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THE METHODS of GAS - AEROSOL POLLUTION CONTROL in ATMOSPHERE by EQUIPMENTS with BEST METROLOGICAL PARAMETERS

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Abstract - **The results of scientific research development of optical-electronic systems and methods for measuring the parameters of gas-aerosol pollution in atmosphere are presented. The results of research of the metrological parameters of developing devices, and the metrological providing of the distant monitoring of gas-aerosol pollution in the atmosphere are.**

Keyword - **Liquid and solid aerosol formations, particle's concentration, distant infrared monitoring, metrological parameters**

I. INTRODUCTION

Presently sharply, interest grew in ecological problems that is foremost related to ever-increasing pollution of environment.

According to the last data on research of atmospheric contaminations in industrial- developed countries, basic sources of pollution are industrial and power enterprises and transport, on the stake of that is more than 80% from the general volume of contamination. Thus, the basic components of contamination of atmosphere are gaseous connections of carbon, nitrogen and sulphur, and solid and liquid aerosol components that present the special danger for the normal vital functions of man and other biological objects.

Considerable contamination of air space and his shattering influence on the health of man, a microclimate and vegetation contingently also the macroscopic losses (or, sometimes by extras) of natural gas from a highway pipeline and vast fires, in particular, forest spaces.

Therefore creation of optical-electronic devices and systems with the best metrological parameters, allowing to carry out an operative analysis of basic ecological parameters and permanent monitoring of atmosphere, and also air infrared ecological control vast forest spaces (with the chain of finding out the hearths of fires, on the early stage of their development) and main pipelines of natural gas, are a very actual task.

The present work is devoted to presentation of results of research and developing works on development and making optical-electronic devices of the ecological setting for the research of basic ecological parameters of gas-aerosol pollution in atmosphere.

II. UNIVERSAL INFRARED SPECTRAL RADIOMETER "USR-A"

With the purpose of realization of spectral and radiometric researches of parameters of atmosphere and thermal objects in the waves of lengths from 0.4 to 14mkm was developed by us and made universal spectral radiometer of "USR-A", the detailed description and principle of work of that are presented in works [1-3].

"USR-A" is intended for measuring of power spectral brightness and radiation temperature (or her over falls) of point and extended sources of infrared radiation in laboratory and field conditions, and also for the distant spectrometry of hot gas objects.

Structurally a spectroradiometer is executed as two blocks: Optical-Mechanical (OMB) and Block of electronic management (BEM). Electric connection between blocks comes true by means of cables. Complete worker the spectral range of device is covered by means of three complete sets of removable color filters and photoreceiver in subranges from 0,4 to 1,1mkm; from 2,5 to 5,5mkm; and from 8 to 14mkm. The optical scheme of OMB is shown on fig.1.

Block of electronic management of table execution. All organs of indication and management are located on the front panel of "BEM".

We will mark some advantages developed by us IR spectroradiometer "USR-A" as compared to existent near analogues (see. for example, [4]). For expansion of functional possibilities in area of spectral researches of thermal objects, except broadband interference color filters for the areas of spectrum from 0,4 to 1,1; from 2,5 to 5,5 and from 8 to 14mkm, a device is provided with also the circular reconstructed color filters.

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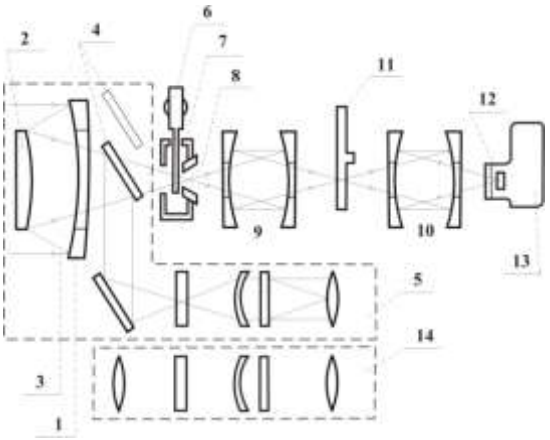

Fig. 1. OMB Optical Scheme:
1-Primary mirror lens; 2-secondary mirror lens; 3-radiation from the object; 4-refractable flat mirror; 5-sight; 6-modulator; 7-bearing cavity; 8-field stop; 9,10-projection lens; 11-disk interference filters; 12-sensitive area of the photo detector; 13-dewar of liquid nitrogen; 14-visual tube.

