.* per 15 grains in bottle.
Iodine, re-sublimed, 2*s.* per oz.
,, Tincture, 1*s.* per oz.
Iodine, Bromide, 3*s.* per oz.
,, Chloride, 3*s.* 6*d.* per oz.
Iron, Protosulphate, pure crystallised, 2*d.* per oz.
,, Ammonia-Citrate, 1*s.* per oz.
Mercury (*variable*), 5s per lb., 4*d.* per oz.
Naphtha for burning in the lamp, 1*s.* 6*d.* per pint.
Oil of Lavender, 1*s.* 6*d.* per oz.
Potassium, Bromide, 4*s.* per oz.
,, Cyanide, 6*d.* per oz.
,, Iodide (*variable*), 1*s.* 6*d.* per oz.
,, Ferrocyanide, 3*d.* per oz.
,, Fluoride, 2*s.* per oz.
Rotten-Stone, finely prepared, 6*d.* per oz.
Rouge, finely prepared, 1*s.* per oz.
Silver Solution, for Etectro-plating the worn-out Daguerreotype Plates, 2*s.* per oz.
Silver, in sheet or wire, pure, 9*s.* per oz.
,, Nitrate, in crystals, 5*s.* per oz.
,, Oxide, 9*s.* per oz.
Soda, Hyposulphite, 3*s.* per lb., 3*d.* per oz.
Syrup of Iodide of Iron, 4*s.* per lb., 4*d.* per oz.
Tripoli, finely prepared, 6*d.* per oz.

*** *The prices in the above List are subject to continual variation, but at all times the lowest prices will be charged.*

Recently Published, in crown octavo, price 5s. bound,

PHOTOGRAPHY: a Treatise on the PRODUCTION OF PICTURES FROM NATURE, by the DAGUERREOTYPE, CALOTYPE, the COLLODION, and other PHOTOGRAPHIC PROCESSES. By ROBERT HUNT, Professor of Mechanical Science in the Museum of Practical Geology. Illustrated by fifty-one Engravings.

MICROSCOPES.



ACHROMATIC MICROSCOPE, No. 2791.

The Microscopes described in the following list, are principally of French Forms. We have described in the Scientific Circular (No. 4, p. 57), a variety of English Patterns of Microscopes, Simple, Compound, and Achromatic. In the same number, at page 63, we have given a Catalogue of Microscopic Objects.

2791. Compound Achromatic Microscope, with body so constructed that it can be used either vertically or horizontally; sliding coarse adjustment, tangent screw fine adjustment, two eye-pieces, three sets of achromatic object glasses, achromatic condenser, three movable diaphragms, condenser mounted on foot, concave and plain mirror, fine screw movable stage, micrometer eye-piece, stage micrometer, forceps, needle, knife; camera lucida, by which a drawing of any object under examination can easily be made; the whole enclosed in a polished mahogany cabinet with lock and key (*fig.* 2791), 16*l.* 16*s.*

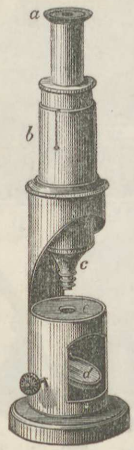
2792. Compound Achromatic Microscope with tripod foot, and jointed pillar, so that the body can be inclined at any angle, concave and plane mirror, revolving diaphragm to stage, two eye-pieces, two sets of Achromatic object glasses, two simple lenses, condenser fitted to stage, for the examination of opaque objects, forceps, needles, and knife for dissections, stage forceps and animalculæ box; the whole enclosed in a polished mahogany cabinet with lock and key, 8*l.* 8*s.*

The lenses of this Microscope are adapted for the investigation of the changes of structure by disease, and are equally applicable to the researches of the physiologist, the botanist, or the amateur. The highest combination of lenses shows the marking on the scales of the Podura Plumbea.

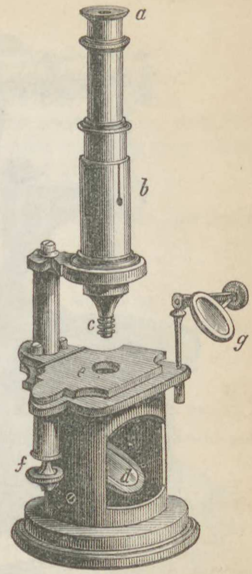
2793. Compound Achromatic Microscope with vertical sliding body, mounted on massive circular base, two eye-pieces, concave mirror, fine tangent screw adjustment, two sets of Achromatic object glasses, forceps, live-box, needles and knife for dissection, and condenser for examining opaque objects; the whole enclosed in a polished mahogany case with lock and key (*fig.* 2793), 5*l.* 5*s.*

This Microscope possesses sufficient defining and magnifying power for the ordinary investigations of the Physician or Student.

