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VISIR OPTIC APPLIANCES DESIGNED FOR OBSERVATION ON THE BOARD OF SPACESHIPS

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Abstract*: The criteria for the efficiency definition of visir optic appliances for observation on the boards of spaceships are related to: the eye characteristics – the pupil diameter in dependence of the background brightness, the visual sharpness and the utmost contrast; the photometric characteristics of the observed object and the background – their brightness and contrast; the optic characteristics of the visir optic appliance – magnification, vision field, entrance pupil diameter, light permeability, etc.*

Because the above mentioned class of appliances for cosmic research is used to observe distant objects, when evaluating their efficiency, it is important to render an account of the atmospheric conditions. The visual distance of the distant objects depends on the photometric characteristics, on the object size and its shape.

The presented in this research criteria for efficiency of the visir optic appliances used for observation on the boards of spaceships and also the coefficient which counts for the atmospheric influence allow evaluating the object visibility in the conditions of a natural landscape.

Key words*: visir, optic*

Taking into consideration the above mentioned conditions and to define the efficiency, it is necessary to define the possibility of observation of distant objects with a high resolution. The efficiency of the observation by means of a visir optic appliance is denoted by E and it can be defined by the correlation

(1) $$E = \frac{\delta_0(l)}{\delta(l)},$$

where $\delta_0(l)$ is the utmost resolution of an observation with the naked eye of an object which is at the distance l;

$\delta(l)$ is the utmost resolution of an observation of the same object by means of a visir optic appliance.

Such method is especially useful to evaluate visir optic appliances with a constant magnification, with a discreet variable magnification and a smooth variable magnification [1…9] because it is possible to choose optimal parameters depending on the requirements and the specific functions of the optic visirs. For example “Visir pricel 15K” (fig. 1) is designed to direct the specter-zonal appliance “Specter–15” for distant Earth research from the board of Orbital scientific stations. “Visir B 3x40” (fig. 2) is designed to direct Electrophotometric appliance “Duga” for research in the sphere of

Fig. 1. Visir pricel 15K

the cosmic physics – registration of polar lights and stable auroral red arcs and Pancratic visir (fig. 3) is designed to direct Impulse photometric appliance “Terma” for discovery of distant objects and registration of fast processes by means of a high space and time resolution.

Fig. 2. Visir B 3x40

The calculation of the utmost resolution $\delta_0(l)$ is made in the following sequience. The angle $\delta_0(l)$ can be defined by known correlations of the eyesight acuteness from the brightness and contrast of the object and background. For this purpose, it is necessary to calculate the visible contrast K

Fig. 3. Pancratic visir

of the object which is situated at a different distance l [5]:

(2) $$K = \frac{B - B_H - \dfrac{B_0 - B_H}{\tau^{\Delta l}}}{B - B_H + \dfrac{1}{\tau^{\Delta l}} \dfrac{B_H}{\tau^{l}}},$$

where B, B_0, B_H is brightness of the background, of the object and of the sky;

Δl is the distance between the object and the background;

τ is the atmospheric permeability coefficient.

In most of the cases the object is situated right in front of the background, i.e. $\Delta l = 0$. Then,

(3) $$K = \frac{K_0}{1 + \dfrac{B_H}{B}\left(\dfrac{1}{\tau^{l}} - 1\right)},$$

where K_0 is a real contrast between the object and the background.

The photometric characteristics of the object and the background are $\frac{B_H}{B}$, $K_0 = 1$. The atmospheric permeability coefficient τ is accepted as 0,85; 0,75 and 0,65 [ ].

To define the utmost resolution when taking into consideration the values of the visible contrast, experimental data from researched objects are used and they allow finding the dependency of the angle δ from the contrast K at different background brightness, i.e.

(4) $\delta = f(k)$, $B = B_1, B_2, ...$

By means of the correlation (4), the angle δ can be found which corresponds to the visible contrast about a different distance of the observed objects and a scale is drawn of the utmost resolution when observing with the naked eye: $\delta = f(b)$ $(B = const)$, which can be seen on fig. 4 and the background brightness is $B = 420$ cd/m^2.

