WORKING CONTROL SYSTEM FOR SPACE–TIME CHARACTERISTICS OF INDUSTRIAL IR LASERS

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UDC 535.8+681.142

The principles of a system for working control and analysis of the space–time characteristics of industrial IR lasers is considered.

The increased use of high-power industrial IR laser in industry calls for the development of systems of working control and analysis of space–time characteristics (STC).

The most interesting emission parameters of lasers for industrial use are the following:

1) the position of the energy center of the radiation beam in space;

2) the variation of the energy center in space and time;

3) the beam divergence;

4) the time variation of the beam divergence;

5) the mode composition of the radiation;

6) the time variation of the mode composition of the radiation.

The problem of monitoring these parameters is solved at present by using mechanical scanning systems with single receivers or receiver matrices. The shortcomings of such systems are the presence of moving parts and the low spatial resolution. The presently available converters for IR radiation and instruments based on them [2] employ photographic recording, with the attendant time loss to processing and photometry of the photographic material; they can therefore not be used for analysis in the course of operation.

It was proposed in [1] to pick off by television the information from luminescent screens (LS) and liquid-crystal panels. The enhancement of the parameters and the development of new designs of LS has made it necessary to analyze the methods of picking off the information from LS, as shown in Fig. 1. A comparison of these methods has shown that the parameters of the converted image hardly differ at angles $\alpha = 15°$.

The system operates in the following manner. The IR emission of laser 1 is applied to beam splitter and the component 4 is diverted to the aperture of a shaping optical system 5 that transforms the radiation and separates the investigated radiation parameter, viz., the two-dimensional distribution of the intensity in the plane of the LS 6, e.g., the focal spot if the beam divergence is measured. The IR radiation acting on the LS causes heating of the luminor excited by source 7, as well as temperature quenching of the source in proportion to the incident IR power. The image on the LS, which corresponds to the power-density distribution, is projected through an optical system that contains a filter 8 opaque to the UV radiation reflected from the LS onto the target of the TV transmitter tube 15. The image is scanned by frame and line scanning blocks 13 connected to a synchro-generator 14. The video signal from the TV tube 15 is amplified by video amplifier 16, corrected, and passes through mixing block 17 together with the line, frame, and blanking pulses to video-control unit 20 and to analog–code converter 21. The output of the latter goes to computing unit 18 from which are picked off the radiation-beam parameters needed for monitoring and control.

The information is picked off the converting LS at regular time instants t_i, and the subsequent storage and processing of the information I(x, y) yield, following a subsequent analysis, the laser STC I(x, y, t).

Translated from Voprosy Metrologichskogo Obespecheniya Izmereniya Parametrov Tekhnologiskikh Laserov, pp. 49–53, 1984.

