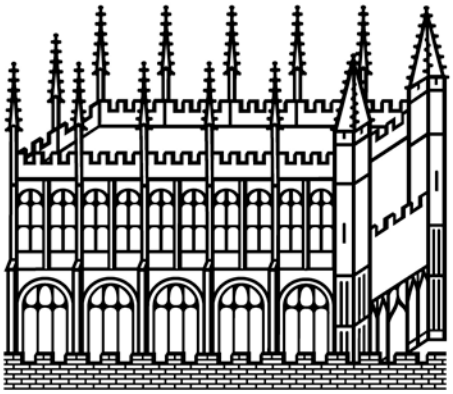


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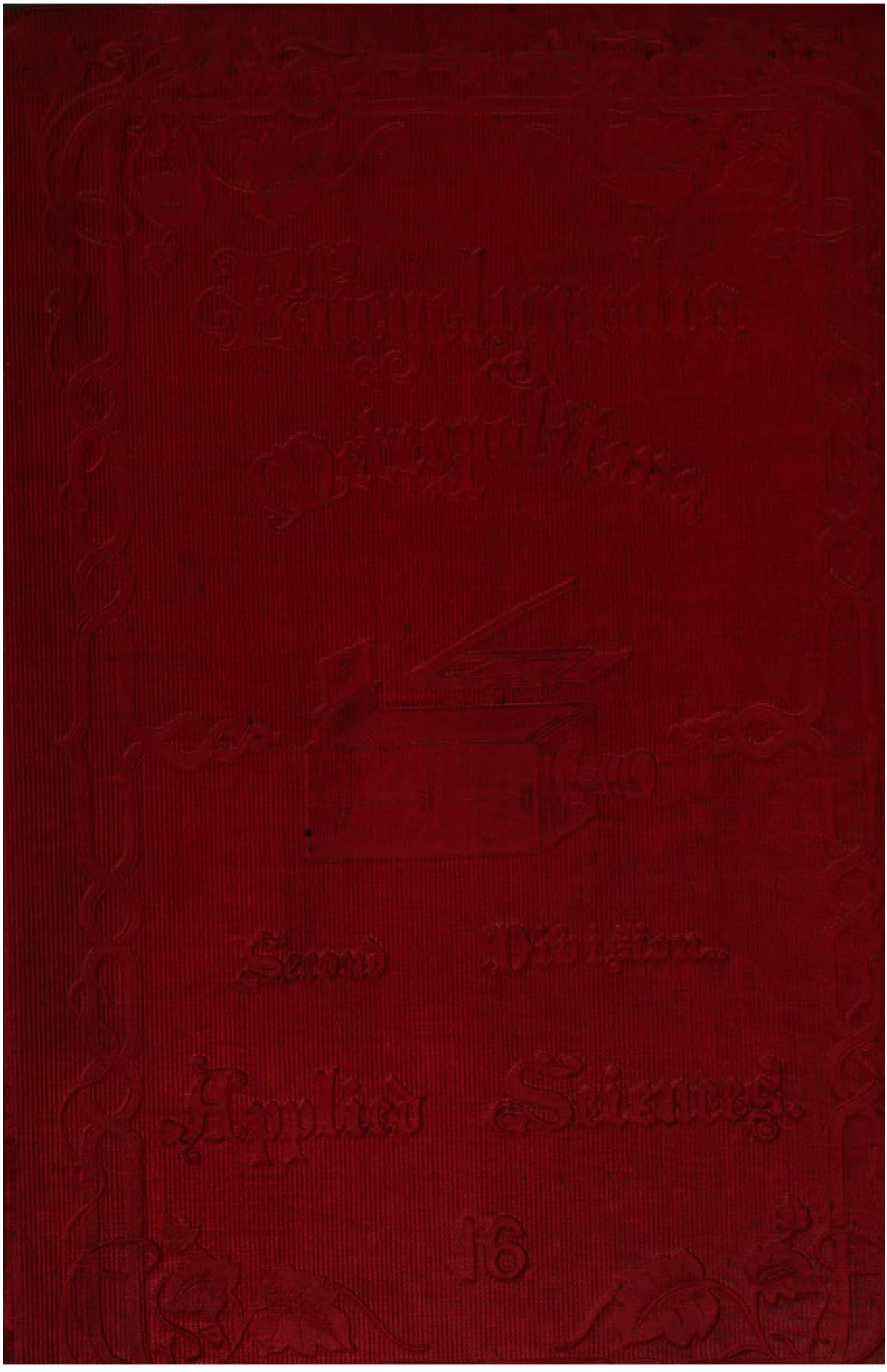
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ROBERT HUNT.

London, July 1851.

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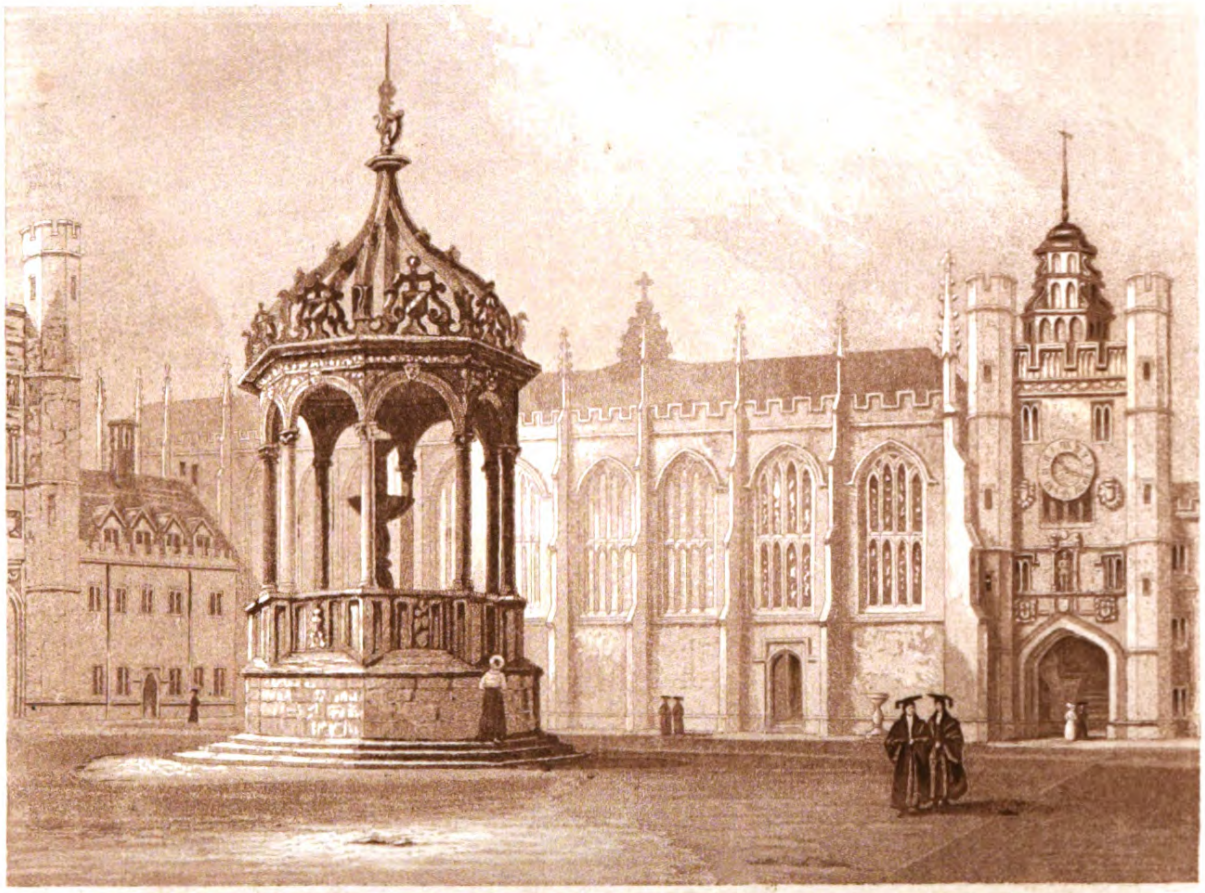
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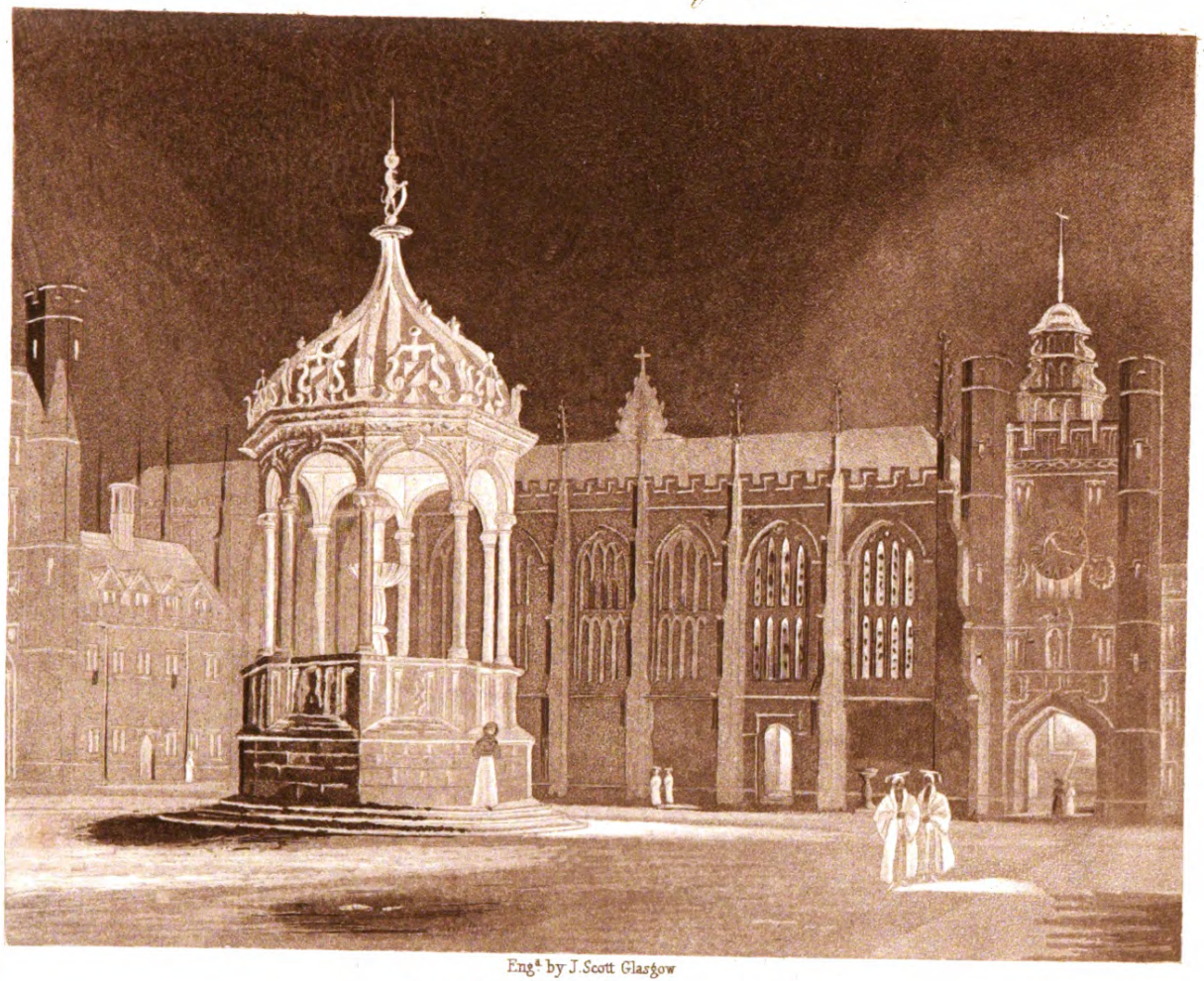
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A Positive Photograph.



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PHOTOGRAPHY.

CHAPTER I.

EARLY HISTORY OF PHOTOGRAPHY.

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 of 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—an element unknown to them—which they called horn silver—as, by fusion, the white powder they obtained by precipitation was converted into a horn-like substance. 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.

The illustrious Scheele, in his admirable *Traité de l'Air et du Feu*, gave us the first philosophical examination of this peculiar change in the salts of silver, and showed the dissimilar powers of the different rays of light in effecting this change. 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.

The revival of gold and silver from their oxides, by the action of the sun's light, also occupied the attention of Count Rumford, who communicated two papers on this subject to the Royal Society. 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 Moyno 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. The earliest recorded attempts at fixing images 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 eminent philosophers 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. From this period no attempt was made to overcome the difficulties which stopped the progress of Davy, until 1814, when M. Niepce, of Chalons, on the Soane, appears to have first directed his attention to the production of pictures by light.

It does not seem his early attempts were very successful ones; 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 designs on metal, 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 the state of advanced etchings; but this was accomplished by a process similar to that pursued in common etchings, to be hereafter explained. Glass, copper plated with silver, and well planished

[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.

tin plate, were the substances on which M. Niepce spread his sensitive preparations. Paper impregnated with the chloride or the nitrate of silver was the material first selected by M. Daguerre. Heliography does not appear at any time to have produced very delicate effects. The want of sensibility in the preparation,—the resin of some essential oils, particularly the oil of Lavender, or asphaltum dissolved in spirit,—rendered it necessary that the prepared plate should be exposed to luminous influence from seven to twelve hours. During so protracted an interval, the shadows passed from the left to the right of objects, and consequently all the fine effects arising from the contrasts of light and shade are destroyed. The first attempts of Daguerre appear to have been little more successful than those of Wedgwood.

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.

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 philosopher 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 copies of objects by means of the solar microscope.

From this period the progress of photography has been rapid. Sir John Herschel has devised many extremely ingenious and useful methods for preparing and fixing the drawings; and the curious scientific results which he has obtained, whilst studying the peculiar functions of the different rays of light, and of the various photographic materials which he has employed, are of the highest importance. It were useless to enumerate all who have by their experiments produced practical improvements in the art; particularly as these will be noticed under the different sections to which their discoveries properly belong. The processes on paper, as well as those on metallic plates, have been improved, until it appears that the highest degree of sensibility has been produced of which any chemical compounds are susceptible. We have only now to study the means by which facilities may be given to the mechanical arrangements, and the best optical conditions obtained, to render the photographic art at once as perfect as its results are beautiful.

CHAPTER II.

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.

