A NEW AEROSOL PARTICLE ANALYSER

B. BINEK and B. DOHNALOVÁ
Institute of Physical Chemistry,
Czechoslovak Academy of Sciences, Prague 2

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In the particle size range below 0·5 μm, important from both the practical and scientific point of view, very complicated method must be used to determine size. The most frequently used methods (separation by electron-microscopic evaluation) have a common disadvantage, in that the measured results constitute in fact comulative values taken over a longer period. Futhermore, for results of adequate statistical significance, measurement is very lengthy and great care is required during sampling and preparation.

A new method for analysing of aerosol particles, the so-called spectral scintillation analysis, was developed in our institute. Several years' research was terminated by the construction of the final prototype of an instrument. This method and the apparatus[1–4] became the subject of patents in Czechoslovakia as well as abroad[5,6]. The patent licence was ceded in 1967 to the firm Sartorius-Werke GmbH[7] (Göttingen, GFR), which is at present realizing the serial manufacture of the instrument.

EXPERIMENTAL AND RESULTS

The further development of the spectral scintillation analyser of aerosol particles led to the realization of an universal instrument termed Scintillating Particle Counter. The design of this instrument set out from an analysis of the measuring methods and the demands placed on the analysis of aerosol not only in research but also in practical fields. This relates to rapid determination of numerical and weight concentration, distribution of particles according to size, chemical composition and degree of electric charge. It is clear that at the present state of measuring technique there exists no direct method for determining these fundamental parameters. For this reason, a combination of two methods was selected: spectral scintillation analysis and scattering of light on aerosol particles. The aerosol being analysed is in both cases introduced into a limited space where the particles directly or indirectly emit a light pulse (scintillation). Consequently it is possible to employ a combined equipment determining volumetric flow rates and an electronic evaluating instrument.

A comparison of both methods applied in this instrument reveals that spectral scintillation analysis is an order of magnitude more sensitive than the method of light scattering, it is independent of the shape but dependent on the chemical composition of the particles. It exhibits a simple relation between the signal and the particle diameter in the entire range of measurable sizes and, therefore, it is easy to calibrate. The maximum limit of flow rate volumes, however, does not exceed 300 cm^3/min. On the other hand, light scattering depends on the physical properties of the particles, and higher flow rate volumes can be employed. A combination of both therefore offers a much wider scope of application in the measuring technique of aerosols.

Fig. 1 illustrates the functional diagram of the instrument. The analysis proper of the aerosol takes place in the measuring chamber *20*, which in spectral scintillation analysis contains the burner of the hydrogen double microflame *1*, the ignition spiral *2*, and the transparent cooling cylinder *19*. This part is exchangeable and replaceable by the system for light scattering on indivi-

dual particles. To the measuring chamber is connected the tube with the sensing optical system *22*, the monochromate *23*, and the photomultiplier *24* fed by a variable voltage from the source *26*. Coaxially with the sensing optical system is seated the calibration device *25* simulating scintillations of particles of different size. The centrifugal pump *21* creates a constant underpressure in the measuring chamber, effecting the aspiration of the aerosol being analysed (*III*) with the electronic control *12*, *13* of the isobaric conditions at the inlet, as well as the required flow of the cooling and the combustion air (*I*, *V*) through the filters *3*, *7*. The valve *4* permits to vary the degree of underpressure in the measuring chamber, where it is controlled by the electronic device *5*, *6*. The concentration of the aerosol being analysed is continuously variable by mixing with clear air (*IV*) in the mixer *18*. The clean air is supplied by the pump *14*, purified by the filter *15*, and its amount is regulated by the valve *16* and measured by the flow meter *17*. The combustion gas (*II*) is introduced by the automatic control *10*, its troughflow volume is regulated by the valve *9* and measured by the flow meter *8*. The automatic control device determines the instant of ignition of the gas and serves as safety device in cases of incorrect attendance or defects. The control and the regulating electronic system are on the common panel *11*.

The electric signal, characterizing the light effects of the analysis of aerosols, is processed by the completely transistorized electronical part of the instrument. The uniform voltages of the integral measurements are amplified by an amplifier and adjusted by the integrator *27* to values directly corresponding to the weight concentration and readable by the digital measuring instrument *28*. The electric pulses, corresponding to the number and size of the particles, are simultaneously visualized by the cathode-ray oscillograph *29*, converted into the acoustic pulses *30* and linearly or logarithmically aplified by the amplifier *31*. From there they are led into the amplitude analyser *32* to be classified into ten size groups and added up by the corresponding digital computers *33*. The time programmer *34* permits to present the exact time of the sampling of the aerosol under analysis.

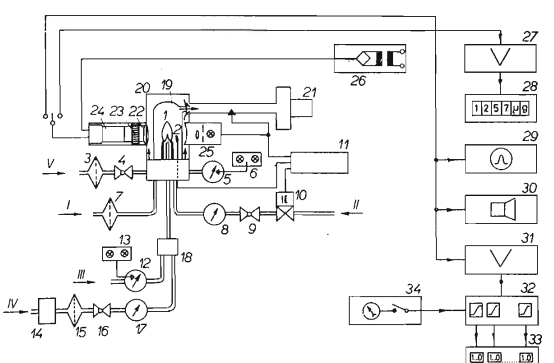

FIG. 1
Functional Diagram of Scintillating Particle Counter

The instrument is constructed by the unit-built system of three basic panels. The top panel contains the analysing unit proper and is exchangeable in dependence on the measuring method selected. The central unit serves as a control with the built-in cathode-ray oscillograph and digital indicator of weight concentration. The results of the numeral concentration can be read in ten channels of the lower panel, which also contains the automatic preselector of the volume of the sample being analysed.

The correct and acurate functioning of all complex instruments is dependent on realiable and easy calibration. The transformation of light pulses into electrical pulses and their evaluation is controlled with a simple calibration device simulating artificial light pulses in the entire range of the particles to be analyzed. Complete calibration of the instrument is performed with monodisperse aerosols generated by a vibrational generator[8-10]. This apparatus is suited for generating monodisperse aerosols of various chemical composition and adjustable particle size in the range of $10^{-6} - 10^{-3}$ cm and concentration in the range of $1-10^4$ particles per 1 cm^3. The degree of monodispersity[11] (relative standard deviation) attainst values up to 10^{-3}.

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