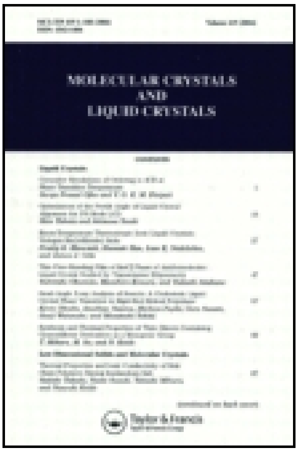

Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

Twist- and Supertwist Antidazzling Devices With Local Reduction of Brightness

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Version of record first published: 04 Oct 2006.

To cite this article: Alexander Kuznetsov, Victor Belyaev & Nikolay Kovtonyuk (1995): Twist- and Supertwist Antidazzling Devices With Local Reduction of Brightness, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 265:1, 591-597

To link to this article: http://dx.doi.org/10.1080/10587259508041725

Mol. Cryst. Liq. Cryst. 1995, Vol. 265, pp. 591–597
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TWIST- AND SUPERTWIST ANTIDAZZLING DEVICES WITH LOCAL REDUCTION OF BRIGHTNESS

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ABSTRACT. Single- and multichannel optoelectronic modulators with twist- and supertwist transmissive or reflective LC cells are described. The possibility of antidazzling aplications of these devices at low background intensity (0,1-10 lx) is discussed.

1. INTRODUCTION.

The liquid crystalline shutters may reduce the light beam by a factor tens and more during a short time interval (0,1-10 ms). It is especially useful to eliminate the blindeness of an operator in many applications. In this paper we describe the design and controlling regime of two types of antiglare modulators with total and local reduction of brigtness of a dazzling light source.

The first one is single-channel optoelectronic transformer with threshold dependence of cell's transmission on input light intensity. This device provides the total reduction of brightness. The second one is an optically addressed spatial light modulator (OA SLM). It consists of an aggregate of optoelectronic shutters with the threshold input-output intensity characteristics. These shutters interact very weak due to low diffusion of charge carriers in photosensitive part of a SLM. The threshold input-output characteristic provides the reduction of intensity only of very bright parts of an image transformed. For antiglare applications twist- or supertwist shutters may be useful. Automative light control sunglasses are described in Ref. 1. The a-Si solar battery controls the transmission of two twist-cells in intensities range 1000-20000 lx. Obviously these glasses may not operate at low illuminance level as an antiglare device. The local reduction of bright parts of an image is described in Refs. 2, 3. The SLMs type "photoconductor - liquid crystal" (PC-LC) were used. These ones are slow in comparison with metal - dielectric - semiconductor - liquid crystal" (MDS-LC) structures which operate usually in a reflective mode. The purpose of our paper is the design of the single - and multichannel optoelectronic antiglare device with total or local reduction of light beam which operate at relative low intensity level (0,1-10 lx).

2. TWIST ELECTROOPTIC SHUTTER FOR ANTIGLARE SPECTACLES.

The problems of road visibility under highway conditions occupy a special position in traffic safety. Up to 15% of all accidents take place in conditions of limited visibility on the average [4]. One of the main reasons for traffic accidents is that the upper beam of head lamps of the oncoming vehicles dazzles a driver. To eliminate the dazzling effect it is necessary to reduce the luminous flux by the factor of 10-50.

This paper describes device that prevents blinding of the driver by the distant beam of head lights of oncoming traffic. The device consists of two electrooptical liquid crystalline shutters (twist cells), the goggles frame and of electronic control circuit, allowing to vary the light transmission of the shutters, as the illuminance of the photodetector varies. The design of the device is presented in Fig. 1. The electronic control circuit comprises a square-wave generator of monopolar pulses. A photodiode is in the supply circuit of the generator, which shuts off the cell's bias voltage in the case of absence of the input exposure.

The thickness of the liquid crystal material layer is specified in accordance with the condition of the second Gooch-Tarri maximum [5]. For liquid crystalline material ZhK-1282, having the birefringence value $\Delta n = 0,14$, the thickness of the layer L is $\lambda\sqrt{15}/2\Delta n$, i.e. $L = 12,6\ \mu m$, if $\lambda = 0,55\ \mu m$. To provide the uniform twist of the LC layer the chiral dopant is introduced into the material with a concentration chosen from to the condition $C < 0,25A/L$, where A is the twisting ability of the dopant.

