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A simple device for the calibration of the Optical Wedge of the Dobson's Ozone Spectrophotometer

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ABSTRACT. The calibration of the optical wedge of the Dobson's Ozone Spectrophotometer is being done by the two well known methods, *viz.*, (1) from sunlight with the help of perforated gauze and (2) by rhodiumised plate and standard lamp, the transmission coefficients of perforated gauze and rhodiumised plate being known.

In this paper the result of the calibration of the optical wedge of the Dobson's Spectrophotometer by means of a circular diaphragm cutting the light intensity from a standard lamp to a known percentage has been explained.

1. Introduction

The calibration of the optical wedge of the Dobson's Spectrophotometer forms part of the routine activity of an ozone observatory. Of the various methods devised for this purpose, the perforated gauze has been in common use in India. It has a large number of uniformly placed small holes of same size, giving a known transmission factor when made to interrupt rapidly any source of light. The calibration with the perforated gauze has to be carried out in the open on the direct sun or zenith blue sky under clear haze-free conditions near noon. Only the S_3 slit of the spectrophotometer is kept open throughout the calibration. For any wavelength pair the dial of the wedge is set at zero to start with and sunlight entering the instrument is rapidly interrupted by the perforated gauze at the same time obtaining a convenient current reading in the micro-ammeter. The removal of the gauze (called 'Out' position), causes the current in the micro-ammeter to rise and is compensated by turning the wedge dial to bring the reading back to the original. This dial difference representing the wedge positions, corresponds to this transmission coefficient of the perforated gauze. The process is repeated by setting the dials at 10°, 20°, 30° etc (or smaller steps at the turning points, if necessary).

There is no doubt that this perforated gauze method is quite simple, as the instrument is not opened at any stage. For places where ozone amounts do not vary much and the skies are very clear, this method has proved quite useful. But this method has certain difficulties. For instance, it is not possible to move the gauze with the same uniform speed by hand. Unless a motor is used, the transmission coefficient is liable to be different from one reading to the other. At places where haze is rarely absent, the readings become somewhat erratic. These two factors may combine to give a calibration curve full of spurious variations, which cannot be called representative of the wedge differences.

Of late, the rhodiumised plate recommended by Dobson (1957) mounted on the clear-opaque shutter in front of S_3 slit has been introduced for the calibration of the optical wedge. The 'In' and 'Out' positions are controlled by the clear-opaque shutter rod. The source of light is, however, a standard lamp, with a transparent U. V. envelope, with a voltage stabiliser. A wedge

TABLE 1

Wedge table (calibration with rhodiumised plate)

Dial reading °	λλA log I/I'	λλD log I/I'
0	..	..
10	..	..
20	..	..
30	..	..
40	2·0133	1·9143
50	1·9265	1·8301
60	1·8400	1·7463
70	1·7529	1·6619
80	1·6643	1·5761
90	1·5733	1·4883
100	1·4791	1·3979
110	1·3811	1·3044
120	1·2790	1·2074
130	1·1726	1·1067
140	1·0617	1·0020
150	0·9459	0·8931
160	0·8282	0·7795
170	0·6994	0·6609
180	0·5689	0·5377
190	0·4341	0·4105
200	0·2961	0·2799
210	0·1558	0·1472
220	0·0142	0·0134

TABLE 2

Wedge table (calibration with diaphragm)

Dial reading °	λλA log I/I'	λλD log I/I'
0	..	..
10	2·3151	2·2503
20	2·2243	2·1597
30	2·1373	2·0748
40	2·0527	1·9933
50	1·9691	1·9125
60	1·8850	1·8295
70	1·7980	1·7435
80	1·7075	1·6536
90	1·6130	1·5594
100	1·5137	1·4613
110	1·4094	1·3596
120	1·2997	1·2540
130	1·1844	1·1447
140	1·0644	1·0319
150	0·9405	0·9163
160	0·8142	0·7971
170	0·6863	0·6742
180	0·5656	0·5462
190	0·4203	0·4122
200	0·2806	0·2740
210	0·1423	0·1373
220	0·0125	0·0121

calibration curve obtained with the rhodiumised plate is given in Fig. 1 for Dobson's Instrument No. 55 in use at Varanasi (Lat. 25° 18′N, Long. 83° 01′E). The wedge calibration tables for A and D settings are given in Table 1.

