UDC 621.307.13

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MULTISPECTRAL PYROMETER

Abstract. The article presents the results of an analytical study for the development of multispectral pyrometers features. The structural scheme of the multispectral television pyrometer is developed, which will be followed by the development of a laboratory mockup for experimental research in the preparation of a master's thesis.
Key words: multispectral pyrometer, temperature.

INTRODUCTION

Temperature is one of the most important parameters of technological processes. It is characterized by some fundamental areas that require the use of a large number of different methods and techniques for measuring it. The need for rapid contactless control and temperature measurement is constantly increasing. Scanning optical-electronic systems for monitoring and measuring temperature fields have wide functional capabilities, which allow to significantly improve the quality and speed of analysis of the state of different heat and power systems [1].

Today, in many fields of science and technology such as medicine, flaw detection, metallurgy, military and space systems, aircraft, machinery, there is a need to measure and control body temperature not only in the form of an integral assessment, but also the distribution of temperature both on the outer surface and in the middle, preferably by contactless measurement methods. In many cases, this is due to the movement of material, the temperature of which must be measured, for example, when you are rolling sheets, profile or pipes in metallurgy. Or measure the temperature of ingots, melt metal or glass, when contact with the metal surface is impossible. In other cases, for example, when measuring the temperature in vacuum chambers, when the use of contact sensors is separated by a range of measurements or under working environment conditions. A large number of currently available temperature measurement methods make it possible to measure it at any point using a contact method of measurement. In the case of contactless measurement, it is possible to obtain temperature values only on the body surface or in the upper layers of the test. Thus, there is a need to study the contactless method of temperature measurement, which would enable it to be determined not only on the surface of the body or in its upper layers, but also at any point in its entire volume.

Surrounding bodies change their properties under the influence of external factors, change their state. External factors may be mechanical when work is applied to the body, and non-mechanical when the body is heated.

According to the molecular-kinetic theory, all the bodies consist of rather small particles - molecules that are in an arbitrary motion. Experience shows that heating increases the arbitrary movement of molecules in the body, increasing the stock of its internal thermal energy, which consists of the kinetic energy of the molecules motion and their mutual potential energy. The dependence of the average kinetic molecule’s energy and gradual amount of heat transmitted to simpler substances - ideal gas is expressed by

$$E = \frac{3}{2}kT, \quad (1)$$

where k – Boltzmann constant, *J/deg*;

T – absolute body temperature.

For real gases, liquids and solids, this dependence is more complicated. The value characterizing the dependence of the body internal energy on the degree of its average kinetic energy is called the temperature, which thus determines the supply of internal energy of the body, which manifests itself in the thermal motion of the molecules.

The temperature refers to such physical quantities that are not directly measurable. Therefore, to determine it always convert to another measurement value.

Methods of radiation pyrometry are used to determine the temperatures of heated bodies. In violation of the thermodynamic equilibrium of the object with the environment on its surface there is an excess of temperature field, the nature of which allows to get information about the desired properties of the object.

The methods of thermal control are based on the interaction of the thermal field of the object with thermodynamic sensitive elements (thermocouple, photodetector), transformations of the field parameters (intensity, temperature gradient, contrast) into an electrical signal and transfer it to the recording device.

The advantages of thermal control are: remoteness, high speed of information processing, the theoretical ability to control any materials, many parametric nature of the test.

FEATURES OF MUSCULAR PYOMETER DESIGN

The intensity of thermal radiation is very much dependent on the body's temperature T. Therefore, pyrometry methods are used to measure relatively high temperatures. At $T \leq 1000$ ºC, the pyrometric methods play a minor role in general, but at $T > 1000$ ºC they are the main ones, and at $T > 3000$ ºC, practically the only methods of temperature measurement.

The temperature of the heated body can be judged on the basis of measuring the parameters of its thermal radiation, which represents electromagnetic waves of different lengths. The higher the body temperature, the more energy it radiates.

Thermometers that are based on the measurement of thermal radiation, called pyrometers. They allow the temperature to be measured from 100 to 6000 ºC and above. One of the main advantages of these devices is the lack of action of the meter on the temperature field of the heated body, since during the measurement they do not come into direct contact with each other. Therefore, these methods are called contactless.

