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Research Article

Thermo-Pelengator Fire Prevention Scanning System

Ruben A[1]*, Norayr K[1] and Hamlet K[2]

[1]Department of Theoretical Metrology, Nationan Institute of Metrology, Armenia
[2]Yerevan State University, Department of Optics, Armenia

***Corresponding Author:** Ruben A, Doctor of Engineering Sciences, Professor, Sisakyan Str. 2, app. 305, Yerevan, 0031, Armenia.

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Abstract

The result of our development and preparation of the experimental sample of automatic optical electronic IR complex for the distant detection of thermal radiation sources (seats of fire) are presented. The complex "SimAr-A" operates in a mode of continuous scanning of the environment with two spaced optical-mechanical units (places on the basic distances) for detection and determination of the distance and directions of seats of fire at an early stage of their development. The system works in a mode of automatic thermo-pelengator, which is possible to use in thermal monitoring of objects and spaces on the Earth surface and in atmosphere. At exploitation of a complex measurements of current meteorological parameters (temperature, relativity humidity and pressure) of air are carried out synchronously.

Keywords: *Infrared Scanning System; Fire Prevention; Thermal Object; Distant Detection*

Abbreviations

IR: Infrared; ''SimAr-A'': cod name; OMS: Optical-mechanical sensors; UEC: Electronic control unit

Introduction

Monitoring of environment, research and control of ecological conditions involve huge attention of mankind, is especial in the present stage of development of the industry and power. Optical-electronic devices and systems intended for application in ecological researches and at occurrence of extreme situations constantly are in the center of attention of scientists and engineers. Complexes, in particular, for early detection of the seats of fire arising at natural disasters are irreplaceable. Hence, development and creation of devices and systems for thermal monitoring an environment is the important problem.

The present paper is devoted to the description of the technique developed by us spectral radiometric measurements of point and extended thermal objects and specially made with this purpose of automatic scanning complex "SimAr-A". The complex is intended for automatic scanning of environmental space with the purpose detection of point and extended thermal sources (in particularly seats of fire) on distance up to 7-10km, under various climatic conditions in the atmosphere. The complex functions in a mode of continuous scanning environmental space with the help of two optical-mechanical sensors (established on the certain base distance from each other) for detection and definition of site of thermal objects, in particular the seats of fire at an early stage of their development. The equipment works as automatic thermo-pelengator and can be applied in thermal monitoring of objects and spaces on the surface of the ground and in an atmosphere. At operation of complex synchronous measurements of the current meteorological parameters (temperature, pressure and rel. humidity of air) are carried out.

Short Description of Equipment

Structurally the complex consists of two optical-mechanical sensors (OMS) established on specially developed scanning platforms and the unit of electronic control joined with personal computer for automatic processing of measurement results of the thermal radiation from researched objects under specially developed program. The complex can be carried out in three various variants:

- Air basing (for example, on the helicopter);
- Mobile (on two automobiles of the microbus type);
- Stationary (established on the special platforms).

The optical scheme OMS is shown on figure 1.