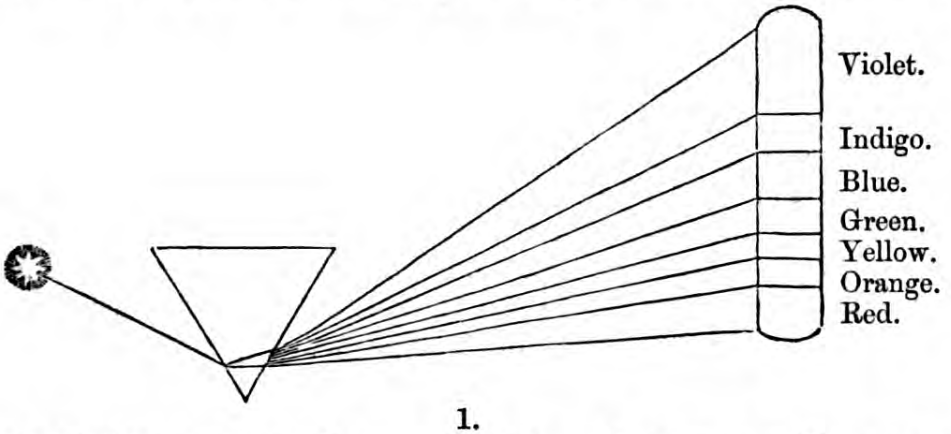
Reasons still mere important than these may be assigned. Notwithstanding the statements which have been too often repeated, to the effect that the practice of photography is exceedingly easy, that the manipulatory details of preparation present no difficulties, and that little more is necessary than 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 delicate processes of the Daguerreotype when he has mastered the rudimentary details of the more simple forms of *actino-chemistry*.

Previously, however, to explaining the practice of photography, 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 shewn 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, presenting the various colours of



1.

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.

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, shewn 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 shewn to be but combinations of the three primaries.

This 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.

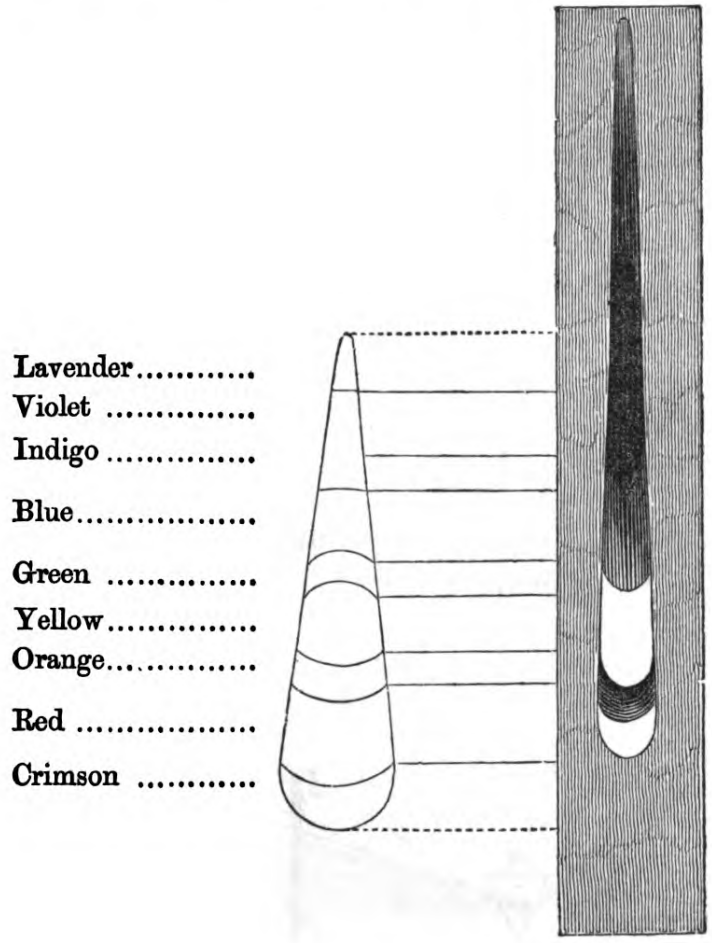
Sir William Herschel, and Sir Henry Englefield, determined the heating powers of these rays to be very varied. A thermometer was placed in each, and the following results obtained:—

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 shewn 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 shewn 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 are as varied as their heating powers.

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. 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

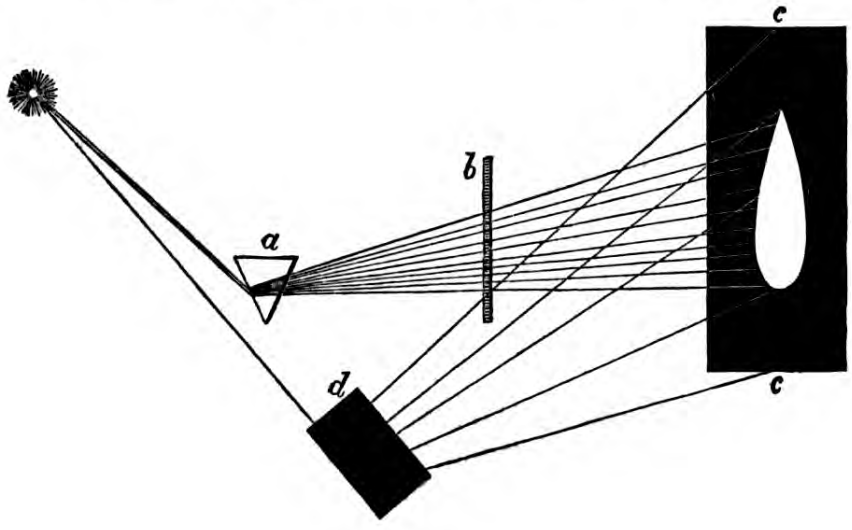


2.

(Fig. 2) will serve to assist the reader in comprehending the phenomena. The chemical radiations have a higher refrangibility than the 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.

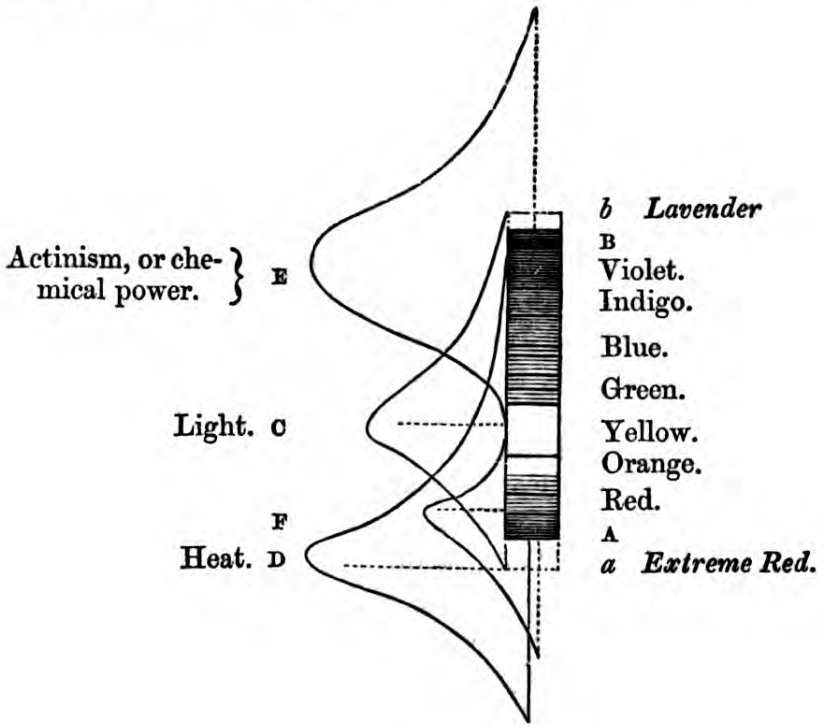
Whenever we throw a prismatic spectrum upon any photographic surface, it is always accompanied by a sufficient quantity of diffused light to produce some chemical change, which shews itself in darkening, over the parts beyond the coloured image. However, there are two points where this change does not 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 first 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 pale yellow glass, 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 chromatic



3.

bands. Notwithstanding the amount of light impinging along this line, no change whatever takes place upon it. Preserving the prism *a*, 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. 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 involving preconceived ideas.



4.

Photography is clearly 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 shall have by and by to consider,—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 (4) shews 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 belong to modern discovery. 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 shewn 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.

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.

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 III.

SELECTION OF PAPER FOR PHOTOGRAPHIC PURPOSES.

It is natural to suppose, that a process, which involves the most delicate chemical changes, requires that more than ordinary care should be taken in selecting 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 plates. Paper is, however, so convenient and so economical, that it is of the first importance to overcome the few 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 the same sheet, arising from trifling inequalities in its texture. 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 each sheet 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 such inequalities are detected. By day it is more difficult to do this than at night, owing to the interference of the reflected 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 ca-

mera, 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. No really sensitive paper can be prepared when this sulphate 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 generally 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 manufactures 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; at present they are not disposed to do this, and our only remedy is a very careful selection. All who desire to make any progress in photography must take the necessary precautions, or be content to meet with repeated failures.

It has been noticed by Sir John Herschel, that "when thin post paper, merely washed with nitrate of silver, without any previous or subsequent application, is exposed to clear sunshine, partly covered by and strongly pressed into contact with glass, and partly projecting beyond it, so as to be freely exposed to air, the darkening produced in a given time is very unequal in the two portions. That protected by the glass, contrary to what might have been expected, is very much more affected than the part exposed; more, indeed, in some instances than in others.

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 endeavour 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, partly under glass, and expose them to the same solar influences.

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 the 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.

CHAPTER IV.

ON THE GENERAL MODES OF MANIPULATION ADOPTED IN THE PREPARATION OF SENSITIVE PAPERS AND THE MORDANT BASES.

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 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 (the common tinned ones will answer, but, if the expense is not a consideration, those made of silver wire will do better), and a glass rod or two.

The materials necessary to produce all the varieties of sensitive paper which will be brought under consideration in this section are—

1. Nitrate of Silver. The crystallized salt should, if possible, always be procured. The fused nitrate, which is sold in cylindrical sticks, is more liable to contamination, and the paper in which each stick of two drachms is wrapped being weighed with the silver, renders it less economical. 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.
2. Muriate of Soda (Common Salt).
3. ——— of Baryta.
4. ——— of Strontia.
5. ——— of Ammonia.
6. ——— of Peroxide of Iron.
7. ——— of Lime.

These salts have very remarkable colorific properties.

8. Chlorate of Potash.
9. Chloride of Soda (Labarraque's disinfecting Soda Liquid).
10. Hydrochloric Acid (Spirits of Salts).

11. Solution of Chlorine in water.
12. Phosphate of Soda.
13. Hydrochloric Ether.
14. Tartrate of Potash and Soda (Rochelle Salts).
15. Iodide of Potassium (Hydriodate of Potash).
16. Bromide of Potassium (Hydrobromate of Potash).
17. Diacetate of Lead (Sugar of Lead).
18. Spirits of Wine.
19. Nitric Ether.
20. Distilled Water, or Boiled Rain Water.

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.

To those who desire only to learn the rudiments of the art by the most simple means, nothing beyond the following solutions are required as the chemical agents.

1. Nitrate of Silver, . 40 grains.
   Distilled Water . . 1 fluid ounce.
2. Common Salt . . . 20 grains.
   Water . . . . . 4 fluid ounces.
3. Hyposulphite of Soda, 1 ounce.
   Water . . . . . half a pint.

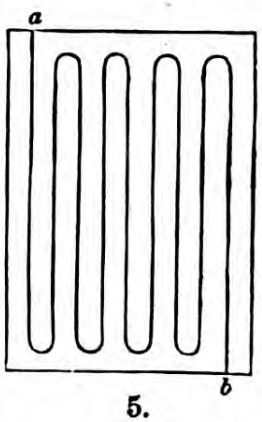
The easiest experiments will be made with a paper simply washed with solution No. 1, by which we prepare what is called—

a. Nitrated Paper.

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 grains 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 figure 5 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.



5.

The nitrated paper not being very sensitive to luminous agency, it is desirable to increase its power. This may 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.

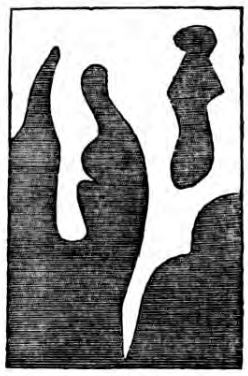
By dissolving the nitrate of silver in common rectified spirits of wine, instead of water, we produce a tolerably sensitive nitrated paper, which darkens to a very beautiful chocolate brown; but this wash must not be used on any sheets prepared with isinglass, parchment, or albumen, as these substances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

b. 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, No. 2, and then, when the paper is dry, with the silver solution, No. 1, 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. 6, 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 a 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.



6.

Whatever may be the process employed, the same kind of manipulation is demanded; it is therefore exceedingly important that the first essays should be made in the most simple manner, and that to all difficulties attending the preparation of the paper. A few experiments of an easy character will be instructive, as pointing out the *modus operandi* to the student.

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.

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.

Experiment 4.—*To determine the character of the change set up by sunshine.*—Solution No. 1 is nitric acid and oxide of silver dissolved in water. 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.

Experiment 5.—Having allowed a mixture of chloride and nitrate of silver with a small portion of organic matter to blacken, by exposure for some hours to sunshine, add some ammonia to the dark powder in a test tube. It will be found that ammonia will not dissolve it. This proves that it is not an oxide of silver, for if oxide of silver is put into ammonia it is immediately dissolved. Pour off the ammonia, and add some nitric acid, a little diluted with water, and the silver dissolves immediately, with the formation of nitrous acid. This proves the fact of the conversion of the silver salts, in the process of darkening, into metallic silver in a state of very fine division.

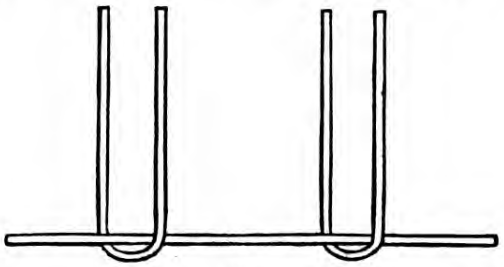
An attentive consideration of these results will serve to teach us the kind and character of the change which takes place. The silver salt is decomposed, and the gaseous element liberated either passes off, or is absorbed by the paper, and the metal forms the dark parts of the resulting picture.

It is a very instructive practice to prepare small quantities of the solutions of salt and nitrate of silver of different strengths, and to cover slips of paper with them in different 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 its surface a glass rod held in two bent pieces of glass, as in fig. 7; 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.



7.

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.

Muriate of strontia, used in the proportion of thirty-five grains to two ounces of water, with a silver solution of one hundred grains to the ounce, the metallic wash being applied twice, as before directed, forms a beautiful and very sensitive paper. Muriate of baryta, in similar proportions, produces a paper as much like it as possible, with this difference, that the barytic paper always assumes a peculiar richness of colour. The colorific action of the barytic salts will become the subject of our remarks by and by.

It may not be entirely useless, or uninteresting, to state the more striking peculiarities of a few of the *mordant* 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.

In order to prevent unnecessary divisions in the subject, under this head will also be embraced a few other solutions, which are analogous to the muriates. It should be understood that, unless the contrary is distinctly stated, the proportion of silver to be used is as above recommended for use with the salts of strontia and baryta.

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

solution is such as to employ all the chlorine they have in their combination. They give rise to pictures having a deep red ground.

Hydrochloric Ether.—When the nitrate of silver is dissolved in this ether, and applied without any preparation to the paper, it does not at first prove very sensitive to light; but, after a little exposure, the darkening process goes on with some rapidity, and at length passes into a deep brown, verging on a black. It is certainly preferable to the simple solution of the nitrate in water, but in no respect equal to the chlorides.

