PHOTO-MICROGRAPHY.

By Dr. Carl Seiler.

All workers in microscopy, doubtless, appreciate the necessity of correctly recording, not only in writing, but also by means of pictures or drawings, many of the appearances seen in the field of the microscope. We can do this by drawing an outline of the objects observed, by the aid of the *camera lucida;* but not only does this require some practice, but also a considerable amount of time, and even then the resulting picture will not be a correct representation of the field of the microscope, because it will always be tinged more or less by the imagination of the draughtsman, and will be more or less diagramatical in consequence.

With photography, on the other hand, an exact reproduction of the image thrown upon the screen can be obtained, and in much less time than it takes to make even a comparatively simple drawing with the *camera lucida.* It is the object of this chapter to give an idea of the means employed to obtain a photographic picture of a microscopic object—means which are in the hands of every microscopist, and which do not require a great outlay of money.

A room with a southern exposure, which can be darkened; a mirror, movable in all directions, outside of the window; an achromatic combination of lenses of from eight to ten inches focal length; a microscope which can be tilted so as to be horizontal, and a stand to hold the screen and sensitive plate, are all the apparatus absolutely necessary besides the chemicals used in ordinary photography.

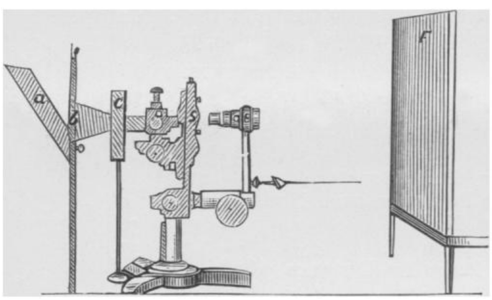

Fig. 1.

These different pieces are disposed of as follows (Fig. 1): The mirror (*a*), which should be eight or ten inches long by about four inches wide, is attached to a board which fist into an opening in the dark shutter of the southern window, and is to be moved by rods from the inside. Instead of this mirror, or in conjunction with it a heliostat is of great advantage to throw the light of the sun constantly in one direction, for, if once adjusted, it need not be disturbed, and thus a great deal of time is saved. Until recently such an instrument was too costly for the use of students, but of late Mr. Kuebel, of Washington, D. C., has put a heliostat in the market which works very satisfactorily and which is sufficiently low in price to be within the reach of many who desire to work in photo-micrography. The board in the shutter has in its centre a circular opening containing an achromatic combination of lenses (*b*), such as the back combination of a one-fourth portrait photographic lens.

The microscope is secured on the window-sill in a horizontal position, so that the axis of the tube is in a line with the axis of the achromatic combination, and at such a distance from it that the burning focus is about half an inch from the back combination of the sub-stage condenser (*d*). The eye piece is then removed from the microscope, and the tube lined with black velvet, to prevent internal reflection, as far as possible, and the whole apparatus is covered with dark cloth, to prevent stray rays of light entering the darkened room. This done, the sun's rays are reflected from the mirror outside the window, through the achromatic combination, which acts as a concentrator and throws a powerful light through the condenser, through the object on the stage (*s*), and thus a brightly illuminated image is formed by the objective (*o*) on the screen, which latter, when the negative is to be taken, is replaced by the sensitive plate.

This image, when thus formed, must be focused with the greatest care and accuracy, in order to obtain a sharp negative; and as the screen must be at some distance from the microscope in order to obtain the necessary magnification of the object, it is necessary to have some contrivance for turning the fine adjustment at a distance. For this purpose it will be found that a small pulley, placed alongside of the microscope, having an endless band running over it and the milled head of the fine adjustment, answers the purpose very well, when the axis of the pulley is connected by means of a universal joint to a fishing-rod, which by its sections can be made longer or shorter, thus bringing its end close to the screen.

The tube of the microscope, even when all internal reflection has been obliterated, still remains a drawback, inasmuch as it reduces the size of the image, or rather the disk of light, the more, the longer it is. There are, however, some stands made in which the tube can be entirely removed, such as the old Ross stand, and they are therefore very desirable for photo-micrographic purposes.