With the purpose of removal of chromatic aberrations in the optical system of device two pairs (see.fig.1) are plugged mirror projection objectives, color filters and receiving ground of fotoreceiver are set in focuses of that.

At the end of this section, we will mark that after some designer revision in the optical scheme of spectroradiometer "USR-A" (addition of entrance baffle mirror) in-process [5] the method of air ecological control of forest spaces and gas main pipelines is described in detail.

III. Metrological Parameters of Universal Spectroradiometer "USR-A"

Metrological attestation of universal spectroradiometer was conducted concordantly to the specially developed program of metrological attestation (AEL2.807.007PMA [6]). During attestation the metrological parameters of device, indicated in the Table-1. During realization of metrological attestation of the spectroradiometer of "USR-A" the necessary measuring devices and facilities were used, indicated in, [6]. Terms and order of realization of attestation are presented in the same work.

Measuring on determination of difference of radiation temperatures, equivalent to noise $\Delta T_{eq.N}$., conducted on setting the chart of that is driven to [6]. Size of difference of temperatures equivalent to noise $\Delta T_{eq.N}$. determined on a formula:

$$\Delta T_{eq.N} = \frac{U_N}{K_{\Delta T}},$$ was found to be 0.05 within ± 10%.

For determination of the basic resulted error of the measuring by spectroradiometer the difference of radiation temperatures, on setting of attestation temperatures of ABB was set in an interval from 288 to 298K and with a step in 10^0, the output signals of device registered oneself five times.

Mean quadratic deviation of results measuring determined on a formula:

$$S_{U_{sr}} = \sqrt{\frac{\sum_{i=1}^{n}(U_{sri} - U_{sr})}{n(n-1)}}.$$

Reduced error of measurement of the difference radiation temperatures was within ± 15%.

Table-1. Metrological Parameters of the Equipment "USR-A"

The Name of the Metrological Characteristics and Units of Measuring	**Nom. Values**	**Permissible Declinations**	**Comment**
Working spectral ranges: mkm			
I channel	0.40 - 1.1	± 10%	Provided with filters
II channel	2.50 -5.50	± 10%	
III channel	7.90 - 13.5	± 10%	
Field of view, mrad, no more than:			
I channel	3	± 10%	
II channel	3	± 10%	
III channel	3	± 10%	
The difference in noise-equivalent radiation temperatures, $\Delta T_{eq.N}$,K, no more than:			
II channel	0.05	± 10%	
III channel	0.05	± 10%	
Summary reduced measurement error of the temperature difference between the radiation range of 0.5 to 20^0 at the lever 293 ± 5^0 K, no more than:			
II channel		± 15%	
III channel		± 15%	

IV. Multichannel Aerosol Spectrometer

Developed multichannel aerosol spectrometer "MASNIK-A" [7, 8], is an optical-electronic automatic device for measuring of concentrations and distribution on the sizes of liquid and solid particles of aerosol formations of natural and artificial origin in laboratory and field conditions.

Structurally a spectrometer consists of two blocks: Optical Electronic Sensor (OES) and block of counting out and management (BCM), connected by the cables.

Principle of action of device is based on measuring of intensity of the radiation dissipated on aerosol particles. The optical scheme of OES is shown on fig.2.