2794. Compound Achromatic Microscope, with vertical sliding body, detached eye-piece, concave mirror, fine tangent screw adjustment, set of Achromatic object glasses, forceps, needles and knife for dissection, in a polished mahogany box with lock and key (*fig.* 2793), 3*l.* 10*s.*



2796.



2793.

2795. Compound Achromatic Microscope (*fig.* 2793), (without condenser or stage adjustment) with vertical sliding body, concave mirror, Achromatic object glass, forceps, live-box, needles and knife for dissection, the whole enclosed in a polished mahogany box, 2*l.* 12*s.* 6*d.*

2796. Compound Microscope (*fig.* 2796), with vertical sliding body, circular stage, concave mirror, three magnifiers, forceps and two prepared microscopic objects, the whole enclosed in a polished mahogany case, 15*s.*

2797. Compound Microscope (*fig.* 2796), with vertical sliding body—circular stage, concave mirror—magnifier—forceps and a prepared microscopic object, the whole enclosed in a polished mahogany case, 10*s.* 6*d.*

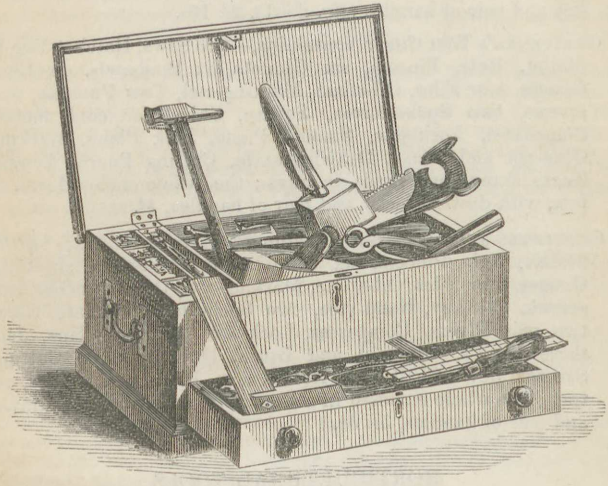
*** *The directions given in Griffin's Scientific Circular, No.* 4 *(price* 2*d. post free), for using the Compound and Simple Microscopes, (Nos.* 2330 *to* 2340*), apply also to the above forms of Microscope.*

Preparing for Publication,

A TREATISE on the USE of the MICROSCOPE, illustrated by numerous Engravings. To form a volume of the "Encyclopædia Metropolitana."

GENTLEMEN'S TOOL CHESTS.

HORTICULTURAL AND EMIGRANTS' TOOL CHESTS.



GENTLEMAN'S TOOL CHEST, No. 2801.

The tools contained in the following chests are all of the best Sheffield quality, Nos. 2798 to 2804 contain tools with polished handles, and the boxes are of polished oak. No. 2805 has a strong deal box, and the tools have rough handles, but are of the best material.

2798. Gentlemen's Tool Chest, containing the following articles—Hand-saw, Hammer, Mallett, Pincers, Brad-awl, Gimlet, Chisel, Gouge, Turnscrew, Tacks, Brads and Screws ; the whole in a strong oak box, 12*s.* 6*d.*

2799. Gentlemen's Tool Chest, containing,—Hand-saw, Hammer, Mallet, Rule, Pincers, two Gimlets, two Brad-awls, Chisel, Gouge, File, Marking-awl, Punch, Turnscrew, Square, Compasses, Tacks, Brads and Screws; the whole enclosed in a strong oak box, with lock, key and handle, 1*l.*

2800. Gentlemen's Tool Chest, containing, Hand-saw, Hatchet, Hammer, Mallet, Rule, Pincers, three Gimlets, three Brad-awls, two Chisels, one Gouge, three Files, Oil-stone, Marking-awl, Punch, Turnscrew, Spoke-shave, Square, Cold Chisel, Plyers, Compasses, Tacks, Brads and Screws in tray; the whole enclosed in a strong oak box with lock, key and pair of handles, 35*s.*

