Since the accuracy of the Type I approximation increases rapidly with the size of the deck, the values given in the second column for the 5×5 case are expected to be correct to within a very few units in the last place. Even in the 4×4 case, the accuracy of the Pearson Type I approximation is already so great that some 170,000 trials (a trial being an observation of r) would be required before one could distinguish with moderate certainty, from the observations, between the set of true probabilities and the direct Pearson approximation. To distinguish observationally between the true values and the binomial values, in the 5×5 case, would require some 30,000 trials.

T. E. STERNE

HARVARD COLLEGE OBSERVATORY

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE MEASUREMENT OF TURBIDITY IN COLORED MEDIA

THE measurement of turbidity photometrically is based on the assumption that there is a linear relationship between the amount of suspended matter and the intensity of the Tyndall beam. Although this holds moderately well within narrow limits when the sample is colorless and faintly turbid, the relationship between the amount of turbidity and the Tyndall beam intensity is much more complex at higher concentrations of suspended material as well as when coloring matter is present in solution.

One of the most disturbing factors is the concomitant weakening of the intensity of the Tyndall beam by absorption. When the suspending liquid is also colored, the absorption effect may be so great that it overbalances the scattering to an extent such that increasing turbidity may give a lower intensity of the Tyndall beam.

According to Sauer,[1] under these conditions the absolute turbidity is given by the following equation:

$$\text{Absolute Turbidity} = A \times f(k) \times D \times t \tag{1}$$

where

A = Relative intensity of the Tyndall beam as measured with the Pulfrich photometer.

D = A factor varying with the thickness of the absorption cell.

t = The absolute turbidity of the glass standard of the instrument.

If d = Depth of layer of solution in centimeters, and k the coefficient of extinction

then

$$f(k) = \frac{kd(\sqrt{2}-1)\,\log_e 10}{10^{-kd}\{1 - 10^{-kd(\sqrt{2}-1)}\}} \tag{1a}$$

In previous work the writers[2,3,4] have shown that the two empirical equations:

$$-\log T = C + N \tag{2}$$

$$N = \frac{R\,b^C}{a} \tag{3}$$

[1] Sauer, *Zeits. techn. Phys.*, 12: 149, 1931. See also Landt and Witte: *Zeits. Ver. deut. Zuckerind.*, 84: 462, 1934.

[2] Zerban, Sattler and Lorge, *Ind. Eng. Chem. Anal. Ed.*, 6: 178, 1934.

[3] Zerban, Sattler and Lorge, *Ibid.*, 7: 157, 1935.

hold for turbidity and color determinations for commercial raw cane sugar solutions as well as for white sugars.

C = Coloring matter expressed as − log T.

N = Turbidity expressed as − log T.

R = Intensity of the Tyndall beam = 100 A of Sauer.

T = Per cent. transmittancy.

(− log T) = 2 − log T.

a and b are constants.

We know now that the term b^C in equation (3) is equal to $f(k)$, and that Sauer's equation is valid if C is substituted in place of the kd term in (1a). Hence the turbidity of a colored solution can be calculated either in terms of the absolute turbidity of Sauer, or else in the system used by the writers. Naturally the two methods are interrelated.

The final relationships are given by the following equations:

$$C = -\log T - \frac{R\,f(k)}{a} \tag{4}$$

$$f(k) = \frac{\left[-\log T - \left(\frac{Rf(k)}{a}\right)\right](\sqrt{2}-1)\,\log_e 10}{10^{-\left(-\log T - \left(\frac{Rf(k)}{a}\right)\right)}\left\{1 - 10^{-\left[-\log T - \left(\frac{Rf(k)}{a}\right)\right](\sqrt{2}-1)}\right\}} \tag{5}$$

When C is zero, f(k) is equal to 1.

Equation (5) is solved for varying values of C, which is the $-\log T - \frac{R\,f(k)}{a}$ term, and a table of corresponding f(k) values is thus obtained. Substitution of these C and f(k) values and increments of R into equation (4) yields a chart from which C is readily found from the − log T and the R values. Practically, C is found from curves based on the chart. The application to cane sugar solutions will be published elsewhere in the near future.

F. W. ZERBAN

LOUIS SATTLER

NEW YORK SUGAR TRADE LABORATORY,
NEW YORK CITY

[4] Zerban and Sattler, *Ibid.*, 9: 229, 1937.