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В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

USING THE METHOD OF LIGHT SCATTERING IN STUDYING BIOLOGICAL AEROSOL

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Contemporary artificial biological aerosols used for immunization of humans and animals are distinguished by a broad range of concentration of particles per unit volume and also by their polydispersed nature (from a fraction of a micron to tens of microns). Under these conditions instruments developed earlier for studying aerosol parameters and operating on the light-scattering principle turn out to be unsuitable.

Our basic task consisted in creating a method and an instrument which would insure sufficient accuracy in determining particulate and weight concentrations and also the spectrum of fractionation of vaccines administered as aerosols by means of atomizers.

It was necessary to create an instrument with high resolution - i.e., one which would insure 1) recording of particles ranging from 0.5 to 40 μm in size, 2) the possibility of measuring aerosol concentration to 500,000 particles per liter, and 3) simultaneous recording of the entire spectrum of particles.

Of the [available] photoelectronic instruments for recording particles in air we found it possible to use the electron-optical system of the AZ-4 instrument and to use it as the basis for the sensor of the installation being developed. The optical schematic of the sensor of the photoelectronic aerosol dispersiometer AD-1 is shown on figure 1.

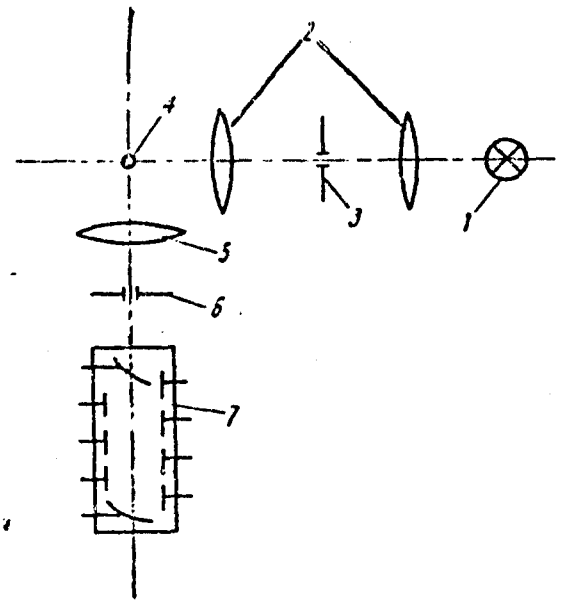

Figure 1. Optical schematic of the sensor. 1 - illuminator; 2 - illuminator objectives; 3 - illuminator diaphragm; 4 - feed line; 5 - PEM objective; 6 - PEM diaphragm; 7 - PEM.

A beam of light from illuminator (1) is shaped into a cylindrical beam with a diameter of 1 mm by means of diaphragm (3) and objectives (2). A flow of aerosol 1 mm in diameter is directed through sleeve 4, perpendicularly to the beam of light which is formed. The intersection of the light beam from the illuminator and the flow of aerosol forms the counting volume of the optical system of the sensor. The visual axis of the photoelectronic multiplier (PEM) is formed perpendicular to the plane of the beam of the illuminator and the flow of aerosol, intersecting the counting volume.

When particles in air enter the counting volume of the sensor they scatter the light from the illuminator, which is collected by

the PEM. As a result of this electrical impulses proportional to the square of the radius of the particles appear on the PEM output. After appropriate amplification the electrical pulses proceed from the sensor over a 5-meter cable to an amplitude selector in the analysis-counting unit. After distribution by fractions the pulses are counted and proceed to the indicator device - an electromechanical counter of the MES-54 type.

The AD-1 installation permits simultaneous recording of pulses in a broad range of particle sizes - diameter from 0.5 to 4 μm and from 3 to 40 μm. This is achieved because the installation contains two subranges with an automatic change in the gain factor of the pulse amplifier and automatic tuning of the amplitude selectors. The installation has five channels with different counting coefficients: 128, 64, 32, 16, and 8, respectively. The aerosol is passed through the sensor at a rate of 0.2 l/min. All of this makes it possible to monitor adequately concentrated artificial polydispersed biological aerosols (200,000-400,000 particles per liter).

