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REMOVAL OF SIDE ILLUMINATION IN THE IMAGE PLANE IN TWO-MIRROR PANCRATYC SYSTEM FOR COLLIMATOR

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Abstract: *The specifics of certain tasks, which are solved by a collimator, as well as the large amounts of light losses in the optic materials which are used in the shortwave and longwave range of the optical specter require the development of mirror and mirror-lens systems. An advantage of these systems is the increased light transmission, small length and the possibility to correct the chromatic abberations. It should only be noted that in the two-component pancratyc systems with reflecting planes with constant optic characteristics there is a danger of illumination of the image plane by side rays – side illuminations. In two-mirror pancratyc system for a collimator it is necessary to exclude illumination of the image plane throughout the whole range of the components movement. In the development process formulas are derived and schemes are presented which help the vizualization when calculating the diaphragm in front of two-mirror pancratyc system and calculation of diaphragm which is located between the components of two-mirror pancratyc system. The results from the calculations of a diaphragm for two-mirror pancratyc system are presented in tables. The results from research of the diaphragms for two-mirror pancratyc sysmem make us conclude that the second method of preventing the image plane from side illuminations is the preferred one. It ensured smaller sized and less change in the diaphragm length.*

Key words: *side illumination, pancratyc system, collimator*

The specifics of certain problems which are being solved by a collimator, as well as the huge light losses of optical materials, applied in the shortwave and longwave range of the optical specter, necessitate the development of mirror and mirror-lens systems. The advantage of these systems is the bigger light transmission, shortness and the possibility to correct the chromatic aberrations. It should only be noted that in the two-component pancratyc systems with reflecting planes with constant optic characteristics there is a danger of illumination of the image plane by side rays – side illuminations.

In a two-mirror pancratyc system for a collimator it is necessary to exclude illumination of the image plane throughout the whole range of the component movement. For this purpose, a cylindrical diaphragm in front of the mirror system or a cone diaphragm, located in the central whole of the fist component are applied in the classical mirror system. The correlations which define the size of the diaphragm should consider the components movement and the change in the magnification when the image has a constant size. The correlations, defining the size of the diaphragm, should consider the components move and the change in the magnification at a constant size image. When deriving ratios, we will have in mind that constructively the aperture diaphragm is located immediately after the second component.

From fig. 1 we can derive formulas to define the size of a cylindrical diaphragm which is located in front of a mirror pancratyc system:

(1) $$D_N = \frac{1}{V}\left[\ 2_{y'} + \frac{a_1(VD_{bx} - 2_{y'})}{P}\ \right],$$

(2) $$L_N = -\frac{(l + a_1 - d)(D_N - 2_{y'})}{D_{ek} - 2_{y'}},$$

where D_N – diaphragm's diameter;

L_N – diaphragm's length;

V – linear magnification of the system;

$2_{y'}$ – image diameter;

D_{bx} – diameter of the input lens;

P – distance from the object to the input lens;

D_{ek} – diameter of the screen second component;

l – distance between the plane and the image plane;

a_1 – distance from the first component to the object;

d – distance between the components.

From formulas (1) and (2) and fig. 1 we can observe that the diaphragm size would be substantial. It is necessary that he diameter D_N is bigger than the first component's diameter and the length L_N is proportional to the square of the distance between the first component and the subject.