Any good objective of wide angular aperture and good definition can be employed for photography, provided monochromatic light is used in making the negative. When such is the case the visual and chemical foci fall in the same plane and a special correction of the objective for photography becomes unnecessary.

Such a light is obtained by passing the rays of the sun through a cell containing a strong solution of ammonio-sulphate of copper (*c*) before they enter the substage condenser. I have found some difficulty in making the cell containing this solution, as the copper salt will dissolve almost any cement, and if exposed to the action of the air, very rapidly becomes decomposed, and the solution is thereby rendered useless for the purpose. I have used with satisfaction a cell made of a brass ring, lined on its inner side with lead or tin, having a thread cut on its outside, to which flanged rings are secured. Upon the edges of the inner ring a ring of rubber packing is applied, and upon it a disk of plate glass is laid, which is tightly pressed upon the rubber by the flanged ring. Thus a cell is obtained very similar to the round, flat spirit levels, and which will hold the ammonia sulphate of copper solution for months without change. In filling the cell care should be taken to leave room for a small air bubble, for if the cell is completely filled the heat of the sun's rays will expand the solution sufficiently to cause leakage.

This solution, besides giving monochromatic light, at the same time filters out almost all the heat rays from the light, so much so that an immersion lens may be used for any length of time without the drop of water evaporating.

At the present time, when dry plate photography has been developed to such an extent that it has superseded, in a great measure, the wet process, it has been thought that it would be the most simple, economical and satisfactory for photo-micrography; but after repeated trials by myself, as well as many others working in the same direction, it has been found that it is not only more expensive, but also takes more time, in the long run. The reason of this is that it is impossible to judge, with any degree of certainty, as to the actinic power of the light forming the image on the screen by merely looking at it, and that a trial plate only will give an idea of the length of exposure necessary for a given day, time of day objective, and subject, to be photographed. It is true we can expose a dry plate for trial, but then we must develop it immediately, and the time of developing a dry plate is about three times that of developing a wet one, and a dry plate is also about three times as costly as a wet one. Therefore the old wet collodion process is the best.

The collodion to be used should be an old one, and contain some free iodine. I have found that a mixture of "Anthony's red labeled" and "McCollin's delicate half-tone" collodions—both commercial articles—some five or six months old, gives very satisfactory results. The nitrate bath should contain forty grains of nitrate of silver to the ounce of water, and should be slightly acidulated with nitric acid. The developer should be a weak one: twelve to fifteen grains of the double salt ammonio-sulphate of iron to the ounce of water, containing a few drops of a solution of gelatin and acetic acid as a restrainer.

After the negative has been fixed in the usual way, with hyposulphite of soda or cyanide of potassium, it is almost always necessary to intensify it, which is easily done by flowing the plate while wet with a watery solution of iodine until the film becomes white; then it is to be washed under the tap and flowed with a solution of sulphide of ammonium, which imparts to the negative a dark brown color, and thus strengthens its printing quality.

The object to be photographed should be as thin as possible, because the lens will depict only one plane of it, and it should present as much contrast and differentiation of its elements as possible; this is especially the case in animal tissues, and when high powers are used, the focus should be taken with the greatest care *for one particular point to be brought out*; a general focus not particularly sharp in any one point, will not give a satisfactory negative.

The screen upon which the image is focused should be of plate glass, having an extremely fine ground surface on one side—the side next to the object. Such a surface can easily be prepared by flowing the glass plate with a good negative varnish, and when this is set but not yet dry, lightly breathing on it, when an extremely fine and even frosting of the surface will show itself, sufficient to arrest and reflect the rays of light forming the image.

In photo-micrography, as well as in ordinary microscopy, proper illumination of the object is of the greatest importance, and frequently a poor objective will show a better definition in the hands of a skilled manipulator than the best objective can when the light is not properly managed. In this one point lies the difficulty of photo-micrography, and it is the stumbling block over which so many fall who undertake to photograph microscopic objects.

