IV.—*An Inexpensive Screen for Monochromatic Light.*

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Plate V.

Monochromatic light for use with the Microscope may, as far as I know, be obtained in three different ways:—

(1) By the use of a prism.
(2) By an incandescent gas or vapour.
(3) By means of a coloured screen.

The beautiful apparatus used and shown by Mr. Nelson some time since is an instance of the first. By this the rays proceeding from an incandescent, lime, or other radiant, after passing through a slit, are dispersed by a prism of glass, and by means of a second slit any portion desired may be selected from the spectrum and used for the purpose required. But this apparatus is expensive, and, unless a second prism be used with the second slit to recompose it, the light thus obtained, although good in practice, does not really produce a uniformly monochromatic field of view, that is to say, the illumination at any one point is not exactly the same as at any other point, and one side of the object in the microscopic field will be illuminated by light many wave-lengths behind that by which the other side is illuminated.

As an example of the second method I will refer to the light produced by burning metallic sodium or thallium, or a salt of either, in the flame of a Bunsen burner, using a suitable support. By this method I was enabled, two years ago, to resolve *Amphipleura pellucida* into distinct dots. But it is difficult to feed the flame continuously, so as to make this method available for photography, and the plates used have to be bathed in erythrosine or cyanine, or some other dye, in order to make them sensitive to these wave-lengths.

The third method, that of the coloured screen, is not subject, as far as I know, to any of these drawbacks, but, in the form in which it has hitherto been mostly used, that of the trough containing chrome-copper solution, either the light is insufficiently monochromatic, that is to say, the band seen in the spectroscope, when it is so examined, is

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EXPLANATION OF PLATE V.

Fig. 1.—Solar spectrum without screen.
„ 2. „ with screen, malachite-green in aqueous solution, prolonged exposure.
„ 3. „ „ yellow glass.
„ 4. „ „ malachite-green, glycerine and picric acid.
„ 5. „ „ effect of 3 followed by 4.
„ 6.—Podura scale × 960, by P. and L. 1/10 in. achromatic N.A. 1·5, with screen as in fig 4.

too broad, or it lies among the rays less refrangible and less suitable for photography. There is also great loss of light.

While at work on the various aniline dyes in connection with their photographic effect on the salts of silver when these are exposed to the light of the solar spectrum, it came to my notice that the absorption spectrum of benz-aldehyde green, commonly known as malachite green, was a very remarkable one.

We have two very broad dark absorption bands (fig. 2), one which has for its centre a point slightly less refrangible than line D in the solar spectrum, and extending from about B to E, with an aqueous solution of mean strength. A second band, having G for its centre and extending from a position slightly more refrangible than F to the calcium lines H_1H_2. These absorption bands, to which I shall not again refer, leave us bands of light at three distinct points, viz. (1) From A to B, a narrow red band of low intensity; (2) from E to a little beyond F, a rather wider, intense band; (3) from H_1H_2 to M, a feeble, invisible band, the position of which can only be ascertained photographically. The band of light from E to F is the one to which I wish more particularly to direct your attention. It is in this region of the spectrum that blue graduates into green, and we may imagine a central point in the band which is neither blue nor green.

Now by dissolving the dye in different liquids, the position of this blue-green band may be modified to a considerable extent. I need not dwell on the fact that in common with most substances in solution which show absorption phenomena, these bands, and especially that one with which we are most concerned, will be widened by further dilution with the *same* solvent. But by the use of *different* solvents the position of the blue-green band in the spectrum may, within certain limits, be so shifted that a line drawn through its centre shall occupy a place more refrangible, or less refrangible, as the case may be, and in this way, and by the addition of other substances, the red band, as shown in aqueous solution, may be considerably reduced in intensity, and the faint band in the ultra-violet entirely removed.

Thus, by solution in glycerin the blue-green band is narrowed and shifted, so that it almost exactly fills the space between E and F when a given thickness or strength of solution is used, and, although narrowed, it is much brightened. At the same time the red band becomes much fainter, so that even for purposes of focusing it may be neglected.