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 organized 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.

The salts of iodine, bromine, and fluorine, have been extensively employed, but as these form the basis of particular processes, any account of the operation of them is reserved until these become the subject of consideration.

CHAPTER V.

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

THE most simple method of obtaining sun-pictures, is that of placing the objects to be copied on a piece of prepared paper, pressing them 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 frontispiece to this volume represents such a *negative* image, and the *positive* impression resulting from it. The mode of effecting this is, having by fixing, given permanence to the negative picture, it is placed, face down, on another piece of sensitive paper, when all the parts which are white on the first, admitting light freely, cause a dark impression to be made on the second, and the resulting image is correct in its lights and shadows, and also as it regards right and left.

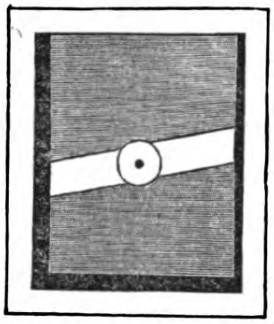
For the multiplication of photographic drawings, it is necessary to be provided with a frame and glass, the most convenient size for which is something larger than a single leaf of quarto post writing paper. The glass must be of such thickness as to resist some considerable pressure, and it should be selected as colourless as possible, great care being taken to avoid such as have a tint of yellow or red, these colours preventing the permeation of the most efficient rays. Figures 8 and 9 represent the frame; the one showing it in front, as in taking a copy of leaves, and the other the back, with its piece of stout tinned iron, 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.

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. Having covered 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. The frame might, for very particular purposes, be rendered more complete, by having the back adjusted with binding screws; but, for all ordinary uses, the bar answers every purpose.



8.



9.

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 nerves 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.

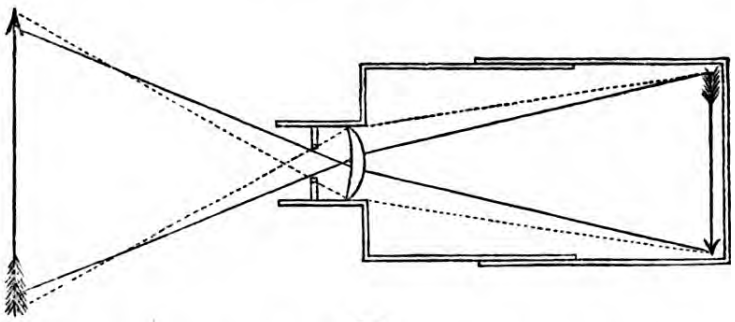
Engravings are to be placed with their faces to the prepared side of the paper, and laid very smoothly on the glass, and then with the cushion and back pressed into the closest contact possible; the least difference in the contact, by permitting dispersion, occasions a cloudiness and want of sharpness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

The copying frame is an indispensable requisite to the photo-

grapher; it is used for copying all small objects by transmission, and multiplying the original pictures 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.

With the copying-frame a great number of experiments should be made 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 boring 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.



10.

If, instead of a darkened room, we substitute a darkened box (Fig. 10) the same effect will be seen to result. 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, and form an image corresponding in size on the back of the dark box. The lens, as shown, refracts the rays, and a smaller but a more perfectly defined image is the result.

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 image. 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, which increases with the diminishing illuminating power of the radiating source, we have the impression made of every gradation according to the colour of the object we would copy.

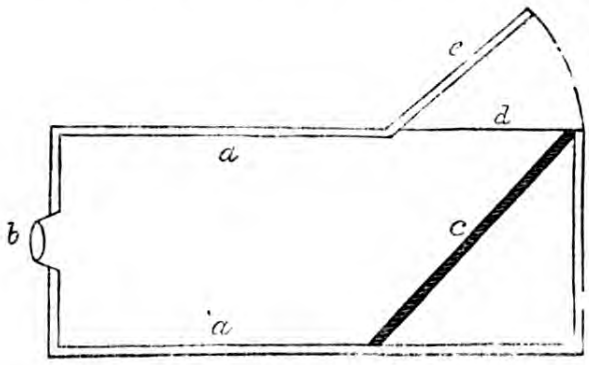
For the practice of photography with such success as approaches the perfection of the art, an instrument of the utmost refinement is necessary; but the learner may content himself with a very simple and inexpensive form of apparatus. Many of my earliest, and these were by no means my worst experiments, were made with a camera constructed from a cigar-box; a hole being pierced in one end of it, and fitted with a lens, the photographic paper being pinned upon a stiff piece of card-board the size of the box, and placed in the focus of the lens. It is necessary that the box be painted on the inside with a mixture of lamp-black and stiff size, to prevent the reflection of the dispersed light. Fig. 11 gives this arrangement; *a* being the lens through which the image falls upon the paper fixed on the moveable board at *d*, this being necessarily moveable, since, according to the distance of the object from *a*, so will be the focal distance from the lens producing the best image.



11.

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

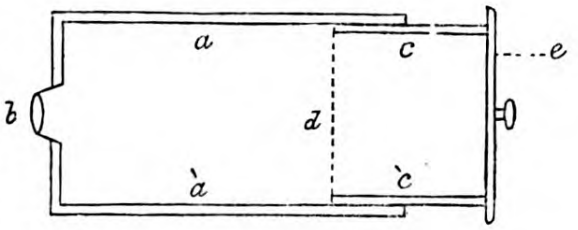
Fig. 12 is a section of one form of such an instrument: *a d* represents the box, in one end of which is fixed the lens *b*. The lenticular image falls on the mirror *c*, placed at such an angle that it is reflected on the plate of ground-glass *d*. *e* is a screen to prevent the overpowering influence 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



12.

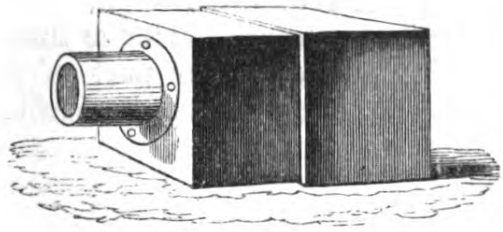
reflection from the mirror so far reduces its intensity, that its action on photographic agents is slow. To obviate the objection of the reflected image, it is only necessary to place the photographic paper in the place of the mirror, but not in an angular position.

Fig. 13 represents the photographic camera of a common, convenient, and very economical form. *a a* is the outer box, in which is fixed the lens *b*, and *c* `*c* another box sliding within it, at the inner end of which is placed the prepared paper *d*: by sliding this box forth and back, we are enabled to adjust the paper to the correct focus of the lens, the image being observed through a small hole at *e*.

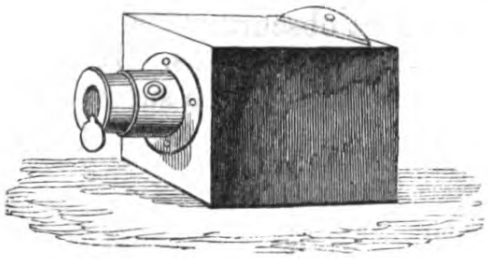


13.

A great variety of these instruments have been introduced to the notice of students of the art, many of them so unnecessarily

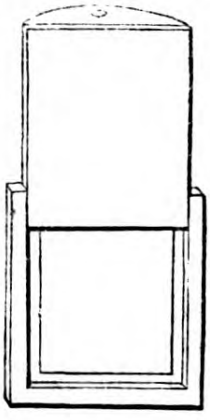


14.



15.

expensive that they are beyond the reach of the humble amateur. 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 in this treatise. Figure 14 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. 15) 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. 16, and a shutter, by which it is protected from the light until the moment it is required to throw the image upon it.

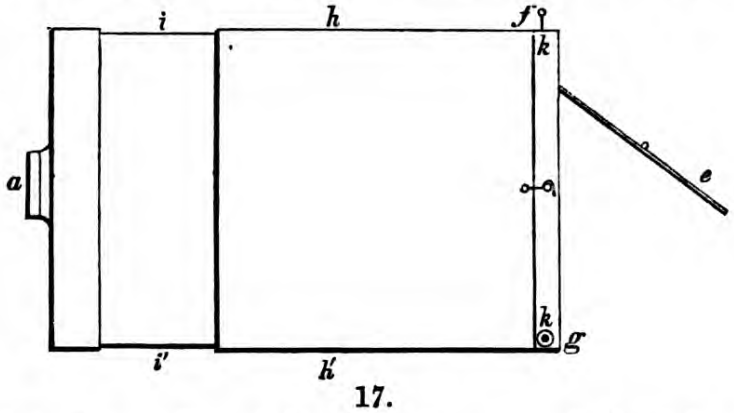


16.

In the former edition of this work, a form of camera was described,

which possesses many advantages; and even after years' practice with various instruments, few have been altogether more successful. 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 light, and consequently weaken the action 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 extent, 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. It is but right I should acknowledge that I am indebted to the suggestions of Dr. Wollaston for part of my lenticular arrangement. (Fig. 17 *a*) represents the aperture of the



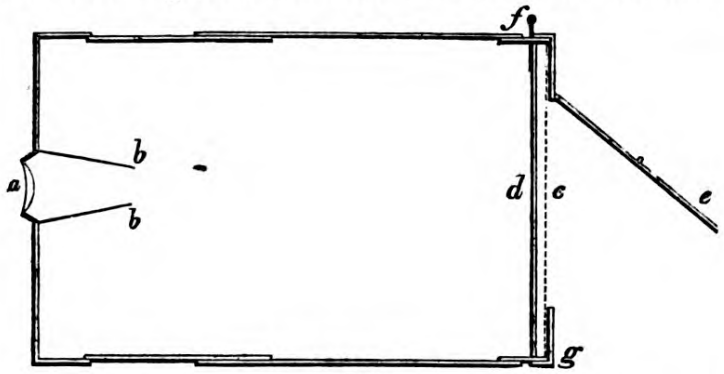
17.

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 18 is a section of the camera. *a* is a lens of a periscopic 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.

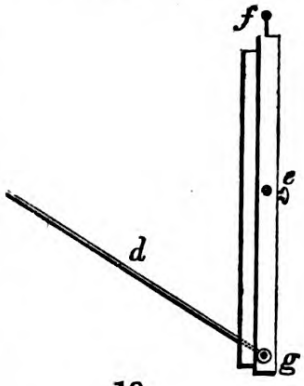
The aperture of the lens itself is made large, but the pencil of rays admitted is limited by a diaphragm, or stop, constructed as in the figure at *b*, between it and the plane of representation, at

about one-tenth of the focal length from the lens. By this arrangement objects are represented with considerable distinctness over



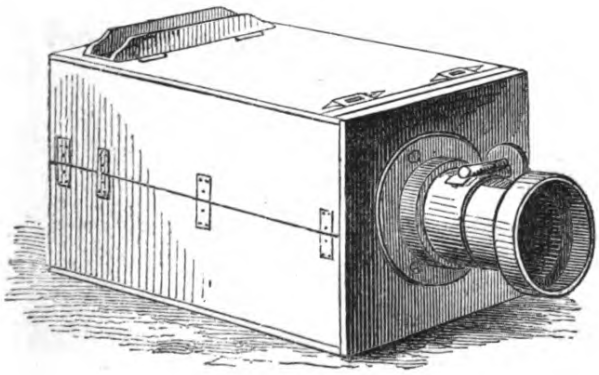
18.

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. Figure 19 represents this 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.

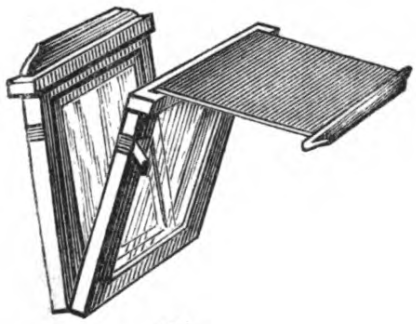


19.

The following figures (Figs. 20, 21, 22) represent a more perfect arrangement, and, at the same time, one which is not essentially expensive. Its conveniences are those of folding, and thus packing into a very small compass, for the convenience of travellers.



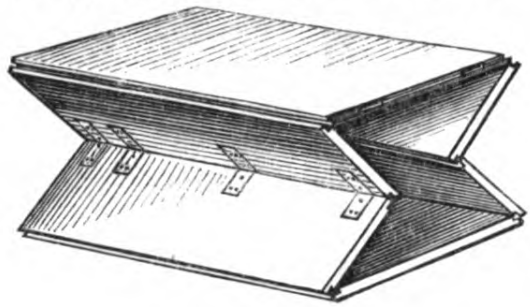
20.



21.

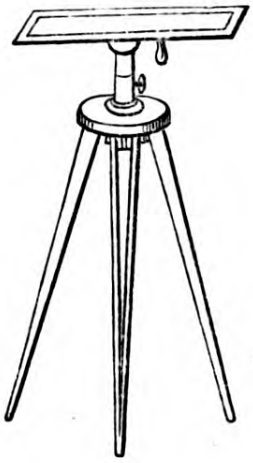
With the camera obscura properly arranged, and the copying frame, the photographic student who confines his attention to the

processes on paper has nearly all he requires. For the 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, 23 and 24, representing those which appear best adapted to the use of the traveller.

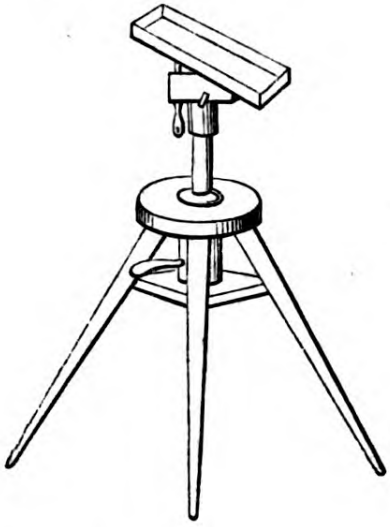


22.

The arrangement of compound legs shown in Fig. 23 ensures greater steadiness than the other; but the range of movement in Fig. 24 gives it some advantages.

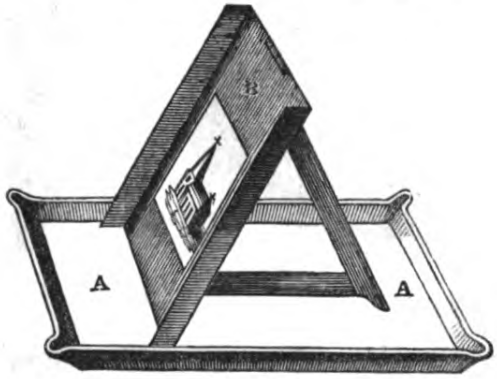


23.



24.

Beyond these things, a few dishes, such as are represented in Fig. 25, A A, and a frame upon which a photograph can be placed for the purpose of being washed, are the only things required for the practice of this branch of photography.



25.

CHAPTER VI.

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, 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 absorb-

ing 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: yet it was afterwards included in Mr. Fox Talbot's patent claim.

