If this axis be held horizontally for obliquely, and a rotary motion be given to the bar about it, on letting the axis go, the weight will no longer bring it down, nor alter its inclination at all, but will cause the whole to turn in azimuth, in a direction opposite to that of rotation.

Application of the Microscope to Photography. By the Rev. W. TOWLER KINGSLEY.*

The author commenced by a brief account of the laws of refraction, the nature of the prismatic spectrum, and the separation of a ray of light into the heating, light-giving, and chemical rays; he then said—

I shall now proceed to state what is the nature of the change produced by the action of light on silver salts. We may easily conceive that the molecules of the simple substances of which a compound body is formed are capable of different periods of vibration, like two strings of different note; and hence, if the vibrations of the luminiferous ether are taken up by one substance and not by the other, and the chemical affinity of the one for the other is at the same time feeble, chemical decomposition would ensue. This, at any rate, seems to be a reasonable view of the case. The salts of silver are very easily decomposed, and there is always a tendency in them to allow the silver to return to the metallic state. For instance, the oxide of silver is reduced to the metal by heat with great ease, or by placing it in contact with any substance that has a considerable affinity for oxygen. This action, however, is much more rapid if the process be carried on in strong sunshine. The iodide of silver follows the same law; but bromine and chlorine have a greater affinity for silver than iodine; and if we expose iodide of silver to the action of bromine or chlorine, or of both in order, we shall disturb the feeble affinity of the iodine for the silver, and render the compound so unstable that the action of light is quite able to reduce the metal; and if we stop short before we reach this point, it is still possible to carry on the further reduction of the metal by the use of substances which have a slightly greater affinity for the iodine than the silver has in its now altered condition. This process constitutes the whole practice of photography; for though other metals than silver can be used for the purpose, it is the cheapest as yet known that possesses the property of returning to its simple form with sufficient ease for the purpose.

The process of Daguerre, as now practised, is to expose a polished and clean silver plate to the action of the vapor of iodine, and then, for a very short time, to that of bromine, and then a second time to that of iodine. This treatment coats the plate with iodide of silver, and then liberates a portion of the iodine, bromine taking its place. The image of the object to be delineated is now formed upon the plate, and then the plate is exposed in the dark to the action of the fumes of mercury, which in a short time whiten the parts that the light has acted on. It used to be thought that the image was formed by particles of mercury being deposited upon the surface of the silver. This, however, I am sure, is quite a mistake; and though I am unable to explain the whole action that takes

* From the Journal of the Society of Arts, London, No. 25.

place, I have no doubt of the nature of it. The vapor of mercury has a decided affinity for oxygen, iodine, bromine, and chlorine; when, therefore, the plate is exposed to it, the vapor deprives the iodide of silver of its iodine, and deposits pure silver. When bromine and chlorine are also present, silver is reduced, and at the same time salts of mercury are formed; and I have no doubt that the different colors of the lights, according to the different proportions of iodine, bromine, &c., are due to these salts of mercury; but as the quantity is very minute, it is a matter of great difficulty to detect them,—calomel and the black oxide I have detected. After the plate has been acted upon by the mercury, it is fixed by first removing the unreduced iodide by a bath of hypo-sulphite of soda, and then by gilding it slightly with hypo-sulphite of gold. If the action of the light be too strong, metallic silver is formed at once, and then the mercury unites with it, and forms an amalgam that is not as light in color as the silver reduced in the first instance. This seems to be one of the points where there is hope of gaining by further experiments; for if some way of reviving the silver on those parts of the plate where the light has not actually reduced the silver can be discovered, without destroying the revived parts, we should be able to make sure of every plate by merely giving time enough to the exposure to the light. I may mention that the vapor of aldehyde gives promise of effecting this object. As a deoxidizing or deiodizing agent, it is most powerful, but the difficulty is to restrain its action. For the microscope, Daguerreotype plates prepared in the usual manner are quite capable of receiving an impression in about a minute's exposure. These impressions, however beautiful, will never be as useful as those taken on glass or paper, and which admit of being copied photographically.