The calculation of the utmost resolution $\delta(B)$ is made in the following sequence. When observing through a visir optic appliance, the contrast and visibility decreases. The decrease of the contrast is explained by the light diffusion in the appliance and the decrease of the contrast is explained by the losses in the optic parts and the restricted outlet pupil diameter, especially if the outlet pupil diameter d' is smaller than the human pupil diameter d. At background brightness $(B > 50...100$ cd/m$^2)$ and the influence of the light diffusion upon the resolution is very minor and it can be ignored in the researched problem. The visual brightness of the image B' attains special influence.

(5) $$B' = \begin{cases} B_{\tau_0} & d' \geq d \\ B_{\tau_0}\left(\frac{d'}{d}\right)^2 & \end{cases}$$

$d' < d$,

where τ_0 is a coefficient of light diffusion of the visir.

The scales 1, 2 and 3 from fig. 4 are drawn from the gathered results and they refer to a pancreatic visir with a smooth variable magnification (fig. 3).

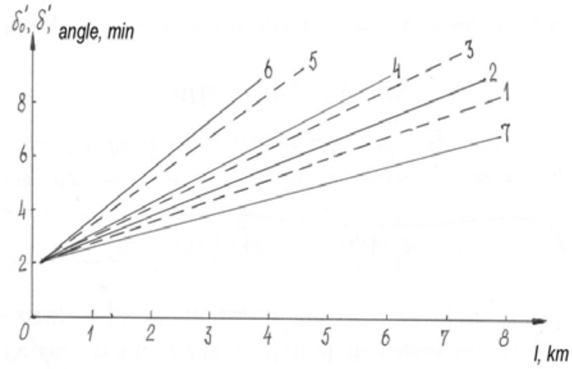

Fig. 4. Utmost Resolution δ_0 and δ' depending on the distance to the objects; $B_H = 3000$ cd/m^2, $B = 300$ cd/m^2, $K_0 = 1$; 1,3,5 – observation with the naked eye (at angle δ_0); τ respectively equals 0,85; 0,75 and 0,65; 2,4,6 – observation through a pancreatic visir; 7 - observation with the naked eye (at angle δ_0, $\tau = 0{,}85$), calculated by formula (3)

The diameter of the human pupil $d = 3{,}00$ mm at $B' = 300$ cd/m^2.07=210 cd/m^2, and at $B' = 300$ cd/m^2.0,55=165 cd/m^2, d=3,1 mm.

The correlations at the lowest visible resolution of the image

$B' = 110$ cd/m^2 at visir magnification 20 times are presented by the numbers 2,4 and 6 on fig. 4. The angle δ' is made without rendering an account of a possible change of the image quality at change in the magnification. It is obvious the utmost resolution in the medium of the object $\delta = \frac{\delta'}{\Gamma}$. The efficiency E has to be presented by the formula:

$$E = \frac{\delta_0(l)}{\delta'(l)}, \quad (6)$$

where $\delta'(l)$ is the utmost resolution in the image medium of the visir telescope system when observing an object at a distance l.

It is necessary to count the atmosphere influence by means of the coefficient A and by comparison of the utmost resolution without rendering an account of the atmosphere influence and with rendering the atmosphere influence, i.e.

$$A = \frac{\delta'(l)}{\delta'(l=0)}. \quad (7)$$

When the weather is cloudy and there is air turbulence, the coefficient which counts the atmosphere influence A (which is defined by experimental data) shows a double increase in comparison with the values in a homogeneous atmosphere.

The following conclusions can be made on the basis of theoretical and experimental results:

1. The theoretical value of the utmost resolution δ' is 7 % higher than the experimental in a comparatively homogeneous medium and when the observation is made by means of a pancreatic visir with a 20 times magnification.
2. At high heterogeneity and atmosphere turbulence which appears in sunny days during the summer, the experimental values of the utmost resolution are influenced by the magnification of the visir telescopic system.
3. The coefficient of atmospheric influence A at homogeneous atmosphere and great meteorological distance of visibility, calculated by theoretical and experimental data, basically coincide.
4. The criteria for efficiency of the visir optic appliances used for observation on the boards of spaceships and also the coefficient which counts for the atmospheric influence allow evaluating the object visibility in the conditions of a natural landscape.

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