

ART. XXXVIII.—*On the Oxy-Calcium Light as applied to Photo-Micrography*; by Lieut. Col. J. J. WOODWARD, Assistant Surgeon, U. S. Army. Report to the Surgeon General of the U. S. Army, dated June 4, 1870.

SINCE the preparation of my report of January 4, 1870, on the use of the Magnesium and Electric lights in Photo-micrography, I have made some experiments with the Oxy-calcium, or Hare's light, as a source of illumination for the same purpose, and have succeeded in obtaining excellent pictures with powers as high as a thousand diameters. This result appears to me of considerable importance, both because of the comparative cheapness of this light, and because the apparatus for its production is so common as to be practically within the reach of every microscopist. In addition to these advantages the oxy-calcium light possesses the quality of steadiness to a greater degree than either the electric or the magnesium lamp and requires much less trouble and skill to manage.

For the purposes of my experiments, I made the hydrogen as I consumed it, in a Hare's self-regulating generator, by the action of dilute sulphuric acid on scraps of ordinary sheet-zinc.

The oxygen was sometimes made in the usual way from chlorate of potassa, sometimes purchased compressed in iron cylinders; in either case it was transferred to a large sheet-iron gasometer for use. The gases were burned under a pressure equal to a column of water fourteen inches high. I used for lamp one of the first-class magic-lanterns, manufactured by J. W. Queen & Co. (No. 924, Chestnut street, Philadelphia, Pennsylvania,) in which the disc of lime is revolved by clock-work before the burning jet of gas and a fresh surface constantly presented to the flame. I simply removed from the lantern the lens intended to magnify the image on the slides, when the apparatus is in ordinary use, and allowed the cone of light proceeding from the large condenser of the instrument to fall upon the achromatic condenser of the microscope, in the same manner as described and figured for the magnesium lamp in my report of January 4th, a reference to which will render any description of the arrangement of the microscope and of the sensitive plate unnecessary in this place.

I employed the ammonio-sulphate cell, as I do in taking Photo-micrographs with other sources of light, but found I could dispense with the ground glass which is necessary in photographing so many objects, if sunlight or the electric lamp is employed; a large portion of the lime disc being luminous, the resulting mixed divergent pencil, like that obtained from the magnesium lamp, does not produce the interference phenomena which result when tissues and many other objects are illuminated by powerful parallel rays. This circumstance, however, renders the calcium light inferior to the sun and the electric lamp, in the resolution of the Nobert's plate and certain lined test objects.

I did not find the time of exposure differed materially from what I had given in making photographs of the same objects with the magnesium lamp, and the pictures produced were not inferior to these in quality. This arose from the fact that the greater steadiness of the calcium light permitted the use of condensers which concentrated the light to a greater degree than I had found advantageous with the magnesium lamp, and not from equality in the actinic power of the two sources of illumination. I have recently made some experiments with the view of obtaining positive information with regard to the comparative actinic energy of the electric, magnesium and calcium lamps which I employ. For this purpose all condensers being removed the divergent pencil proceeding from each lamp in turn was permitted to fall, for the space of five seconds, on an exposed circular portion of a sensitive plate thirty feet distant.

The whole operation was completed in less than a minute, when the plate being developed in the ordinary way three cir-

cular spots appeared as the results of the exposures. The spot produced by the electric light was intensely black, that by the magnesium of a rich middle-tint, while the circle impressed by the calcium light was extremely pale. Want of time prevented me from continuing these experiments and obtaining as I desired numerical values for the relative actinic powers of these sources of illumination under definite conditions; this I have however regretted the less, as the actual energy of the naked flames is not really the measure of their availability in photo-micrography; here the question of steadiness, involving, as it does, the possibility of great concentration, plays a most important part and materially modifies the result.

So far as I know, the Calcium light has never before been successfully employed as the source of illumination for making Photo-micrographs in this country. My friend Dr. R. L. Maddox, however, writes me that it has been experimented with in England by Drs. Abercrombie and Wilson. He thinks they used powers as high as an eighth with pleasing results. This information has directed my attention to the essay of Dr. Wilson in the *Popular Science Review* for 1867, volume vi, page 54, in which that gentleman gives in detail the process employed by himself and Dr. Abercrombie. He experimented with an oil lamp and with the Oxy-calcium and magnesium lights: "I can scarcely think it would be used now that the more active light of magnesium is within the reach of every one." And of the magnesium: "The light fails only in steadiness, and if some means could be devised for burning the metal uniformly and at a fixed point nothing would be left to desire." Dr. Beale (*How to work with the Microscope*, 4th edition, p. 248) tells us that some of the pictures of these gentlemen were remarkably good, "they possess a peculiar delicacy in the half tones and the shadows, with much roundness of the objects, but the definition, as might be expected, does not quite equal in some of the finest markings, prints obtained from sun negatives." A perusal of Dr. Wilson's paper will show that my process differs from his in the use of the following precautions: the interpolation of an ammonio-sulphate cell to exclude the non-actinic rays, the use of lenses specially made for photography for all powers from the $\frac{1}{8}$ th down, the use of much larger condensers to concentrate the light and so to shorten the exposure, and in the case of the magnesium light, in the use of a clock-work lamp to increase the steadiness of the illumination. Each of these points are in my judgment essential to obtain the best results.

I learn from the same letter of Dr. Maddox that he had himself made experiments with the magnesium lamp some time before those of Abercrombie and Wilson. He used powers as

high as a fifth, and appears to have obtained better results than I supposed any one had done prior to the publication of my report. He gives me the following account of his experience: "The first picture I took with the magnesium light was done in a very rude way. An inch and a quarter of wire was held in a small spirit flame and advanced by hand as burnt. The objective was Beck's $\frac{3}{8}$ ds, the object the sycamore-leaf insect, and about $\frac{3}{8}$ ths of an inch of wire remained after use. I sent a print, with a sun print of the same to the British Journal of Photography, and in the number for July 1, 1864, you will find some remarks by myself and the editors. Now to try and meet any error that might arise from what we may term want of correction, I used the $\frac{3}{8}$ ds with the correcting lens, which is excellent for sunlight; the picture was soft, full of half tone, but wanted, as in other pictures I had seen by artificial light, the decision of definition in the outlines." "After this I used the $\frac{1}{2}$ th with the little apparatus sketched in Beale's book (page 275) and which I venture to think, embraces all that is required for its use, provided the condenser has its focus at the burning point, and that the reflector has the same." With the $\frac{1}{2}$ th, fibers of cotton and muscular fibrillæ of boiled shrimp, with several other objects were taken, but I did not use any higher power, nor indeed pay much attention to the subject as I gave the preference to the sunlighted prints and negatives." I give these extracts with great pleasure as showing the experience in this direction of one of the most distinguished laborers in the field of Photo-micrography, and regret that I was not acquainted with them at the time of publishing my first report. The method of Dr. Maddox, however, differed from mine in the same essential points as that of Abercrombie and Wilson, and the peculiar fitness of the magnesium light for photographing the animal tissues and those objects generally, which require the use of ground glass when sunlight is employed, would appear to have escaped the observation of these accomplished gentlemen, and to have remained unnoted until the publication of my report.

In conclusion I append to this paper two illustrative photographs. The first, which represents the 6th square of the Möllers type-plate of the diatomaceæ, taken with Wales's $1\frac{1}{2}$ inch objective, arranged to give thirty-five diameters, will serve for comparison with the photographs of the same object with the same lens taken by sunlight and by the electric and magnesium lamps, which were published with my former report. The second represents the Navicular Lyra, taken with the Powell and Lealand's immersion $\frac{1}{16}$ arranged to magnify 1000 diameters.