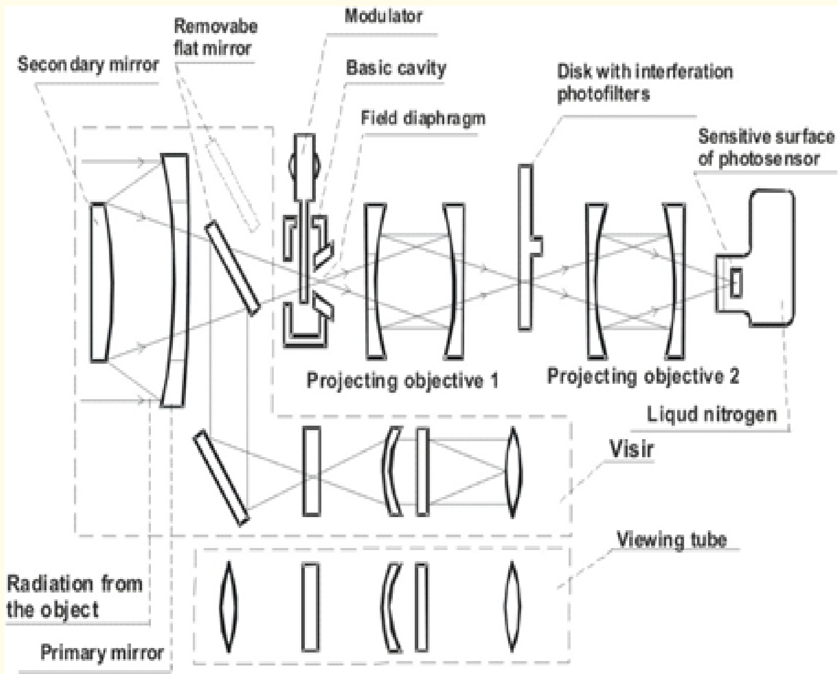

Figure 1: *The optical scheme of OMS "SimAr-A" complex.*

The Entrance mirror objective of Cassegrainian type in diameter 108mm and with focal length 200mm. OMS provides the temperature resolution no less then 0.5^{0}C in a range of temperatures of researched thermal objects from 300 up to 1000^{0}C. Detection of a thermal source (under normal meteorological conditions in the atmosphere) the sizes 3x3m^2 on distance about 7km.

The Electronic Control Unit (UEC) structurally of desktop execution. All bodies of indication and management are located on the forward panel. In laboratory conditions UEC is established on a table, and field conditions it is mounted in auto laboratories with the help of shock-absorbers. Appearances OMS and UEC complex "SimAr-A" are shown on figure 2.

Shortly the principle of work "SimAr-A" of radiometer consists in the following: In OMS the stream of radiation from researched object gathers with help optical system (see figure 1) and is focused on a sensitive platform of a photo detector. Further the preamplifier strengthens an electric signal and transfers to UEC. In UEC electronic circuits strengthen, demodulate and filter a signal from an output of photo detector, in result on an output there is a signal which amplitude is a measure absolute IR radiation of object. Knowing size collected radiating power (with the help of the data which have been preliminary carried out of the device power graduation [1]), spectral filtering properties of system and a degree of amplification , the output signal can precisely transform to absolute measurement of IR Radiation characteristics of object.

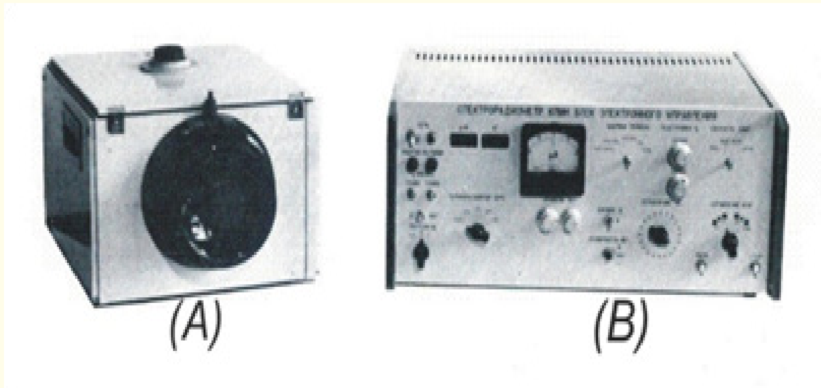

Figure 2: *OMS-(A) & UEC-(B) of "SimAr-A" Complex.*

Measurement Methodology of IR Radiation from Extended and Point Thermal Sources

Before carrying out of natural measurements with the help of complex "SimAr-A" power graduation of IR radiometer is carried out. The purpose of graduation is measurement of the response of the device on a known standard source-is usual a black body with known temperature. In work [1] the technique of power graduation for before developed by us similar IR Spectral Radiometer is in detail analyzed and for spectral graduation characteristics of the device k (λ) (in the region of lengths of waves from 2.5 up to 5.5 μ m) the following relation is received:

$$K(\lambda)=\frac{S(\lambda)}{\beta\{r(\lambda,T)\cdot\tau(\lambda,l)-r(\lambda,T_0)+r(\lambda,T_a)[1-\tau(\lambda,l)]\}} \quad (1)$$

S (λ)-amplitude of output signal; β-factor of amplification of the electronic system; r (λ ,T) -Planck function at the temperature calibration black body T (in our case T=2600C) and on length of a wave λ ; τ (λ ,l) -atmospheres transparency on a way; l-between the calibration source and device; T_0-temperature of the internal basic black body ($T=24.2^0C$); T_a-temperature of air during experiment (power graduation). Values of the graduation characteristics k (λ) enter the name in constant memory of processing system of the equipment for further use at automatic processing results of measurements in natural conditions.

