junction of the two parts. The formula is

$$\tan mh \,.\, \tan mk = \frac{\text{area of mouth part}}{\text{area of stopped part}}, \qquad (1)$$

where h is the length of the mouth part, k is the length of the stopped part, and m is $2\pi/\lambda$ or $2\pi n/a$ (n = frequency, a = velocity of sound). While this formula might be expected to be satisfactory in the case of bottle-pipes with parts of moderate length, it would, I think, scarcely be expected to hold good if the length of the bottle were much less than a quarter of the wave-length belonging to the fundamental tone of the bottle. In such a case we should expect to get better results by using Rayleigh's formula for the frequency of a Helmholtz resonator, namely—

$$n = \frac{a}{2\pi}\sqrt{\frac{c}{Q}}, \qquad (2)$$

in which, for a bottle-pipe, c would be the hydrodynamical conductance (Rayleigh's "conductivity") of the mouth part and Q the volume of the stopped part. It appears from this, therefore, that for small bottle-pipes the important factor is the *volume* rather than the *length* of the stopped part.

The point to which I wish to direct attention, however, is that, notwithstanding the apparent diversity of equations (1) and (2), Rayleigh's equation (2) can be obtained as a limiting form of (1) when h and k are made small compared with the wave-length. In this case we have approximately $\tan mh = mh$ and $\tan mk = mk$, and if σ_1 is the area of the mouth part, and σ_2 the area of the stopped part, we obtain

$$m^2hk = \frac{\sigma_1}{\sigma_2},$$

or

$$n^2 = \left(\frac{a}{2\pi}\right)^2 . \left(\frac{\sigma_1}{h}\right)\Big/\sigma_2 k.$$

Since σ_1/h (area divided by length) is the conductance of the mouth part (end-correction being neglected) and $\sigma_2 k$ is the volume of the stopped part, we have

$$n = \frac{a}{2\pi}\sqrt{\left(\frac{\sigma_1}{h}\right)\Big/\sigma_2 k} = \frac{a}{2\pi}\sqrt{\frac{c}{Q}}. \qquad (3)$$

It appears, therefore, that either of the two forms (1) or (2) may be used for obtaining the approximate frequency of the fundamental tone of a small bottle-pipe. Rayleigh's formula, however, has the disadvantage that it does not help us to discover the frequencies of the overtones.

If in equation (1) we suppose h, but not k, to be small compared with the wave-length, we have the case of a pipe with a narrow mouth. Equation (1) becomes

$$mh \tan mk = \frac{\sigma_1}{\sigma_2},$$

or if $\sigma_1/h = c$ (the conductance of the mouth),

$$\tan mk = \frac{c}{m\sigma_2}, \qquad (4)$$

an equation which was given by Rayleigh in 1871 ("Scientific Papers," vol. i, p. 46, equation (15); the right-hand side is inadvertently shown with a minus sign).

Again, if k but not h is small compared with the wave-length, we have the case of a long tube connected with a reservoir. Equation (1) becomes

$$\tan mh = \frac{\sigma_1}{m\sigma_2 k} = \frac{\sigma_1}{mQ}, \qquad (5)$$

Q being the volume of the reservoir. This equation was also given by Rayleigh. E. T. PARIS.

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Abney Sectors in Photometry.

THE following may be of value to those interested in photometry.

The instrument known as the "Abney Sectors" used for reducing, for photometric purposes, the intensity of powerful illuminants, such as searchlight projector arcs, by means of a rotating disc fitted with continuously variable sectors, is difficult to construct, and, unless perfectly made, is liable to stick at high speeds.

I have found the following a simple and efficient instrument.

A disc 12 to 18 inches in diameter, in which curved edged V-shaped slots are cut (Fig. 1), is mounted vertically on a board together with a driving motor. Between the illuminant and the disc, close to the latter, but mounted separately, is a screen in which is cut a small rectangular aperture. The beam of light under investigation passes from the source through the aperture and interruptedly through the rotating sectors of the disc to the photometer. The rays are alternately obstructed and allowed to pass by the sectors of the rotating disc, just as in the case of the Abney Sectors. By moving the board on which both disc and driving motor are fixed with respect to the aperture, more or less obscuration as desired may be obtained.

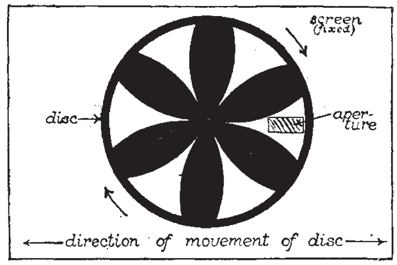

FIG. 1.

The board may move in a groove graduated to show degrees of obscuration. G. F. WOOD.

Forest Research Institute,
Dehra Dun, July 12.

Aurora, Potential Gradient and Magnetic Disturbance.

IN view of suggestions which have been made from time to time that a relationship may exist between the intensity of the earth's electric field and the phenomena of the aurora, or of terrestrial magnetism, the available data from Cape Evans—the winter quarters of Capt. Scott's last expedition—have been examined. The original intention to make a comparison between the auroral data and the potential gradient data was formed on the publication of the first meteorological volume. This intention was stimulated by the fact that the time of maximum of the daily variation in potential gradient at that station lay between the time of maximum frequency for auroræ (4 A.M.) and the time of maximum magnetic disturbance (10 A.M.)—in time of the 180th meridian. In addition, Dr. Simpson had recorded slight anomalies in temperature and in pressure at the time of day when the aurora was most frequently observed. By the courtesy of Dr. Simpson, copies of the original data for potential gradient were made available, but it was found that the hours during which conditions were favourable both for observations of aurora and for potential gradient measurement (wind less than 10 miles per hour) were not sufficiently numerous to repay investigation.