ENGINEERING RESEARCH INSTITUTE
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PROGRESS REPORT NO. 1

UNIFORM-DROP-GENERATOR METHOD FOR CALIBRATING SPRAY ANALYZER

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Project 1886-1

DeVILBISS COMPANY

July, 1954

ABSTRACT

A drop generator is described which delivers uniform, reproducible, convenient streams of drops. A glass capillary is vibrated magnetically to deliver the drops.

The application of this generator to the calibration of the electronic spray analyzer is described, and a typical calibration curve is presented.

UNIFORM-DROP-GENERATOR METHOD FOR CALIBRATING SPRAY ANALYZER

For the past several years this project has been concerned primarily with the development of an electronic spray analyzer which could rapidly determine the size distribution in a large sample of a spray. One of the most difficult and elusive techniques involved in the development and operation of the analyzer is that of calibration. The problem of determining how the analyzer responds to a particular size of drop and how the response varies with drop size must be adequately solved in order that the results of an analysis can be accurately specified.

Calibration of the electronic spray analyzer requires the production of uniform drops, continuously and in a usable form, which lend themselves to an accurate determination of size.

This report describes the application of a unique method of drop generation to the rapid calibration of the spray analyzer. This method, which consists of feeding the liquid through a magnetically vibrated glass capillary, was independently developed here, but we discovered that a similar apparatus was developed earlier by N. A. Dimmock.* The application of this method of drop generation is still worthy of detailed description, inasmuch as methods of calibrating spray analyzers are few in number and have various difficulties which this method avoids.

Included in this report is a description of apparatus, a discussion of its operation, the procedure for obtaining uniform drops and identification of size, and a review of the application of this method of drop generation to the calibration problem.

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*Nature, 166, 686, October 21, 1950.

EQUIPMENT

Drop Generator

The drop generator is shown in Fig. 1. A glass capillary is pulled on the end of a length of 1/4-inch soft-glass tubing. A ball of rubber cement and iron filings is attached slightly below the neck of the capillary. The tubing is rigidly held by a binding screw in a movable support which is in turn moved by a screw mechanism attached to the plastic frame. Suspended from the frame and directly under the capillary support is a magnet made from a 1/4-lb spool of number 36 wire, tapped at the center for one of the leads. The core of the magnet is a bar of sintered iron of the same length as the coil. Sixty-cycle current from 0-110 volts is supplied through a potentiometer. The capillary support is designed to move the capillary axis in a direction perpendicular to the face of the magnet core.

The proper length of capillary is determined by activating the magnetic field with the capillary in position and full of liquid and then shortening the capillary by breaking off from the end increments of about 1/16 inch until a high degree of resonance is obtained and the capillary has a high amplitude of vibration.

Liquid is supplied to the capillary from a 5-inch-diameter, 8-inch-long tank through a flexible tube so that the tank may be raised or lowered relative to the drop generator.

Sampling System

Samples of particles produced by the drop generator are collected in special glass dishes (shown in Fig. 2). Each dish has a flat bottom and two flat discs fused into the sides in order that vertical and horizontal projections of the contents of the dish may be viewed and photographed.

An optical comparator which magnifies the field of vision by 10 is used to determine the size of particles in the sampling dishes. Figure 3 shows the positioning of the comparator. Ordinarily the image is focussed on the ground glass on the face of the comparator. For photographs, the screen is removed and the image focussed on the screen of a plate holder mounted parallel to the face of the comparator. Particles less that 200 microns cannot be accurately measured with a 10X magnification and a 50-100X lens is necessary for smaller drops. The particles are measured with a simple hand scale because they appear as circles ranging from 0.2 to 3.0 cm in diameter for drops larger that 20 microns.

Note: For Figures 1, 4, and 5, refer to file copy.