In dependence k (λ) from λ the powerful strip of absorption of atmospheric carbonic gas with the center on length of wave 4.28 μ m [1, 2] is distinctly visible.

Researched objects, a stream of radiation from which completely are filled with a field of vision of the device, are at these measurements extended. In this case at researches the spectral density of power brightness of object W (λ ,T) is measured in terms of w/cm2ster . μ m. According to (1) output signal of radiometer S(λ) it is possible to express by the following relation:

$$S(\lambda)=K(\lambda)\cdot\beta\{W(\lambda,T)\cdot\tau(\lambda,l)-r(\lambda,T_0)+r(\lambda,T_a)[1-\tau(\lambda,l)]\} \quad (2)$$

$$W(\lambda,T)=\frac{S(\lambda)/K(\lambda)\cdot\beta+r(\lambda,T_0)-r(\lambda,T_a)[1-\tau(\lambda,l)]}{\tau(\lambda,l)]\}} \quad (3)$$

The transparency of atmosphere τ(λ ,l) or is simultaneously measured, or according to synchronous measurements meteoparameters (temperature, pressure and rel. humidity of air) pays off with the help literature data [3,4].

Radiation from point sources completely field of vision of the device is usual does not fill. If the area of the radiation surface of object A is known, it is possible to measure its spectral density of power brightness according to the above-stated technique, i.e.

$$W_p\left(\lambda,T\right)=W\left(\lambda,T\right)\cdot\varpi\cdot\frac{l^2}{A}\quad(4)$$

Where ω-a solid angle of a field of vision of radiometer (equal 3mrad.); W (λ ,T)-the full measured spectral density brightness on (3); l-distance from researched object up to the device.

At measurements of point objects represents also interest spectral contrast of a source of radiation when radiation of a background is comparable to radiation of object. In this case it is necessary to allocate a signal of a background SB (λ) from a signal "source + background S (λ). And we shall receive spectral radiating contrast of a source:

$$W\left(\lambda\right)=\frac{\Delta S(\lambda)\cdot\varpi\cdot l^2}{K(\lambda)\cdot\tau(\lambda,l)\cdot A}\quad(5)$$

Where Δ S(λ)=S(λ)-SB(λ). If the area of radiating surfaces of the researched object A is unknown, it is possible to determine contrast spectral force light of a source (in terms of w/cm2ster . μ m):

$$I\left(\lambda\right)=W(\lambda)\cdot A\cdot=\frac{\Delta S(\lambda)\cdot\varpi\cdot l^2}{K(\lambda)\cdot\tau(\lambda,l)}\quad(6)$$

The described measurement methodology of IR radiation fluxes from point and extended thermal objects underlies reception and automatic processing of the measuring data with the help of complex "SimAr-A". In the end we shall note, that complex "SimAr-A" except for the ecological control environmental space, with the purpose of detection and prevention of occurrence of fires, can used also in scientific researches of physical properties point and extended IR sources, for monitoring an environment at extreme situations and natural disasters.

Conclusion

In IR Radiometer System for decrease of overall dimensions and rise of sensitivity, usually, using entry objectives of a type Cassegrainian [5,6] as is executed in our operation. But the matching developed by us Spectral Radiometer "SimAr-A" with closely existing analog [7] shows at least two clear advantages of the instrument, described in the present paper. With the purpose of the greatest elimination of chromatic aberration in the optical "SimAr-A" system two pairs projections mirror of objectives are applied, and in second, for the extension of instrumentation functionality's on ring disks of a mode of light filters (on region from 3 to 5, and 8 to 14 μ m) are placed half-ring variable cline light filters [8] for spectral measurements of spectrum.

On the developed by us Universal Infrared Spectral Radiometer "SimAr-A" received Patent AM No1678 A2, 28.11.2005.

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