ers, but for some reason the reagent is contaminated by contact with the ground glass stopper of the amber-colored dropping bottle. Hence it seems preferable to make up at once only a sufficient amount of the reagent for use within two or three days' time, rather than attempt to store it in only partially light-proof bottles which might produce contamination.

A common artist's slab with circular depressions one inch in diameter and one fourth inch deep is the most convenient vessel for conducting the test. One drop of the solution to be tested is transferred to one of the depressions by means of an eye-dropper pipette. Four drops of the reagent are added, and the liquid stirred with a two-inch glass rod until a full color develops, which requires about two minutes. The intensity of the blue color is an approximate quantitative measurement of the nitrate nitrogen content, within the limits of from 1 to 25 p.p.m. of nitrates expressed as nitrogen. Above about 25 p.p.m. the blue color is so intense that little variation can be observed. In such cases the liquid to be tested must be diluted five, ten or more times, so that one drop of the diluted liquid will fall within the above limits. In such cases the final test is on the basis of one drop of the diluted liquid to four drops of the reagent, with calculation of results on the basis of the dilution.

A color chart of satisfactory accuracy can be made up with water colors. The color blocks in Ridgway's "Color Standards and Nomenclature," that most closely approximate the chart used by the author, is as follows:

Nitrate nitrogen concentration p.p.m.	Color name	Book Plate 1 No.
1	Pale forget-me-not blue	XXII
2	Pale violet blue	IX
3	Light violet blue	IX
5	Dull violaceous blue	XXII
7	Phenyl blue	IX
10	Helvetia blue	IX
15	Hays blue	IX
20	Cyanine blue	IX

The purity of the reagent can be ascertained by a blank test with one drop of distilled water. If no permanent blue color appears, the reagent is satisfactory for use on that day.

The results of the author and one of his associates in the determination of nitrate nitrogen in the leachate from 136 greenhouse lysimeters containing seventeen different soils, some pots of which had been previously treated with urea, both with and without lime, are of interest as an evidence of the accuracy of the spot-plate test. One person made the nitrate-nitrogen determination by the accurate phenyldisulphonic acid method, while the other conducted the spot-plate tests. Results were compared subsequent to recording the results. Space does not permit publication of the individual results, but the following table summarizes the data in comparative form:

No. of samples in group	Exact method NO_3-N p.p.m.	Spot-plate tests	
		NO_3 N p.p.m. range	No. of samples within group limits
23	0– 20	0– 25	20
18	21– 50	20– 75	14
27	51– 100	30– 150	19
28	101– 200	75– 300	20
19	201– 350	200– 500	16
15	351– 500	300– 600	11
6	501–1000	500–1000	5

Several applications of this test suggest themselves. For soil tests, the author employs the special porcelain block used in connection with the LaMotte-Morgan Soil Testing Set to obtain the soil extract. Where the soil compartment of this block is filled to its normal capacity and distilled water permitted to soak through the soil in amount sufficient to fill the test cup, one drop when transferred to the artist's slab and tested for nitrates as described above gives results in p.p.m. of soil extract which can be interpreted as pounds of nitrate nitrogen per acre to plow depth. Dilutions are employed when necessary.

Another very important use of the test is the determination of nitrates in expressed plant juices and extracts. A suggested method is the maceration of small portions of fresh plant tissue in one compartment of the artist's slab, the addition of a drop or two of water if necessary in order to obtain a drop of expressed juice for transfer and the subsequent test. Good results have been obtained with green tissue in studies of the nitrate content of newly developed nodal portions of herbaceous pasture and forest plants.

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THE CAPNOMETER, AN INSTRUMENT FOR THE MEASUREMENT OF AIR POLLUTION

FROM the beginning of Mellon Institute's Air Pollution Investigation, a year ago,[1] it was recognized that the photoelectric cell would play an important part in the determination of the amount of atmospheric contamination and its distribution outward and upward from sources. Sampling devices ordinarily enable one to estimate the content of solids in a small volume of air at a given time and place, or the total amount at a given place over a period of

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[1] L. W. Bass, SCIENCE, 70: 186, August 23, 1929.

time. It was desirable, however, for us to have a continuous record, not only of the amount of pollution, but also of the effects of atmospheric conditions upon the distribution of solids after their emission from stacks or other sources.