Hyposulphite of soda is manufactured very cheaply, or it can be prepared by the chemical amateur in the following manner:—

Form, in the first instance, a solution of caustic soda, by dissolving a pound of soda in a quart of boiling water, and mixing it, while hot, with half a pound of fresh burnt lime, slaked with another quart of boiling water. The mixed solution is to be carefully covered from the air until cold. The clear liquor is then to be poured off, and made to dissolve, by boiling in an earthen vessel as much sulphur as possible. The deep yellow solution formed is to be decanted off into a deep vessel, and a current of sulphurous acid gas passed through it until it becomes quite colourless. This is very easily done by mixing, in a retort with a long beak, some linseed oil and sulphuric acid. On applying a little heat, the sulphurous acid gas is given off in great abundance. By plunging the beak to the bottom of the vessel, it passes through, and is rapidly absorbed by the solution. If it is desired to crystallize the hyposulphite, the fluid should not be allowed to become quite free of colour. Whilst still a little yellow, it should be filtered and evaporated, in a porcelain or earthen vessel, over a quick fire, to the consistence of a syrup. The liquid thus evaporated is mixed with half its volume of alcohol, and well shaken. The alcohol takes up all the sulphuret, and floats above; the lower solution is left to cool under the alcoholic one.

The hyposulphite of soda must be preserved in well-stopperedglass bottles, and never be exposed to any bright light. It is best to keep it in small bottles, as the action of the oxygen of the atmosphere has a tendency to form a sulphate, and precipitate the sulphur.

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 is then to be dried, and, 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 probable 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 processes 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 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 this means you obtain directly the 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 fluidounce 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 VII.

ORDINARY PHOTOGRAPHIC PROCESSES ON PAPER OF THE EARLIEST VARIETY.

It has already been noticed that Wedgwood was certainly the first who made any attempts to use the sunbeam for delineating the objects through which it permeated. In 1802 he published an account of his process 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 paper 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 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 still 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."

In 1839, 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.

Chloride of Silver.—"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 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, 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.

The proportions in which the muriate of soda 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, solution 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 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.

The combinations of organic bases with lead and the argentine salts have been already described in Chapter IV.

Iodide of Silver.—This salt was employed very early by Talbot, Herschel, and others. It enters as the principal agent into Mr. Talbot's calotype paper; but a description of this process is reserved for a separate chapter. 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. Opening as this does a wide range of highly interesting and most important experiments, it is to be hoped some one may pursue the

subject, and endeavour to establish the peculiar phenomena which present themselves on some scientific basis.

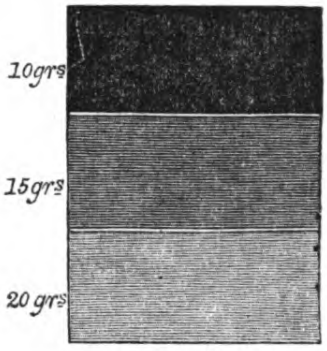
If iodide of silver is precipitated by mixing together solutions of iodide of potassium and nitrate of silver in a concentrated state, a heavy yellow powder falls, which will scarcely change in colour by an exposure of many days to sunshine. But if the solutions are infinitely diluted, so that on mixing 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.

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.

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.

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



26.

margin. 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 appli-

cation). 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 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.

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.

CHAPTER VIII.

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.

The uncertainty attending the application of these salts, arising from the above cause, has greatly circumscribed their use as photographic agents. However, 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.

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 experience since that time.

The variable texture of the finest kinds of paper occasioning irre-

gularities 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 drawings 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 ferrocyanate 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 hydriodic 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, were 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 following directions, 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:—

Soak the paper for a few minutes in a muriated wash, 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 sun-

shine, 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.

Hydriodates of Potash and Soda.—The former of these salts being more easily procured than any other 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 soda. This preparation is, however, so readily decomposed, that the size of the paper occasions a liberation of iodine, and the consequent formation of yellow-brown spots.

Hydriodate of Iron.—This metallic hydriodate acts with avidity 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 very 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 (April, 1851), 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 definedness, 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.

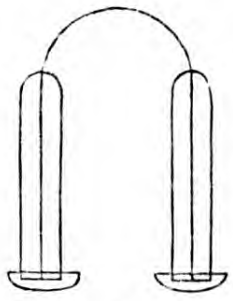
Take a photograph thus formed, and place it in a vessel of water, in *a few days* it will fade out, and bubbles of oxygen will gather around the sides. If the water is examined, there will be found no trace of either silver or iodine. Thus it is evident the action has been confined to the paper.

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, LIGHT, 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.



27.

Place a similar arrangement in the dark; iodine is slowly liberated. *No iodide of silver is formed*, but around the wire a beautiful crystallization 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 watchglasses, 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.

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 quitting 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.

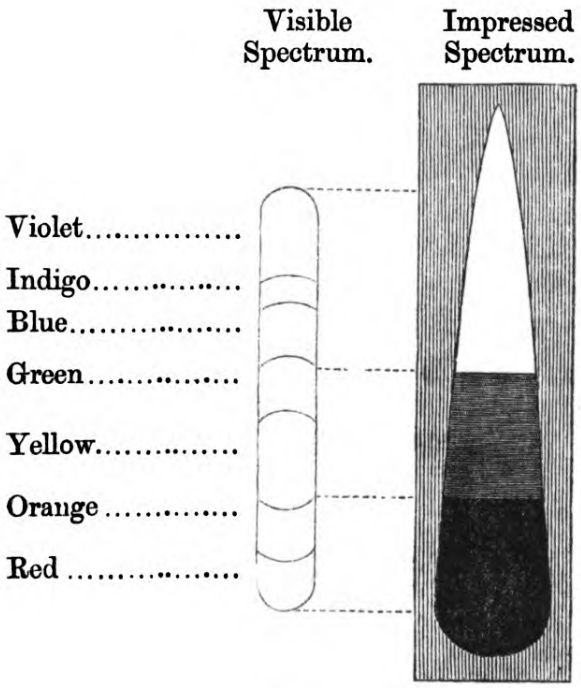
M. Bayard simply allowed ordinary letter paper, prepared according to Mr. Talbot's method, to blacken by light. He then steeped it for some seconds in a solution of iodide of potassium, and laying it on a slate, he placed it in the camera.

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 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,



28.

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 28, 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. This subject will be again the object of consideration.

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 IX.

THE PROCESSES OF MR. H. FOX TALBOT, AND MODIFICATIONS.

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, and some nitrate of silver in excess. These need not be any further described than they have already been. Those desirous of studying the history of the progress of the art, are referred to the original communications.[1]

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 the calotype process of 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, and his remarks are printed *in extenso* in the *Comptes Rendus*, from which the following passages are translated.

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, as some disposition has been shown on the part of some 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 obstables 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

[1] London and Edinburgh Philosophical Magazine, March 1839.

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,—perfect prints, it is true, but which are as light as the vapour from which they are produced; and, indeed, to bring the voluminous collection of these fragile products through the accidents incident to long, difficult, and sometimes perilous voyages. Attempts are being made, at this time, to fix the images produced by the Daguerreotype. 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 a less troublesome removal from place to place, as also of more easy preservation.

The utility of sensible 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 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 reaction 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 shades, 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 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 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 foot 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 sensible or more rapidly acted on. In the hyacinth, the stalk and the green leaves produced scarcely a faint trace of their configuration; and they produced it especially in the parts of the outline, where more or less perfect specular reflection is operated. 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 gradation of lights and shades, which constitutes 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 sensible 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.

There are but few points on which M. Biot has touched but which have been found to be substantially true. Numerous improvements have been introduced, but still physical difficulties, such as those which he has indicated, surround the photographic processes.

Mr. Talbot's description of his process, the patent for which is dated 1842, is as follows:—

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 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;* he in a second patent included the following points:—

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 it 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. Another patent has been obtained by Mr. Talbot, but as this belongs peculiarly to the use of porcelain, the notice of it must be referred to another section.

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 watermark, 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 crystallised 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 exquisitely 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 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 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 has 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* re-dissolved.

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 upon 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.

But little remains to be added to this very clear and satisfactory description of the Calotype 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. This peculiarity in the papers of different manufacturers was first noticed by Sir John Herschel. 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. Martin uses the spirits of wine after the picture has been developed, to improve the tone of the picture.

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 ozs.
	Concentrated solution of cyanide of potassium	7 drops.
Second.	Nitrate of silver	7 drachms.
	Distilled water	10 ozs.
	Strong acetic acid	2 drachms.
Third.	A concentrated solution of gallic acid.	
Fourth.	Good spirits of wine.	
Fifth.	Hyposulphate of soda	1 oz.
	Distilled water	10 ozs.

For the positive pictures—

First.	Chloride of sodium	168 grains.
	Distilled water	10 ozs.
Second.	Nitrate of silver	1 oz.
	Distilled water	10 ozs.
Third.	Hyposulphite of soda	1 oz.
	Distilled water	10 ozs.

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.

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 from being distributed 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 superb 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 is employed, and the picture is allowed to remain in it until every trace of yellowness is removed from the paper.

M. Le Gray has also employed collodion—gun cotton dissolved in ether—mixed with spirits of wine, and spread over paper, instead of the isinglass, with very good effect.

Mr. Cousins mentions, in his translation of M. Le Gray's paper, that the following were the improved proportions in which he recommended an albuminous mixture to be made for paper:—

White of Eggs, 2 fluid ounces and 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. Victor's, and his own application of albumen, must not be neglected.

Method of preparing paper with albumen, so that it may be employed whilst 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 minnte; 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.

PHOTOGRAPHIC PROCESSES ON GLASS PLATES.

THE first published account of the use of glass plates for photographic purposes is to be found in Sir John Herschel's Memoir "*On the chemical action of the rays of the solar spectrum on preparations of silver and other substances.*" (Philosophical Transactions, Part 1 for 1840.) The interest which attaches to this is so great, and there appears to be in the process recommended by the English experimentalist so many suggestive points, from which future photographists may start, that the passage is 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 crystallization 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 re-agents. 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 discolouration 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 spread 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,

and the edge removed; the silver is exposed to the action of diluted chlorine, to the vapour of iodine or bromine, until it is converted into compound with one of these elements, after which we may proceed as in the former case.

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, 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 is reduced to a thick white froth, to let it repose all night; the next day decant the viscous liquid, which has deposed, 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 pasting 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 it to dry spontaneously, keeping it in an horizontal position and free from dust. When the coat of albumen is well dry, 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 then becomes perfectly insoluble, and ready to receive the aceto-nitrate of silver.

The glasses 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 the same 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 albumen paper, which I will describe 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.

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 absorptoin 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 phenomena 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."

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.

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.

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 Evrard 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 iodine, 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. In a subsequent chapter the peculiarities of these salts will be the subject of consideration. The moment intimation was given of the employment of glass plates for the negative photographic pictures, an attempt was made in this country to include them in a patent; but the previous publication of Sir John Herschel's experiments on glass prevented this. Mr. Talbot has, however, patented the use of unglazed porcelain. It is impossible to say what may be the result of the experiments of this gentleman, but there appear to be many objections to the use of this material; and it is also very doubtful if such plates can be manufactured sufficiently true for the delicate purposes of photography.

From the specification we glean the following particulars of the process practised by Mr. Talbot upon the biscuit-ware tablets.

Pictures on Porcelain Tablets, and Mr. Fox Talbot's last Patent.—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 very 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 patentees 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 patentee's 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 improve-

ment 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 then 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 above described by Mr. Malone. The images on oiled paper are said to be exceedingly good, and this may be a valuable suggestion

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, just 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 slides. 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: it, however, originated in England about two years since.

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.

The use of glass tablets cannot be dismissed without a notice of the process of Niepce, for although he employed metal in most cases, glass offers some advantages for the reproduction of the resinous pictures, and enables us to produce some very pleasing effects: therefore it is thought advisable to deal with the *heliographic* process in this place.

Heliography.—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 com-

[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.

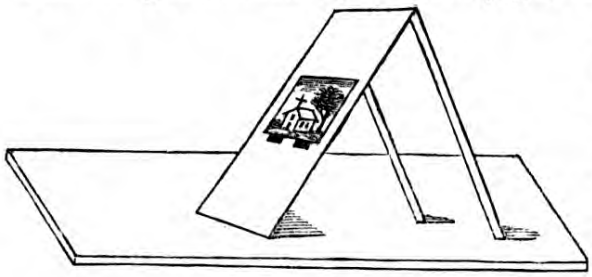
pletely saturated. I afterwards add as much more of the essential oil as causes the whole to stand about three lines above the mixture, which is then covered and submitted to a gentle heat until the essential oil is fully impregnated with the colouring matter of the bitumen. If this varnish is not of 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, 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 long board, fixed at a large angle, 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 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.



29.

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*, an article which it is rather difficult to obtain in England. 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 given 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 makes the remark, that numerous experiments tried by him 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.

The use of glass plates must not be entirely dismissed without a notice of a very pretty method of producing

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.

CHAPTER X.

THE PROCESSES 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. The 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.

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 do doubt that the process, in a great majority, if not in all cases, which have been noticed among inorganic substances, is a deoxidizing 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 deoxidizing 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 spon-

taneously 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 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-nitrate of iron.

"The ammonio- and potasso-tartrate fully possess, and the per-

chloride *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 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, seems 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

picture 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 re-agents. 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 de-oxidized, 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, and, when quite so, remained most permanently impressed upon the paper.

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.

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 neutralized 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 no wise 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 recal, 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.

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.

Extending his inquiries still further into these very remarkable changes, the following process presented itself, 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 re-dissolved 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 added 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 develops 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.

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.

Of the Colours of Flowers in General.—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 for but a few minutes) irrecoverebly 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 due intensity till after complete drying. The temporary destruction of the colour of the blue heartsease by alcohol has been noticed in my former paper (Art. 90), nor is that 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 che-

[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.

mical 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 gray, 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 and 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 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 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 that ingredient. But one remarkable instance of absolute dormancy induced by that agent, has occurred to me in the case of the *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 compe-

tent 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, 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 *Viola 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, the maximum being at – 8·0, and the sensible limits of the impression (corrected for semidiamater) being – 11·0 and + 56·4, of which, however, all but the first five or six parts beyond the fiducial 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-gray, 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 herbaccous 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 effected 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.

CHAPTER XI.

MISCELLANEOUS PROCESSES.

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 kind of 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 quan-

tity 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 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 Chromotype.—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 chromotype 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 they act 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.

On the Use of the 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.

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 gold and platinum. 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.

The Energiatype or Ferrotype.

This process, which is of remarkable sensibility, was discovered by the author, and published in the Athenæum. 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 is 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 the energiatype 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.

Negative Pictures.—In the camera, for a building, an exposure of half a minute in strong sunshine is usually sufficient; for a portrait, which can only be taken in the shade, two or three minutes are required.

Exact copies of prints, feathers, leaves, &c. may be taken, 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.

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 develop itself. Having mixed together about one drachm of a saturated solution of *protosulphate of iron* and two or three drachms *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.

Positive Pictures.—These are procured in the same manner as the copies of the prints, &c. just described; using the negatives before obtained in place of the objects themselves. 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 shewed, 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 shewn 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, has been the principal cause why it has not been as generally employed as the gallic acid. Mr. Robert Ellis has recommended the use of the protonitrate of iron as a developing agent.

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 ferrocyanate 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.

