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AN APPARATUS FOR THE MEASUREMENT OF ATMOSPHERIC ATTENUATION OF LIGHT

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The attenuation of white light is demonstrated by the masking of street lamps by fog, by the loss of illumination during overcast weather, and in other ways. Many attenuation studies of white light have been made and transmission values for air having varying degrees of moisture content are available in the literature (1). Among such values, for example, are 93 per cent transmission per 1,000 yards in exceptionally clear weather and 0.0005 per cent transmission per 1,000 yards in heavy fog (1). Less apparent, however, is the variable attenuation of certain wave lengths in relation to properties of the atmosphere, such as particle size and concentration. Such phenomena are demonstrated by the apparent blueness of the sky produced by selective scattering of the shorter wave lengths of the sun's radiation and by the redness of the sunrise and the sunset when the greater atmospheric mass through which the light must travel causes almost total scattering and absorption of the shorter wave lengths. The degree of this selective attenuation is subject to investigation and correlation to meteorological conditions.

In the present studies (2) it became apparent that more dependable values of selective attenuation should be obtained. A light source and a spectrophotometer, 350 feet apart, constitute the basis of the Ordark system for obtaining these values. The short light path provides a homogeneous atmosphere. The range is free of obstructions and light-reflecting surfaces. A 200-watt incandescent projector bulb is the source and it receives power from a Sorenson voltage regulator. The spectrophotometer consists of a lens 4½ inches in diameter with a long focal length, a Bausch & Lomb constant-deviation spectroscope, a photomultiplier tube and its power supply, and a General Electric microampere recorder. The slits of the spectroscope are placed at the focal point of the lens, with the arm parallel to the optical axis. The entire assembly is mounted rigidly on a concrete and steel base. The photomultiplier tube is fixed over the eyepiece and its output is fed directly into the recorder.

During each series of determinations of the light reaching the spectrophotometer, the setting of the spectroscope is changed so that the wave length of the light striking the photo-sensitive tube varies from 4,000 A to 7,000 A. Permanent traces of the tube output are made on the recorder, together with wave-length notations by the operator. As stray light is not entirely eliminated, a background determination is made for each test. This is done by repeating the spectroscope settings with the light source turned off, the difference between the two sets of values being that part of the illumination contributed by the light source. The maximum background observed to date was approximately 10 per cent of the response to the light source. Interpretation of the curve is made, expressing the response in terms of luminous flux.

The most important component of this apparatus is the photomultiplier tube, which offers appreciable response to very low light levels. The tube chosen for this work has a photosensitive surface with a so-called S-4 response which extends from 3,000 A to 7,000 A, with peak response near 4,000 A. The tube operates on the secondary-emission principle, with successive stages of multiplication. The latter is accomplished through electron acceleration by increased potential in each of 9 stages. Two models of tubes having an S-4 response have been tried: the 931-A, which is suitable for moderate light levels, and the 1P21, which is best for low levels, because of its extreme sensitivity. The 1P21 has been adopted because it allows narrow band-setting of the spectroscope.

Instability resulting from the high sensitivity of the 1P21 to stray light and its susceptibility to fatigue, and the change in tube response caused by fluctuations in the voltage on the stages are primary problems. Sensitivity became less bothersome when adequate shielding against random light was provided by placing the slits of the spectroscope at the focus of the lens. Voltage fluctuations were reduced to a minimum by use of an electronically-regulated power supply.

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This apparatus functions satisfactorily over the range tested. Absolute attenuation values could not be obtained from the comparatively few tests made to date. However, such values can be determined with this spectrophotometer when a sufficiently large number of tests have been made during varying weather conditions.

References

(1) *Illuminating Handbook for 1947.*
(2) Ordark Research Project.