The most simple process is that known under the name of the Collodion Process, introduced by Mr. Scott Archer.

It is not worth while to describe the method of making collodion, as it can be bought ready made as cheap as it can be made. With it a very small quantity of iodide of silver, dissolved in iodide of potassium or in cyanide of potassium, is mixed. This is now to be poured on a plate of glass, and the excess poured off again, so as to leave a film of the preparation on the glass surface. The plate is now to be plunged into a bath of nitrate of silver, 30 grains to the ounce of water; and as soon as the whole of the plate will retain the water without running into streaks, the plate is to be exposed to the action of the light; then it is to be plunged into a bath of pyrogallic acid, 3 grs.; water, 1 oz.; glacial acetic acid, 1 drachm. This deiodizing and deoxidizing bath develops the image; the unreduced iodide is then to be removed by hypo-sulphite of soda. This is the ordinary process, and the method is simple and good. If we add to the collodion mixture a small quantity of iodide or bromide of iron, and develope with protonitrate of iron, the process is rendered much more energetic; for we obtain on the plate, as soon as it goes into the silver bath, nitrate of iron, which deiodizes the plate as soon as the light strikes it. I do not find these preparations of iron to keep well, and therefore the preparation should be made only a short time before it is to be used. Iodide and bromide of arsenic are also admirable accelerators, and appear to keep for months without change; with them either the pyrogallic solution

or protonitrate of iron may be used. I do not think that the collodion process will be as good as the paper processes, because it is a very difficult matter to coat large glass plates; and after they are finished, they take up a great deal of space; also, they are more troublesome to take positives from.

I may here mention that albumen, treated exactly the same as the collodion, only dried and heated after being poured on the glass, acts just as well and as quickly.

I shall now describe the method of preparing the paper I use. I have no doubt that many others are just as good.

I prefer Canson's paper, and use it either waxed or not, with nearly the same results; but the waxed paper is the more easily managed, on account of its not becoming so tender from soaking. The paper is first to be soaked for some hours in a bath as composed below:

Distilled water, 1 pint;
Iodide of potassium, half-an-ounce;
Bromide of potassium half-a-drachm;
Fluoride of potassium, 1 drachm;
The whites of two eggs.

If this is done under the air-pump, so much the better. The paper is now to be hung up to dry, sheet by sheet; and so prepared, it keeps well, certainly for months. If arsenic be added, as in the collodion, the paper is more sensitive. When it is to be used, it is to be plunged into a bath composed as follows:

Nitrate of silver, 30 grains;
Acetic acid, half-a-drachm;
Distilled water, 1 ounce.

After the paper has become saturated in this bath, it is to be placed on a sheet of pure blotting paper, and that on a sheet of glass, on which it will adhere from the superabundant fluid; it is now to be exposed to the action of the light for the required time, which of course depends upon the intensity of the light; with my microscope, from two to five minutes is quite enough. It is then to be developed in a bath of saturated gallic acid; if the image does not seem dark enough in an hour, a few drops of the silver bath should be added. Hypo-sulphite of soda as usual is the fixing agent. The silver may be used over and over again, if it be filtered with animal charcoal after each time it is used, or as soon as it shows the least sign of becoming discolored.

In these processes we have the affinity for the iodine disturbed by the action of the light; the developing agent carries this further, and the oxygen of the air or water or acid, which has always a slightly greater affinity than iodine for silver, combines with the liberated silver, and produces the dark parts of the impression; if the action is carried still further, we get the silver revived; and in the collodion process this produces a positive. To obtain these collodion positives, the quantity of silver in the collodion should be small, and the exposure only for an instant; after the plate is developed and fixed, it should be put into a bath containing either aldehyde or grape sugar, which will revive the silver with great bril-

liancy. The paper pictures may be developed by placing them in the mercury box, but it is not a good way of doing it. There is one use of the collodion which is of service. In the use of very high powers with very delicate objects, it is not easy to see the image formed on the vesiculine screen as described hereafter. When therefore an approximate focal distance has been obtained, a collodion positive on a small scale of a portion of the image can be taken in a few moments, and so the correctness of the arrangements tried before placing the paper in its place.