For calibration purposes, there is no doubt about the superiority of the rhodiumised plate over the perforated gauze, in view of the uniformity of conditions introduced in the process and absence from all atmospheric influences. The method, however, requires the removal of the cover of the instrument and careful mounting of the rhodiumised plate on the clear-opaque shutter. Repeated handling of the rhodiumised plate may also lead to a change in the transmission percentage.

2. The New Method

In this paper the result of an attempt with a simple device, which combines the simplicity of the perforated gauze and the standard conditions of the rhodiumised plate is presented. It consists of a metal mounting which can carry the standard lamp, fitted into the opening in front of the S_1 slit of the spectrophotometer. A fixed diameter circular diaphragm provided on a metal plate slides in and out of a slot of the mounting. The 'In' position of the diaphragm reduces the light from the standard lamp into the instrument and the 'Out' position being regarded as 100 per cent light passing through the S_1 slit. Various sizes of the diaphragms can be used in separate metal plates to get different

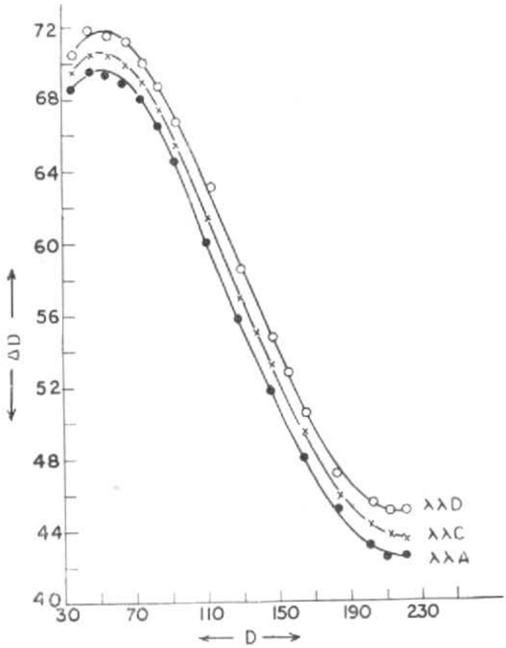

Fig. 1. Wedge calibration with rhodiumised plate

transmission coefficients. The photographs of the mountings and the sections are shown in Figs. 2 to 4.

3. Calibration

The first step was to determine the transmission coefficient of the diaphragm in use. Without removing the ground quartz plate the diaphragm with the standard lamp was mounted on the instrument. Dial was set at zero to keep the clearest portion of the optical wedge in front of the S_3 slit, the other slits (S_2 and S_4) being kept closed. The readings on the micro-ammeter in the 'In' and 'Out' positions give the transmission coefficient of the diaphragm. The dial setting at zero may not provide an absolutely transparent condition in front of the slit S_3. These values will, therefore, have to be finally corrected with the use of the two-lamps method as soon as the equipment becomes available. The readings of the transmission coefficients for λλA and λλD were found to be very consistent and were 77·3 and 80 per cent respectively. The difference in the values for the different pairs of wavelengths may be due to the diffraction effects of the edges of the diaphragm. In view of this difference it was decided to prepare the wedge calibration tables for each wavelength-pair with the transmission coefficient obtained for that pair.

The calibration of the optical wedge was thereafter carried out in the usual manner with the help of the diaphragm and standard lamp. The results are given in Fig. 5 and Table 2. It will be seen that this wedge calibration curve is very similar to that given in Fig. 1, obtained with the rhodiumised plate. The diaphragm having a higher transmission coefficient has brought out some finer structures, *viz.*, at dial readings 35 to 55 and from 130 to 160*. With the use of a diaphragm having a high transmission coefficient the thinner portion of the wedge could be calibrated so that the wedge calibration corresponding to dial readings (as low as 6° or 7°) could be determined.