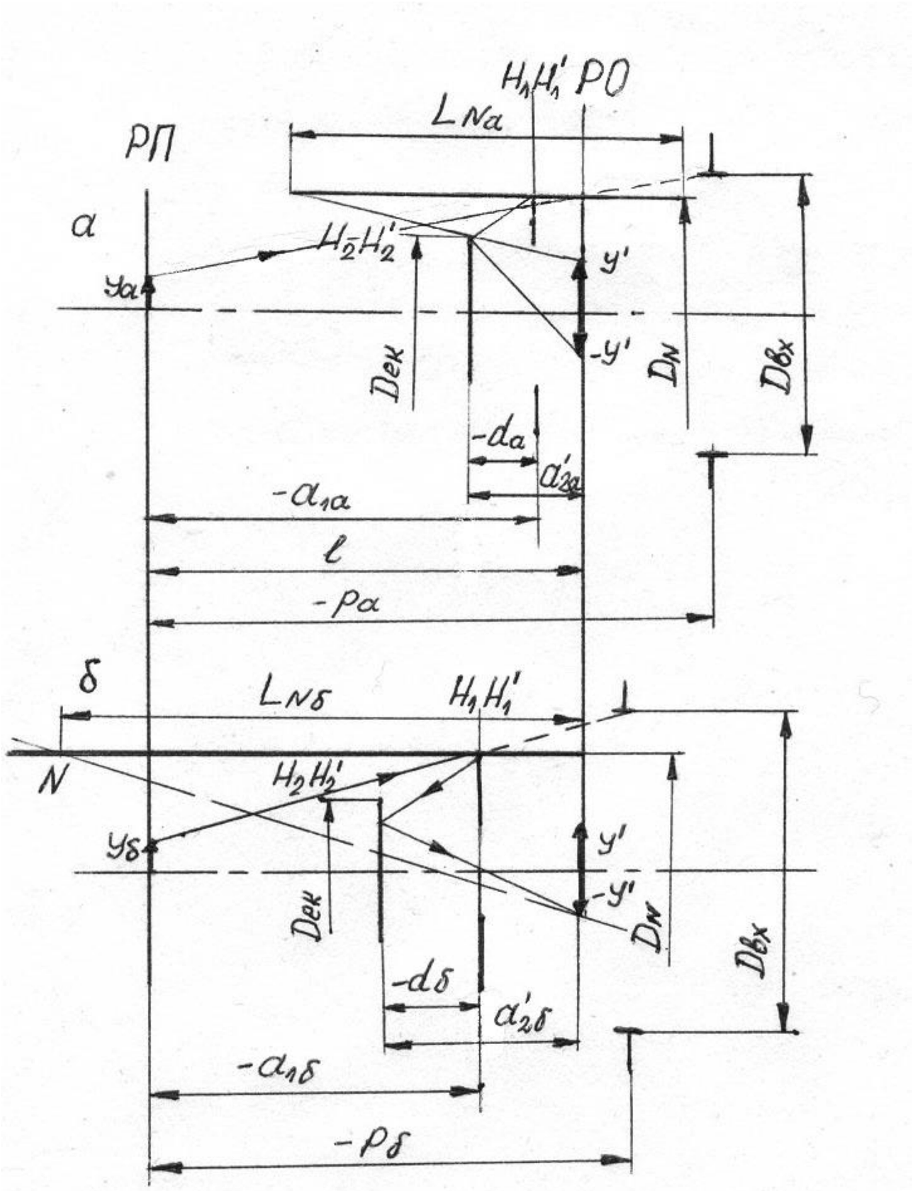

Fig. 1 Calculation of a diaphragm in front of a two-mirror pancratyc system: a – far right position of the components b far left position of the components

On fig. 1 the variables, which are marked with the index a and b correspond with the position of the components, PΠ is the object plane, ΠO is the image plane.

The method of the image plane prevention by means of cone and cylinder diaphragm is of great importance for pancratyc systems with mirror components. In this case the diaphragms are a little bit bigger and they do not enlarge the central screening as much.

A two-mirror pancratyc system in the two end positions has been presented on Fig. 2 by means of the main planes HH`. The diameter and the length of the cylindrical diaphragm are marked respectively D_S and L_S. The formula for defining D_S when II beams are going through is:

$$D_S = 2_{y'} - \frac{L_S (D_{ek} - 2_{y'})}{l + a_1 - d} \quad . \tag{3}$$

The value of D_S when III beam is going through equals:

$$D_S = \frac{2_{y'}}{V} + \frac{a_1 (VD_{ek} - 2_{y'})}{V(a_1 - d)} - \left[\frac{2_{y'}}{Vf_1'} + \frac{VD_{ek} - 2_{y'}}{V(a_1 - d)}\left(\frac{n_1}{n_2} + \frac{a_1}{f_1'}\right)\right](l + a_1 + L_S)\,. \tag{4}$$

After we substitute (3) into (4) and we transform the expression, we get the formula for defining L_S:

$$L_S = \frac{(l + a_1 - d)\{(a_1 - d[2_{y'}(V - 1) + K_1(l + a_1)](VD_{ek} - 2_{y'})\}}{(a_1 - d)[(VD_{ek} - 2_{y'}) - K_1(l + a_1 - d)]}, \tag{5}$$

where $K_1 = \frac{2_{y'}}{f_1'} + \frac{VD_{ek} - 2_{y'}}{a_1 - d}\left(\frac{n_1}{n_2} + \frac{a_1}{f_1'}\right).$

The cone diaphragm is attached to the second component and it moves together with it.

