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INTELLIGENT INFORMATION-MEASURING SYSTEMS WITH SENSORS BASED ON DIFFRACTION GRATING

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Abstract: *The relevance of the present study devoted to the creation of modern information measuring systems with sensors based on diffraction gratings is shown. Information on the acousto-optic effect and acousto-optic materials is presented. A comparative assessment of the characteristics and possible applications of instruments and systems based on different physical effects and phenomena was carried out on foreign and domestic patent and technical literature. Based on the analysis of the literature, the task was set and the choice of effective ways of achieving the goal of the present work was accomplished. Perspective information and measuring systems with sensors based on diffraction gratings, as well as inadequate attention to design issues, have been established. The need for research in this field has been formulated.*

Keywords: *information-measuring systems, sensors based on diffraction gratings, diffraction grating.*

Introduction

The urgency of scientific research. The use of intelligent information and measurement systems with sensors based on diffraction gratings is one of the most promising directions for the development of intellectual structures. Such sensors provide a new level of integration of the sensor system and the controlled structure.

The basis of the work of such information-measuring is the interaction of sound and light waves, as a result of which the modulation or deviation of the light current occurs. The propagating ultrasonic wave is accompanied by mechanical stresses of the medium. Due to the effect of photoelasticity, mechanical stresses cause deformation of the electron shells of atoms and molecules of the medium, this leads to a change in the dielectric constant and, consequently, to a change in the refractive index. As a result of the propagation of an acoustic wave, periodic layers with different refractive indices moving with the speed of sound are formed in the sound duct. The period of the layered structure is equal to the length of the ultrasonic wave. This periodic structure plays the role of a diffraction grating.

Currently, intelligent information and measurement systems with sensors based on diffraction gratings are at the research stage, which means they are products of the nearest future. They, unlike optical products of the volumetric type, are suitable for integration, which opens wide prospects for their practical implementation and application [1, 2].

Theoretical foundations and principles of building intelligent information and measuring systems with sensors based on diffraction gratings in our country were laid down mainly at the Moscow State Technological University STANKIN and the Novosibirsk Institute of Automation and Electrometry. The main developers and manufacturers of such systems of

this type are the companies "Hewlett-Packard" (USA), "Renishaw" (Great Britain), "Carl Zeiss" (Germany) and others.

Advances in the field of nano technologies allow creating intelligent information-measuring systems with motion sensors based on diffraction gratings with a small discreteness step of the report (about 0.01 μm or less). In such systems, lasers are used that have high spatial and temporal coherence, which makes it possible to obtain the necessary measurement error. An important component of the measuring system is the way and the signal processing scheme, at present new methods are proposed that increase the accuracy and speed of conversion [1].

The authors of this scientific work have made an attempt to generalize and systematize the experience of the development and creation of intelligent information and measuring systems with sensors based on diffraction gratings to create a scientific basis for the development of new similar systems with improved quality indicators (accuracy and reliability). In domestic and foreign literature, this aspect of intellectual information measuring systems with sensors based on diffraction gratings was not generalized.

1. Comparative evaluation of the characteristics and possible areas of application of instruments and systems

To this end, we will carry out a comparative assessment of modern developments in the development of instruments and systems based on various physical effects, using materials of patent offices and new publications in the form of articles in scientific and technical journals and books by domestic and foreign publishers [1-34].

Analyzing and comparing devices and measuring systems based on different physical effects and phenomena, we can conclude that the most effective of them are intelligent information and measuring systems with sensors based on diffraction gratings that have high quality indicators: reliability, accuracy, immunity, stability of characteristics, high speed, durability, small dimensions, high sensitivity.

In practice, often with respect to intelligent information-measuring systems with sensors based on Bragg gratings, the term optoelectronic devices and systems is used, referring to a structure containing optical and electronic components.

The sphere of application of intelligent information-measuring systems with sensors based on Bragg gratings: power engineering, mechanical engineering, medical technology, avionics, auto electronics, metallurgy, chemical and oil and gas industry.

In the military sphere, a great effect can be obtained in the design of cruise missiles and the use of optic-electronic correction systems and satellite navigation. It is very important to remember the high speed of fiber-optic and electronic components: magneto-optical (10^{-9} sec); electro-optical (up to 10^{-12} sec); acousto-optical (10^{-9} sec); avalanche photodiodes (10^{-9} sec) [10].