If glycerin-jelly be used for the solvent, the blue-green band occupies a place midway between that of the same band in aqueous and glycerin solutions, transmits almost as much light as glycerin, and photographs more rapidly.

A solution in cedar-oil may be made without great difficulty, and in this case the band is even less refrangible than in the case of glycerin, and broader, and there is slightly more light, less being lost by reflection from the glass surfaces in contact with it.

A crystal of picric acid may be added to all malachite-green solutions containing glycerin; this removes the band in the invisible violet entirely (fig. 4), but it must be borne in mind that this band is extremely faint, even when a quartz prism is used, and I have been unable to detect it after the light has passed through the Microscope; probably it will not pass balsam. It is rather difficult to add the picric acid, which is apt to throw down the dye, unless care is taken always to add the picric acid in crystals after the dye has all been dissolved and the solution filtered. With a flame or lime-light spectrum this band is hardly to be traced, and the picric acid is quite unnecessary. In any case both this and the red band may be entirely removed by passing the light through a blue-green glass, such as Messrs. Baker supply with their Microscope-lamp, and this may be useful for focusing with the aqueous solution where the red band is strong. After focusing, the blue-green glass may be removed.

Malachite-green may also be dissolved in plain collodion, or in balsam, or any white varnish, and in this form it gives the blue-green band, brilliant and narrow, almost identical with that given by the glycerin solution.

By the gradual addition of almost any acid to any of these solutions, the band may be moved down towards the red, until it finally coalesces with the red band and is lost. Except in this case, the blue-green band appears to be movable up and down the spectrum *pari passu* with the refractive index of the solvent used, and for photographic purposes a solution in absolute alcohol would be the most useful, were it not for the small amount of visual effect and consequent difficulty of focusing, the band then lying almost entirely on the more refrangible side of F. And were it not for this same difficulty, a still greater shifting towards the violet might be accomplished by the addition of a small quantity of cyanine.

Almost any of these solutions may be made of sufficient strength for mounting between two cover-glasses in a layer little thicker than one of them, or in shallow cells on a glass slip. There is considerable advantage in mounting between glass-covers, which may then be inserted in the substage condenser in place of a diaphragm, or may occupy a position on a rotating wheel of stops.

The advantages I venture to claim for malachite-green used in this way are as follows:—

(1) It gives a field of view uniformly monochromatic.

(2) There is more light than with chrome-copper solutions, and the light is more monochromatic if certain precautions are taken.

(3) It need not be used in solution, but, if so used, a very thin stratum is sufficient, and no large troughs or bottles are necessary.

(4) No bathing of plates in erythrosine, or cyanine, or phosphine N is necessary, an ordinary rapid plate being sufficiently sensitive in this part of the spectrum; in fact, more refrangible light cannot conveniently be used, or there would not be enough light to focus by.

Monochromatic light in this form is therefore well adapted for photography with powers from 1/20 in. to 1/50 in., which may thus do work little inferior to that with apochromatics, provided they are of corresponding aperture, and I do not think that these highest powers have yet been made apochromatic.

In conclusion, and although out of place here, I hope you will allow me to call attention to an advantage which might be gained by the use of malachite-green screens for colour-correct landscape photography. I need not refer at length to the well-known gap which remains in the spectrum impressed on a cyanine-bathed plate, and which lies between lines E and F, in the case of an unboiled, between E and D in the case of a boiled emulsion. By over-exposure this gap may be filled up, but to the detriment of the remainder of the spectrum. Instead of this, by using a suitable malachite-green screen after a preliminary exposure without a screen, the gap may in either case be filled without damage to the remainder, and the plate be very uniformly impressed by all rays of the solar spectrum from A to H, and further, if an ordinary yellow-brown glass screen be used for the preliminary exposure, a photographed spectrum very nearly identical with the visual spectrum may be obtained. The gap appears to me to be due to the colour of the gelatin, which absorbs less light of this refrangibility than of any other, the absorption of light by the gelatin possibly accentuating its action as a sensitizer. With erythrosin-bathed plates the same defect is noticeable, and I have always found landscapes taken with these or cyanine plates lacking in the greens. Possibly this application might also be useful for reproducing objects in their natural colours by the Lippmann method, but I have as yet made no experiments in this direction.