As a general rule the best light is obtained when the back lens of the sub-stage condenser is about half an inch beyond the burning focus of the larger condenser in the shutter, that is about eight and a half inches from this condenser, and when the light is *absolutely central*. But this distance cannot be strictly adhered to, inasmuch as different objectives require different illumination. In practice, I find that in order to obtain the proper distance of the condenser for a particular objective, it is best to put a blood-slide, upon which the corpuscles are in one layer only, on the stage, and project the image on the screen, moving the condenser backward and forward until, when sharply focused, no concentric rings are seen in the disks. The object to be photographed can then be substituted for the blood-slide, and the light will be found to be all that is desired. *(Compendium of Microscopical Technology.)*

Professor Helmholtz will issue a collection of his scattered scientific memoirs in the autumn.

PLANTÉ AND FAURE BATTERIES.

The annexed illustrations of the secondary batteries, which are exciting so much interest at the present time will, with the accompanying description, enable the reader to understand their construction. At the recent soirée given by the Council and academical staff of King's College, several forms of electric-lighting apparatus were used; but that which attracted most attention was a battery of forty-four accumulators of Faure's design, working twenty of Swan's lamps. The cells were charged in Paris by a Gramme machine, and were arranged in groups of four in cubical boxes, the whole being coupled up in series. The current supplied by this arrangement, shown by a galvanometer in the circuit while the lamps were alight, was about twenty-three webers, and was perfectly steady—the Faure battery yielding an almost equal current during the whole time, until the charge becomes exhausted, when it breaks down suddenly, without any noticeable warning. Mr. Spottiswoode also uses the Faure battery to work Swan

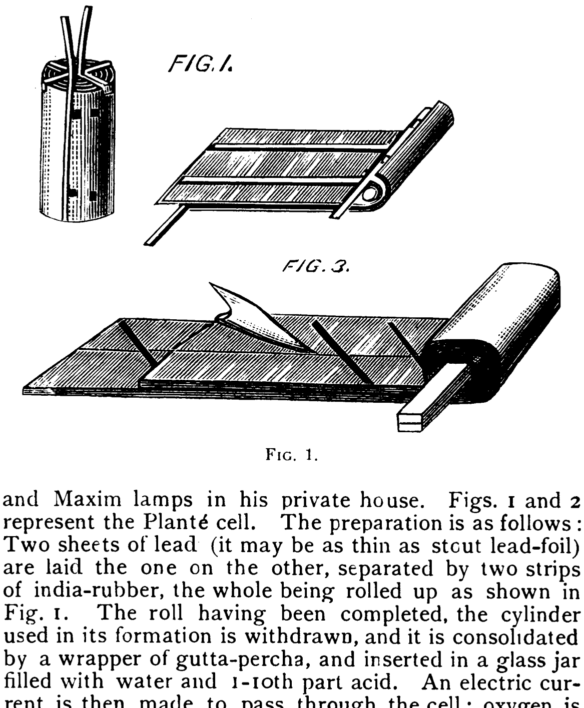

Fig. 1.

and Maxim lamps in his private house. Figs. 1 and 2 represent the Planté cell. The preparation is as follows: Two sheets of lead (it may be as thin as stout lead-foil) are laid the one on the other, separated by two strips of india-rubber, the whole being rolled up as shown in Fig. 1. The roll having been completed, the cylinder used in its formation is withdrawn, and it is consolidated by a wrapper of gutta-percha, and inserted in a glass jar filled with water and 1-10th part acid. An electric current is then made to pass through the cell; oxygen is given off, and produces a thick cushion of peroxide of lead on one sheet; hydrogen is given off at the other sheet. If the current with which the cell has been charged be cut off, and the two sheets are connected, a current will be produced, owing to the presence of the oxygen, which leaves the sheet where it has accumulated and attacks and oxidises the other sheet. This secondary current, which is very small at first, gains strength each time the operation is repeated; in course of time the surfaces of the sheets are changed, the one being covered with a cushion of peroxide of lead, the other with lead reduced to a spongy mass. The cell is then complete, and in a state of electrical accumulation. That was Planté's first successful battery. Subsequently he tried the plan of separating the two sheets of lead by canvas, the cell taking the form of Fig. 2. He then found that it was necessary to leave a small space between the sheets to provide for the escape of the gases which were produced at the end of the charge; subsequently india-rubber bands were employed in preference to canvas. M. Planté also tried carbonate of lead, minium, &c., but without improving upon the results already obtained. The