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SAFETY GOGGLES WITH LOCAL-SPACE MODULATION

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Abstract The goggles based on LC spatial light modulator for protection observers' eyes from blinding objects are disoussed.

INTRODUCTION

The problem of eye protection from blinding objects and radiation sources arises commonly in different kinds of human practice. The solution of this problem is especially vital in welding and transport facilities handling in case when blinding objects appear in the field of view (the sun, clouds, sun glare etc.). Under such conditions observation may cause eye and total fatique, visual fitness to work and other visual functions deterioration. Considering that a human being recieves nearly 90% of external information by the visual perception, a great need in different devices, protecting an eye from blinding objects, becomes evident.

All currently available radiation attenuators can be classified into two groups: static and dynamic. The spectacles with colour or neutral protective light filter, polarizing spectacles of different types, etc., fall into a class of the static attenuators. Such spectacles reduce the viewed picture brightness, whether the blinding objects are present or not in the field of view. The dynamic attenuators

are free of such shortcomings due to the fact that they are controlled by the threshold device set on a certain illuminance level, produced by blinding objects. Such dynamic attenuator can employ the photochromic glasses[1] or ferroelectric ceramics[2].

There are many different problems, however, in practical applications due to the slow response of photochromic glasses and to the fact that ferroelectric ceramics control requires a high-voltage power supply (hundred Volts). The performance shortcomings mentioned above are of principle character, thus leading to necessity for a search of new media for light safety goggles with suitable operating parameters.

The goal of this work is the feasibility study of the LC-based spectacles intended for development of observers' eyes automatic protection.

LC SPECTACLES WITH RADIATION MODULATION OVER THE ENTIRE FIELD OF VIEW

Safety LC goggles are based on the use of twist-effect in nematic, which show high-speed as compared to photochromic glasses (tens - hundreds msec) and lower control voltages as compared to ferroelectric ceramics (units Volts).
The results obtained in the experimental study of spectral characteristics in the visible region:

the initial light transmission is 0,3;
contrast ratio is 1:1000;
speed of response is up to 20 ms at 20^{0}C and U=5V;
the initial UV transmission is less than 0,05;

have proved the spectacles practical feasibility and outlined the range of application. They can replace the family of the light filters that are used for eye protection in welding and gas cutting. In this case, an additional advantage of the LC spectacles is the possibility to carry

out a smooth adjustment of the radiation attenuation degree. Several LC cells, assembled in series, can be used for enhancing the controlled light attenuation range. A review of the relevant patent literature has shown that a number of patent are available that differ mainly in control curcuits. The SPEEDGLASS welding filters produced by Swedish firm Hörnell are also well known. A common disadvantage of the safety goggles considered and the mentioned patent solutions is that they realize modulation over the entire field of view.

SAFETY GOGGLES WITH LOCAL-SPACE MODULATION

In many practical cases the necessity of radiation intensity attenuation occurs only for blinding objects, the possibility of observing other objects being retained. For this purpose we have developed the safety LC goggles with local radiation modulation based on the use of optically adressed spatial light modulator (SLM)[3] (Figure 1). The spectacles employ a binocular telescopic unit-magnification direct image system consisting of objective lens 1, pentaprism 2, collective prism 3, SLM 4, retangular prism 5 and eyepiece 6. The SLM is placed in the focal plane of the objective lens which projects the observed object's image on the SLM. The SLM is based on the photoconductor- LC structure, the former being monocrystalline GaP or ZnSe. When the voltage is applied to the electrodes in no-optical-signal condition, the voltage drop occurs mainly across the photoconductor layer, while the LC molecules retain their initial orientation state. When the photoconductor is illuminated and the voltage is applied to the elecrodes, the voltage drop is redistributed between the photoconductor and the LC contacting with the photoconductor illuminated area. This results in the local LC molecules reorientation and, consequently, in the local light

transmission reduction. By selection of the operational voltage the SLM is tuned to a certain threshold illuminance produced by blinding objects in the image plane. If the threshold illuminance is exceeded in the light relief zones then the local light modulation will take place. In this case the remaining (not illuminated) zones will be transparent. Each binocular telescopic arm is encased in a housing and is fixed on the holder by the nut. This makes it possible to adjust the device eyepiece base to the observer's eye base.

