TRANSIENT PROCESSES IN A FLEXIBLE ADAPTIVE MIRROR FOR ADAPTIVE OPTICAL SYSTEMS WITH VARIABLE FOCAL LENGTH

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In this paper we present the results of experimental investigations of a flexible adaptive mirror with variable focal length driven by a controlling voltage of special shape. Peculiarities in the operation of such a mirror are examined.

In remote sensing of optical and meteorological parameters of the atmosphere the construction of optical systems with variable focal length which must be adjusted automatically as information from different atmospheric layers is received is an urgent problem. Meanwhile, the typical switching time must be of the order of a few milliseconds. Clearly, varying the focal length of these optical systems by mechanical means is impossible. The use of a flexible adaptive mirror based on piezoceramic plates with a single continuous controlling electrode for this purpose was first proposed in Ref. 1. The frequency characteristics of such a mirror were also investigated in this reference. However, in the construction of optical systems with variable focal length, along with the frequency characteristic such a characteristic of the mirror as the type of transient processes being driven by the controlling voltage is also important. The numerical solution of the problem of calculating the shape of a transient process in a flexible adaptive mirror is very problematic because simply constructing an adequate mathematical model of a real mirror is a complicated problem by itself. In this connection, the results of experimental investigations of these transient processes, aimed at providing a basis for guiding the development of special systems for controlling these mirrors, are of definite interest.

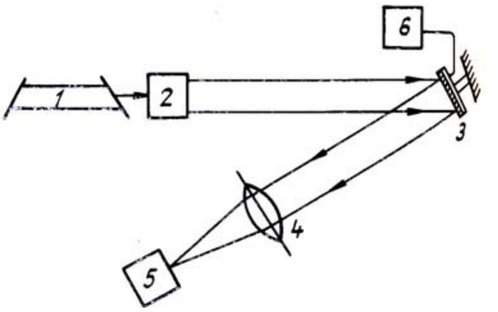

FIG. 1. Block diagram of the experimental setup: 1) laser, 2) collimator, 3) piezoceramic mirror; 4) lens, 5) photodetector, and 6) controlling device.

For the experiments we prepared a flexible adaptive mirror fabricated from PCR-6 ceramic with a single continuous electrode. A block diagram of the experimental setup used to perform the measurements is shown in Fig. 1. A photodetector, provided with a broad-band amplifier with time constant $\tau_a \approx 10^{-5}$ sec, was used to record the signals. Thus, the recording device had no effect on the shape of the signals.

The response of the mirror to a controlling signal of rectangular (Fig. 2a) or linear-ramp (Fig. 3a) shape was investigated. The first case corresponds to the model of an optical system with a stepwise-varying focal length, the second case corresponds to a linearly varying focal length. The pulse duration was 1.5 and 3 msec, and the width of the leading edge was of the order of 100 μsec. The response of the mirror to such an input is depicted in Figs. 2b, 3b and 2c, 3c, respectively. As can be seen from these figures, in this case we failed to obtain a smooth peak and base of the pulse. This fact may be explained by the fact that a piezoceramic mirror is a distributed vibrational system, and, under the effect of a sufficiently broad-band signal from the controlling device, the mirror is excited at its mechanical resonance frequencies, which are close to the frequencies of the spectrum of the controlling signal. This results in the rough form of the transient characteristic of the mirror. Narrowing the transmission band of the control device with the help of a low-pass filter, which is equivalent to an increase in Δt, enables us to reduce this effect owing to a decrease in the amplitude of the high-frequency components of the spectrum of the controlling signal. However, in this case the switching time of the adaptive mirror increases with increase of the width of the leading edge of the controlling signal. We can also suppress nonuniformity of the peak and base of the pulse by damping the natural frequencies of the flexible adaptive mirror with the help of a viscous liquid or a layer of viscoelastic polymer applied to the reverse side of the plate.

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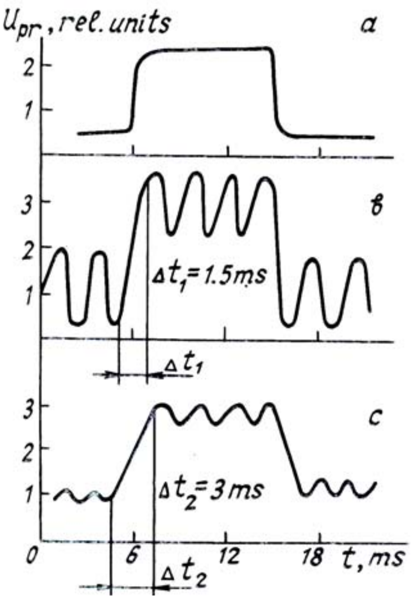

FIG. 2

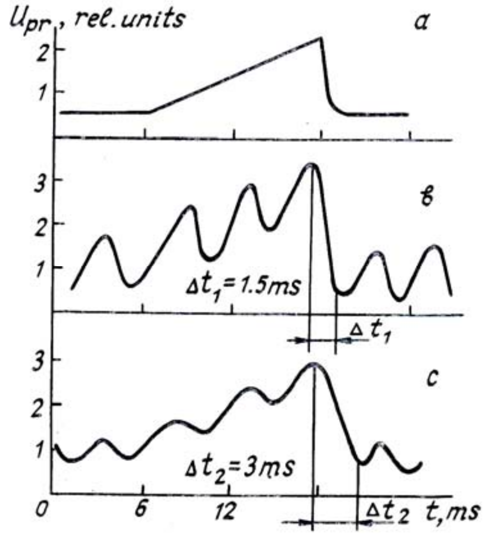

FIG. 3

Thus our experimental investigations have shown that the choice of the shape of the controlling signals, which depends on the required shape of the transient processes and on damping of the natural frequencies of the mirror, is very important in the construction of control systems of flexible mirrors with variable focal length.

REFERENCE

1. D.A. Bezuglov, Z.P. Mastropas, E.N. Mishchenko et al., Atm. Opt. **2**, No. 12, 1119–1123 (1989).