With the helpful cooperation of members of the staff of the Westinghouse research laboratories, experiments were made first for work at short range, and in consequence a combination has been developed that may be used at night or in the daytime. It consists essentially of a source light with a modulator, a receiver and amplifier, tuned, and an indicator or recorder, calibrated. It differs from "smoke indicators" in that it need not be attached to a smoke-pipe or stack and also in that it operates independently of any influence from daylight or artificial light other than that from the controlled source.

At the suggestion of W. A. Hamor, assistant director, Mellon Institute, the apparatus has been named the *capnometer* (> Greek *kapnos,* smoke, and *metron,* measure), for its purpose is to measure smoke—*capnometry.*

From the results of the work done in the laboratory, there is every indication that the apparatus will be very helpful in the capnometric part of Mellon Institute's program and in securing data concerning the influence of furnace and firing conditions, precipitation, wind velocities, etc., upon the density due to pollution of the atmosphere.

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SPECIAL ARTICLES

A THEORY OF THE RING METHOD FOR THE DETERMINATION OF SURFACE TENSION

DURING the last few years several papers concerning various phases of the ring method for the determination of surface tension have appeared in SCIENCE. It is desirable that this discussion also appear here especially because it is closely related to one of these papers. An experimental study of the ring method by Harkins, Young and Cheng[1] has shown that this method, as usually carried out, does not give true surface tension values. The results of Harkins and his collaborators are expressed in the form of a series of empirical correction curves which involve a value of the surface tension given by an absolute method. They have demonstrated that the value of the surface tension as given by the pull on a ring and the relationship

$$W = 4\pi R \gamma \qquad (1)$$

must be modified by these correction curves if that value is to be regarded as being, in fact, that of surface tension. The purpose of this preliminary paper is to announce that a theoretical basis for this empirical correction procedure has been developed, thus making the ring method, as modified, an absolute one, since by it surface tension may be determined without reference to any other method.

The basis of our theory is Laplace's equation for stable liquid surfaces expressed in the particular form applicable to surfaces of revolution, with the capillary constant (a^2) eliminated,

$$\frac{du}{d\bar{x}} + \frac{u}{\bar{x}} = \pm 2\bar{y} \qquad (2),$$

where u is the sine of the angle made by a tangent to the surface at any point ($\bar{x}$, $\bar{y}$) with the $\bar{x}$-axis. The $\bar{x}$-axis in this case is chosen at the undisturbed level of the liquid, and the $\bar{y}$-axis is the axis of symmetry. In this form the equation expressed shapes of surfaces, not their actual dimensions. If the latter are to be expressed, a^2 or its equivalent $\frac{2\gamma}{gd}$ must be known, where γ and d are respectively the surface tension and density of a particular liquid. Barred symbols as used by us are dimensionless, thus $\bar{x} = x/a$ and $\bar{V} = V/a^3$. But we shall speak of them, for convenience, as lengths and volumes. This equation formulates the shapes of all types of stable liquid surfaces of revolution. The ring method involves two of these types, the meniscus and the surface held up by a wetted disk. To get the actual shapes of these surfaces the equation must be integrated, which must be done in this case by series.

The shapes of the meniscus formed inside the ring are obtained by numerical integration in the ordinary way. But the integration for the outer slope presents a difficulty in that there is no known point at which to start. We have obviated this difficulty by an assumption which, however, introduces an error much less than any in the experimental procedure. These two integrations give a cross section of the liquid raised by the ring in any position. It takes the form of two curves tangent to a circle, one curve being the shape of the meniscus, the other being that of the outer slope, and the circle being the cross section of the wire, of radius r, of which the ring is made.

The volume below these surfaces is calculated. It

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[1] Harkins, Young and Cheng, SCIENCE, 64: 93, 1926.