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Satellite absorption ozonometer

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The study of atmospheric ozone and the determination of the total ozone content (TOC), and the restoration of its vertical distribution in particular, is a topical problem whose solution calls for a continuous increase in the effectiveness of satellite ozonometric experiments [1, 2]. At present, the most suitable methods for the purpose seem to be the optic (spectrometric) ones which are based on the absorption principle, i.e. ozone ability to absorb emission in some parts of the UV region of the optic spectrum.

Recently, ozonometers, based on some disperse element — a prism or a diffraction grid (HIRS, LIMS, TOMS, TOVS, grid ozone spectro-photometer, BUFS-1, BUFS-2, SUFS-M ,etc. [3—7]), have been widely used. Notwithstanding their exploitational advantages or shortcomings, a common shortcoming shared by all of them is the insufficient quickness of their operation.

The present paper is dedicated to the satellite absorption ozonometer SAO-2, designed and implemented in the Space Research Institute of the Bulgarian Academy of Sciences, and intended for exploitation on board of the METEOR satellite under the Meteor-Ozone Space Project [8].

Following the requirements of the Technical Mission [9], four block-scheme versions of the ozonometer [10] were worked out. As a result of the comparative analysis, version 2 was chosen. In Fig.1, the global block-scheme of the satellite absorption ozonometer is shown, which consists of the following major blocks: *1*—light-protective blind, *2*—input scanning system, *3*—optic deviator, *4*—reflective element, *5*—object-glass, *6*—interference filter, *7*—photoreceiver, *8*—signal-processing device, *9*—object-glass, *10*—dispersion system, *11*—photoreceiver, *12*—signal-processing device, *13*—microprocessor system, *14*—electromechanical system, *15*—low-voltage power supply, *16*—light-protective device, *17*—high-voltage power supply, *18*—thermostatic system.

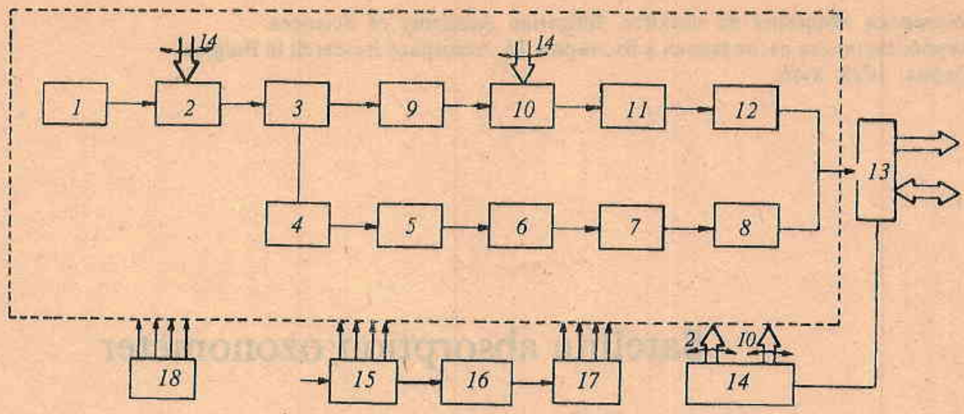

Fig. 1

On Fig.2, the functional scheme of the SAO-2 ozonometer is shown. The light-protective blind located in front of the flat scanning glass *2* with reference source *3*, servicing the photometric and the spectrometric channels, represent the input scanning system. In front of the concave glass *5*, the reflective prism *4* is immovably mounted which directs part of the optic signal to the photometric channel. By the flat glass *6*, the input slit *7*, and the concave glass *4*, concave glass *5* is optically connected with diffraction grid *9*, and furtheron, through the camera object-glass *11* and the output slit *12* — with the photocatode of photoreceiver *13*. The input scanning system is activated by the step electric motor *28* and the gear-drive *29*, whose feedback is effected by an angle-to-code photoelectric transducer. The reflective prism *4* is optically connected with the photo-receiver *18* through the flat glass *14*, object-glass *15*, interference filter *16* and the optic lens *17*. Photoelectric multipliers *13* and *16* are electrically connected through the amplifier and the analogue-to-digital converters *21* and *22* with microprocessor system *20*, to which thermostatic system *19* is connected, as well.

The step electric motor *32* is mechanically connected through the coupled gear-drive *31*, the forked shaft *33* and the arm *34* to diffraction grid porter *10*. The angle-to-code photoelectric transducer *35* is also connected to forked shaft *33*.

The low-voltage power supply *23* is connected, on one hand, to microprocessor system *20*, and on the other hand, through the light-protective device *24*, to the high-voltage power supply *25*.

The glass of monitoring system *27* is shifted to 180° with respect to the direction of the incoming rays of the input scanning system at a positioning angle.