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.
Fluate of soda . . .	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."

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 $2\frac{1}{2}$ drachms of 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.

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 copper-plate 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 carbonized 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.

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.

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:—Many 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 Daguerréotypes; 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 conve-

nience. 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 realising 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.

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 ensure the same degree of strength in the solutions, a very uniformly 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 hindrances 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

[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.

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.

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 blacking 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.

Supplement to the preceding paper.

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.

With the advance of this beautiful art, there appears to be a progressively increasing desire to produce more artistic results; and numerous manipulatory improvements have recently been introduced, many of them with the most decided advantages. It is thought desirable therefore to devote a short space to the description and consideration of such of these as are the most important.

The use of collodion promises to be exceedingly advantageous. 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. 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.

Having obtained the collodion, the mode of proceeding best adapted for ensuring success appears to be the following:—

Iodide of silver is precipitated from a solution of the nitrate of silver by adding iodide of potassium to it; the yellow precipitate being well washed, so as to remove every trace of nitrate of potash: it is then dissolved in a saturated solution of the iodide of potassium. This mixture is added in small quantities to the collodion, and the whole well agitated; by this means we obtain a combination of this peculiar substance with iodide of silver and potassium. Mr. Archer, who has devoted considerable attention to this pre-

paration, prepares what he calls a collodo-iodide of silver: whether prepared in the above manner we are not certain. Mr. Archer's preparation is exceedingly sensitive, but the above is believed to be equally so. No other manipulation is necessary in using it than to pour the mixture over a glass plate held upon the hand, moving it to and fro to ensure the complete coating of every part; the fluid is poured off by one of the corners, and the film which adheres to the glass dries almost immediately. This is then washed over with the gallo-nitrate of silver, in the same manner as in the albuminized glass plates, and it is ready for the camera. Where the proportions have been happily hit upon, the result is the production of a picture almost instantaneously: very fine portraits are obtainable in about ten seconds in diffused light; the image is developed in the same manner as in the calotype process, by the use of the gallo-nitrate of silver, and fixed by means of the hyposulphite of soda.

Mr. Horne has favoured me with the following process adopted by him with much success:—

"Take a piece of flat glass cut to the size of the frame, and, having washed it with water, and wiped the same quite dry, then, either by holding it at one corner, or if large, placing it on a levelling-stand, pour on the centre of the plate a good body of liquid, which will readily diffuse itself equally over the surface, Immediately pour the liquid off again into the bottle from one corner; and by bringing the hand holding the plate down a little, that the liquid may run to the lower edge, and drawing the mouth of the bottle along, those lines first formed will run one into the other, and give a flat, even surface. Very little practice will soon enable any operator to obtain this result. The plate is now *immediately*, and before the whole of the ether has had time to evaporate, to be immersed in a bath of nitrate of silver, 30 grains to the ounce, *until the greasy appearance which it first presents on immersion is entirely gone, and the silver solution flows freely over the surface.*

"The plate should now, and in its moist state, be placed in the camera, and the picture taken; the time of exposure varying, of course, with the light, but for a portrait, and with a moderately quick lens, from three to thirty seconds will be sufficient. Mr. Fry, who was the first to practise with collodion, has obtained beautiful portraits by placing the sitter in the open air, and simply removing the cap from the lens, and closing it again as soon as possible.

"The agent for developing these pictures is unquestionably the pyro-gallic acid, as recommended by Mr. Archer; and I am told the proto-nitrate of iron also answers equally well. The solution of pyro-gallic acid should be made as follows:—

Pyro-gallic acid	3 grains.
Glacial acetic acid	1 drachm.
Distilled water	1 ounce.

The plate having been placed, face upwards, upon a levelling stand, a sufficient quantity of the above solution should be poured equally and quickly over the surface, and the picture allowed to develop, occasionally slightly moving the plate, to prevent the deposit which will take place settling at one spot. A few drops of a solution of nitrate of silver, five grains to the ounce, may also, in dull weather, be added to the pyro-gallic, with advantage, just before pouring it over the plate; but in very bright weather the picture will develop sufficiently quick with the pyro-gallic acid solution alone.

"The development may be readily judged of by holding a piece of white paper occasionally under the plate; and as soon as sufficient intensity has been obtained, the solution must be poured off, and the plate washed by a gentle stream of water. After this, the surface should be covered with a saturated solution of hypo-sulphite of soda, which will almost immediately remove the iodide. Another stream of water must then again be poured over, to free the plate from hypo-sulphite, and the picture is finished.

"In this state they are more or less negative by transmitted light, and, if not too much brought out, positive by reflected light. But I have found the most beautiful and decided positives may be obtained by the simple addition to pyro-gallic solution of a minute quantity of nitric acid; care being taken not to add too much. I have also obtained purple and green pictures, the former by adding acetate of lead, and the latter with acetate of lime and ordinary gallic acid."

The resulting negative pictures on the glass are not quite so adherent as those formed with albumen; care must therefore be taken to avoid rubbing it off, or the glass plate may be covered with a colourless spirit varnish, by which, when dry, the photographic image is perfectly fixed.

In this process the ether, without doubt, plays a very important part, although the largest portion evaporates readily; an intimate chemical combination of this volatile hydro-carbon takes place with the peculiar substance—gun-cotton—employed. At a very early period of photographic investigation, it was found that both alcohol and ether produced several remarkable effects; in some cases the processes were very much quickened; in others, the resulting tone of the darkened paper was of a much deeper and richer colour.

Experiments are yet required to determine the operation of these organic compounds. From the action of many of them it would appear that it is to this order of chemicals that we have now to look for the greatest improvements in photography.

Lacturine and caseine have been both recommended as media

for preparing glass surfaces for the photographic processes. These compounds, which are of a very analogous character, are prepared from butter-milk, by the action of acids: it is proposed that they should be used dissolved in ammonia. When this is done, the glass being uniformly coated by flooding the solution over it, it may be allowed to stand in a warm place, free from dust, to dry: this occupies some time, but if the process has been carefully attended to, the resulting coating is very uniform and clear. Iodide of potassium or of ammonia may be mixed with the caseine solution before it is applied, the other parts of the process being precisely similar to those already described. It has always been deemed of the utmost importance in the processes on paper to keep the chemical agents which are to be operated upon by the solar radiations, as much as possible on the surface. Several plans have been proposed, and albuminized paper has been largely employed. It is, however, found that wax paper answers far better than any other. The fact that water cannot be spread upon wax may appear to be a difficulty in the way of successful manipulation, but there are means by which this can be overcome; the most successful being the following:—A sheet of good writing paper is placed upon a hot iron plate, and rubbed over with wax until thoroughly saturated, taking care that the wax is uniformly diffused. If there should be an accumulation in any part, the paper is to be held up by one corner, in front of a fire sufficiently hot to liquify it and allow it to flow off from the opposite corner. A great many sheets of this paper can be prepared at a time, and kept until required. To give these the sensitive coating, a large dish must be procured, and filled with a solution of the iodide of potassium; if the paper is simply dipped in and then removed it will be found to remain quite dry, owing to the repulsive action exerted between the water and the wax. Sheets of waxed paper are to be passed into the solution one after another, taking care to remove any air-bubbles which may form on the surface of each, until as many as may be required are inserted, and the whole allowed to remain two or three hours. In that time a considerable quantity of iodide of potassium has been absorbed, and on removing the papers and drying them, it will be found, upon the application of the nitrate of silver, that a beautiful surface of the iodide will be produced on these papers, whether we employ the calotype or the ferrotype process, from the circumstance that the chemical agents are retained on the very surface of the paper. The resulting pictures are beautifully transparent, not in any respect inferior for copying from than those negatives which are waxed after the picture has been obtained, and all the details are very charmingly preserved.

The addition of the fluoride of sodium to the iodide or chloride, in the first preparation of the paper, we have alluded to, and there

can be no doubt but it possesses considerable accelerating power. This preparation has been recently introduced as a novelty, but the following process is described in the author's Researches on Light:—

The fluorates of soda and of potash have been used in many different manners, and variously combined. It has been found that the fluorate of soda has the property of quickening the sensibility of bromidated papers to a very remarkable extent; and from this quality a new process, which I would distinguish by the name of the fluorotype, results.

The Fluorotype.—This process, which is characterized by its manipulation, and by the sensibility of the papers when carefully prepared, consists in the formation of a salt of silver, which I suppose must be considered as a fluo-bromide of silver. It is at present somewhat difficult to say which is the most efficacious manner of proceeding; but the difference, as it regards the sensibility of papers, is so very trifling, that this is not of much consequence. The paper may be washed first with the bromide of potassium, and then with the fluorate of soda; or, which will be found on the whole the best plan, the two salts may be united. The strength of the solutions should be as follows:—

Bromide of Potassium	20 grains.
Distilled Water	1 fluid ounce.
Fluorate of Soda	5 grains.
Distilled Water	1 fluid ounce.

Mix a small quantity of these solutions together when the papers are to be prepared, and wash the paper once over with the mixture, and when dry, apply nitrate of silver in solution, 60 grains to an ounce of water. The papers appear to keep for some weeks without injury, and they become impressed with good images in half a minute in the camera. This impression is not sufficiently strong to serve, in the state in which it is taken from the camera, for producing positive pictures, but it may be rendered so by a secondary process.

The photograph is first soaked in water for a few minutes; it is then placed upon a slab of porcelain or stone, and a weak solution of the protosulphate of iron applied, which very readily darkens all the parts on which the light has acted, to a deep brown, and every object is brought out with great sharpness. When the best effect is produced, the process must be stopped, or the lights suffer. All that is necessary is to soak the paper in water, and then fix the drawing with hyposulphite of soda. This process admits of numerous modifications, and in several experiments with the spectrum, an impressed image in natural colours was obtained.

Indeed the most satisfactory evidences of photographic colouration yet obtained involved the use of the fluoric acid in some of its combinations.

Pyro-gallic acid, which is easily obtained by sublimation from an extract of galls, may be employed with much advantage as a developing agent instead of gallic acid, over which, indeed, it possesses some advantages.

CHAPTER XII.

DAGUERREOTYPE.—THE ORIGINAL PROCESS OF DAGUERRE.

From the primary importance of this very beautiful branch of the photographic art, I shall devote a considerable space to a description of the original process, and add thereto some account of each improvement which has been published, having any practical advantage, either by lessening the labour required, or reducing the expense.

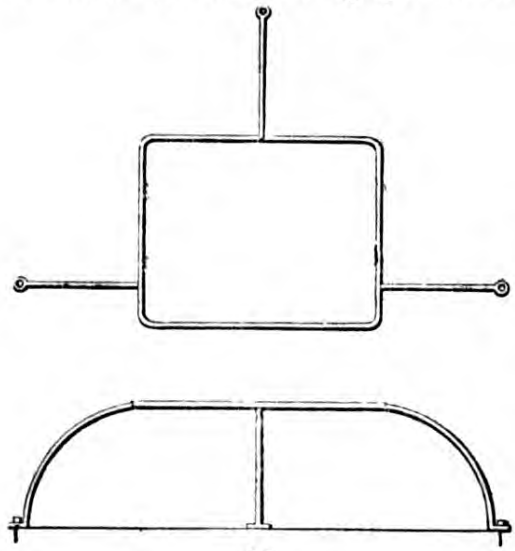
The pictures of the daguerreotype are executed upon thin sheets of silver plated on copper. Although the copper serves principally to support the silver foil, the combination of the two metals appears to tend to the perfection of the effect. It is essential that the silver be very pure. The thickness 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 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 *ioduret 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.

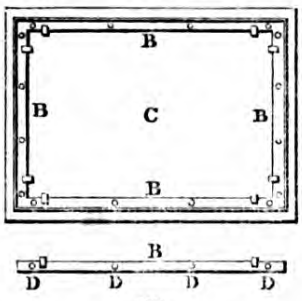
The plate being first powdered over with pumice, by shaking the bag, a piece of cotton, dipped into the olive oil, is then carefully rubbed over it with a continuous circular motion, com-

mencing 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.



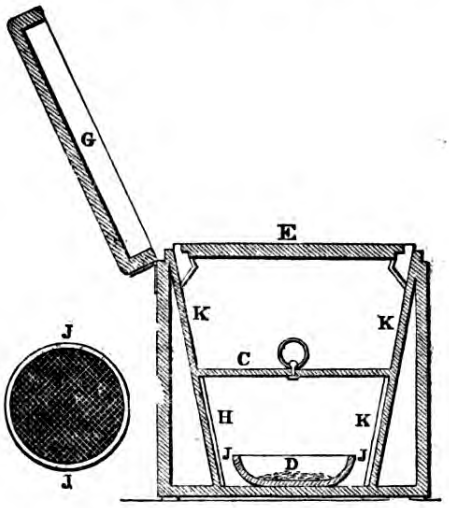
30.

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 with 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 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.

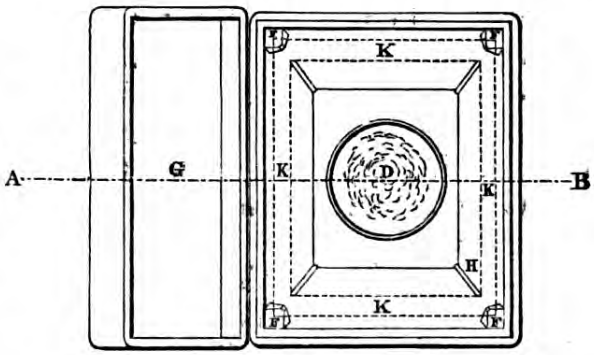


31.

Second Operation.—It is necessary for this operation, which is really the most important of all, that a box, similar to figs. 32 and 34, be provided. Figure 32 represents a section, supposed to pass down the middle of the apparatus by the line A B, in fig. 33, which represents the box as seen from above. C is a small lid which accurately fits the interior, and divides the box 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 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 small projecting pieces, F, fig. 33. 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.



32.



33.

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.

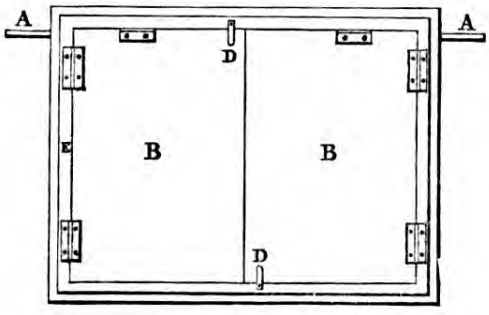
In this position the plate remains until the vapour of the iodine has produced a definite golden yellow colour, nothing more nor less.[1] If the operation is prolonged beyond the point at

[1] If a piece of iodine is placed on a silver tablet, it will speedily be surrounded with coloured rings: *two yellow* rings will be remarked, one without and the other within the circle. The outside yellow ring alone is sensitive to light. This experiment will show the necessity of stopping the process of iodidation as soon as the first yellow is formed over the surface of the silver.

