

cal sources of variance can be considerably reduced by judiciously applied vibration treatment.

In designing and constructing an instrument, due consideration should be given to the effect of variance errors in practically limiting the sensitivity to be sought in adjustment, as well as the interval between the graduations and the smallness of the units of graduation. It is suggested that in view of this condition, the mean interval of graduation of laboratory instruments should not be less than five times the mean variance, while for commercial or plant instruments the ratio of mean scale interval to mean variance may be of the order of two to one. Likewise the sensitivity may easily be disadvantageously high, inducing erroneous estimates of the precision of results and requiring special care in the calibration and use of the instrument.

The factors of maximum or mean inaccuracy, (or accuracy) sensitivity, variancy and specific set (the amount by which the variance loop may fail of closure, divided by the range of the deflection cycle) may be referred to the total range of graduation instead of to particular values of the measured quantity under observation, as a convenient means of arriving at single significant numbers to be composed into a "figure of merit" for an instrument whose characteristics are being determined.

Persons having problems of instrument design on hand who may be desirous of obtaining copies of the full paper in advance of its publication, may do so by application to the author, at the cost of blue-print reproduction of the manuscript (34 pages and 7 figures).

MEASUREMENTS ON THE INDEX OF REFRACTION OF AIR FOR WAVE-LENGTHS FROM 2218A TO 9000A.²

By W. F. Meggers and C. G. Peters.

[ABSTRACT.]

A SURVEY of previous researches on refraction of air shows that many investigators have worked either with white light or with one monochromatic radiation, and dispersion measurements have been limited to a small interval of the spectrum. No index measurements exist for waves longer than those corresponding

²Scientific papers, No. 327.

to orange light, and in the ultra-violet the dispersion formulæ disagree by more than 10 per cent. of the refractivity.

Recent work in spectroscopy makes it very desirable to have more accurate and extensive data on the index of refraction and dispersion of air. The international system of standard wave-lengths expresses the lengths of waves in air at 15° C and 760 mm., and all wave-length measurements made under other conditions require small corrections because of the effect of temperature and pressure of the air upon its optical dispersion. Furthermore, it is often desirable to multiply wave-lengths measured in air by the indices of refraction of air for these wave-lengths and thus convert them to their value in a vacuum. An accuracy of one part in several millions is now striven for in the measurement of wave-lengths and to maintain their relative accuracy in the reduction to vacuum values it is necessary to know the indices of refraction within a few units in the seventh decimal place.

For several years the Bureau of Standards has been engaged in the accurate measurement of wave-lengths. Interferometer comparisons of standard wave-lengths have been made throughout a large range of spectrum and the grating spectra of more than fifty of the chemical elements have been photographed and measured in the red and infra-red spectral regions. In connection with these accurate measurements of wave-lengths it was thought advisable to measure the absolute indices of refraction of air for the entire spectral region which is accessible to photography.

Accuracy and efficiency recommended the use of the Fabry and Perot interferometer for this work since this apparatus can be conveniently enclosed in a chamber in which the temperature and pressure of the air can be regulated as desired, and it also permits simultaneous observations for a large number of different wave-lengths. Sections of the circular fringes, produced by various radiations from a source of light illuminating the parallel plates of the interferometer, were photographed either with a grating or a rock salt prism spectrograph, first when the space between the plates was evacuated, and then when dry air at measured temperature and pressure was present.

The index of refraction for a particular wave-length was obtained directly from measurements of the photographed interference fringes which allowed the ratio of lengths of this wave

in vacuum and in air to be calculated. Observations were made at spectrum intervals of about 40 Å from the extreme ultra-violet at 2200 Å, through the visible spectrum and in the infra-red to 9000 Å.

Complete sets of observations were made on dry air at atmospheric pressure and at temperatures of 0°C, 15°C and 30°C.

These are quite closely represented by the following dispersion formulæ of the Cauchy form.

$$\begin{aligned}(n-1)_0 \times 10^7 &= 2875.66 + \frac{13.412}{\lambda^2 \times 10^{-8}} + \frac{.3777_1}{\lambda^4 \times 10^{-16}} \\(n-1)_{15} \times 10^7 &= 2726.43 + \frac{12.288}{\lambda^2 \times 10^{-8}} + \frac{.3555}{\lambda^4 \times 10^{-16}} \\(n-1)_{30} \times 10^7 &= 2589.72 + \frac{12.259}{\lambda^2 \times 10^{-8}} + \frac{.2576}{\lambda^4 \times 10^{-16}}\end{aligned}$$

These observations are used in the construction of a table giving the corrections which must be applied to wave-lengths measured in air where density is not normal. A table of corrections to convert wave-lengths or frequencies measured in air to their values in a vacuum is also given.

The coefficient of index variation with temperature was found from these measurements to be a function of the wave-length. For long waves this optical temperature coefficient is identical with the density temperature coefficient, *i.e.*, $\frac{1}{273}$ but as the ultra-violet absorption band is approached it increased rapidly, becoming $\frac{1}{258}$ at 2500 Å.

There seems to be no definite evidence of any strong absorption of infra-red light by dry air and it is therefore possible to represent the optical dispersion of air by the first term of Sellmeier's formula quite satisfactorily.

THE INFLUENCE OF QUALITY OF GAS AND OTHER FACTORS UPON THE EFFICIENCY OF GAS-MANTLE LAMPS.*

By R. S. McBride, W. A. Dunkley, E. C. Crittenden, and A. H. Taylor.

[ABSTRACT.]

THIS paper describes the apparatus and methods employed and the results obtained in studying the effects of several variables such as gas pressure, gas adjustment, air adjustment, and gas

* Technologic papers, No. 110.