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SPECTROPHOMETER DEVICE FOR RESEARCH OF THE ATMOSPHERIC OZONE

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ABSTRACT: A PAPER IS PRESENTED FOR THE DESIGN OF A SPECTROPHOTOMETER WHICH CAN MAKE THE RESEARCH OF THE TOTAL CONTENT OF THE ATMOSPHERIC OZONE ON THE BASIS OF THE ABSORPTION PRINCIPLE. THE APPARATUS IS DESIGNATED FOR WORKING IN THE NEAR ULTRAVIOLET PART OF THE OPTIC SPECTER, WHERE ARE THE HARTLEY – HUGGINS ABSORPTION BANDS AND IT ALSO GIVES INFORMATION FROM OBSERVATIONS IN THE VISIBLE PART WITH CHAPPUIS ABSORPTION BAND. AS A BASIC DIFFRACTING ELEMENT OF THE DESIGNED SPECTROPHOTOMETER, IS THE DIFFRACTION GRATING. A PHOTOMETRIC CHANNEL IS PROVIDED WHICH READS THE ALBEDO OF THE SURFACE AND THE PROTUBERANCE OF THE SUN.

KEY WORDS: SPECTROPHOTOMETER, ATMOSPHERIC OZONE, ULTRAVIOLET PART OF THE OPTIC SPECTER, HARTLEY – HUGGINS ABSORPTION BANDS, DIFFRACTION GRATING, PHOTOMETRIC CHANNEL, PROTUBERANCE OF THE SUN.

IN [1–7], the requirements for rational selection of scanning radiometers and spectrophotometers' parameters are specified and the method developed to calculate the optimal parameters of the optic-electronic tract is presented. This provides to minimize the total error at measuring the brightness of non-homogeneous emission and ensures the specified accuracy for measurement of average brightness during studies of non-homogeneous emissions of arbitrary form, such as the spectral composition of atmosphere [8-15].

THE contribution aims to develop a method for rational selection and evaluation of the optic-electronic tract's transmission characteristics parameters in a scanning spectrophotometer intended to register dot-source emissions (the Sun, the Moon) which, while passing through the atmosphere, provides to determine the spectral composition of the atmosphere using absorption methods.

THE spatial variations of emission brightness are, in their essence, external noise, against the background of which dot-source emissions are registered (atmospheric turbulence, silvery cloudiness etc.).

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IN practice, usually the spectrophotometer is required to have rectangular view field with uniform sensitivity and to scan along the x line with angular velocity ω_x.

DEVELOPING the method, it was assumed that the emission is registered by a receiver with predominant white noise, the optic system is isoplanatic, the function has the form of a 2D Gaussoid, the electronic tract describes the product of the transmission characteristics of n pieces of integrating units with one and the same time constant, and external and internal noises at the output of the optic-electronic tract are uncorrelated.

In case of registration of dot-source emissions, it is expedient to determine the parameters of the optic-electronic tract (angular view field along the scanning lines ω_x, accordingly along the y line – ω_y; time constant of the units of the electronic tract τ; angular size of the dissipation spot of the optic system ω_a) based on the total measurement error minimization conditions. In the case of registration of a signal originating from a remote dot emitter, the total least square error ε is equal to:

$$\varepsilon^2 = \varepsilon_a^2 + \varepsilon_\tau^2 + \varepsilon_t^2 + \varepsilon_f^2 \qquad (1)$$

and it includes in itself the systematic errors caused by the part of energy lost while the emission passes through the image analyzer – ε_a, the effect of the time constant and the pulse form at the input of the electronic tract – ε_τ, as well as the random errors – ε_τ, related with the noise's dark component and the background brightness' fluctuation – ε_f.

