ANALYTICAL METHODS FOR DETERMINATION OF AEROSOLS BY MEANS OF MEMBRANE ULTRAFILTERS. XVII.*

CONTINUOUS MEASUREMENT OF SOLID AEROSOLS BY MEANS OF MEMBRANE FILTER RIBBONS AND AN AMERICIUM SOURCE**

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Received June 1st, 1970

Movable filtration ribbons for continuous and registering measurements of concentrations of atmospheric aerosols have found first application more than 15 years ago[1], mostly as measurement of light absorption in the layer of the arosol sample. This principle is also exploited in the instrument recently described by the present authors[1]. At this equipment in contradistinction of the previous methods, two improvements were introduced. Formely used filtration papers were replaced by a ribbon of membrane filter, of which advantage inheres primarily in retaining aerosol on the filter surface and in a high filtration efficiency. A further improvement was represented by a differential measurement of a "pure" and "choked" filter, eliminating errors resulting from a variable thickness of the filtration ribbon. The instrument enables one to measure concentrations of atmospheric aerosols from 50 $\mu g/m^3$ to higher values. However, the method[1] has two drawbacks .The light absorption in the retained aerosol sample naturally depends on its optical properties. Thus, the calibration procedure should be repeated for each kind of aerosols, *e.g.* for each city, industrial region, *etc.* In addition to this, electrical units of the instrument (particularly the measurements of the light intensity by means of photoresistences) remarkably depend on temperature conditions in the atmosphere where measurement carried out.

The adjustment and completion — described in this paper — made it possible to achieve a higher sensitivity of the measurement and to simplify the calibration procedure. The absorption of radioactive radiation is used for measuring the amount of the retained aerosol instead of the light absorption. This principle was also formerly utilized[2-4], however, those times aerosol samples were collected on either filtration ribbons made of common filtration paper, or filtration ribbons consisting of organic or glass microfibres. Those filtters are not so suitable for retaining finely dispersed aerosols as porous filters (particularly Membrane and Nuclepore ones) used is by the present authors[5,6].

EXPERIMENTAL

The following three kinds of porous filters were used for retaining samples: Czechoslovak membrane filter (Synthesia, average pore diameter of about 1·5 μm), membrane filter (average pore diameter of about 3 μm), and General Electric Nucleopore filter (pore diameter of about 0·8 μm). Sizes of filtration ribbons used were of 15 . 2,000 mm.

* Part XVI: This Journal *36*, 950 (1971).

** This work has been supported by IAEA, contract No 411.

A basic square weight of filtration ribbons used, that represents a governing factor in selecting a proper emitter, ranges between 1—3 mg cm^{-2}. Of β-ray emitters, *e.g.* ^{14}C, whose half value layer amounts to about 2 mg cm^{-2}, could be used, however proper α-ray emitters are also available. The authors selected ^{241}Am for given instrument (energy of 5·5 MeV and half-life time of 458 y). Ranges of α-particles having this energy in air are of about 4 cm. The activity of the source used was of 120 μCi. The same mechanical units of the instrument, *i.e.* pump (a membrane pump yielding the output of 2 l/min), flow meter, flow-rate stabilizer, device for moving the filtration ribbon, *etc.* were used as by the former instrument[1].

The operation of a preliminary instrument is obvious from Fig. 1. The filtration ribbon (*FP*) is moved discontinuously in front of the window of the radioactive source (*Z*). A zero position of the registering galvanometer (*Reg*) is reset while shielding the emitter. After that the shield is removed. An electric current is developed in the ionization chamber (*IK*) and an electric voltage formed on the resistor (*R*). This corresponds to a measurement with a pure ribbon. The voltage is subsequently compensated during the field measurement to avoid effects of a variable thickness of the pure filtration ribbon. Then, the sucking device is switched on and the filtration ribbon is stopped for a properly chosen time interval Δt (10—100 min). Aerosol particles are retained on the filter surface, thus continuously reducing the radiation intensity from the source (*Z*). The registering galvanometer yields a record of an increase in the current with time. A curve obtained indicates an increase in the α-ray absorption with time corresponding to an increasing width