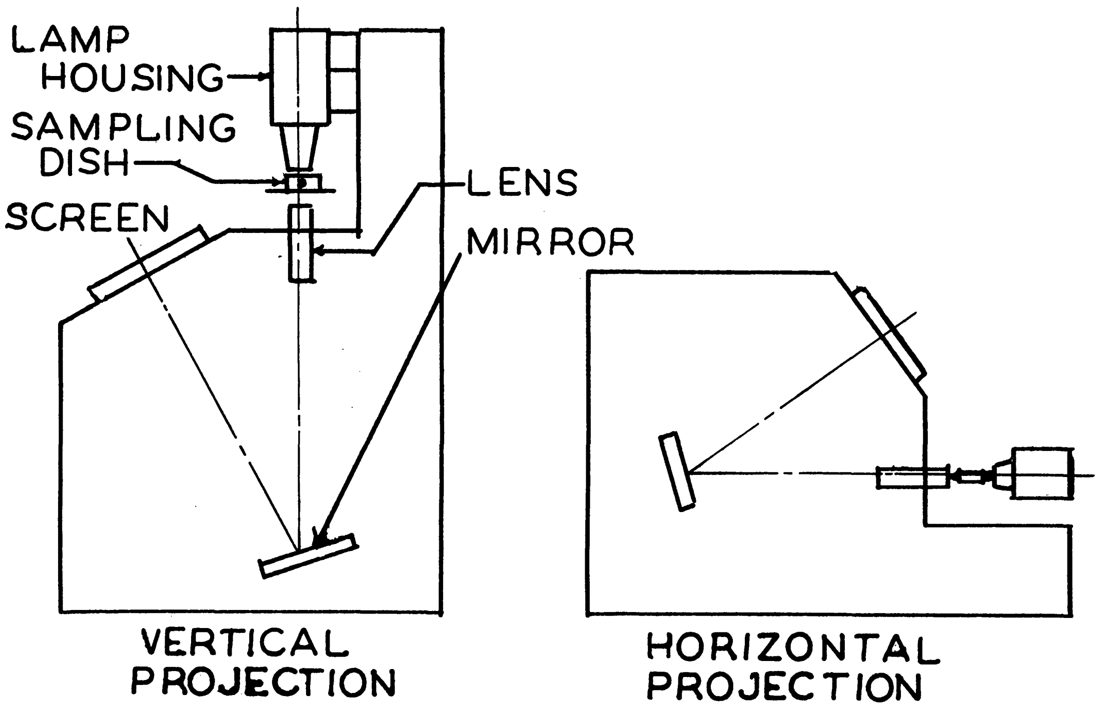


Figure 3. Positioning of Comparator for Viewing Vertical and Horizontal Projections of Drops Being Sampled.

OPERATION OF GENERATOR

After the capillary length is fixed, as described above, current is passed through the magnet causing the capillary tip to vibrate in an elliptical motion. Particles of fluid are thrown away from the tip as it rotates. Varying the voltage by adjusting the potentiometer will cause the amplitude of vibration to vary, which in turn changes the manner in which fluid is thrown away from the tip. In general, the capillary vibration can be so regulated that it will produce one or more streams of particles, each reproducibly following the same trajectory. Figure 4 shows the generator in operation.

The sampling dish is filled with a fresh charge of collecting fluid and some of the particles in a given stream are allowed to fall into the dish. The fluid used is turpentine or toluene when sampling water particles. These liquids are satisfactory since no breakup occurs upon collection, and no detectable evaporation occurred while samples were being measured. The dish containing a sample of drops is placed on the comparator and the sizes are recorded. Figure 5 is a typical sample as seen on the comparator. Size distortion in the dish is about 2 percent.

A uniform stream can be reproduced by holding a particular capillary in the same position relative to the magnet and in the same magnetic field. The generator can be shut down for long periods and started up again to give the same drop size. Minor changes in voltage will shift the direction of the stream without seriously affecting the drop sizes. Varying the head of liquid on the capillary varies the flow rate and therefore the drop sizes over a considerable range. Replacing the capillary with one of different diameter will shift the entire range of drop sizes delivered.