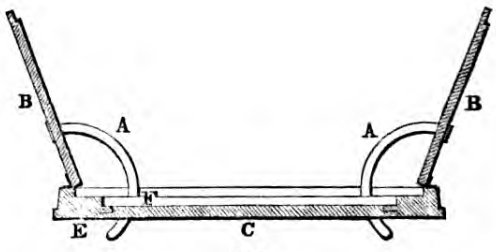
which this effect is produced, a violet colour is assumed, which is much less sensitive to light; and if the yellow coating is too pale, the picture produced will prove very faint in all its parts. The time for this cannot be fixed, as it depends entirely on the temperature of the surrounding air. No 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 produce 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



34.

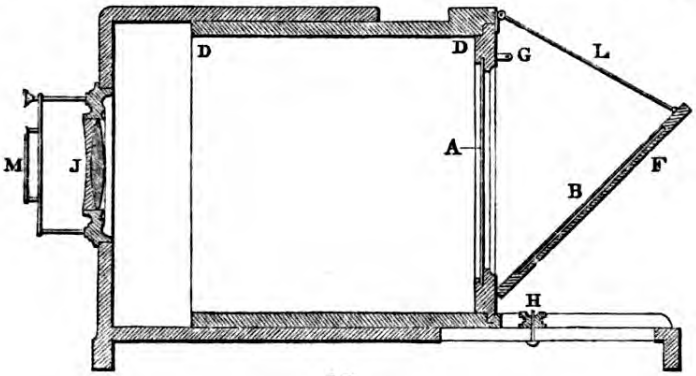


35.

prevent the access of light. The figures represent this frame, fig. 34, with the doors, B B, closed on the plate; and fig. 35, 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. 36 is a perpendicular section, lengthwise, of

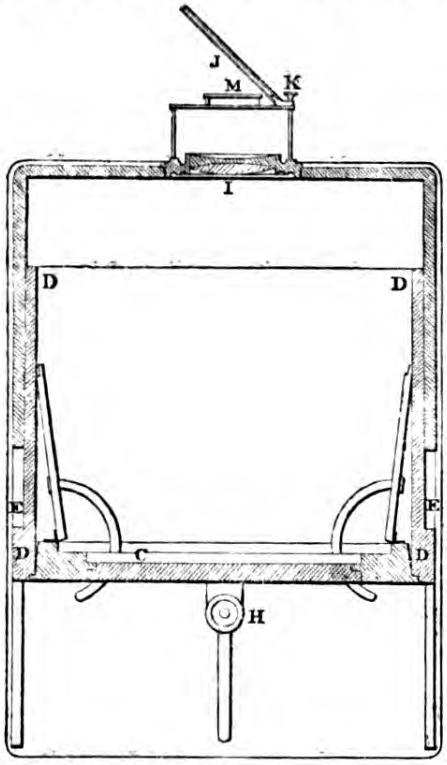


36.

Daguerre's camera. A is a ground glass by which the focus is adjusted; it is then removed, and the photographic plate substituted, as in C, fig. 37. 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 fourteen 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 37. 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

[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.

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.

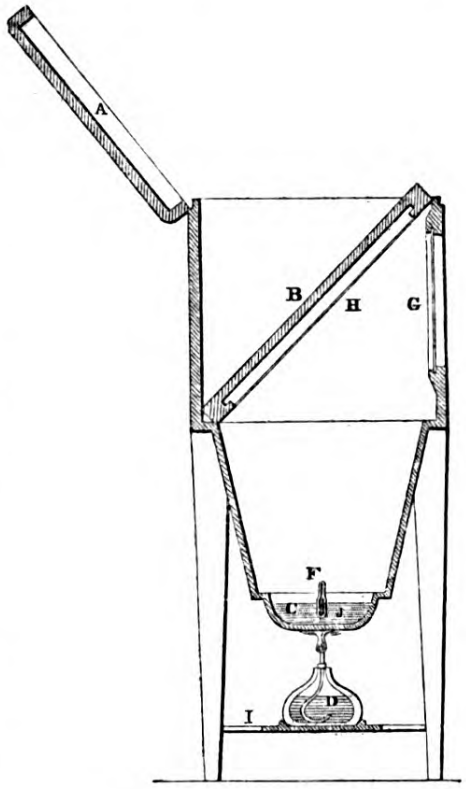


37.

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 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.

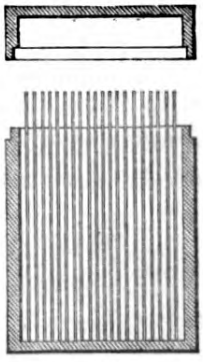
Fourth Operation.—The apparatus required in this operation is represented by fig. 38. A, is the lid of the box; B, a black board with grooves to receive the plate; C, cup containing a little mercury, J; D, spirit lamp; F, thermometer; G, glass through which

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.)



38.

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.


39.

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. 39), 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.

The above constitute the substance of the directions given by M. Daguerre, in his pamphlet and patent specification. The process has, however, been much simplified and shortened: the enormous expense of the original apparatus having been found quite unnecessary.

Improved Method of Iodizing the Silver, by M. Daguerre.

The inventor has given some very decisive experiments, showing the necessity of using metal strips of the same kind as the tablet, or of cutting a deep line round it. He has shown that in using strips of copper, of glass, of gum lac, of card board, or of platina, the edges of the tablet are surcharged with iodine. 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 from the side of the object of which we wish to take the image, and the time that the chloride of silver takes to become of a greyish slate colour will be the time required for the light of the camera to produce a good effect on the iodated silver.

Dr. Draper, of New York, acting on the suggestions of Mr. Towson relative to the adjustment of the focus, who published his views and experiments in the Philosophical Magazine for 1839, 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 iodated surface. This has been shown to be an error, for, even when the sun shines but dimly, there is no difficulty in delineating 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 miniatures 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 parts have made any decisive representation. We have

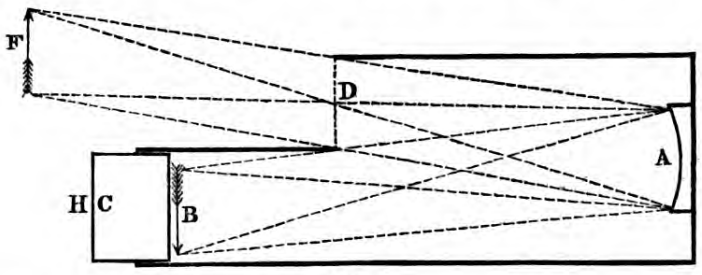
therefore to make use of temporary expedients. A person dressed in a black coat and open waistcoat of the same colour, must put on a temporary front of a drab or flesh colour, or, by the time that his face and the fine shadows of his woollen clothing are evolved, his shirt will be solarized, and be blue, 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 was taken 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 very easily constructed. Fig. 40 is a sectional view of the apparatus. At one end of a box,



40.

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.

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 at least 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.

"MODE OF OPERATING.

"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.

"OBSERVATIONS ON THE POLISHING OF 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 glazing (*vitrage*) 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.

"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."

Without detailing any further the various stages of improvement which took place at short intervals, it is thought advisable to describe the forms of manipulation by which the most satisfactory images are obtained on the silver plates.

There are many varieties of accelerating liquids 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 Bromée, 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, but the colour to be attained differs according to the solution employed. 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 solution until it is of a deep yellow tint, and over the bromide 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 becomes 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 to answer best. 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 mixtures 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 solution 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 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 appears to have been 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 plans 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 chloro-iodide 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 accelerator; or by combining the chloro-iodide of lime with a little of the bromide, a mixture similar

[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."

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.

"I have hastened to communicate this during the present fine weather, believing that it will be acceptable to all interested in this beautiful application of science."

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 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; 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

[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."

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.

When bromide of iodine or the chloride are used, every precaution must be adopted to secure a uniform coating; and the methods suggested by Daguerre are the best which can be recommended. When the plate has been exposed in the camera the proper time, it is subjected, as already directed, to the action of mercurial vapour; and then, being washed with the hyposulphite of soda, subjected to M. Fizeau's process of fixing with solution of gold.

The process, as described by M. Fizeau, 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.

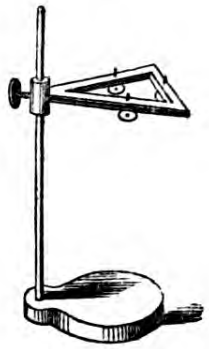
"This solution ought to be changed for each experiment, and to consist of about one part of the salt to fifteen of the water: the rest of the washing is done in the ordinary way, only taking care that the water should be as free as possible from dust.

"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. 41, and pour upon its surface

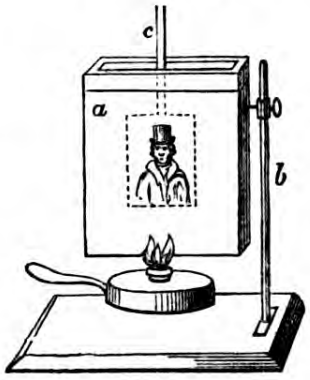
a sufficient quantity of the salt of gold that it may be entirely covered, and heat it with a strong spirit-lamp; the picture will be seen to brighten, and become, in a minute or two, of great force. When this effect is produced, the liquid should be poured off, and the plate washed and dried.

"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 some way darkened by the thin film of gold which covers it, from which results a strengthening of all the darks. 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."



41.

The plates are then washed by means of an arrangement of this order. The apparatus represented in fig. 42 may be employed. *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.



42.

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.

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.

Upon the suggestion of Mr. Towson, who published his paper in the Philosophical Magazine for 1839, a new mode of adjusting the focus was introduced, by which the difference between the chemical and the luminous rays was allowed for, and to this was mainly due the acceleration of the process sufficiently to obtain pictures from the life.

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 ($61\frac{1}{4}$° or $63\frac{1}{2}$° 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.

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, and any one may have constructed for himself, for less than twenty shillings, a set of apparatus, by which he shall be enabled to produce pictures equalling, in every respect, those procured with the set sold at twenty pounds.

My apparatus consists 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 future 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 their 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 leave 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 oxidized, 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 I hope in a little time to turn my attention again 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 photo-

graphy is opening for inquiry, in the hope they may induce some person to pursue the subject.

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, 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]

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.

[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.

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 discovering the properties of these different metals, one of which aids in promptitude, the other in the vigour of the impression, &c.[3]

From the concurrence of these substances arises a power which neutralises all the unknown effects which so often oppose the formation of the image.[4]

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

[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.

[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.

[3] 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.

[4] 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.

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.

DESIGNATION OF THE NEW SUBSTANCES.

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.

PREPARATION OF THE SUBSTANCES.

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.[1]—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, 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 1 gramme of chloride of gold, and 50 grains of hyposulphate 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.

MODUS OPERANDI.

First Preparation of the Plate.

Note.—For the sake of brevity in the following description, I will abridge the name of each substance. Thus, I will say, to

[1] 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.

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 fricton 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 be only dried, and not polished.

This concludes the first preparation of the plate, which may be made a long time previously.

Second Preparation.

Note.—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 then rubbed very strongly, and passing several times over the same places, with cotton impregnated with cyanide.

[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.

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 time, 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, in such a manner as 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.

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° Fah. 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 as I have just 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.

[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 acidulating oil and red oxide, to operate 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.

SUMMARY OF THE OPERATIONS.

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.

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.

On the fixed Proof.

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.

On the unfixed Proof.

Alcohol with rouge for removing the traces of oil, and continuing as above, beginning from No. 6, alcohol, &c.

OBSERVATIONS.

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 sensible 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.

In concluding this chapter on the daguerreotype process, 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. 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 and 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
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

GOLD.

Chloride of	Rumford	1798
	Herschel	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
Chromate of	Do.	1843
Deutiodide of	Do.	1843
Nitrate of	Herschel	1840
Protonitrate of	Herschel	1840
Chloride of	Boullay	1803
Bichloride of	Vogel	1806

IRON.

Protosulphate of.
Persulphate of.
Ammonio-citrate of.
Tartrate of.

Attention was first called to the very peculiar changes produced in the iron salts, by	Sir John Herschel	1845
Cyanic compounds of (Prussian blue)	Scheele	1786
	Desmortiers	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 —— with ferroprussiates Iodide of	Do.	1844
TIN.		
Purple of cassius	Uncertain.	
COBALT.	Hunt	1844
Arsenic sulphuret of	Sage	1803
Arsenical salts of ANTIMONY BISMUTH CADMIUM 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 & Thénard	1809
Chlorine (tithonized)	Draper	1842
—— and ether	Cahours	1810
GLASS, manganese, reddened	Faraday	1823
CYANOGEN, solution of	Pelouse and Richardson	1838

METHYLE	Cahours	1846
Crystallization 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
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 phænomena	E. Becquerel	1839

CHAPTER XIII.

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

[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.

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 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 through 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.

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 un-

folding 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.

CHAPTER XIV.

ON THE THEORY OF THE DAGUERREOTYPE.

FEW papers have been published which so completely investigate the phenomena of the daguerreotype, as that of Mr. George Shaw, of Birmingham, who pursued his experiments in association with Dr. Percy. This paper, published in the Philosophical Magazine for December, 1844, we transfer, as giving a large amount of the most valuable information.

"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 care-

fully 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 bromide 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;* 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

* "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."

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 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 *solarization*; 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 experiment 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."

Similar researches have been pursued by M. Claudet, from whose Memoirs we extract the following particulars:—

The phenomena which have not yet been satisfactorily explained, and of which I shall have to treat in the present paper, 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 last meeting of the British Association, which took place at Swansea, I announced 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.

This fact had not been observed before. 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. I have proved this unexpected 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 I have 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. The daguerreotype image is due to this property, which is the most beautiful feature of Daguerre's discovery.

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 my photographometer, to the principle of which I shall presently refer, I have 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 wonderfully 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 I communicated to the Royal Society on the 17th of June, 1847 (see Transactions), and an abstract of which I read before the Association at Oxford, I 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. I 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.

But I 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. It seems, therefore, that I was right in saying that there was no de-

composition of the compound during the short action which is sufficient to give the affinity for mercury, and in ascribing the formation of the image only to that affinity. 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. I must notice here a singular anomaly; 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 develop 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.

I have observed that the iodide of silver without bromine is about 100 times more sensitive than the bromo-iodide to the action of light, which produces 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. This seems another reason for supposing that the two actions are different. 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 I have described, and also explain the anomaly of the continuation of the action of light 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 my own 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. I prove, by a very simple experiment, the comparative photogenic action of rays which have passed through such media, and of those which have met with no similar obstacle; also that media which intercept the photogenic rays can let pass freely the illuminating rays.

If I cover an engraving one-half with light yellow glass, and place it before my camera obscura, in order to represent the whole on a daguerreotype plate, I 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 I 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; 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 photogenic rays; and some others, under which the reverse will take place.

Considering how difficult it is to judge by the eye alone of the photogenic state of light, we can understand why the photographer is constantly deceived in the effect he tries to produce, having no means to ascertain before hand, with any degree of certainty, the intensity of light. For these reasons I turned my attention to contrive an apparatus by which I could test at the same time the sensitiveness of the daguerreotype plate and the intensity of light.

I succeeded in constructing an instrument which I have called a photographometer,—the description of which is given in another page.

By this instrument 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 develops 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 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, 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 same others, long before light has acted as a chemical agent?