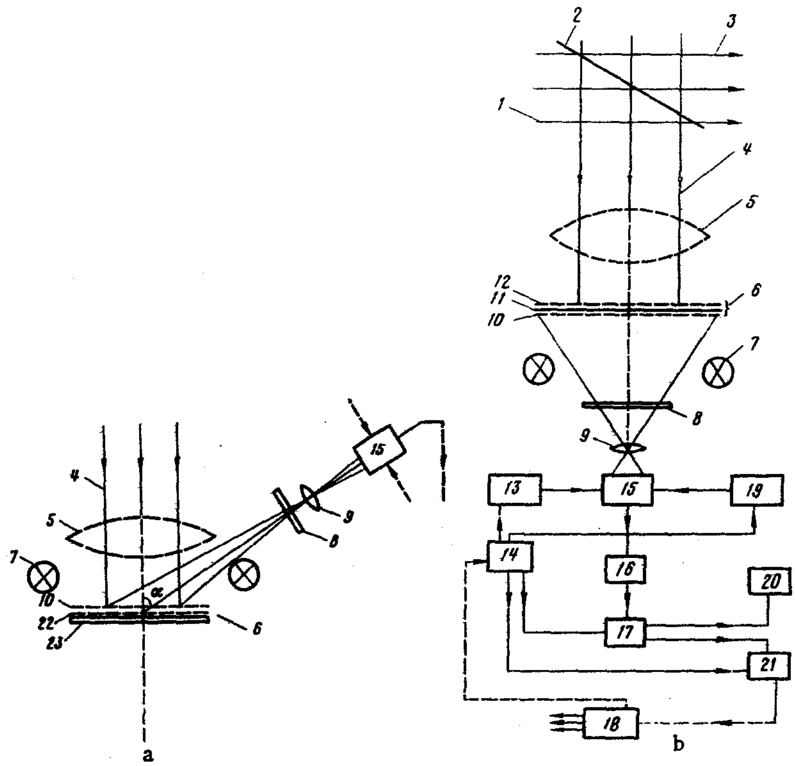

Fig. 1. Information pickoff from LS by transmission (a) and reflection (b): 1) IR laser beam, 2) beam splitter, 3) transmitted radiation beam, 4) diverted radiation beam, 5) optical shaping system; 6) luminor screen (converter of IR into visible radiation); 7) source of luminor UV excitation; 8) filter blocking the UV radiation; 9) optical projection system; 10) luminor layer based on ZnS; 11) organic-film substrate; 12) IR-absorbing layer; 13) frame scanning block; 14) synchro-generator; 15) TV transmitter tube; 16) video amplifier; 17) mixer; 18) computing unit; 19) line-scan block; 20) video-control unit; 21) analog-code converter; 22) liner (thermal insulator); 23) bulky metallic substrate.

The main conditions that must be met in the normal course of the measurements are the following:

$$\tau_f \ll \tau_{conv};$$
$$t_{t\,f} > \tau_{conv};$$
$$\tau_{char} > \tau_{conv};$$
$$\gamma_{tv} \ll \gamma_{conv},$$

where τ_f — the frame duration;

τ_{conv} — the (thermal) time constant of the converting medium (LS);

τ_{char} — characteristic time of use of the laser parameters;

γ_{tv} — spatial resolution of television system;

γ_{conv} — spatial resolution of converting medium.

The investigations have shown that these conditions are quite easily met in most cases encountered in practice.

The recording screen was an $ZnS_{50}CdS_{50}Ag$ $3 \cdot 10^{-4}$, Ni $3 \cdot 10^{-6}$ LS luminor deposited on a polyethylene-terephthalate film with an absorbing layer. The luminor preparation technology and the screen preparation are described in [2]. The LS was excited and a wavelength 365 nm and at a density $5 \cdot 10^{-5}$ W/cm². The LS parameters were measured in the cw regime using a CO_2 laser at 10.6-μm wavelength.

In the estimate of the values and character of the distortions, account must be taken of the characteristics of the beam splitting, of the shaping optical system, of the uneven UV excitation over the LS area, of the projection-system parameters, and of the nonlinearity of the television channel. The sensitivity and dynamic range of the recording can be increased by the television difference half-frame technique.

PRINCIPAL TECHNICAL PARAMETERS OF SYSTEM

Frame frequency, Hz (interlaced scanning)	50
Size of transmitting TV tube (vidicon), mm	9 × 12
Reduction factor of projection optical system	5-100
Diameter of LS (for PLIT-1), mm	60
Time constant of LS, less than	0.6
UV irradiance, W/cm²	10-4
Dynamic-range factor:	
of TV system with LS	from 50 to 100
without the use of ranging and of methods of suppressing spatial noise	from 10 to 16
Working spectral range, μm	0.2-20
Sensitivity threshold, W/cm²	$7 \cdot 10^{-3}$
Continuous operating time, h	8

The information can be picked off the system by several methods:

1) visual from video control unit;

2) using an oscilloscope to separate the lines;

3) recording with a VCR;

4) feeding the information to a computer;

5) photography from video control unit screen.

The investigations of the system of working control of the space-time characteristics of industrial IR lasers have shown that, compared with the photographic method, the time of picking off the information from an LS is greatly shortened (10-0.1 sec) while the quality of the resolved elements remains unchanged.

LITERATURE CITED

1. I. V. Groshev, L. M. Zaitsev, G. I. Rukman, et al., 14th Int. Congress on High-Speed Photography and Photonics, VNIIOFI, Moscow (1980), p. 284.
2. M. M. Klyukin and V. M. Klyuchnikov, Kvantovaya Elektron. (Moscow), 3, No. 5, 1095 (1976).