The ozonometer operates in the following way:

The flat scanning glass *2*, activated by the step electric motor *28* and the gear-drive *29*, performs scanning within the angular range $\beta=\pm45°$, which is regulated by the feedback, provided by the angle-to-code photoelectric transducer *26*. From concave glass *6*, through input slit *7*, the optic signal falls onto concave glass *8* and the parallel bunch of beams, generated in it, is then passed to

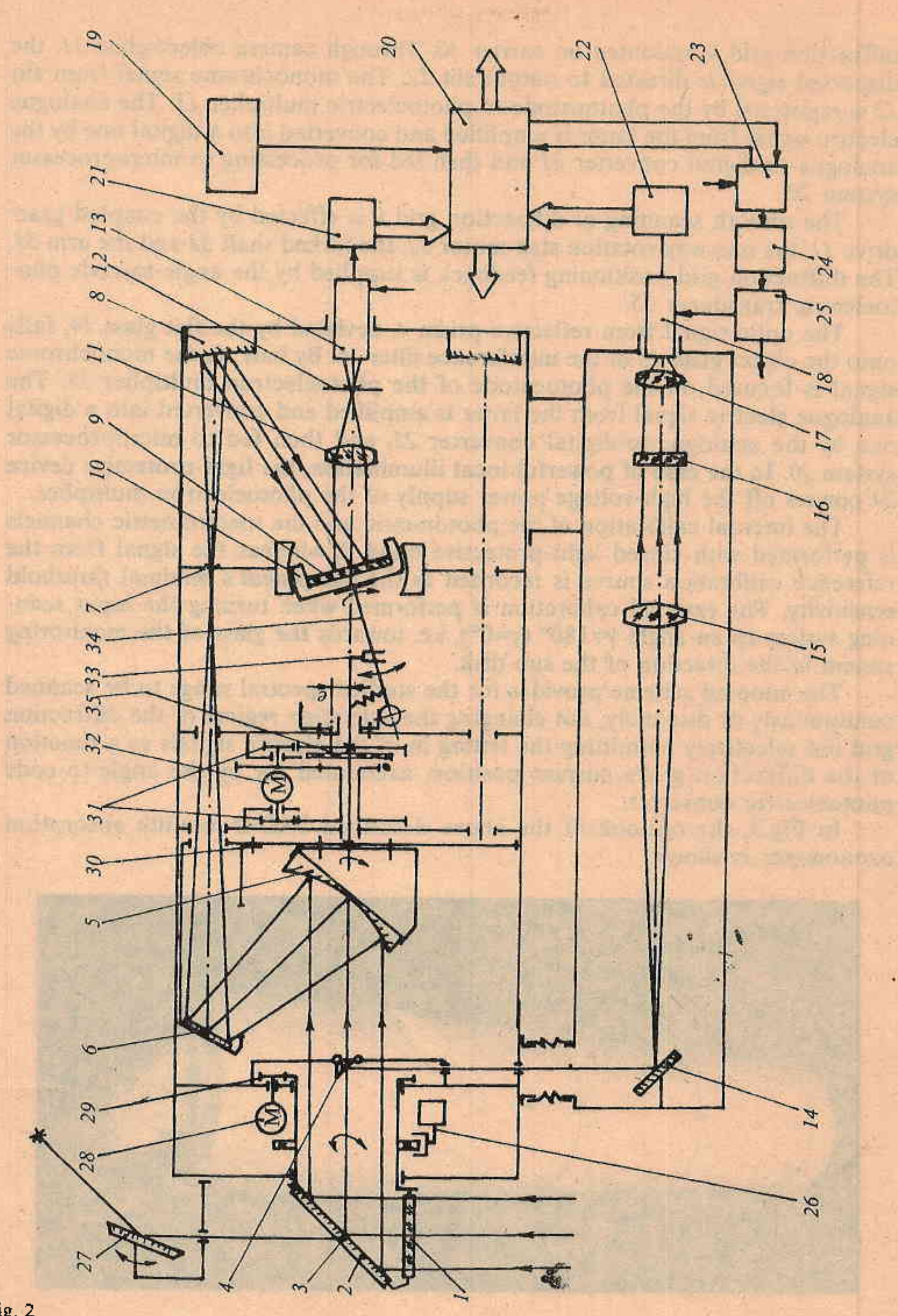
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Fig. 2

diffraction grid *9*, mounted on carrier *10*. Through camera object-glass *11*, the dispersed signal.is directed to output slit *12*. The monochrome signal from slit *12* is registered by the photocatode of photoelectric multiplier *13*. The analogue electric signal from the latter is amplified and converted into a digital one by the analogue-to-digital converter *21* and then fed for processing to microprocessor system *20*.