Now we describe the method of the operating device. The threshold value of the dazzling illumination on driver's eyes is equal to 1,4 - 2 luxes according to [4]. When the photodetector illumination exceeds this value, the control curcuit generates a consequence of monopolar voltage pulses into the electrooptical shutters. As a result, the transmission of liquid crystal shutter decreases 40 - 50 times. When the input exposure decreases up to the level below the threshold value, the control curcuit shuts off the generator , the LC

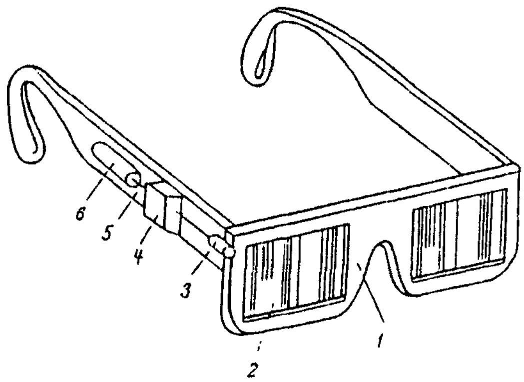

Fig. 1. Design of antiglare device: 1 - frame, 2 - electro - optic shitters (twist cells), 3 - photodetector, 4 - modulator (electronic key), 5 - wires, 6 - battery (or generator)

orientation relaxes into the initial position and the shutter is open. In the case of full reorientation of the liquid crystal the width of angular dependence is inversely proportional to the product of optical anisotropy and thickness of the liquid crystal layer. The half-width of angular dependence was 0,5 rad at the thickness of ZhK-1282 12 μm.

Under these conditions an appreciable attenuation of the distant light of oncoming traffic and small attenuation of close light of a driving car take place[6]. The use of antidazzling spectacles by drivers of transport vehicles in conditions of darkness enables the drivers to adapt to distant and close headlight beams what leads to reduction of eye's accomodation time, and increases the safety of driving.

3. SUPERTWIST REFLECTIVE SPATIAL LIGHT MODULATOR WITH LOCAL REDUCTION OF A BRIGHT LIGHT SOURCE

Any SLM consists of photosensitive and light modulating parts which are distanced by a dielectric mirror. The first one is the MDS-structure (ITO electrode - optical glue - GaAs plate 50 m thick). The dielectric mirror reflects the visible range of spectrum and transmits the IR one. Therefore, we use the infrared beam to write an image on the MDS and the visible beam to read the image transformed. The electrooptic layer is a planar oriented twisted nematic LC. The twist angle $\varphi = 63,6^{\circ}(2m+1)$ (m - an integer) and optical phase retardation $\Delta nL = (\lambda/2\sqrt{2})(2m+1)$

(Δn - LC birefringence, L - LC layer thickness, λ - read light wave length) are chosen from [7,8] to transform a linear polarization into a circular one. When a LC layer is not deformed by the electric field the output after by the electric field the output polarization is perpendicular to the input one after the reflection. The deformed LC layer does not change the polarization of a read light beam. The electrooptics of such cells was investigated in Ref. 9.

The twist angle φ =191° provided steeper voltage - transmission characteristics and higher photosensibility of the SLM. The low value of Δn = 0,045 reduces the requirement to the LC layer thickness homogeneity. The white light beam is transformed by the SLM without a sinificant colouring. The similar design of the LC layer were used in Ref. 10 in an a-Si SLM.

The experimental scheme is shown in Fig. 2. The objective O_1 projects an image of low-angle bright light source on the semiconductor surface. The polarizing light d ivider C transformes the phase-modulated reflected read-beam into the amplitude-modulated one and guides it on ocular O2 before the operator's eye.

The input-output intensity characteristics is shown in Fig. 3. The flat interval of Iout (Iin) dependence corresponds the absence of variation of intensity of transformed image when the input intensity increases, i.e. the reduction of brightness of a light source relative to the background intensity. The threshold intensity I_{th} and reduction coefficients K_{red} may be controlled by the variation of driving parameters: voltage U and frequency f. When f increases the I_{th} value increases too and K_{red} diminishes. The steepness of Iout(Iin) characteristics depends strongly on a ratio of thicknesses of LC and dielectric layers and on LC parameters, such as dielectric anisotropy and elastic constants ratio [11,12].

The real value of K_{red} of white light beam was 10-30 at I_{in} =100-1000 lx. It is necessary to enlarge this value and use additive electrooptic shutter for welding applications.