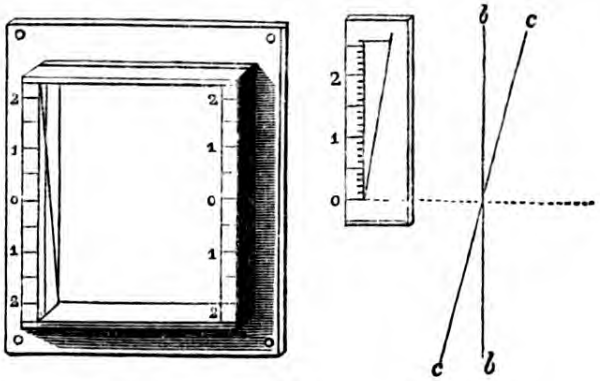
The question of the photogenic focus is involved in another kind of mystery, which requires some attention. I have found that with the same lenses there exists a constant variation in the distance between the two foci. They are never in the same relation to each other: they are sometimes more or less 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 photo-

genic 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 photogenic 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 photogenic 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 photogenic 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 photogenic 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 their dispersive power.

There is no question so important in photography as that which refers to finding the true photogenic focus of every lens for various distances. I have described the plan I have adopted for that purpose. By means of that very simple instrument, every photographer can always obtain well-defined pictures with any object-glasses. But there is another method of ascertaining the difference between the two foci, which has been lately contrived by Mr. G. Knight, of Foster Lane, London. That gentleman has been kind enough to communicate to me the very ingenious and simple apparatus by which he can at once find the exact difference existing between the visual and photogenic focus, and place the daguerreotype plate at the point where the photogenic focus exists. I am very glad he has entrusted me with the charge of bringing his

invention before the British Association. For the scientific investigation of the question, Mr. Knight's apparatus will be most valuable to the optician, as it will afford him the means of studying the phenomenon with mathematical accuracy.

Mr. Knight's apparatus consists in a frame having two grooves;



43.

one vertical, in which he places the ground-glass, and 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.

In addition to these valuable communications, I would give my own remarks as they were formerly published, which, as it appears to me, still satisfactorily express the phenomena.

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.

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, decomposes the film of *ioduret of silver* to different depths, according to the order of refrangibility of the rays: the violet ray effecting perfect decomposition, whilst the red acts to a depth inappreciably slight. Thus it is, that the spectrum impressed on a daguerreotype plate reflects the natural colours, in the same manner as Sir Isaac Newton has shown thin films act under other circumstances; 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 a state of oxide, mixed, in all probability, with some revived metal; but on the silver tablet the iodine is liberated from 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 *ioduret* is removed by the hyposulphite of soda.

Daguerre himself laid much stress upon the necessity of exposing the plate to the mercury at an angle of about 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 ioduret 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.

CHAPTER XVI.

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

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 copper-plate, 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. Brooks, and adopted in some of our magnetic and meteorological observatories.

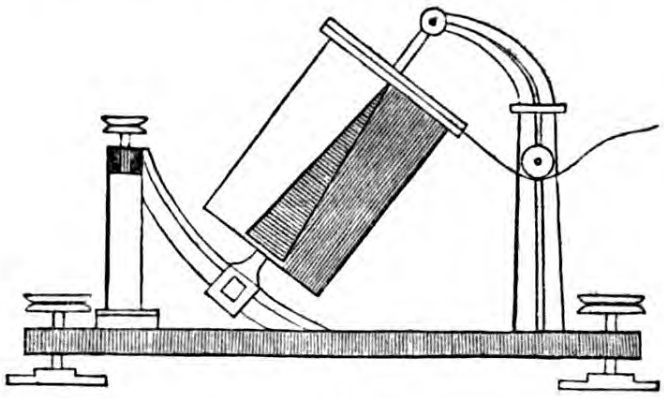
Mr. Brooks attaches a reflector to the end of a delicately suspended magnet; this reflects a pencil of strong artificial light upon photographic paper placed between two cylinders of glass, which are kept in motion by a small clock arrangement. As the paper moves in a vertical direction whilst the magnet 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.

One subject, however, which, at the same time that it is highly philosophical, is of a more popular character, must not pass unnoticed. 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 well-known talents to the inquiry, and have, both of them, devised instruments of great 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 radiation, but also the amount of general illumination in the visible hemisphere, which constitutes daylight; 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.

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 44 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

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

to revolve about this once in twenty-four hours by a clock movement. It has a triangular aperture cut down its whole length, as



44.

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 are expressed 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.

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.

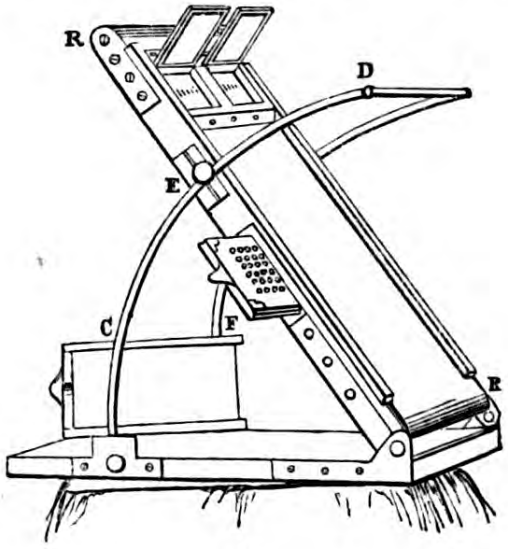
10. Electrical phenomena are quickened by actinism, and retarded by light.

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.

THE PHOTOGRAPHOMETER.

Mr. 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:—

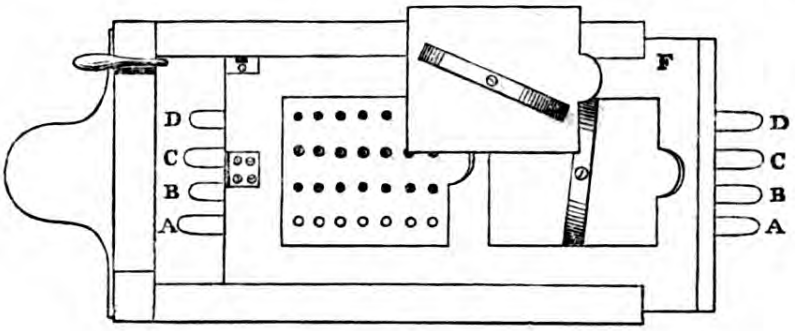
The accompanying figure (45) shews the photographometer complete. The sensitive plate or paper is placed in a dark box,



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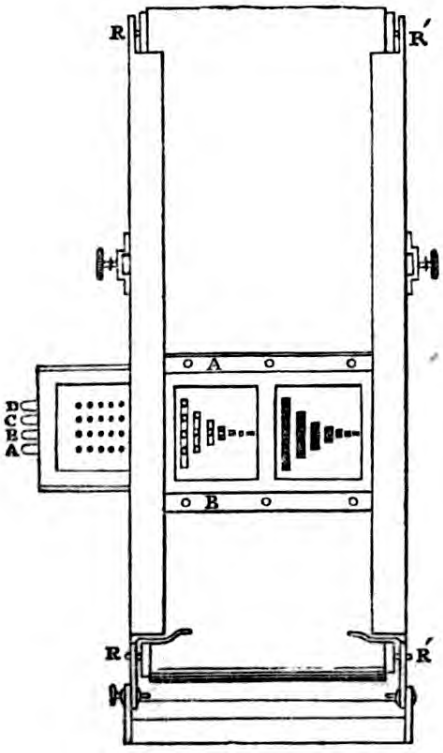
which is fixed in an independent frame, as shewn, Figs. 46 and 47, and as placed in its position at F in the adjoining cut. A black

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 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



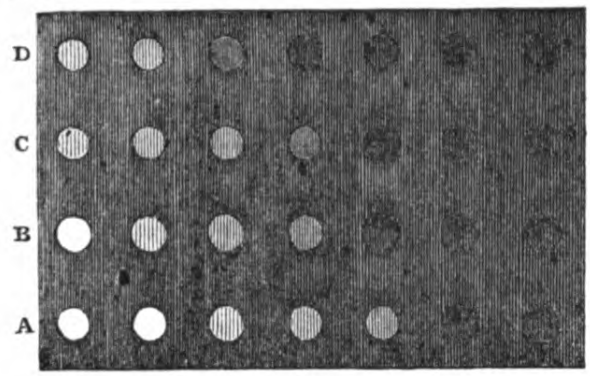
46.

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.

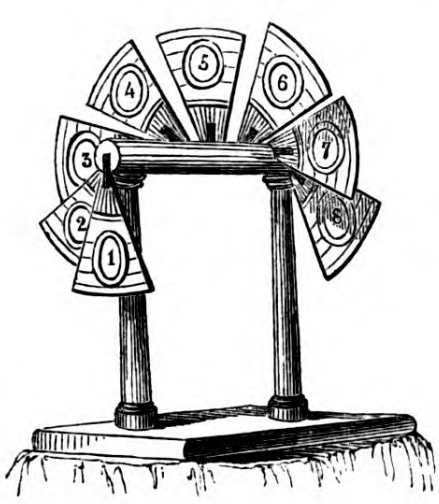


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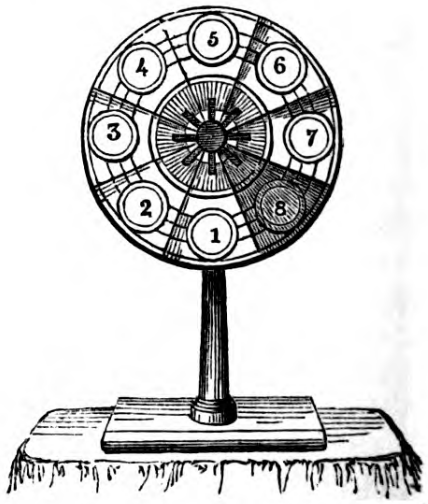
The box in which the plate or paper is placed for experiment, is pierced with holes, and these correspond with the slits in A B. (fig. 47.) By inclining the instrument, which can be very readily done to any degree, by means of the curved arms C D E, any velocity can be given to the falling screen, and thus the plate be exposed to the action of the chemical rays for any period of time we please. Fig. 48 shows the result obtained on a plate by this instrument; the letters corresponding with the holes in the other wood-cuts. In Fig. 47 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.



48.



49.



50.

THE FOCIMETER.

Mr. Claudet has also devised a very ingenious instrument for focusing, which he calls his Focimeter. (Fig. 49.) 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 (50), 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.

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.

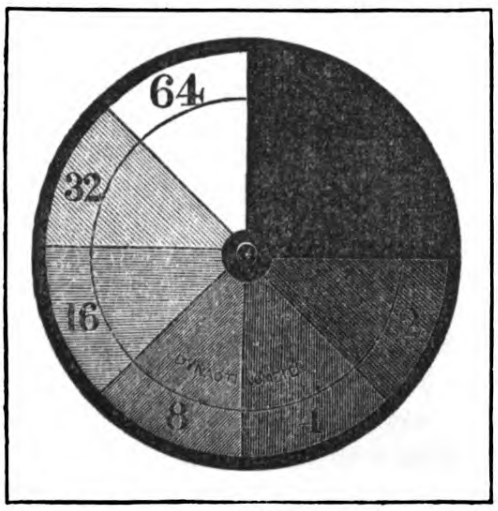
If a daguerreotype plate receive the image of the dynactinometer during its revolution, it is obvious that each segment indicates an effect in proportion to the intensity of light and to the time that it has remained uncovered; also that the number of seconds marked on the first segment visible is the 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

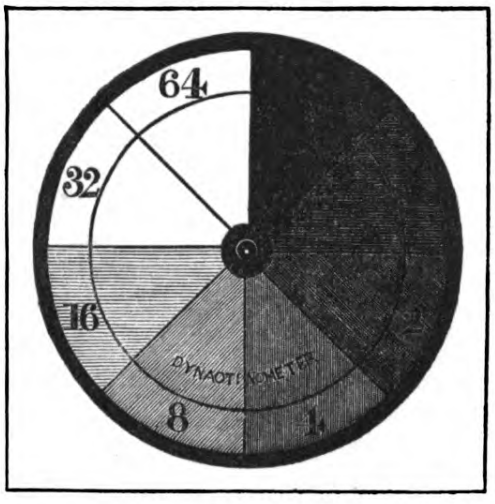
seconds in order to produce an effect in the camera obscura; and if, on the other plate or paper, the first seven segments have remained black, and the eighth segment is the first upon which the light has operated, the conclusion will be that the object-glass which has produced the effect on the first 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.



51.



52.

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. 47, will indicate the sensitiveness of the plate; and in comparing the two images given by the dynactinometer, Fig. 51, 52, 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.

CHAPTER XVI.

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; 2d, the blue, the green, and a portion of the yellow rays; 3d, the green, 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 colorific 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 copperplate, 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 colour. 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; and still more recently Mr. Hill, of New York, states that he has obtained more than fifty pictures from nature in all the beauty of native colouration. This process is not disclosed, but we are assured that it is a modification of the daguerreotype—one material, quite new, being introduced—and as soon as the manipulatory details are perfected the whole is to be published.

CHAPTER XVII.

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 it as a final chapter to this treatise on Photography, merely reprinting my original communication on the subject.

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 Konigsberg, "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 more than an ordinary degree of interest. A discovery of this kind, changing, as it did, the features, not only the theories of light adopted by philosophers, but also the commonly received opinions of mankind, was more calculated to awaken attention than anything which has been brought before the public since the publication of Daguerre's

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

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 nasturtium 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 mercuria-

lisation, 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 beautifully 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

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

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 pure 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.

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Wilson and Ogilvy, 57, Skinner Street, Snowhill, London.

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AND

MATERIALS,

ON SALE BY

JOHN JOSEPH GRIFFIN AND COMPANY,

CHEMICAL MUSEUM, 53, BAKER STREET, LONDON;

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JULY, 1851.

THE Articles contained in the following List are all made by the best London and Paris workmen, and the Prices will be found unusually moderate. Arrangements have been made to add to the Stock every New Instrument and Reagent useful in the Art, and they will at all times be charged at the lowest Prices.

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SETS OF CALOTYPE APPARATUS.

No. 1.—COMPLETE SET OF APPARATUS FOR THE CALOTYPE PROCESS,

For taking pictures on paper 5 inches square, including a sliding Camera, mounted, with meniscus lens and sliding adjustment (figure 14), 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, stoppered bottles, and a supply of the following chemicals:—acetic acid, gallic acid, ammonia, iodide of potassium, nitrate of silver, hyposulphite of soda; the whole packed in a coloured deal case, with lock, key, and handles, £3. 13s. 6d.

No. 2.—Complete Set of Calotype Apparatus,

As above enumerated, with an additional stock of chemicals, and photographic paper, adapted for travellers going abroad, or for exportation, £4. 10s.

No. 3.—Complete Set of Calotype Apparatus,

For obtaining pictures on paper, 7 inches by 6 inches, including a portable folding camera, figs. 20, 21, and 22, 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 all the paper and glass processes, including acetic acid, nitrate of silver, iodide and bromide of potassium, hyposulphite of soda, gallic and succinic acid, protosulphate and ammonia-citrate of iron, ferro-cyanide of potassium, bichromate of potash, sulphate of copper, collodion, and ammonia, in strong glass bottles. The whole packed in two neat coloured deal cases, adapted for travelling, £7. 7s.