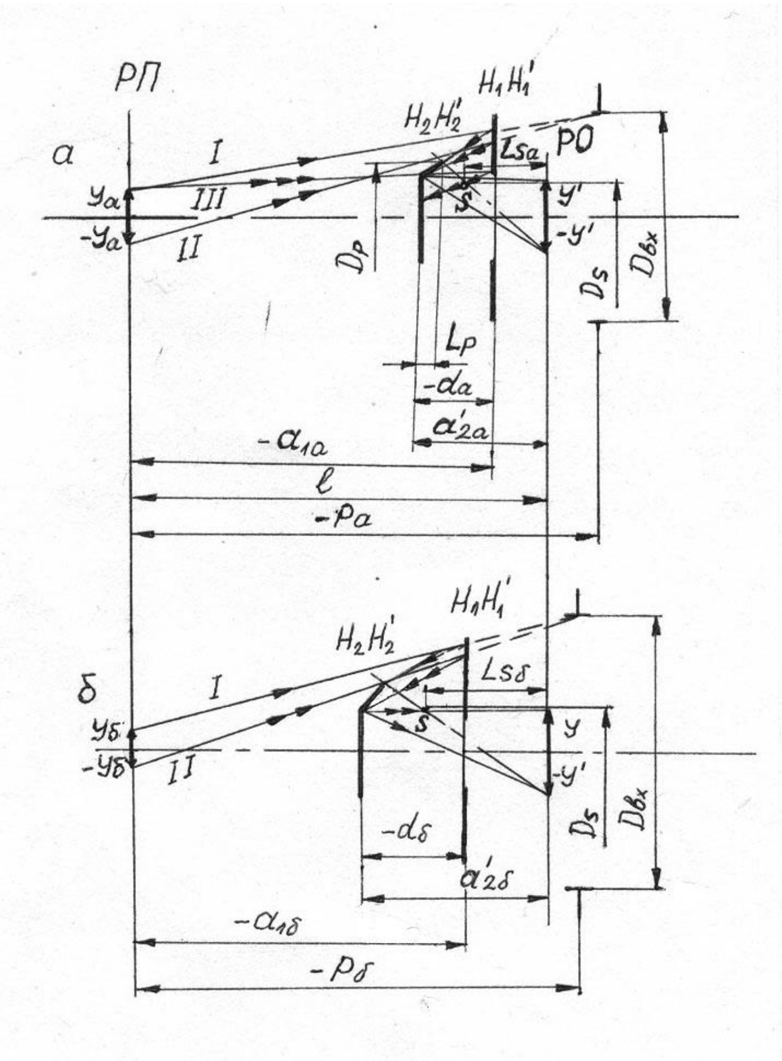

Fig. 2. Calculation of diaphragm, located between the components of two-mirror pancratyc system: a – far right location of the components; b – far left location of the components

The projection of the diaphragm on the optical axis is L_P, and the biggest diameter is D_P. The value of D_P when passing through the beam I equals:

$$D_P = D_{ek} - \frac{1}{V}\left[\frac{2_{y'}}{f_1'} + \frac{VD_{ek} - 2_{y'}}{p}\left(\frac{n_1}{n_2} + \frac{a_1}{f_1'}\right)\right]L_P . \tag{6}$$

The equation which corresponds to D_P for the straight line PS is represented by:

$$D_P = \frac{D_S + 2_{y'}}{L_S}(L_P - l - a_1 + d) - 2_{y'} \ . \tag{7}$$

If we substitute (6) into (7), we get:

$$L_P = \frac{V[L_S(D_{ek}+2_{y'})+(l+a_1-d)(D_S+2_{y'})]}{V(D_S+2_{y'})+K_2L_S}, \tag{8}$$

where $K_2 = \frac{2_{y'}}{f_1'} + \frac{VD_{ek}-2_{y'}}{p}\left(\frac{n_1}{n_2}+\frac{a_1}{f_1'}\right)$.

A solution with cylindrical diaphragm witch fluctuating length L_S can be used. In this case the sizes D_P and L_P of the conical diaphragm and D_S of the cylindrical are considered to be constant and defined by (3...5) and (6...8), and the change in the length of the cylindrical diaphragm L_S after the transformation of (8) is presented by the expression:

$$L_S = \frac{V(D_S+2_{y'})(L_P-l-a_1+d)}{V(D_{ek}+2_{y'})-K_2L_P}.$$

The value of L_S is changed when the components are moved in such a way that every position corresponds to a certain combination of V, a_1 and d.

The results from the research of the diaphragm for two-mirror pancratyc system allow us to make the conclusion that the second method of protecting the image plane from side illuminations is the preferred one. It provides smaller sizes and less change in the diaphragm length.

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