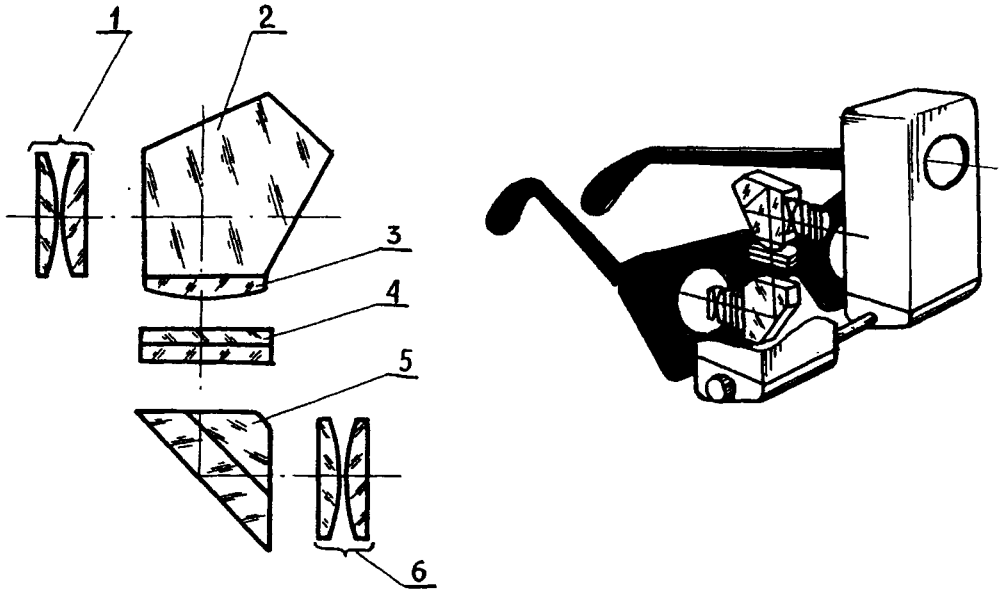

FIGURE 1. Optical scheme of safety goggles: 1-objective lens, 2-pentaprism, 3-collective lens, 4-spatial light modulator, 5-prism, 6-eyepiece.

The nemato-chiral mixture with optically active dopants based on l-mentole and tigogenin caprinat derivaties was

used in the SLM. The uniform helix pitch of the mixture was longer than the LC layer gap, that was 5 μm. The contrast ratio was the same as that of the polarizers and did not depend on the wavelength within the range of 400–800 nm. The photoconductor layers of 2 μm thickness were deposited by vacuum evaporation in the quasiclosed volume and were transparent in the visible range. The orientation was carried out by the oblique evaporation of cerium oxide. The performance characteristics of the safety goggles with local-space modulation for ZnSe photoconductor are presented in Table 1.

TABLE 1 Performance characteristics of the safety goggles

PARAMETER	VALUE
Magnification	1^x
Field of view	24^o
Eye base	58–72mm
Resolution	1'
Voltage	15V/5 μA
Initial transmission	0,1
Transmission at 15 V	1.10^{-3}
Sensitivity range	0,4–0,6 μm
Transmission range	0,5–2 μm
Threshold illuminance	5 lux
Rise/decay time at t=20°C, U=15 V and illuminance 100 lux	0,01/0,05 s
Service life	more than 2000 h

The field tests of the devices described above have confirmed the goggles operation efficiency. Further designers' efforts have to be focused on the initial light transmission, speed of response and modulation depth increasing. Thus we have demonstrated the feasibility of the automatic localy-modulated safety goggles development based on the SLM placed in the image plane of the telescopic system. Experiments have proved the comfortability enhancement of the visual perception of the informational field containing blind sources and glaring objects, however retaining the possibility of observing other objects in the field of view. The goggles with the local modulation of radiation demonstrate new trends in development of observation instruments. They can be used in welding and gas cutting operations, in transport facilities handling and for observing the sun.

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