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PASSIVE OPTICAL ATHERMALIZATION OF DIOPTRIC LENSES FOR THERMAL IMAGING DEVICES

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The infrared (IR) equipment gets wide application in metrology, military enginery, scientific researches. IR devices are often used in difficult environmental conditions. A number of scientific publications are devoted to the design of thermally independent lenses. For example, in [1] methods of opto-mechanical passive athermalization of optical systems are considered. However, far too little attention has been paid to the passive optical athermalization algorithm. The analysis of such publications shows that the greatest attention is paid to opto-mechanical methods of athermalization, while passive optical athermalization is nowadays increasingly used due to a number of advantages: simplicity of construction, high accuracy and reliability, reduction of mass and dimensional characteristics. In particular, the significant advantage of optical methods is when the contribution of mechanical structural members to thermal defocusing can be minimized by applying materials with negligible temperature coefficient of linear expansion for mechanical parts of optical devices. Currently, there are only general recommendations that can be used in design of athermalized lenses, while the question of mathematical algorithms for passive optical athermalization remains open.

At lenses design process for IR equipment, developers widely use three-component optical systems. These systems allow to get good image quality without using aspherical surfaces. At the same time, the task of maintaining image quality over a wide temperature range in most of these compositions remains unresolved. This paper material is devoted to development of mathematical apparatus that allows to design athermalized and achromatic IR triplets with possibility of minimization of necessary image aberrations for the case of uniform temperature distribution in optical system [2].

Operating requirements for such equipment often include provision of the working temperature range ±50 ºC, because the most significant environmental factor that influences to image quality of IR technique is the temperature field change [3]. This leads to the emergence of thermal defocusing in the optical system – change of the back focal length size, and image thermal aberrations. As a result, there is a significant reduction of the resolution and deterioration of lenses main characteristics. Consequently thermal stabilization of lens image quality at the environmental temperature changes is an important and actual problem that needs to be solved at the design stage of IR device.

The question of thermal stabilization can be solved by applying active, semi-active and passive methods. Main advantages of passive optical athermalization are high reliability, absence of any moving parts and need of manual adjustment, minimization of weight and size properties and simplicity of design. Perspectives of this direction development are also caused by constant expansion of the optical materials list for IR spectral range [4].

The synthesis of an athermalized dioptric objective is based on optical materials combinations with different signs of the thermo-optical constant. During thermal stabilization it is possible to minimize image aberrations and to choose optimal material of the supporting structure for lenses at the same time. Proposed method allows to synthesize athermalized IR objectives, which include two or three lenses, using only two different optical materials [5].

Temperature fluctuations of the environment during the infrared technique operation significantly affect to its characteristics, such as quality and informativeness of the image, so at the design stage of high-precision and sensitive devices it is expediently to carry out an athermalization of the optical system. Athermalization and achromatization of IR triplets can be carried out by selection of optical materials compositions. During athermalization the main aberrations of IR dioptric lenses image are also minimized.

Synthesized in accordance with developed technique IR triplet with 50 mm focal length, 1:1 relative aperture, field of view angle 12º is characterized in the temperature range from -20ºC to + 60ºC by 4 μm changing of back focal length, that is 1-2 orders less than for non-athermalized lenses with similar operational parameters [6].

Further work in this direction should aim to improve design techniques of achromatic and athermalized infrared optical systems in order to get an algorithm that will allow to obtain a complete design parameters set for optical system without requirement of additional optimization; to minimize optical system aberrations; to design optical systems consisting of more than three components.

Keywords: passive optical athermalization, image quality thermostabilization, dioptric objective, optical system.

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SYSTEM FOR DEFINITION OF DEFECT'S COORDINATE

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The problem of coordinate recording of testing results during manual scanning is not new for modern flaw detection [1, 2]. Some foreign companies offer their own designs to solve the mentioned problems. One of the simplest designs that is used in scanning devices is a mechanical system for determining the coordinates of the transducer, proposed by "Olympics", USA.

The composition of such a system includes two roulette-type length meters, which are fixed on the surface of flat objects using pneumatic or magnetic devices. These devices have reversible readers, which according to the number of marks on the measuring tapes of these roulettes determine their length. The coordinates of the transducer in this system are determined from the compiled system of equations, which figure the distances between the transducer and each reader, as well as the size of the measurement base.

The disadvantage of such mechanical coordination systems is the low accuracy of determining the coordinates relative to this reference frame. In this case, a reduction in the measurement error is achieved by linking the coordinates of the measurement base to the real coordinates of the testing object.

With the development of modern electronics, it has become possible to use wireless technologies in non-destructive testing [3]. One of the methods for determining the coordinates of the measuring transducer, excluding the mechanical elements of the system, is based on the use of electromagnetic waves of super high frequencies. The system is built on a principle allows you to transmit the received information remotely.

The disadvantage of this coordinates determining method is the lack of accuracy and the results reliability. Since, the radiation of electromagnetic waves of ultrahigh frequencies even of low power can cause reverberation of signals reflected from the surface of the testing object and other objects, which leads to a distortion of the signal phase at the inputs of phase shift meters.

Today, the most commonly used in defectoscopy systems for determining the coordinates of transducers use the properties of ultrasonic fluctuations [4]. However, it should be noted that this method of determining coordinates has a significant disadvantage, which is expressed in the dependence of the speed of propagation of ultrasound on the movement of air.