III.—*On the Use of a Metallic Electric Arc in Photomicrography.*

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SOME time ago I described to this Society a method of using a mercury vapour arc for visual microscopic work. I explained that it had such advantages that it was probably substantially ahead, as a source of light, of any other illuminant then available—an opinion that subsequent experience has more than confirmed. As the light is derived from the luminous arc itself, and not from either of the luminous electrodes, it follows that its spectrum is a bright-line one, and that it is possible, by a suitable arrangement of prisms, or by suitable colour screens, to obtain illumination in the Microscope that is truly monochromatic. While for visual work the amount of light so obtained is amply sufficient for use with the highest powers, when it comes to photomicrography the exposures are in many cases prolonged, and sometimes unduly so. I have therefore been experimenting for some time to see whether a metallic arc with solid metal electrodes might be made available for the purpose mentioned.

I must at once admit that up till quite recently the results obtained have not been favourable, as it is extremely difficult to get an electric arc with metallic electrodes to burn with any degree of steadiness; and, further, there is always the difficulty that with most metals the electrodes themselves either quickly melt, or the arc changes its position, owing to bending or displacement of the metals. Again, if, for instance, we take an arc formed between iron electrodes, in which the metal itself has not a low melting-point, and which may, by suitable arrangements, be made to run steadily, we are confronted with the difficulty that its spectrum consists of a great number of lines of moderate intensity which are distributed pretty evenly throughout the spectrum, so that, owing to the closeness of the lines one to another, there is no advantage over a source of light with a continuous spectrum, such as an ordinary carbon arc.

Of all metals giving a suitable spectrum, other than mercury, none so thoroughly fulfil the necessary conditions as cadmium; but unfortunately cadmium has a particularly low melting-point, rather lower even than that of lead, so that to use it in a pure state is simply impossible. A recent paper by Dr. T. Martin Lowry, on "A New Method of Producing a Cadmium Arc," has suggested that

by combining silver and cadmium in suitable proportions, electrodes are produced that have a very high melting-point, and that under ordinary conditions will produce a very good arc. The proportion of silver to cadmium may conveniently be 60 p.c. cadmium to 40 p.c. silver, and such an alloy has a melting-point above 700° C.

On examining the spectrum given, it is found that the principal lines are situated in the blue, green, and red portions of the spectrum, so that it is possible to obtain a monochromatic source of light at will in either of these regions, and of almost unlimited intensity—the intensity, in fact, being only dependent on the size of the electrodes, and the number of amperes used. If an attempt is made to run an arc with pure-metal electrodes of almost any sort, it will be appreciated how very difficult it is to so adjust the arc that anything approaching a constant source of light may be obtained. With the cadmium-silver arc the conditions are very much better, but to obtain the best result the electrodes should be rotated in opposite directions during the time that the arc is burning. This method is, of course, one perfectly well known, and requires no further explanation here. It is not one that entails any considerable complication in apparatus, in fact, it is quite practicable for the short exposures required in photo-micrography, to have a hand-driven type of mechanism, which is both inexpensive and sufficiently efficient.

It may be urged that owing to the fact that the electrodes suggested are an alloy, that the spectrum of silver will be equally evident with that of cadmium, and this is, of course, the case; but fortunately the spectrum of silver is such that it does not interfere to any extent with the cadmium spectrum, the principal cadmium lines, in fact, being so brilliant that the others are almost negligible. The red cadmium line, with a wave-length of $6438\cdot^{10}$ m., is a particularly brilliant one not far from the region of the orange, so that it has considerable visual luminosity. The green line wave-length, $5085\cdot^{10}$ m., is in the most brilliant portion of the spectrum, and running the cadmium silver arc with 10 amperes, a fully exposed plate may be obtained in a few seconds, even with the highest powers, using, of course, a suitably sensitized plate. The blue line wave-length, $4799\cdot^{10}$ m., has very high luminosity for the blue part of the spectrum, so that it may be used for work with diatoms, or where the greatest visual resolution is required. It might be interesting to note that the bright lines in the cadmium spectrum are extremely narrow ones. It follows that the light transmitted, whether screened off, or obtained by spectroscopic methods, is of one wave-length.

In the case where this arrangement is used in conjunction with a monochromatic light apparatus, in which the light is split up by the aid of prisms, the slit may be opened very wide indeed so that the light transmitted becomes a very broad band, quite

sufficient to fill the field with moderate or high-power microscopic objectives.

It may be urged that the method, although, perhaps, not without scientific interest, is impracticable owing to the cost of the cadmium silver electrodes, and it must be admitted that this is not altogether a negligible factor. Cadmium is now, however, not a rare metal, and can be bought cheaply, whilst the value of silver is well known to you all. I may say, moreover, that I have recently obtained some of this alloy from Messrs. Johnson Matthey, the Metallurgists, of Hatton Garden, and that the cost of a single electrode works out at five shillings. This is sufficient for a fairly long run, so that after all the expense would not, in most cases, be an insuperable objection where some special result is aimed at.