GENTLEMEN'S TOOL CHESTS—*continued.*

2801. GENTLEMEN'S TOOL CHEST, containing,—Hand-saw, Hatchet, Hammer, Mallet, Rule, Pincers, four Gimlets, four Brad-awls, four Chisels, two Gouges, three Files, Oil-stone, Marking-awl, Punch, two Turnscrews, Spokeshave, Square, Claw-wrench, Plyers, Compasses, Lock-saw, Plane, Marking-gauge, Glue-pot and Brush, Tacks, Brads and Screws in tray; the whole enclosed in a strong oak box, with drawer, lock, key and pair of handles (*fig.* 2801), 2*l.* 10*s.*

2802. GENTLEMEN'S TOOL CHEST, containing,—two Saws, Hatchet, two Hammers, Mallet, Rule, Pincers, six Gimlets, six Brad-awls, six Chisels, four Gouges, four Files, Oil-stone, Marking-awl, Two Punches, three Turnscrews, two Spokeshaves, Square, Chisel for cold metal, Plyers, Compasses, Lock-saw, Smooth Plane, Jack Plane, Marking Gauge, Glue-pot and Brush, Drawing-knife, Cutting Punch, Scraper, Bevil, Tacks, Screws and Brads, in trays; the whole enclosed in a strong oak box, with drawer, locks, and pair of handles, 4*l.*

2803. GENTLEMEN'S TOOL CHEST, containing,—three Saws, Axe, two Hammers, Mallet, Rule, Pincers, six Gimlets, six Brad-awls, six Chisels, four Gouges, four Files, Oil-stone, Marking-awl, three Punches, three Turnscrews, Bed-key, Hand-vice, two Spokeshaves, Square, Claw-wrench, two pair Plyers, Compasses, Lock-saw, Smooth Plane, Jack Plane, three Gauges, Glue-pot and Brush, Drawing-knife, Cutting Punch, Scraper, Bevil, Chalk Line Reel, Tacks, Brads and Screws, in divided tray; the whole enclosed in a strong oak box, with two drawers, locks, and pair of handles, 5*l.* 5*s.*

HORTICULTURAL TOOLS.

2804. HORTICULTURAL TOOL CHEST, containing,—Garden Hoe, Dutch Hoe, Triangular Hoe, Spud, Weeding-hook, Garden Rake, Garden Shears, Improved Slide Pruning Shears, Sliding Pruning Scissors, Flower Gatherer, Vine Scissors, Pruning Saw, Garden Trowel, Garden Hammer, Garden Reel, Pruning Knife with Stag handle, Budding Knife with ivory handle; all the tools requiring it are made to screw into a socket attached to a hard wood handle; the whole enclosed in a strong oak box, with lock, key and handles, 3*l.* 10*s.*

EMIGRANT'S TOOL CHEST.

2805. EMIGRANT'S TOOL CHEST, containing,—Canadian Adze, Carpenter's Adze, Pickaxe, Carpenter's Hand-saw, Carpenter's Tenon-saw, Carpenter's Compass-saw, Jack Plane, Smooth Plane, one pair Grooving Plane, Rabbet Plane, five firmer Chisels, three Gouges, three Mortise Chisels, three Socket Chisels, plated Square, Improved Auger Pad, three Augers, Spokeshave, two Turnscrews, Marking Gauge, Brass slide Mortise Gauge, best Brace with eighteen assorted Bits, Bench and Roofing Hammer, three Files, six Gimlets, six Brad-awls, Carpenter's Mallet, Boxed Whetstone, Marking-awl, Brad Punch, Compasses, Carpenter's Pincers, Glue-pot and Brush, Plyers, and Chalk Line Reel; the whole enclosed in a strong deal box, 30 inches long, 16 inches wide, 17 inches deep, fitted with drawers and partitions, lock, key and pair of handles, 8*l.* 8*s.*

MINERALOGY AND GEOLOGY.

In addition to the CABINETS of ROCKS, MINERALS, and FOSSILS, described in former parts of the Scientific Circular (see pages, 9, 11, 14, 70, 71, 72), we beg to announce that we have now on sale the following important Collections :—

2806. The HEIDELBERG SUBSCRIPTION COLLECTION of ROCKS and FOSSILS, prepared under the superintendence of Professors LEONHARD and BRONN. Seven Hundred Specimens.