The smooth scanning of diffraction grid *9* is effected by the coupled gear-drive *31*, the one-way-rotation step motor *32*, the forked shaft *33* and the arm *34*. The diffraction grid positioning feedback is supplied by the angle-to-code photoelectric transducer *35*.

The optic signal from reflective prism *4*, deviated by the flat glass *14*, falls onto the object glass *15* of the interference filter *16*. By lens *17*, the monochrome signal is focused on the photocatode of the photoelectron multiplier *18*. The analogue electric signal from the latter is amplified and converted into a digital one by the analogue-to-digital converter *22*, and then fed to microprocessor system *20*. In the case of powerful local illumination, the light-protective device *24* powers off the high-voltage power supply of the photoelectron multiplier.

The internal calibration of the photometric and the spectrometric channels is performed with closed light-protective blind *2*, whereas the signal from the reference calibration source is recorded as the equipment's minimal threshold sensitivity. The external calibration is performed when turning the input scanning system to an angle $\gamma=180°$ ($\gamma=0°$), i.e. towards the glass of the monitoring system in the direction of the sun disk.

The adopted scheme provides for the studied spectral range to be scanned continuously or discretely, not changing the activation regime of the diffraction grid but selectively permitting the letting in of the electric signals as a function of the diffraction grid's current position, accounted for by the angle-to-code photoelectric converter.

In Fig.3, the outlook of the above described SAO-2 satellite absorption ozonometer is shown.

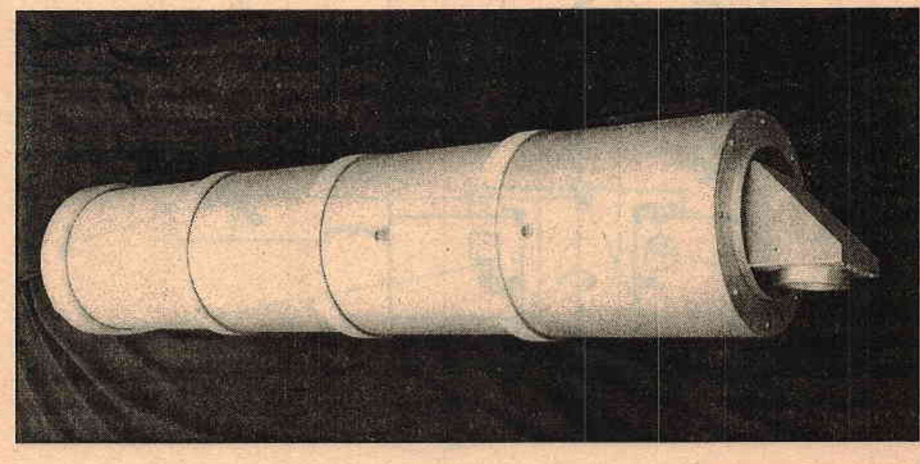

Fig. 3

The laboratory tests confirmed the results from the theoretical analyses. The designed ozonometer has the following advantages:

1. Its functional scheme is characterized by high lightpower, compact input scanning system, and unified blocks.
2. It can work as a pseudopolichromator without changing the operational regime of the dispersion system electric motor.
3. The mechanism of the dispersion diffraction grid lacks dead stroke which provides for great precision of the measured wavelength.
4. On determination of the total ozone content and restoration of its vertical distribution, data for the aerosol reduction spectrum is also obtained.

The shorcomings of the device are as follows:

1. Relatively great size and mass.
2. A lot of reflective planes.
3. Long period of by-spectrum scanning.

Except on board of aerospace aircraft, the described ozonometer SAO-2 can be also used in ground measurements, where its major shortcoming — relatively great size and mass — becomes negligible.

Major technicoexploitation features of SAO-2

1.	Precision of the determination of:	
	— total ozone content	≥ 10%
	— vertical distribution of ozone in the height range starting from the ozone layer with maximum concentration up to 45 km with height resolution H=10 km	> 15%
2.	Width of the viewing band	2000 km
3.	Spectral range	160—400 nm
4.	Number of spectral subranges with discrete scanning	12
5.	Spectral resolution	1 ± 0,2 nm
6.	Viewing field	0,5×1,5°
7.	Spectrum measurement interval	0,16 s
8.	Consumed electric power	≤ 50 VA
9.	Mass	42 kg

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(Резюме)

Статията е посветена на разработения в Института за космически изследвания при Българска академия на науките сателитен абсорбционен озонометър САО-2, предназначен за измерване на общото съдържание и вертикалното разпределение на атмосферния озон от борда на сателит от серията МЕТЕОР.

Показани са блоковата и функционалната схема, действието, начинът на вътрешна и външна калибровка и някои основни техникоексплоатационни характеристики на озонометъра.