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.

No. 4.—Complete Set of Daguerreotype Apparatus,

For obtaining pictures on plates up to 4¼ inches by 3¼ inches, including a sliding camera, fig. 36, with achromatic lens mounted in brass, rack and pinion adjustment; three dark frames; focusing glass in frame; iodine and bromine pans, with glass covers and frames; three plate boxes; plate holder; two polishing buffs; mercury box with thermometer; washing tray, and stand of best porcelain; spirit lamp; pliers; gilding stand on foot, with adjusting screws; glass funnel; packet of 100 filters in box, with the necessary chemicals and polishing substances. The whole packed in two neat coloured cases, with lock, key, and handles, £6. 6s.

No. 5.—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; three dark frames; a focusing glass; improved iodine and bromine apparatus; three plate boxes; plate holder; polishing buffs; mercury box with thermometer; washing tray and stand; spirit lamp; pliers; fixing stand, and the necessary chemicals in stoppered bottles. The whole packed in two boxes, with lock, key, and handles. Price £9. 9s.

No. 6.—The same Apparatus for larger Plates,

Up to 6½ inches by 4¾ inches, complete, in cases. Price £16. 16s.

No. 7.—The same Apparatus for larger Plates,

Up to 8½ inches by 6½ inches, including a full supply of every article necessary for the processes on paper, glass, and silver. Price £31. 10s.

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No. 1.—Daguerreotype Camera, with sliding front,

Of mahogany or walnut, fitted with three dark frames for plates, 2½ inches by 2 inches, 2¼ inches by 2¾ inches, and 4¼ inches by 3¼ inches, mounted with an achromatic lens, 1¾ inch in diameter, fig. 14, with rack and pinion adjustment. Price £1. 15s.

No. 2.—Sliding Daguerreotype Camera,

Of mahogany or walnut, fig. 36, fitted with ground focusing glass and folding shutters; three dark frames for plates, 2½ inches by 2 inches, 3¼ inches by 2¾ inches, and 4¼ inches by 3¼ inches; single achromatic lens, 1¾ inches in diameter, mounted in brass, with rack and pinion adjustment. The camera is so arranged, that lenses of different foci may be employed, and the plates used either upright or lengthwise, and may be used for the calotype by placing the sensitive paper between two plates of glass occupying the same position as the dark frames for the plates. Price £2. 15s.

No. 3.—Daguerreotype Camera,

Same construction and size as the last, but with a double combination of achromatic lenses, mounted in brass, with adjustment. Price £3. 13s. 6d.

No. 4.—Daguerreotype Camera,

Same construction but of larger size, with double combination of achromatic lenses, and six dark frames for plates, up to 6½ inches by 4¾ inches. £6. 10s.

No. 5.—Daguerreotype Camera,

Larger size, with seven dark frames, for plates up to 8½ inches by 6½ inches. Price £12.

CAMERAS FOR THE CALOTYPE OR TALBOTYPE PROCESS.

No. 1.—Calotype Camera,

Of mahogany or walnut, with brass sliding front and meniscus lens, 1¾ inches in diameter, ground focusing glass and extra frame for the prepared paper, capable of producing pictures 5 inches square. £1. 10s.

No. 2.—Calotype Camera, similar to No. 1.

Fitted with achromatic lens, mounted in brass, with rack and pinion adjustment. £1. 18s.

No. 3.—Calotype Camera,

Of mahogany or walnut, capable of producing pictures 7 inches square, fitted with meniscus lens, 2 inches in diameter, in sliding tube adjustment, and two frames, one for the focusing glass, and the other for holding the prepared paper. Price £2. 2s.

Ditto, fitted with achromatic lens, mounted in brass, with rack and pinion adjustment. Price £2. 12s. 6d.

No. 4.—Calotype Camera,

Of mahogany or walnut, capable of producing pictures 10 inches square, fitted with meniscus lens 2¼ inches diameter, in sliding brass adjustment, focusing glass in frame, and frame for prepared paper. Price £2. 10s.

No. 5.—The same Camera as No. 4.

Fitted with achromatic lens, mounted in brass, with rack and pinion adjustment. Price £3. 3s.

No. 6.—Calotype Camera,

Of mahogany or walnut, capable of producing pictures 12 inches square, fitted with achromatic lens, 2½ inches diameter, mounted in brass, with rack and pinion adjustment; focusing glass in frame, and frame to receive the prepared paper. Price £4. 4s.

No. 7.—Portable Calotype Camera for Travellers,

which packs up into a very small compass, figs. 20, 21, 22, consisting of a mahogany 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, 2¼ inches diameter, mounted in the best manner, with rack and pinion adjustment, capable of producing a picture 7 inches by 6 inches. Price £4.

ACHROMATIC LENSES, without Cameras.

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, and with greater distinctness, than a single lens.

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2. A Double Combination of Achromatic Lenses, 2·4 inches in diameter, having a combined focus of about 10 inches, mounted in brass, with rack and pinion adjustment, producing a picture 6½ inches by 4¾ inches. Price £4. 10s.

3. A Double Combination of Achromatic Lenses, 3·2 inches in diameter, having a combined focus of about 12 inches, mounted in brass, with rack and pinion adjustment, producing a picture 8½ inches by 6½ inches. Price £9.

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 just described must be employed.

1. Single Achromatic Lens, 1¾ inch in diameter, 7 inch focus. Price 9s.
2. Ditto, mounted in brass, with rack and pinion adjustment. Price £1. 5s.
3. Single Achromatic Lens, 2 inches in diameter, 8 inch focus. Price 12s. 6d.
4. Ditto, mounted in brass, with rack and pinion adjustment. Price £1. 15s.
5. Single Achromatic Lens, 2¼ inches in diameter, 10 inch focus. Price 16s.
6. Ditto, mounted in brass, with rack and pinion adjustment. Price £2.
7. Single Achromatic Lens, 2½ inches in diameter, 14 in. focus. Price £1. 1s.
8. Do. mounted in brass, with rack and pinion adjustment. Price £2. 12s. 6d.

MISCELLANEOUS APPARATUS.

Improved Mercury Box, of walnut or mahogany, with sliding legs, cast iron cistern, glass windows for inspecting the development of the picture, mounted with thermometer for ascertaining the temperature of the mercury.

No. 1, with three frames for plates up to 4¼ inches by 3¼ inches. 18s.
No. 2, with five frames for plates, up to 6½ inches by 4¾ inches. £1. 4s.
No. 3, with six frames for plates, up to 8½ inches by 6½ inc. £1. 12s. 6d.

Mercury Bottle, of box-wood, for holding the mercury necessary for use with the mercury box, not liable to fracture, 2s. each.

Daguerreotype Spirit Lamp, with screw cap, japanned tin, for heating mercury box, 2s.

Thermometer for the mercury box, 5s.

Improved Double Iodine and Bromine Box, of walnut or mahogany, enclosing two stout porcelain pans: each pan is furnished with an air-tight glass cover. On the upper edge of the box is a groove, in which slides the frame 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 slid over the bromine pan, 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 slid 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.

No. 1. with three frames for plates up to 4¼ inches by 3¼ inches, £1. 15s.
No. 2. with five frames for plates up to 6½ inches by 4¾ inches, £3.
No. 3. with six frames for plates up to 8½ inches by 6½ inches, £4. 10s.

SQUARE PORCELAIN DISHES, with air-tight glass covers, for either bromine or iodine mixtures; the body and glaze firm and compact, and not liable to be acted on by any photographic compound.

No. 1. For plates up to 4¼ inches by 3¼ inches, with three dark frames for holding the plates, 5s.

No. 2. For plates up to 6½ inches by 4¾ inches, with five dark frames for holding the plates, 7s. 6d.

No. 3. For plates up to 8½ inches by 6½ inches, with six dark frames for holding the various sizes of plates, 10s. 6d.

GRADUATED GLASS PIPETTE, for dosing the bromine, 3s. 6d.

DAGUERREOTYPE PLATES, of a superior manufacture—

No. 1 size,	2 inches by 2½ inches,	6s. 6d. per dozen.
2 size,	2¾ inches by 3¼ inches,	10s. 0d. per dozen.
3 size,	3¼ inches by 4¼ inches,	14s. 0d. per dozen.
4 size,	4 inches by 5 inches,	£1. 1s. 0d. per dozen.
5 size,	4¾ inches by 6½ inches,	£1. 10s. 0d. per dozen.
6 size,	6½ inches by 8½ inches,	£2. 12s. 6d. per dozen.

Daguerreotype plates sometimes contain so thin a layer of silver, that even with the greatest care the copper will shew itself after the plate has been used to obtain two or three pictures. The plates above enumerated are of a superior description.

MAHOGANY OR WALNUT BOXES, fitted with grooves for holding 24 plates, fig. 39.

No. 1. For holding the No. 1 plates, 3s. 6d. each.

2. For holding the No. 2 plates, 3s. 6d. each.

3. For holding the No. 3 plates, 3s. 6d. each.

4. For holding the No. 4 plates, 5s. each.

5. For holding the No. 5 plates, 6s. each.

6. For holding the No. 6 plates, 7s. each.

APPARATUS FOR RE-SILVERING 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 12s. 6d.

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.*

PLATE-HOLDER, for holding the small size plates while being cleaned and buffed. Price 1s. 6d.

PLATE-HOLDER, French pattern, for securing the plates firmly and conveniently, for Nos. 1, 2, and 3 plates. Price 4s. each.

Ditto, ditto, for Nos. 4 and 5 plates. Price 5s. each.

Ditto, ditto, for No. 6 plates. Price 6s.

APPARATUS for bending the edges of Daguerreotype plates, so as to prevent the sharp edges cutting the buffers in buffing. Price 9s.

HAND BUFFS, covered with velvet, full size. Price 3s. 6d. each.

FINELY-CARDED COTTON-WOOL, freed from grease, &c. Price 3d. per oz.

FIXING STAND, with iron foot, and levelling screws, for supporting the plates while fixing, fig. 41.

No. 1, for plates up to 4¼ inches by 3¼ inches. Price 4s. 6d.
2, for plates up to 8½ inches by 6½ inches. Price 6s. 6d.

APPARATUS FOR DRYING DAGUERREOTYPE PLATES, consisting of a flat-shaped copper vessel, tinned inside; a holder for the plate, and a support, fig. 42.

No. 1, for plates up to 4¼ inches by 3¼ inches. Price 7s.
2, for plates up to 6½ inches by 4¾ inches. Price 9s.
3, for plates up to 8½ inches by 6½ inches. Price 10s. 6d.

GLASS FUNNEL, for filtering the fixing solution, 2 inches in diameter. Price 4d.

CIRCULAR FILTERS to suit the funnel, cut ready for use. The packet of 100, 7d.

SUPPORT FOR PLATES DURING WASHING, French porcelain, to be used with the shallow porcelain dishes, fig. 25, B.

No. 1, 6 inches by 4½ inches.
2, 7 inches by 5¾ inches.
3, 9½ inches by 7½ inches.

STEEL PLIERS for holding the plates whilst drying off. Price 2s.

CLAUDET'S APPARATUS for ascertaining the exact difference between the chemical and visual focus of lenses. Price £1. 10s.

PARALLEL MIRROR, mounted in brass, for attaching to the front of the lenses, when portraits, views, &c. are required to be taken in correct positions by the Daguerreotype process.

No. 1, Mirror, 2¼ inches by 3 inches, mounted in brass. Price £1. 10s.
2, Mirror, 4 inches by 3 inches, mounted in brass. Price £2. 10s.

STAND for supporting the camera in taking portraits and views, &c., fig. 23. Price 16s.

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. Price 7s. 6d.

PREPARED COLOURS, for colouring Daguerreotype Pictures, in boxes containing 10 different colours in bottles, gold and silver shells, prepared brushes, &c., complete. Price 16s.

MOROCCO LEATHER CASE, lined with silk velvet, fitted with oval or square gilt mat, glass and cover.

No. 1, for plates, 2½ inches by 2 inches. Price 15s. per dozen.
2, for plates, 3¼ inches by 2¾ inches. Price £1. 4s. per dozen.
3, for plates, 4¼ inches by 3¼ inches. Price £1. 10s. per dozen.
4, for plates, 5 inches by 4 inches. Price £2. 2s. per dozen.

PASSE-PARTOUT, or cardboard frames and glasses, elegantly ornamented, for holding Daguerreotype Pictures.

No. 1, for plates 2½ inches by 2 inches. Price 8s. per dozen.
2, for plates 3¼ inches by 2¾ inches. Price 9s. per dozen.
3, for plates 4¼ inches by 3¼ inches. Price 10s. per dozen.
4, for plates 5 inches by 4 inches. Price 1s. 3d. each.
5, for plates 6½ inches by 4¾ inches. Price 1s. 6d. each.
6, for plates 8½ inches by 6½ inches. Price 2s. 6d. each.

SHALLOW PORCELAIN DISHES, with flat bottoms, for containing the solutions in the preparation of paper for the Calotype Process, &c.—fig. 25 A.

No. 1, 5 inches by 7 inches, 1s. 6d.
2, 7½ inches by 10 inches, 2s. 6d.
3, 11 inches by 14 inches, 4s. 6d.

CAMEL'S-HAIR PENCILS for Photographic Purposes,
2 inches wide. 1s. 6d. each.
3 inches wide. 2s. 6d. each.

GRADUATED GLASS MEASURE for measuring drachms, in making the Gallo-nitrate of Silver. Price 1s. 6d.

PRESSURE FRAMES, for producing Positive Pictures, copying Botanical Specimens, Flowers, &c. figs. 8 and 9.

No. 1, for pictures 6 inches by 5 inches. Price 7s. 6d.
2, for pictures 8½ inches by 6½ inches. Price 9s.
3, for pictures 12 inches by 10 inches. Price 12s.

IMPROVED PRESSURE FRAME, so constructed that the development of the picture may be ascertained without shifting the paper.

No. 1, for pictures 8½ inches by 6½ inches, £1.
2, for pictures 12 inches by 10 inches, £1. 5.

STEAM APPARATUS FOR DEVELOPING THE PHOTOGRAPHIC PICTURE by a jet of steam. Price 6s.

The employment of this apparatus prevents the browning of the picture which sometimes takes place when a dry heat is employed.

OIL LAMP, with yellow glass shade, for viewing the development of the Daguerreotype Picture, preparing sensitive paper for the Calotype, &c. Price 4s.

BALANCE, and set of weights, with steel beam and brass pans, in oak box. Price 3s.

BALANCE, and set of weights, with steel beam of superior make, and glass pans, in mahogany box. Price 10s. 6d.

DISTILLING APPARATUS for preparing pure water; a tin-plate still of one gallon capacity, with a worm-tub, complete. Price 16s.

Stoneware Water Bottle, with stopcock, 1 gallon size, for holding distilled water. Price 4s.

PAPER FOR CALOTYPES.

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