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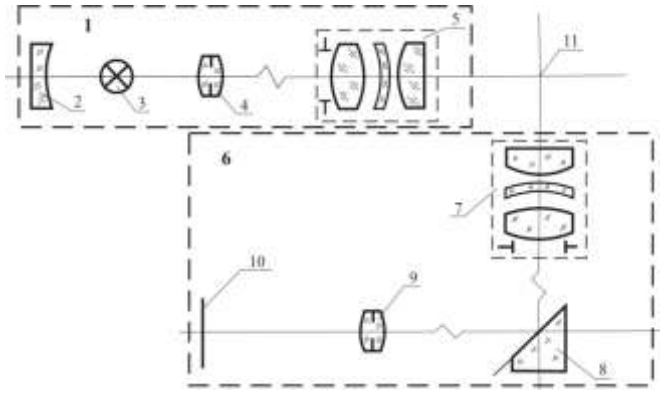

Figure 2. Optical Scheme of the Spectrometer "Masnik-A"
1-illuminating; 2-spherical mirror; 3-lamp lighting; 4,9-condenser with integrated field diaphragm; 5,7-projection lenses; 6-photometer; 8-mirror flat; 10-sensitive area of the photo detector; 11-space of work volume.

The optical systems of lighting and photometer (fig.2) are intended for the optical forming of account volume (poses.11 on fig.2) sensor. He is a luminous block with the discrete change of his sizes that is arrived by replacement of the field diaphragms that is inflicted on the flat-glued together surfaces of condensers.

Before realization of the natural measuring in an atmosphere the optical calibrating of spectrometer is conducted on the standard particles of polistirol latex.

At the end this section, it should be noted that by advantage of the aerosol spectrometer developed by us, as compared to on-the-road presently analogical devices [9], there is possibility of change, during exploitation of device, sizes of the field diaphragms of light and photometer, that in turn, causes the change of geometrical sizes of working volume (or account volume, see.fig.2) device, that allows considerably to extend a range measureable to the account concentration of aerosol particles from surrounding space, and also structural execution of spectrometer of "Masnik-A" in two blocks exploitation of that provides safety of attendant operator from possible dangerous influence of surrounding aerosol.

V. METROLOGICAL PARAMETERS OF MULTICHANNEL AEROSOL SPECTROMETER "MASNIK-A"

Metrological attestation of multichannel aerosol spectrometer "Masnik-A" was conducted concordantly to the specially developed program AEL2.851.002PMA [10]. During attestation the metrological parameters of device, presented in a Table 2.

List of all facilities, terms and an order, and description of the measuring setting, for realization of metrological attestation is expounded in [10].

The relative error of producibility of calibration description of device is determined on a formula:

$$\delta_g = \frac{d_u - d_0}{d_0} \cdot 100\%$$

where d_0 - nominal size of aerosol particles used reference, du - measured values of particles in micron. The deviation of the reproducibility of the calibration of the instrument was within ± 15%.

Table-2. Metrological Parameters of the Equipment "Masnik-A"

The Name of the Metrological Characteristics and Units of Measuring	Permissible Declinations
The relative error in the reproducibility of the calibration of the instrument at the reference desk of monodisperse aerosol particles, no more than	± 15%
The relative error in the measurement aerosol particles sizes in the range from 0.4 to 40 mkm, no more than	± 20%

To assess the relative accuracy of measurement of dimensions of the aerosol particles, all operations were carried out as set out in [10] and for particle of size 0.5 microns.
According to the formula is defined relative error of measuring the size of aerosol particles, which proved to be within ± 20%.
When the ambient temperature changes from -40 to 40^0 C additional error measure the size of aerosol particles does not exceed 20% of the relative error of measurement.
It should be noted that the above optical-electronic systems, we designed two patents for inventions.

VI. CONCLUSION

The developed optical-electronic systems present possibility of realization of the controlled from distance researches of physic-ecological parameters of atmosphere and IR sources, and aerosol constituent in surrounding space.

The results of experimental researches of metrological parameters of the developed devices confirm high exactness of measuring.

The mobile variant of the created measuring devices can successfully be used for the operative estimation of the physic-ecological state of ambient air, and for the controlled distant researches of thermal sources.

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