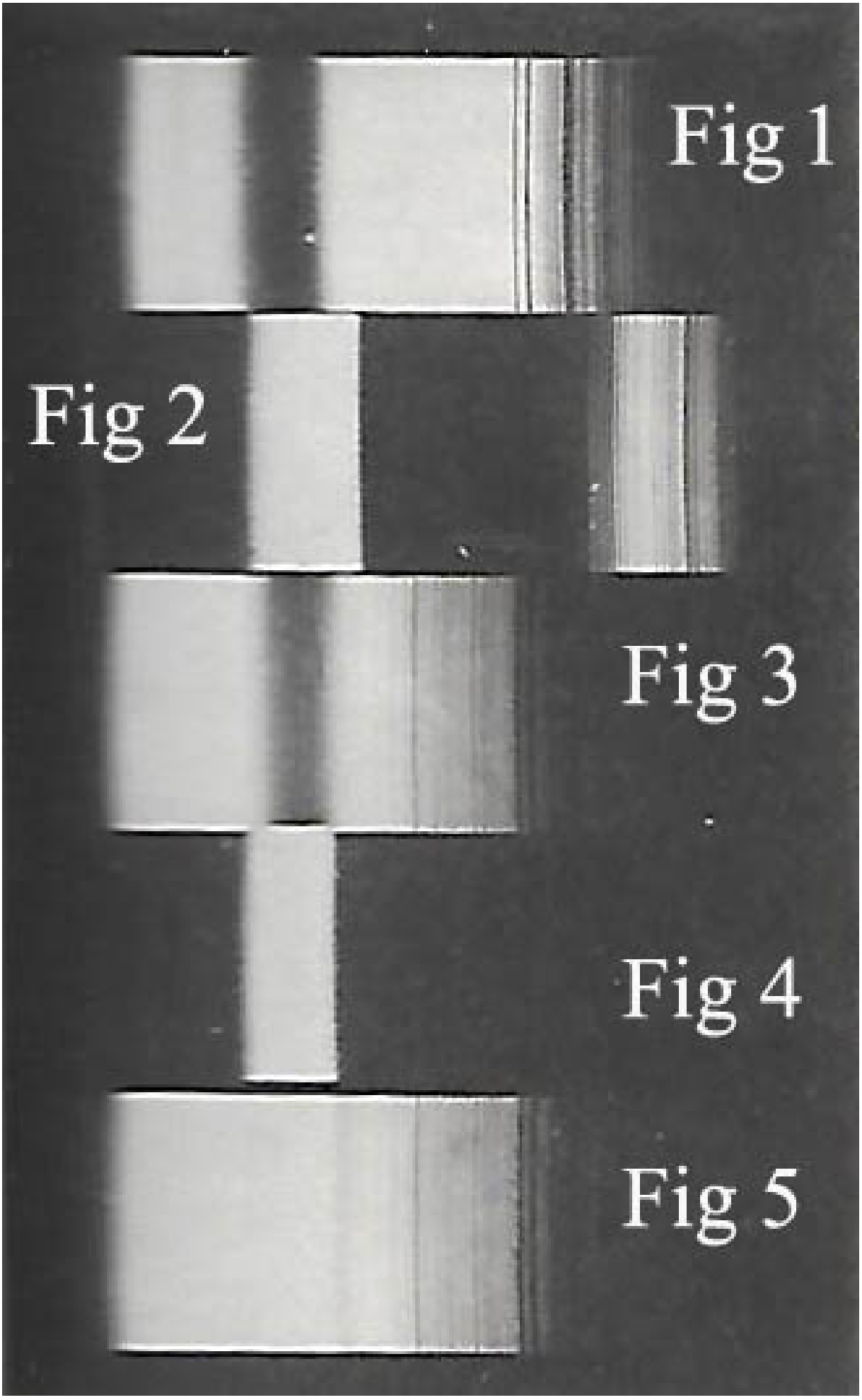
Fig 1
Fig 2
Fig 3
Fig 4
Fig 5