The maximum particle counting concentration A is determined by the illuminated volume of aerosol flow in the sensor. On the basis of the Poisson distribution two and and more particles will enter the illuminated volume of the aerosol with a probability of no more than 5% if the average number in the volume does not exceed 0.4 particles. Taking the diameter of the aerosol jet as d=0.1 cm and the width of the light beam which the particles intersect as h=0.1 cm, we find

$$A=\frac{4\cdot 0.4}{\pi d^2 h}=500 \text{ particles/cm}^3.$$

The instrument is calibrated against a relative monodispersed preparation - Lycopodium, 80% of whose spores have a diameter of 28 μm, which permits evaluating the magnitude of aerosol particles with sufficient accuracy.

The calibration procedure is as follows. An electron-optical sensor is installed with the collector pipe downward. A pump is connected on the opposite side and air is pumped through the illuminated volume of the sensor at a rate of 0.2 l/min. Gently shaking out a small quantity of Lycopodium in front of the collector fitting creates an aerosol cloud which is picked up by the air flow so that the Lycopodim particles enter the counting volume of the sensor, where the light which they scatter is converted into electrical impulses recorded on an oscillograph. By determining the amplitude of the electrical pulse corresponding to a particle with average size of 28 μm and by considering the relationship of the pulse amplitude to be proportional to the square of the particle radius [1], it is possible to construct graph for tuning the amplitude selectors of the instrument (figure 2). After this, using a pulse generator, the triggering threshold of the selectors of all five channels are tuned on two subranges.

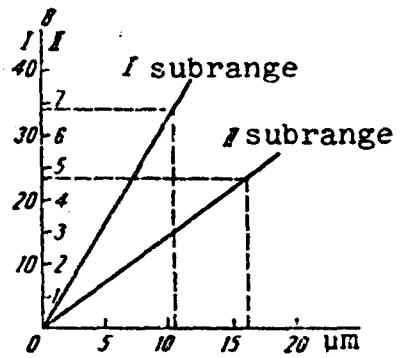

Figure 2. Graph for tuning the triggering thresholds of the instrument amplitude selectors. Abscissa - square of particle radius (in μm); ordinate - pulse amplitude (in V).

In order to compare the accuracy of calibration described above a more laborious calibration was carried out on a sedimentometer with an oil fog obtained by bubbling. No significant deviations were detected.

Experimental tests were carried out with chambers of different volumes: 0.7, 5.6, and 112 m^3. Several dry aerosol vaccines from the Moscow Scientific Research Institute of Vaccines and Serums im. I. I. Mechnikova were used in the experiments. Vaccines were

atomized with a PAV-65 instrument. Pumping of air through the counting volume of the sensor was established at a rate of 0.2 l/min and was measured with a glass flow meter with a calibrated scale up to 1 l/min from a type 822 aspirator. Sampling sessions in the experiments were 15 minutes long. The collecting fitter of the sensor was located horizontally. The weight concentration was monitored in parallel by two methods: protein content (Lowry method) and by the fluorescence of the test solution of vaccines (electronic fluorometer EF-3M). These samples were taken with an impinger.

Spectra of the counting and weight distributions of dry aerosol vaccines were obtained on the basis of numerous experiments.

Fractionation of dry vaccines by the PAV-65 instrument was subject to an exponential law, while the maximum weight concentration was found to be of particles 19 μm in diameter. This creates favorable conditions for vaccination - low reactogenicity with good immunogenic effect.

Thus, in our view, the photoelectronic method for studying particles of polydispersed biological aerosol vaccines in a flow of air is the only sufficiently reliable method for studying the spectrum of aerosol particle sizes, permitting analysis of the number and size of particles per unit volume, and also observation of the kinetics of the changes in particle concentration in the course of the experiment [2].

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