Small mass-dimensional indicators of optoelectronic components allow to reduce the overall dimensions and weight of the control system and increase the combat charge of the rocket.

2. The principle of constructing intelligent information-measuring systems with sensors based on diffraction solutions

In Fig. 1, an intelligent information-measuring system with sensors based on diffraction gratings [10], which contains two optical identical channels consisting of the first and second sources of coherent light emission 1 and 2, the first and second acousto-optical transducers 3 and 4 associated with the object (not shown), the first and second photodetectors 5 and 6. Outputs first and second photodetectors are

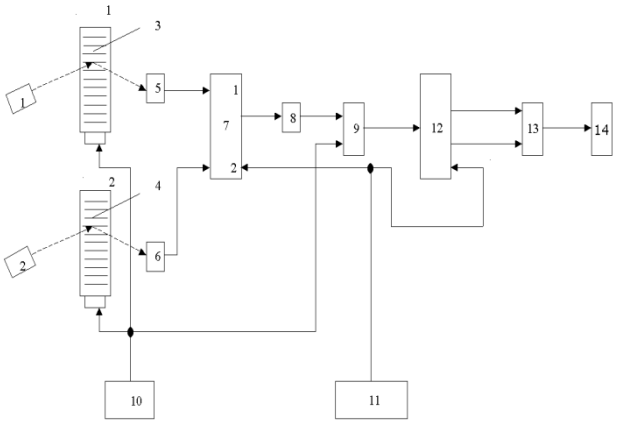

Fig. 1 ***Intelligent information-measuring system with sensors based on diffraction gratings.***

connected to the input of the first switch 7, an amplifier 8 whose input is connected to the output of the first switch 7, and the output is connected to one of the inputs of the integrator 9. The signal generator 10 is connected to the inputs of the first and second acoustooptic transformations 3 and 4 and the second input of the integrator 9. The output of the control oscillator 11 is connected to the control inputs of the first and second switches 7 and 12. The input of the second switch 12 is connected to the output of the integrator 9, and the outputs to the averaging device 1.

The operation of acoustooptic converters (AOC) in the diffraction mode does not require large acoustic signal powers, which has a beneficial effect on the life of the AOC material. Due to these properties the device has increased reliability and accuracy.

In its information essence, an intelligent information and measuring system with sensors based on diffraction gratings is a three-dimensional information converter, represented in a spatio-temporal form. The carriers of this information are two kinds of signals - acoustic and light, each of which is described by a three-dimensional function: two spatial coordinates and time, which allows using these devices in a variety of qualities, including the realization of an acousto-optic linear displacement transducer.

An intelligent information-measuring system with sensors based on diffraction gratings consists of the following main components: a light source (for example, a laser), an acoustooptic modulator AOM located at an angle of Bragg to a source of light radiation (much less the right angle - with Raman-Nath diffraction). AOM is an optically transparent sound conduit with acoustic wave propagating in it. The AOM sound tube is usually a plane-parallel plate, at one end of which a pie-transducer is mounted, which excites ultrasonic waves, and the second end is skewed to eliminate the backward acoustic wave.

At the present, the list of materials recommended by various authors as acousto-optical media exceeds one hundred names. Nevertheless, even a cursory review of the literature shows that the overwhelming majority of the most interesting and significant works in the field of acoustooptics were made on practically the same materials. Even fewer materials are used in industrial development. So, many foreign companies, such as Zenith and others, prefer one of the least exotic materials - glass [25-34].

Conclusion

Intelligent information-measuring systems with sensors based on diffraction gratings are designed to determine the movements and positions of control points of objects relative to the light beam. They have proved to be highly accurate and effective controls, which can be successfully applied both in laboratory conditions and directly in the shops of machine-building plants.

The analysis of patents and scientific and technical literature of foreign countries and the Russian Federation allows us to identify the most probable areas of practical application:

- control of the profile of the surface under study;
- control of deformations of various engineering objects;
- checking the end measures of the length (dimensions) of the object;
- geodetic information-measuring system;
- use as a means of active control in the processing of parts;
- control of the movements of the working parts of the equipment in order to improve the accuracy of machining.

Since intelligent information and measuring systems with sensors based on diffraction gratings are a relatively new high-precision measuring instrument, the application areas of these converters will be significantly expanded in the near future.

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