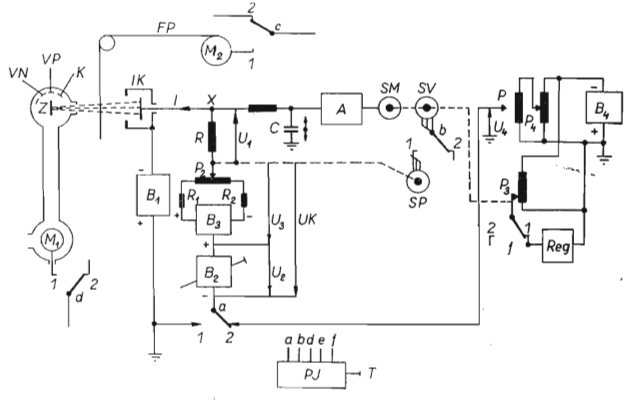

FIG. 1

Circuit Diagram of the Aerosol Concentrameter with a Radioactive Source

Z Radiation source, *K* diphragm, *VP* diphragm — simulation of the filtration ribbon, *VN* diphragm for simulating the sample, M_1 pump, M_2 device for driving the filter ribbon, *IK* ionization chamber, *FP* filtration ribbon, B_1 power supply for *IK*, B_2, B_3 power supply for capacitor, *C* vibration capacitor, *SM* servomotor, *SV* master selsyn, *SP* slave selsyn, *Reg* recording instrument, *P* potentiometers, *R* resistors, *U* voltage, *a*, *b*, *c*, *d*, *e*, *f*, contacts, *I* current.

of the layer of aerosol particles. After elapsing the preselected time interval Δt, the device sucking air is switched off. After that, the ribbon is shifted to the next measuring position, the instrument is automatically reset and a new measurement is started.

Electronic and measuring units were mostly produced by the Tesla Company (RDE-101, EB-201). The ionization chamber is filled with argon at a moderate overpressure. The collecting electrode represents the anode. This provides together with the use of argon effective capturing electrons to avoid an excessive ion recombination.

The whole equipment consists of three components: *1.* The filtration ribbon and the device for a preselected shift of this ribbon. *2.* The pump, the flow meter, the flow rate stabilizer, an indicator element of the electrometer and the whole electronic part. *3.* Recording galvanometer.

RESULTS AND DISCUSSION

A higher sensitivity of the measurement and more reliable calibration were achieved by replacing the optical measurement with measuring the α-ray absorption (the sensitivity is expressed as the minimum aerosol concentration that can be measured with the error $\leqq \pm 20\%$). In the instrument with the optical measurement[1], the sensitivity was of 0·2 mg m^{-3} whereas using the ^{241}Am source, the sensitivity of about 10 $\mu g\ m^{-3}$ was achieved. The filtration area where the aerosol sample is collected (at the flow rate of 2 l/min) is of 0·1 cm^2. A change of the square weight of the ribbon of 5% corresponds to the full scale. For example, when using the filtration ribbon made of a classical menbrane filter of the square weight of about 2 mg cm^{-2}, the full scale corresponds to 100 μg of the sample. For a Nucleopore filter having its square weight of about 1 mg the value is of 50 μg of the sample. Thus 10 and 5 μg can be determined with a sufficient accuracy for the former and latter cases, respectively. A concentration of atmospheric aerosols of 50 $\mu g/m^3$ may be considered as a low one. This level can be measured with help of the described apparatus in 100 min. Naturally, higher concentrations can be easily measured and the level of 50 mg m^{-3} can be considered as a upper limit (concentrations occuring in dusty plants, mines, *etc.*). With respect to characteristic properties of the filtration process, the equipment may be used in measuring concentrations of finely dispersed aerosols (particle size less than 2 μm in diameter).

A calibration procedure is carried out in the same manner as in the case of the optical measurement[1], *i.e.* by weighing and microweighing. In an aerosol chamber a constant concentration is provided of the aerosol to be used for the calibration. For constant time intervals aerosol is sampled onto previously weighed, either Membrane or Nuclepore filters[7] and the concentration is measured with the equipment described. In this way, the scale of the recording concentrometer of aerosols with the radioactive source can be directly calibrated in $\mu g\ m^{-3}$. For each kind of the filtration ribbon, only one calibration procedure is sufficient. From time to time the results of the calibration may be controlled.

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Translated by the author (K. S.).