4. Observational checks

In order to have an idea of the accuracy of the values of ozone with the use of the new wedge table the extra-terrestrial constant was determined in the usual manner utilising the same set of readings. The two sets of values of ozone, one corresponding to the use of the rhodiumised plate and

*This is due to the fact that when the wedge is calibrated with rhodiumised plate or perforated gauze having lower transmission coefficient, the difference between the R1 and R2 dial readings are larger and as such finer differences in △D are masked. Finer differences in △D are shown when the differences in R1 and R2 are small with higher transmission coefficient. Hence it is felt that a higher transmission coefficient (diaphragm, perforated gauze or rhodiumised plate) would make the wedge calibration curve more representative.

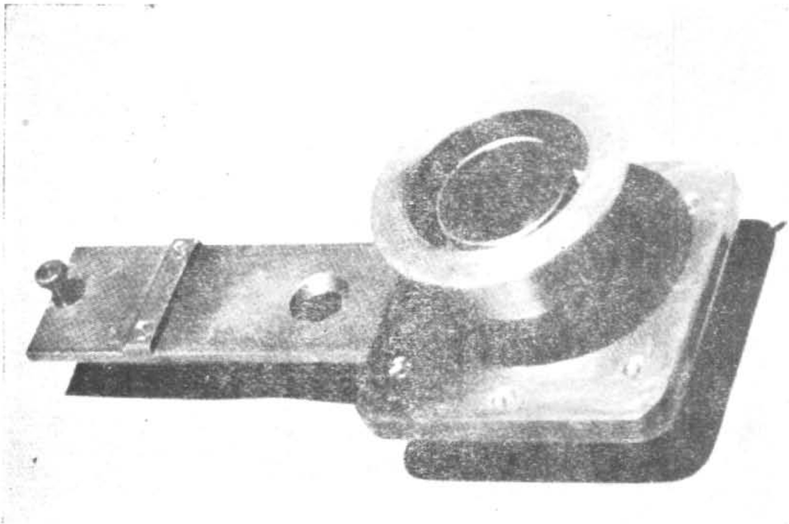

Fig. 2

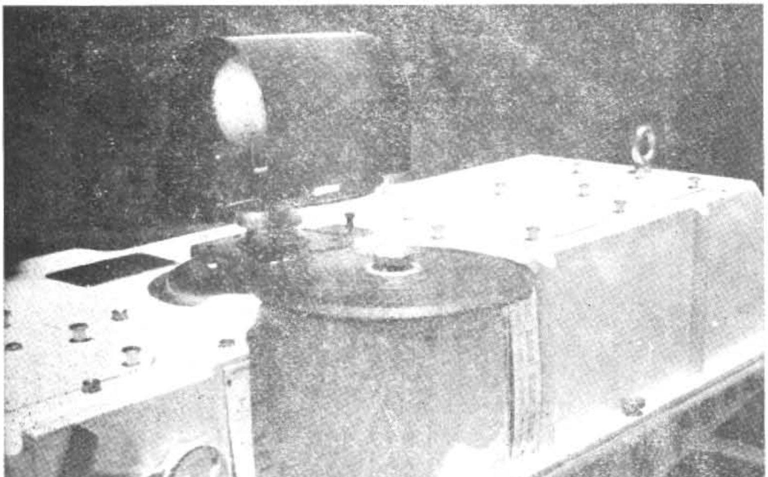

Fig. 3

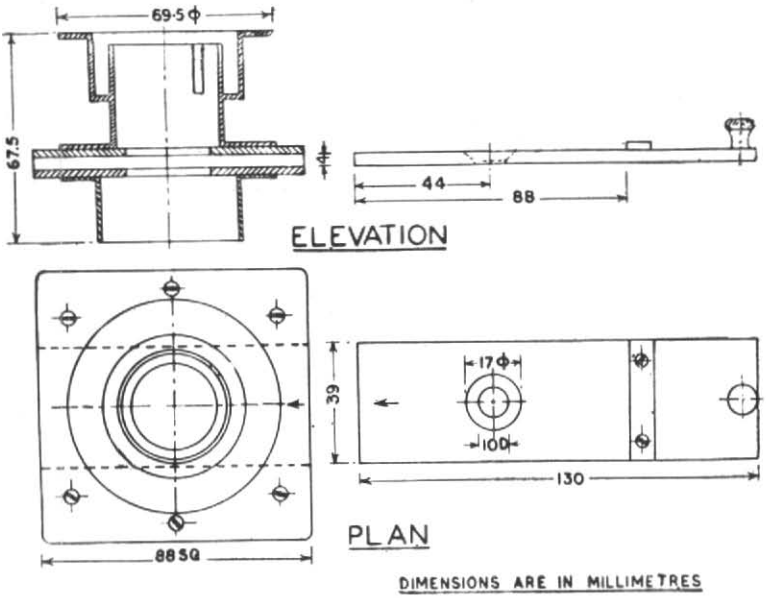
69·5 ϕ
67.5
44
88
ELEVATION
17 ϕ
10 D
39
130
88 SQ
PLAN
DIMENSIONS ARE IN MILLIMETRES

Fig. 4

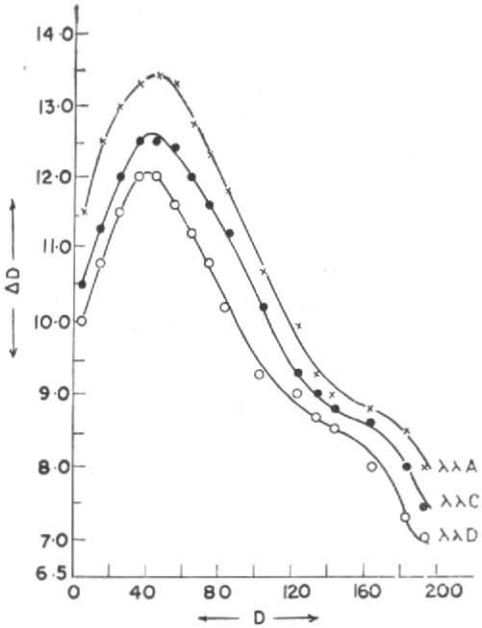