I shall now proceed to describe the instrument I use. Sunlight is of course far superior to any artificial light, when we can obtain it; but as the sun will not shine whenever we choose, it is of the greatest importance to construct the instrument for artificial light, and then modify it so as to be applicable to sunlight. The light I use is the common oxyhydrogen light; magnesia or quartz may be substituted for lime ball with advantage.

The optical parts of the instrument divide themselves into four groups. The light collecting, the condensing, the objective and magnifying lenses. The first group for collecting the light consists of three lenses; the first a meniscus of about three inches focal length and two and a half diameter, the second plano-convex, and the third a double convex with the radii of the surfaces one and six. The focal lengths of these two lenses being respectively six and eight inches.

The second group, or condensing lenses, is a similar one turned the other way and on reduced scales to suit the different object glasses; between these two systems there is a plano-convex placed at its focal length from the focus of the collectors, so as to allow the rays to pass parallel to the condenser. This lens and the condensers must be changed with the object glasses; for it must be borne in mind that we have to arrange the instrument so as to make the image of the lime ball just cover the paper to be acted upon; and so if we diminish the focal lengths of the condensers at the same time that we increase the magnifying power of the instrument, we shall have just as great an amount of light with the highest as with the lowest powers.

The next group of lenses are those of the object-glass, which requires to be very much under corrected for visible color, leaving strong red fringes. A very simple way of making the object-glasses of an ordinary good microscope do for photographic purposes is to have a new front lens made for them; so that they can be used for either the ordinary or the photographic microscope. At this point of the arrangement we have a very good form of the oxy-hydrogen microscope; but it is a bad one for photography, as we cannot have the screen on which the image is to be formed, so near, as to enable us to use the slow motions of the various arrangements at the time we are looking at the image, except for very low powers.

We now come to the last group, which occupies the place of the eye-piece of the ordinary compound microscope. This group is a form of the Ramsden or positive eye-piece, which ordinarily consists of two plano-convex lenses, placed at two-thirds their focal length, which is the same in both, and with their plane sides out. This eye-piece is not achromatic, being under corrected. The addition of a plano-concave flint lens to a double convex crown, is used by me in the place of the lens next the

object. This enables me, by a slight change of distance, to make the correction perfect.

I have only to describe the best way of using this instrument; and here, it must be remembered, that all depends upon the object-glass being good; it is very easy to get one of small angle that will give very short outlines of objects, but we must not be content with such images as these; we must get object-glasses of large angular aperture, made perfect for this purpose, so as to show well the structure of objects, as well as their outlines. This is quite feasible. Suppose, then, that we have got a perfect instrument.

At the place of the focus of the object-glass place a screen of æsculine, and a dark blue glass between the collectors and condensers; we shall now, "thanks to Professor Stokes," see the chemical image; and the correction for spherical aberration must now be made in the ordinary manner. Now put in the eye-glass or magnifier, and the æsculine at the screen, and adjust the focus. This focus will be found even in the case of chemically corrected lenses, beyond the visible; but in the case of the ordinary best object-glasses, the difference is enormous; for instance, in the case of a very fine one-fifth in my possession, if I form an image at one foot from the eye-glass, I find the chemical image ten feet further back; of course, such a lens is of *no* use for photography.

The æsculine also enables one to see at once when the light on the screen is the most intense for chemical action.

In conclusion, I have to state that one of the specimens sent was taken upon a disk of five feet diameter, which was illuminated equally, and therefore anything may be taken on that scale on paper with artificial light, and I dare say on a very much larger scale still. I look upon it, therefore, that we must give our chief attention to the corrections of the lenses, as all the other parts of the process seem to require little further than mere care in the use of common formula. I have also to add, that the focal length of the condenser being selected, in order to give the image of the incandescent spot of lime on the right scale, its angular aperture should be a shade less than that of the object glass.

Also, if a spot of tin-foil be placed on the condenser, we can get the object bright on a dark ground; and if an opaque object be placed in the focus of the collecting lenses, and the object-glass and eye-piece be turned round to the front of the object, a very good image may be got with low power.