THE constituent signal errors caused by the internal noises of the optic-electronic tract are known and may be determined by the formula:

$$\varepsilon_t = \frac{S_v P_t^2 Q T B_f W_a^2 \alpha\beta}{4\tau}, \qquad (2)$$

where: S_v – integral sensitivity of the emission receiver;
P_t – threshold sensitivity in dark regime;
Q – useful area of the input slit;
T – transmittance capacity of the optic system;
B_f – average component of background brightness;

$$\alpha = \frac{W_x}{W_a};$$

$$\beta = \frac{W_y}{W_a}.$$

THE systematic component of signal errors may be determined using the equation for dot-source signal at the output of an ideal receiver which may be derived using the dissipation function:

$$u(t) = S_v F \frac{\beta}{2}\left(\alpha - \frac{2V_x}{W_a}\right) + \left(\alpha + \frac{2V_x}{W_a}\right), \qquad (3)$$

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where F is the emission flow on the image plane of the dot-source (on the back focal plane of the optic system).

THE reduction of the signal amplitude at the output of the optic-electronic tract as a result of the energy lost during the emission’s passing through the image analyzer may be determined by the formula:

$$\Delta u_a = S_V F(1-\alpha\beta) \ . \qquad (4)$$

THE average square error is equal to:

$$\varepsilon_a^2 = S_V^2 F^2 \left(\frac{1-e^{-\beta^2}}{\beta\sqrt{\pi}} \right)^2 \frac{e^{-2\alpha^2}}{\pi\alpha^2} \ . \qquad (5)$$

IN accordance with the performed calculations and with [6], the spectrum of the signal’s power G_W at the output of the electronic tract of a scanning spectrophotometer will be:

$$G_W = S_V^2 T^2 Q^2 W_x^2 W_y^2 \frac{G_B}{V_x} \ , \qquad (6)$$

where the power spectrum of the spatial variations of background brightness $\frac{G_B}{V_x}$, determined by Fourrier transformation is equal to:

$$\frac{G_B}{V_x} = \frac{2\sqrt{2W_f}}{V_x\left(1+2\frac{W_f^2}{V_x^2}\right)} \ , \qquad (7)$$

and the signal dispersion at the output of the optic-electronic tract caused by the spatial variations of background brightness within the bandwidth of the electronic tract is equal to:

$$\varepsilon_f^2 = \frac{1}{\pi}\int_0^{\frac{1}{\tau}} G(w)dw$$

or

$$\varepsilon_f^2 = \frac{2\sqrt{2}}{\pi} S_V^2 T^2 Q^2 W_a^4 \alpha^2 \beta^2 \left[\frac{1}{\sqrt{2}} \operatorname{arctg}\left(\frac{\sqrt{2}\frac{W_f}{V_x}}{\tau} \right) \left(1 + \frac{\alpha^2 \frac{W_a}{V_x}}{\tau \frac{W_a}{W_x}} \right) \right] . \qquad (8)$$

THEREFORE, if there are no background brightness fluctuations, the measurement errors are reduced by augmenting the view field along the scanning line, while with increasing background dispersion, the function takes the form of a minimum, corresponding

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to the optimal parameters of the preliminary characteristics of the spectrophotometer's optic-electronic tract.

In Fig.1, the emission source 1 is shown, providing signal in the ultraviolet, visible and infrared part of the optic spectrum, as well as spectrophotometer 2, intended to study the spectral composition of atmosphere, and the registration module 3 of the equipment complex.

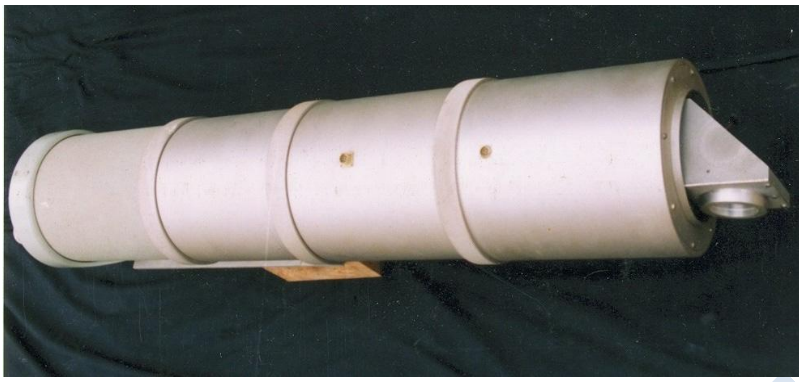

Fig. 1. *Spectrophotometric device for distant research of the atmospheric ozone*

