LOSS OF LIGHT IN A SPECTROPHOTOMETER

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In comparing the intensities of two sources of light, wave length by wave length, with the aid of a spectrophotometer, a number of precautions must be taken.

The usual conditions for sensibility must be observed, namely, two fields to be compared must be placed side by side with only a very fine dividing line between them; these fields must be of sufficient size, subtending an angle of at least two degrees in the field of view; and the fields must be of sufficient intensity but not too bright.

If there is any lack of symmetry in the optical paths of the two beams of light, empirical corrections must be resorted to, in order to allow for this dissymmetry. Stray light must be eliminated by means of suitably placed diaphragms or absorbing material, or at least rendered as symmetrical as possible, as it often forms surprisingly bright images. If for instance we look through a long brass tube with a small aperture at the far end, we see the latter surrounded by a series of bright concentric circles.

The loss of light in lenses and prisms is quite large, and is much increased if the surfaces are not clean. In Nutting's Outlines of Applied Optics it is stated: "Losses by absorption and reflection amount to from 20 to 50 per cent in ordinary corrected objectives. The loss by reflection amounts to roughly 10 per cent for each pair of free surfaces. Losses by absorption are seldom over 5 per cent, but a lens containing glass visibly yellowish in tint may absorb as high as 25 or even 50 per cent in the blue and violet."

If we let I represent the intensity of light incident upon a lens (or prism), and p the fraction of the intensity lost in passing through it, then $I(1-p)$ is the fraction of the intensity which passes through and reaches the next lens. If the same fraction of intensity is lost in each lens (or prism), then $(1-p)$ of the incident intensity $I(1-p)$ will be transmitted by the second lens or $I(1-p)^2$ will be incident on the third lens. It followss that in passing through n pairs of surfaces the incident intensity I will be cut down to $I(1-p)^n$.

At the last meeting of the Illinois State Academy of Science, an "optical arrangement" was described *by means of which a Hyde sector disk could be used to better advantage in spectrophotometric measurements. In this arrangement, which is present in only one of the beams compared, and which, therefore, introduces dissymmetry in the system, there are four achromatic lenses and two totally reflecting prisms. The loss of light at the cemented surfaces of the achromats and at the hypothenuse surfaces of the prisms is negligible, but there are six pairs of free surfaces.

A number of tests were made to determine the loss of light in this system. A standard light source was compared with a test source enclosed in a case having an opal glass window for diffusing the light. This opal window was placed at a fixed distance from the collimator slit of the spectrophotometer and the intensity of the test source was determined under these conditions.

The optical arrangement was then inserted in front of the spectrophotometer slit, and the test source with its opal window was placed at the same distance as in the previous test, in front of the collimator slit of the optical arrangement so that the cone of light falling on the two slits was the same in both trials. The width of the slits on all three collimators was made the same. The intensity of the transmitted light was determined under these new conditions.

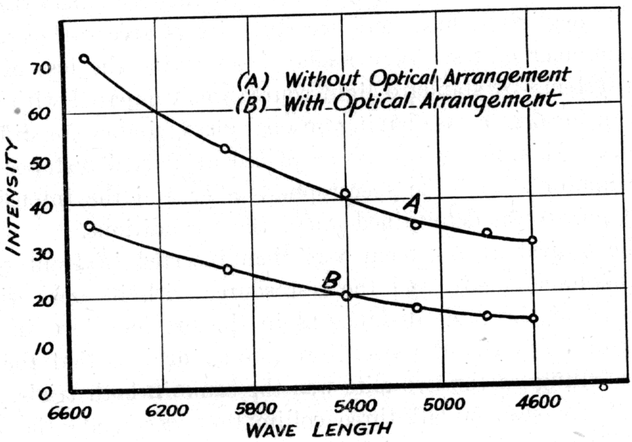
The ratio of these two measured intensities gave the per cent of the incident light which was transmitted and this was determined at a number of wave lengths throughout the visible spectrum.

A sample set of data is shown in the accompanying table and curves, which give the results from the comparison of a 100 and a 400 watt frosted tungsten bulb. The wave lengths are expressed in Angstrom units. The readings are proportional to the intensities of the lights compared, and those marked *B* were taken with the optical arrangement between the 400 watt bulb and the spectrophotometer, those marked *A* with this optical arrangement removed.

Wave length	6500	5900	5400	5100	4800	4600
A	72	52	42	35	33	31
B	36	26	20	17	15	14
Per cent transmitted	50.0	50.0	48.95	48.57	45.46	45.16

* Trans. Ill. Acad. Sci., Vol. XXI, 1929, p. 233.

The average per cent of transmitted intensity is 48.02 and the number of pairs of free surfaces is 6. Therefore, $(1-p)^n = (1-p)^6 = 0.4802$; and solving for p we get $p = 0.115$; that is, each lens or prisms of our system reduces the intensity of the light incident upon it by about 11.5 per cent. It will, therefore, be necessary to use high intensities of the light sources to be tested with this arrangement.



From the curves it will be seen that there is a gradual, almost continuous decrease from 50 per cent to 45.16 per cent in the intensity transmitted, as we pass from the longer to the shorter wave lengths of the spectrum.

As the loss by reflection may be assumed constant for all wave lengths, this increase in loss must be due to the greater absorption of the glass for shorter wave lengths, which is a little less than 5 per cent in this case.

These curves will serve as suitable correction curves for the instrument.

I take this opportunity of thanking Mr. E. Winter, Jr., for assistance in taking the readings.