Mr. FOSTER, as an amateur in photography, wished to express his high sense of importance of Mr. Kingsley's experiments, especially with regard to lenses, in respect to which they were far from having arrived at perfection. The data, however, furnished by Mr. Kingsley's experiments would, he trusted, lead to results more satisfactory than had hitherto been gained.

A Gentleman, referring to some of the experiments Mr. Kingsley had just shown, asked if there were anything peculiar in his mode of bringing out the Daguerrean image?

Mr. Kingsley said he had merely performed the experiment in question for the purpose of showing that the development of the image on a daguerreotype plate did not depend, as some suppose, on the precipitation of mercury on its face. The agent he had used for that purpose was merely a solution of common pyro-gallic acid.

The Chairman said, that as by means of the microscope beauties were discovered which were not seen before, he wished to ask Mr. Bowerbank to what extent these magnified images might be again magnified, and what advantages might be obtained by the process?

Mr Bowerbank said, no good was to be gained by magnifying any object beyond the point of obtaining a good definition. Referring to one of the specimens exhibited, he remarked that it was even too large to be of service for the purpose of physiological science; whereas, had it been taken by a low-power glass, with considerable penetration, instead of by a high-power glass with a large angle of aperture, he thought Mr. Kingsley would agree with him that it would have been better. With the greater number of microscopic objects, increase of size was not so much to be desired as extreme penetration. He was glad to see the progress which Mr. Kingsley and some other gentlemen were making in this department of the photographic art. In the last number of the *Microscopic Journal*, he understood there were one or two figures given, showing not only the possibility but the probability that periodicals would be illustrated in this manner, and thus much greater accuracy obtained than could be arrived at by means of the pencil. He hoped the time was coming, when photographic pictures in journals would be as common as those by the *camera lucida*.

Mr. Varley confirmed the observations of Mr. Bowerbank.

Mr. Samuel Highley, Jun., said that the value of the application of photography to the microscope could not as yet be sufficiently estimated; but undoubtedly it would perform a very important part in the advance of the science of microscopy, for not only were we enabled to multiply and distribute delineations of scarce objects, and thereby elicit the opinions of other observers, but in many instances where there was diversity of opinion and contradictory statements regarding minute structure, it would aid others in forming an opinion as to what had really been seen; as a faithful representation of what existed in the field of the microscope was insured to us, entirely free from the suspicion of having been delineated by a hand biased by pre-conceived ideas. With the permission of the meeting, he would read a letter which he had that day received from Mr. Fox Talbot, as it conveyed information as to the first employment of sensitive media for securing delineations of magnified objects.

“LACOCK ABBEY, May 10, 1853.

“DEAR SIR:—I have great pleasure in replying to your question. The first person who applied photography to the solar microscope was undoubtedly Mr. Wedgwood, as appears by his paper in the *Journal of the Royal Institution* for 1802; but none of his delineations have been preserved, and I believe that no particulars are known. Next in order of time to Mr. Wedgwood's, came my own experiments. Having published my first photographic process in January, 1839, I immediately applied it to the solar microscope, and in the course of that year made a great many microscopic photographs, which I gave away to Sir John Herschell, Sir Walter Calverley Trevelyan, and other friends. The size of these pictures was generally that of a half sheet of writing paper, or about eight inches square. The process employed was my original process, termed by me at first “Photogenic drawing,” for the calotype process was not yet invented. I succeeded in my attempts, chiefly in consequence of a careful arrangement of the solar microscope, by which I was enabled to obtain a very luminous image, and to maintain it steadily on the paper during five or ten minutes, the time requisite. From the negative, positives were made freely, in the usual way. The magnifying power obtained was determined by direct measurement of the image and the object itself, which gave for result a magnifying power of seventeen times in linear dimensions, and consequently of 289 in surface. The definition of the image was good. After the invention of the calotype process, it became of course a comparatively easy matter to obtain these images; and I then ceased to occupy myself with this branch of photography, in order to direct my whole attention to the improvement of the views taken with the camera.

I remain, &c.,

H. F. TALBOT.

“Mr. Samuel Highley, Jr.”