THE results obtained from the evaluation analysis of the transmission characteristics of a spectrophotometer intended to study the spectral composition of atmosphere at dot-source emission registration provide to make the following conclusions:

1. WHEN measuring emission originating from uniform background source, the increase of noise components as a result of the view field's augmentation along the scanning line may be compensated by reduction of the electronic tract's bandwidth at increasing measurement accuracy, whereas the rational selection of the optic-electronic tract's transmission characteristics parameters is substantiated primarily by the device's structural features according to the conditions of the experiment.

2. IN the presence of spatial background variations, the developed method allows for a compromise between the influence of the systematic error ε_a at small α and the random error ε_f at increase of α, providing to minimize the total ε for the conducted measurements.

References

1. **Apenko, M., Dubovikm, A.D. 1971:** Prikladnaya optika, Moskva, Nauka
2. **Boychev, B.1998:** Malki dvukanalni fotomeri po proekt "Aktiven" i "APEKS". Aerokosmicheski izsledvaniya v Bulgaria No 14, p 92-100.
3. **Filipova, M. (2006)** Ekologiya iopazvane na okolnata sreda. Izdat. Komplex na NVU "V. Levski",Veliko Turnovo
4. **Filipova, M., Stoyanov, S. 2011:** Ekologichen Monitoring i upravlenie na okolnata sreda. Izdat. Asociaciya "Nauchno-prilozhni izsledvaniya", Sofia, 337 p.
5. **Getzov, P. :2002:** Kosmos, Ekologiya, Sigurnost, NBU, Sofia, 211 p.
6. **Getzov, P., G. Mardirossian, S. Toyanov, I. Hristov 2003:** Vliyanie na parametrite na optiko-elektronnite uredi vyrhu skorostta na skanirane na prostranstvoto. Peta nauchna konferenciya "Smolyan 2003", s. 170-175.
7. **Guzin, G. 2003:** Izsledvane atmosfernovo ozona. Gidrometeoizdat, Moskva
8. **Zhekov, Zh. G. MArdirossian, S. Stoyanov, I. Hristov 2003:** Model za imitaciya na negausov fon. Sb. nauchni trudove "Prirodni nauki Fizika", Shumenski Universitet "Episko K. Preslavski", p. 135-138
9. **Mardirossian, G. 2003:** Aerokosmicheski metodi v ekologiata i izuchavaneto na okolnata sreda. Akad. Izd. "Prof. M. Drinov", 208 p.

10. **Stoyanov S., G. Mardirossian 2001:** Analiz na syshtestvuvashtite metodi I sredstva za izsledvane na obshtoto sydyrzhanie na atmosfernia ozon I negovoto vertikalno razpredelenie. Godishnikna Tehnicheski Universitet – Varna, s. 910-915.
11. **Stoyanov S. 2001:** Concise characteristic of spectrums of absorption of the atmospheric ozone and gasses in the optical range when researches with ground-based and space-based instruments are concerned. – Technical University – Varna
12. **Stoyanov S., I. Hristov, G. Mardirossian, Zh. Zhekov 2000:** Optiko-elektronen trakt v aparatura za registrirane na optichni atmosferni emisii. Sb. Nauchni trudove "Nauchno tehnologichen transfer", IKI-BAN, p. 42-45
13. **Stoyanov S. 2009:** Optichni metodi za izsledvane na atmosferniya ozon. Izdat. "Faber", Veliko Turnovo, 231 p.
14. **Stoyanov, S. 2009:** Prilozhna optika. Izdat. "Faber", Veliko Turnovo,234 p.
15. **Smith, H. 1998:** JOSA, vol. 42, N 2, p. 483.