The size of these specimens is 9 square inches, each specimen is accompanied by a printed descriptive ticket in English, French, and German, and there is a printed Catalogue of the whole.

Great labour and expense have been incurred to ensure for this Geological Collection the character of unusual completeness and usefulness. It contains not only a collection of well-characterised specimens of all the Rocks and Fossils of most frequent occurrence, but also specimens of great rareness and excellence, including complete suites from the Paris Basin, the Vienna Basin, the Tyrol, from Sicily, North America, Brazil, &c. The names of the specimens being given on the authority of those eminent Geologists, Professors Leonhard and Bronn, may be implicitly relied on, which gives a high scientific character to this Collection.

Messrs. John J. Griffin & Co. having been appointed by the Heidelberg Mineral Institution to be their Sole Agents in England, are enabled to offer this Magnificent Geological Collection of Seven Hundred Specimens for the low price of 20 guineas, delivered in London free of expense.

MINERALS.—Several fine Collections of 200, 300, 400, and 500 Specimens, prepared by the Heidelberg Mineral Institution, for sale at moderate prices.

ELEMENTARY COLLECTIONS IN CABINETS.

The following collections are recommended to those who are commencing the study of Mineralogy and Geology. They are all contained in *handsome polished Mahogany Cabinets*, opening with doors, and containing mahogany drawers. Every specimen is placed in a separate pasteboard tray, covered with enamelled green paper.

Size of Specimens about three square inches.

2807. Cabinet of 100 simple Minerals, 2*l.* 12*s.* 6*d.*
2808. Cabinet of 100 Rocks and Fossils, 2*l.* 12*s.* 6*d.*
2809. Cabinet of 150 simple Minerals, 4*l.* 4*s.*
2810. Cabinet of 150 Rocks and Fossils, 4*l.* 4*s.*
2811. Cabinet of 200 Minerals, Rocks, and Fossils, 5*l.* 5*s.*

2812. ELEMENTS of MINERALOGY and GEOLOGY. By PROFESSOR SCHOEDLER. Edited by H. Medlock, F.C.S., Senior Assistant in the Royal College of Chemistry, London. Illustrated by 128 woodcuts, 2*s.* 6*d.* cloth.

2813. *The same work, interleaved with ruled paper, for writing Notes, or Catalogue of Specimens, bound in cloth, 5s.*

MEDICAL CHEMISTRY.

2814. CABINET OF APPARATUS AND MATERIALS FOR THE ANALYSIS OF URINARY DEPOSITS, according to Dr. GOLDING BIRD.

See his work entitled "Urinary Deposits, their Diagnosis, Pathology, and Therapeutical Indications. By Golding Bird, A.M., M.D., F.R.S., F.L.S., &c. Third Edition, 8vo. London, 1851."

In a polished mahogany divided Cabinet, with lock and key, 2*l.* 12*s.* 6*d.*

ECONOMY IN SUGAR-MAKING.

2815. Just published, in crown octavo, illustrated by 20 Woodcuts, price 3*s.* cloth, or free by post to any of the British West Indian Colonies, 3*s.* 6*d.*

DIRECTIONS FOR TESTING CANE-JUICE, so as to determine the exact quantity of QUICKLIME required to temper a given quantity of Cane-Juice, with Practical Instructions for Conducting the Process of CLARIFICATION. By JOHN SHIER, Esq., LL.D., Agricultural Chemist to the Colony of British Guiana.

The OFFICIAL REPORT on the CLARIFICATION OF CANE-JUICE, addressed by Dr. SHIER to the GOVERNOR of British Guiana, has been published in Demerara, but not hitherto in this country. It is now reprinted, to accompany a collection of CHEMICAL APPARATUS, which has been prepared on a plan arranged by Dr. SHIER, for the use of PLANTERS who may be inclined to adopt his improved process of CLARIFICATION.

In order to render the operation of TESTING as intelligible as possible to those not well acquainted with Chemical Experiments, Dr. SHIER drew up, during his recent visit to England, the PRACTICAL DIRECTIONS FOR TESTING CANE-JUICE, which form the Second Part of this Work; and, at his desire, there has been added, an illustrated description of the Apparatus and Materials that are required to carry his method of TESTING into operation.

The *actual beneficial results of the process* are stated in the following summary, contained in the OFFICIAL REPORT, presented (18th May, 1850,) by Dr. SHIER to his Excellency, GOVERNOR BARKLY:—

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