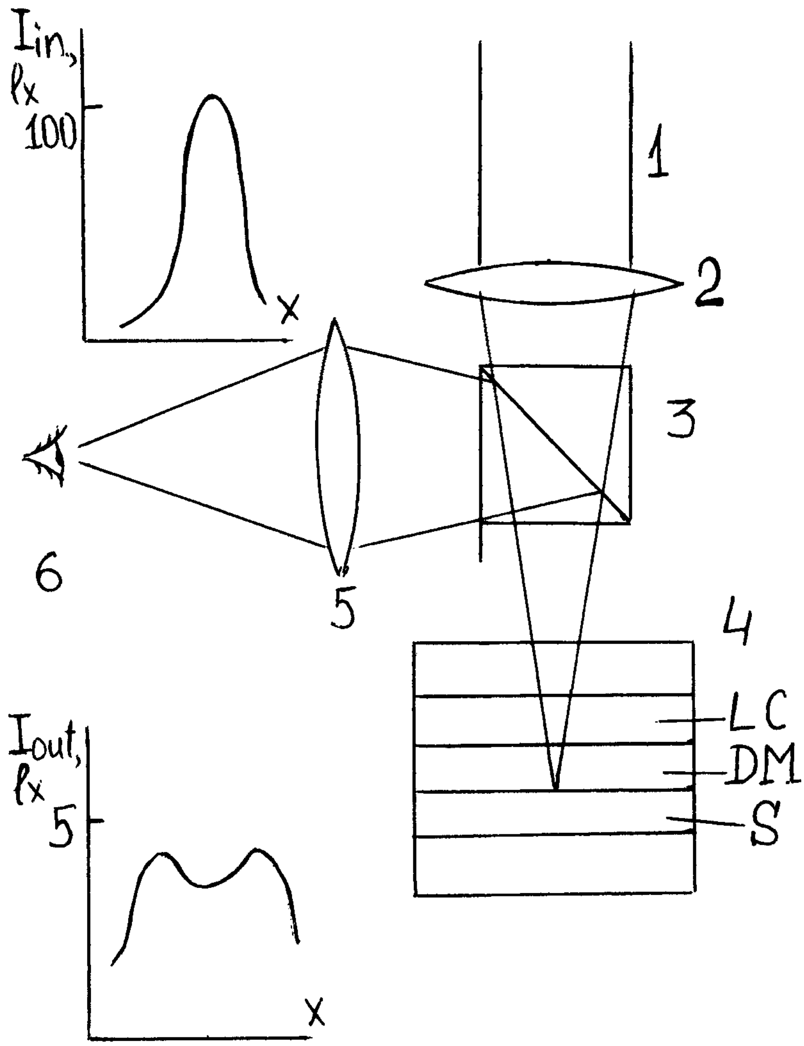

Fig. 2. Scheme of measurement of parameters of local brightness reduction. 1 - input light beam, 2 - objective O1, 3 - light - divider, 4 - SLM (LC - liquid cristal, DM - dielectric mirror, S - semiconductor layers), 5 - ocular O2, 6 - observer's eye or photodetector. Iin and Iout light beams are also shown.

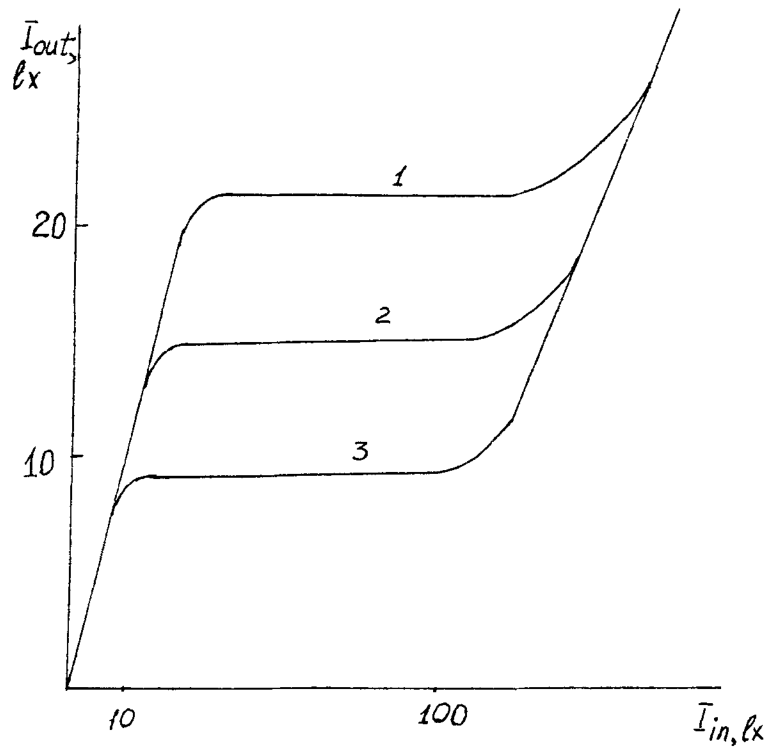

Fig. 3. The dependence of output image intensity Iout on input intensity Iin at supply frequencies 5 (1), 1 (2), 0,1 (3) KHz.

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