In a letter to the editor of the *Athenæum*, which appeared in that *Journal* last summer, Mr. Dallas again drew attention to the application of photography to the microscope, and stated that he had obtained very favorable results; but he did not give the details of the means employed. In the autumn of last year, whilst in Edinburgh, he (Mr. Highley) had an opportunity of seeing some of these views, but they were wanting in definition. In October, 1852, Mr. J. Delves introduced to the notice of the Microscopical Society, some very beautiful Collodion positive and negative pictures, in which the definition was

extremely sharp. This Mr. Delves attained by removing the eye-piece of the microscope, and inserting that end of the body into a dark chamber or camera, twenty-four inches in length; beyond this point the image was not sufficiently defined; the object was placed on the stage, the direct rays of the sun received on the mirror, and reflected in the direction of the axis of the microscope; the object was then focused on the ground glass of the camera, the sensitive collodionised plate replaced the focusing glass, and an image was obtained in from 10 to 60 seconds. As the chemical and visual foci did not coincide in microscopic object glasses, in consequence of their being *over-corrected*, allowance for this was necessary, and was effected by bringing the lens nearer to the plate by aid of the fine adjustment. The amount of correction varied with every object glass, and must be ascertained by direct experiments; but whilst the lower powers required a considerable amount of correction, the higher needed but a slight, if any alteration. Mr. Highley then introduced to the notice of the Society a microscopic camera, founded on the arrangement of Mr. Delves, but presenting the advantages of compactness, and being always arranged for immediate use; whilst to those photographers who were not already possessed of a microscope, it would be found an economical arrangement. It consisted of a tube which screwed into the flanch of a photographic lens, and carried the object-glasses. Over this fitted another tube, and by the sliding movement formed the coarse adjustment. This outer tube carried the stage and its fine adjustment on its upper side. To its under surface was attached a smaller tube, to which the mirror fitted, and which likewise carried the fittings for the polarizing prisms. Behind the object-glass was a fitting for the analyzer. Mr. Highley was of opinion that in many instances where the object was of a nature that depolarized light, advantage might be taken of this property to bring them up to *actinic* tints by the employment of polarized light and Darker's Selenite Stage; for whilst by this means the object would be of a color that would produce the greatest amount of chemical effect, the plates of selenite being *minus* the thickness and refracting power of the object, would produce a background several tints less intense in color and in actinic action. He referred to a diagram representing the various colors exhibited by a plate of selenite of varying thickness when viewed by polarized light, and likewise to the object itself in a polaroscope; also to another diagram representing crystals brought up to a deep blue by aid of selenite plates, the ground being of a greenish tint; and to the objects themselves arranged under polarizing microscopes. By such an application we should likewise probably be enabled to obtain representations of the internal structure and directions of tension in crystalline bodies. In reference to the asserted necessity for complete steadiness, Mr. Highley stated that Mr. Shadbolt had taken a great many views by the camphine light, in London, without any special arrangement for securing greater steadiness than was usually obtained in houses in London.

Mr. Kingsley [said that this was done with low powers; whereas the specimens which he had exhibited were taken with higher powers. He wished to show that the very highest powers of the microscope might be used, and that the light could be obtained for the highest magnifying powers they had. He had taken one as high as fifty thousand diameters; the time required being about ten minutes.

Mr. Bowerbank handed to the Chairman a photograph of a *Navicula angulata*, taken by Mr. Delves with a one-twelfth object-glass.

On the Composition of the Substances employed by the Chinese in the Decoration of Porcelain. By MM. EBELMEN and SALVETAT.*

(Continued from page 133.)

6. Reds.

It has already been stated, that the substance called *fan-hong*, contained both in the collection of the Musée Céramique and in that of the Ecole des Mines, although classed amongst the reds, was not a color, but only an oxide of iron serving as a base to several colors. The authors have found that four colors in M. Itier's collection contained this substance. Three of these were nothing but *fan-hong* mixed with a substance, the object of which is to fix and glaze the oxide of iron; to these M. Itier has

* From the London Chemical Gazette, No. 244.