14·0
13·0
12·0
11·0
10·0
9·0
8·0
7·0
6·5
ΔD
0
40
80
120
160
200
D
λλA
λλC
λλD

Fig. 5

TABLE 3

Date	μ	X_{AD} by diaphragm calibration	X_{AD} by rhodiumised plate calibration	Difference
2-12-63	2·215	·231	·233	·002
	3·173	·229	·233	·004
4-12-63	1·673	·231	·236	·005
	2·160	·234	·235	·001
	2·708	·234	·237	·003
5-12-63	1·609	·227	·233	·006
	1·880	·234	·235	·001
	2·322	·239	·239	·000
	3·201	·235	·239	·004
7-1-64	1·486	·233	·239	·006
	2·560	·240	·240	·000
	2·781	·237	·241	·004
17-1-64	2·723	·271	·275	·004
	2·039	·273	·274	·001
	1·446	·266	·272	·006
27-1-64	2·858	·256	·259	·003
	2·015	·258	·259	·001
7-2-64	1·319	·293	·299	·006
	2·031	·291	·292	·001
17-2-64	2·077	·270	·272	·002
26-2-64	1·987	·269	·272	·003
	2·989	·261	·265	·004

the other with the diaphragm are given in Table 3, for comparison. Considering that the transmission factor of the diaphragm has not been corrected by the 2-lamp method, the agreement seems to be quite satisfactory.

5. Acknowledgement

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REFERENCE

Dobson, G. M. B. 1957 *Instruction Manual of Ozone Spectrophotometer.*