Based on the analysis of existing television pyrometers, the scheme of the pyrometer was chosen as the basis. The block diagram of this device is shown in Figure 1.

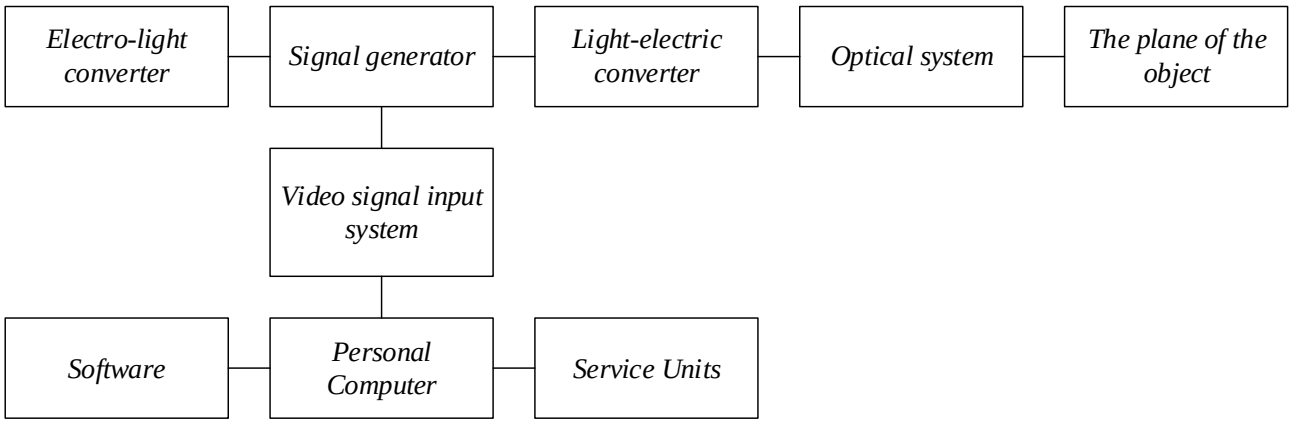

Figure 1 - Block diagram of the multispectral television pyrometer

The modern element base allows us to use the modular principle of constructing a multispectral pyrometer. In this case, the main modules are an optical system, a transmitting television camera, which includes a light-electric converter and signal generator in the computer. In terms of technical specifications, the optical system is perhaps the most important component of the multispectral pyrometer. An important role of the optical system is due to its location in the structure and the specificity of the purpose, which consists in forming an image in the form of a plane optical field of considerable size. The latter circumstance requires some elaboration of the issues related to the characteristics of the multispectral pyrometer optical system and more balanced approaches to their justification when choosing or developing it.

In some multispectral pyrometers, a device for inputting video signals into a computer is included in the list of mandatory modules. But video adapters of modern computers allow in most cases to refuse this device.

The multispectral pyrometer optical system forms the primary image, while making spectral and spatial selectivity, which, in the right approach, increases the signal-to-noise ratio. The light-electric converter determines the principal capabilities of the multispectral pyrometer, in particular, the spectral range and resolution. In this case, the light-electric converter converts an optical signal, which is a function of spatial coordinates and time, into an electrical signal. The already formed signal is fed to the computer where the transformation is performed, the purpose and type of which is determined by the purpose of the television pyrometer and the software.

An important role in pyrometers, that based on the analysis of the spectral brightness of radiation in two or three ranges (multispectral pyrometers) play light arbitrary elements. The most commonly used prisms or dichroic plates, which allow separating a single stream into spectral components. For the final formation of the necessary spectral ranges after separation is applied by adjusting the filters. After that, separate streams are directed to individual light-electric converters for further analysis or for the formation of a color image. For this purpose, a single light-electric converter can be used. The image forming device in the multispectral pyrometry belongs to the field of thermal imaging technology and can be used to form an image in pyrometers.

CONCLUSIONS

The article presents the results of the analytical study of multispectral pyrometers features. The structural scheme of the multispectral television pyrometer is developed, which will be followed by the development of a laboratory mockup for experimental research in the preparation of a master's thesis.

LIST OF LINKS

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