APPLICATION OF THIS TECHNIQUE TO THE ELECTRONIC SPRAY ANALYZER

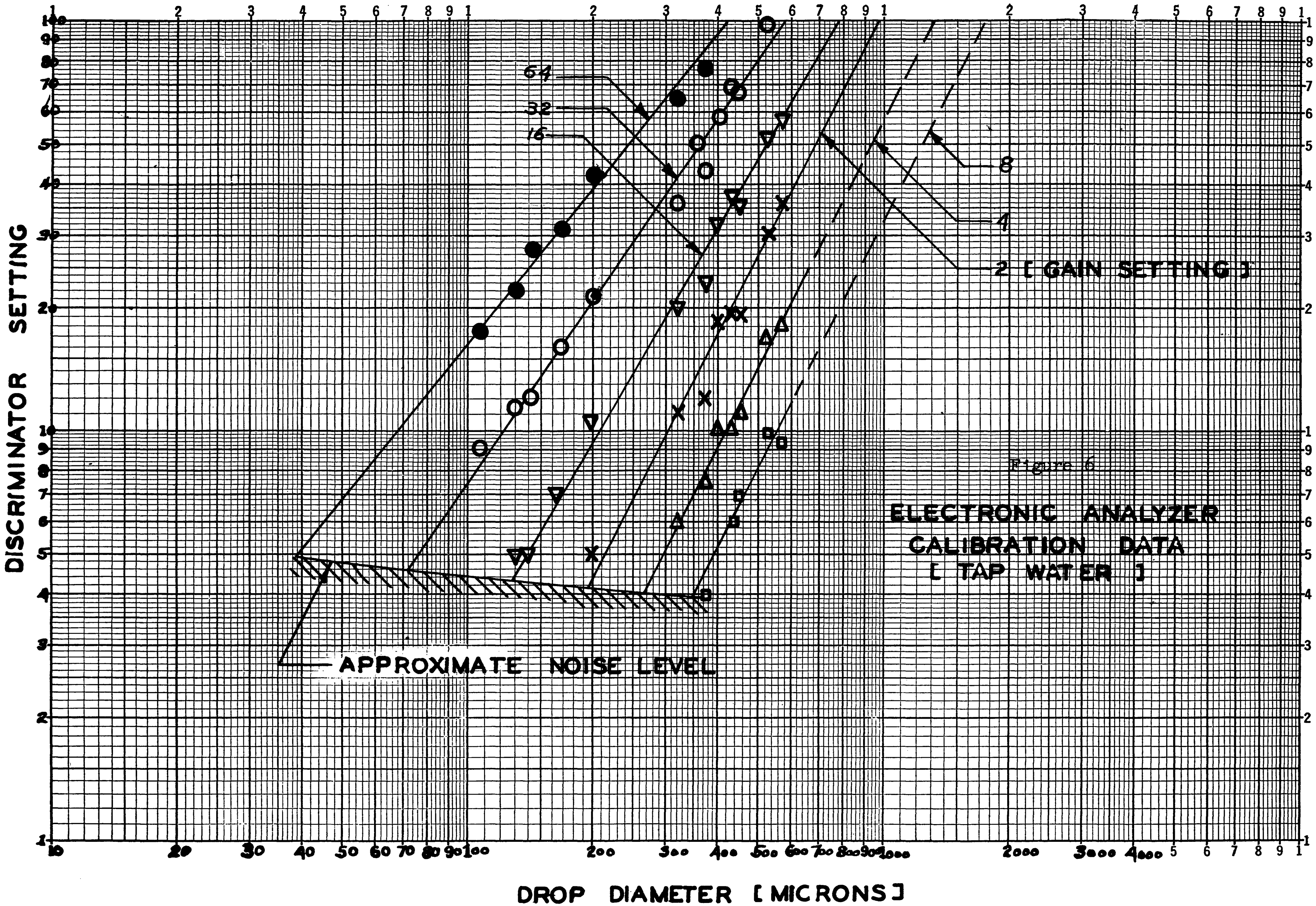
With the size in a stream of particles known exactly, the response of an analyzer to the particles of that particular size can be determined without the difficulties involved in using a spray with a distribution of sizes.

The electronic spray analyzer consists of: (1) a probe whose potential varies so rapidly as to form a pulse when a neutral particle touches it, (2) a linear amplifier which magnifies this pulse, (3) a discriminator circuit which transmits pulses larger than a certain size, and (4) a counter which records the rate of transmitted pulses. The impulse corresponding to a particle is a function of the diameter of the particle, increasing with increasing diameter. By setting the discriminator at some level, s, all pulses larger than s will be counted and those smaller than s will not.

With the drop generator producing uniform particles, it is an easy matter to determine the discriminator setting, s, corresponding to a given size by finding the setting above which no counts appear and below which all drops are counted. Actually, the change from counting all particles to counting none occurs over a small range of settings, the center being chosen as the equivalent setting. The magnetic vibrator provides a constant reference count of 120 drops per second, which simplifies determination of the setting below which all drops are counted.

Application of this drop generator to the electronic spray analyzer involves a special correction factor. An initial charge on the drops, opposite in potential to that of the probe, results from the high potential of the probe and its nearness to the capillary. The impulse at an infinite distance corresponds to an uncharged drop such as would exist in a free spray. Generally, a distance of 4 cm suffices to eliminate this effect, but it should be checked for each probe, generator, fluid, and potential.

By determining the discriminator setting for various drop sizes, a plot is obtained which can be used to convert counting rate vs pulse size as received in an actual spray into a size-frequency curve for the spray. Figure 6 shows a typical calibration curve for the generator.



64
32
16
8
4
2 [GAIN SETTING]
Figure 6
ELECTRONIC ANALYZER
CALIBRATION DATA
[TAP WATER]
APPROXIMATE NOISE LEVEL
DISCRIMINATOR SETTING
DROP DIAMETER [MICRONS]

COMMENTS AND RECOMMENDATIONS

The technique described affords a fast and accurate calibration. It provides a rapid check of the calibration and is reproducible. It provides the necessary basis of comparison in terms of uniformity, availability, and reproducibility.

The calibration also is applicable to sprays of any fluid, because the generator can be run with the actual fluid to be analyzed. This ability to utilize various fluids will provide a means of determining the ability of the electronic analyzer to operate in sprays of liquids other than water.

The application of this calibration technique would need modification when used with other analytical techniques, but the characteristics of the generator are distinctly advantageous in testing various phenomena relating to drops and dependent upon their size.