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TRACING OF A RAY IN A LIGHT SHAFT IN THE FORM OF A FRUSTUM OF A CONE

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An algorithm is developed for tracing a ray in a light shaft in the form of a cut straight circular cone with a mirror reflection of light from the inner surface and horizontal upper and lower bases.
Keywords: a light shaft, tracing of a light ray, a mirror reflection, luminance distribution of sky.

Formulation of the problem. Methods for calculating the illumination from the school with mirror reflection of light [1, 2], designed for the standard distribution of brightness in the clouds of the sky [3] and not adapted to the other 15 types of standard relative brightness distributions. An arbitrary calculation point under the US is illuminated by the parts visible to it: the sky (direct light) and the inner surface of the U.S. (reflected light).

Let's consider the modeling of the illumination created by the reflected light. Each settlement point P_T highlights the US region on the inner surface Q, which reflects light in it (Fig. 1). The shape and parameters of the area depend on the position P_T, which is considered in detail in [1, 4]. Brightness $L_{вих}$ the output beam $4\,P_T$ (Fig. 2) depends on the number k reflection of the beam before its exit from the school and brightness $L_{вх}$ this beam at the entrance to the light shaft:

$$L_{вих} = L_{вх} \cdot \rho^k, \qquad (1)$$

where ρ – coefficient of mirror reflection of the wall of the mine.

The brightness of the input beam 1 (Fig. 2) is determined by its direction in the coordinate system, which includes models of standard relative brightness distributions [3]. So, we simulate the trajectory of the return path of the ray from the calculated point P_T to the point P.

Analysis of recent research and publications. The tracing of the light beam in the prismatic UH was considered in [5]. Conditions for passing the beam through the school in [6].

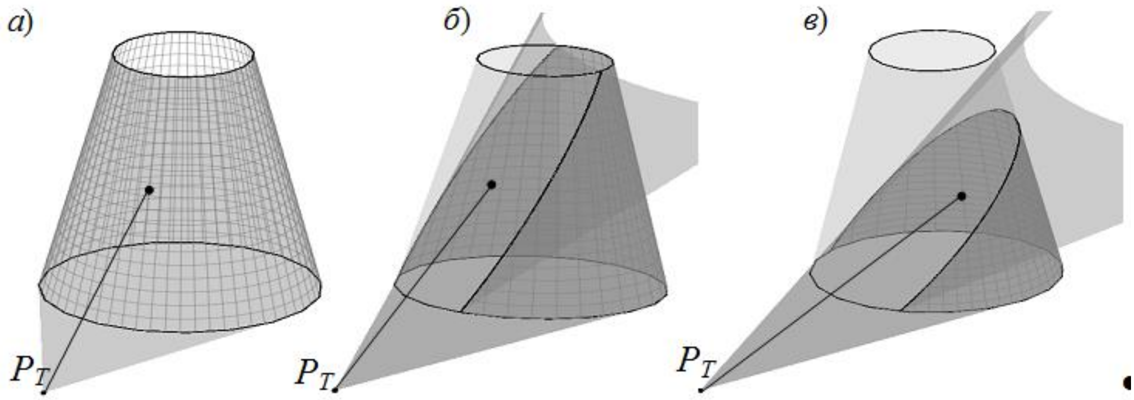

Fig. 1. Areas Q the inner surface of the school, reflecting the light in P_T: a) the entire interior of the US; б) and в) part of the inner surface of the US, which is allocated by a grid

Formulating the goals of the article. The purpose of the article is to develop an algorithm and the corresponding software for beam tracing in the US in the form of a cut cone.

Main part. The algorithm for beam tracing in the school system consists of the following actions.

1. We set the parameters of the CS and the coordinates of the output beam (calculation point P_T and the last reflective point in the area Q) $4P_T$ in the spatial coordinate system (Fig. 2). Moreover, the coordinate system, to which the surface of the US is assigned, is coordinated with the coordinate system, to which the celestial sphere belongs, used in the models of distribution of brightness by the sky. For example, the Z axis will go to the zenith, the X axis to the east, Y axis to the south.

The surface of the SS in the form of a straight circular cut cone (Fig. 2) with a vertex O_S to the mountain, we set the rotation of a line passing through a point $(r,0,0)$, at a distance from the axis of the applicator and lies on the abscissa axis, and that point $O_S(0,0,H-h)$, at a distance $H-h$ ($h-$ height of US) from the axis of abscissa and lies on the axis of the applicator, this position corresponds to the location of the center of the upper base at the origin $O(0,0,0)$, the original basis with the appliance $z=-h$ and radius $R=\dfrac{H\cdot r}{H-h}$.

2. We turn to the coordinate system on the plane (Fig. 3) which passes through the vertex of the cone and the output beam $4P_T$. She crosses the surface of the mine by the creators A_4B_4 and A_5B_5, on which there are respectively two consecutive points of reflection of the beam: 4 - the point of the last reflection; 5 is the point of the imaginary reflection which would be if the surface of the cone of the US is continued below the initial basis. The points (0, 1, 2, 3, 4, 5) of successive reflections lie on the generating

cones of the U.S., which intersect the circles of the upper and lower bases of the UL at points A_0, A_1, K, A_4, A_5 and B_0, B_1, K, B_4, B_5, in accordance. Consistently joining the points on the upper and lower bases, we have two broken pieces, each of which consists of an equal chord.

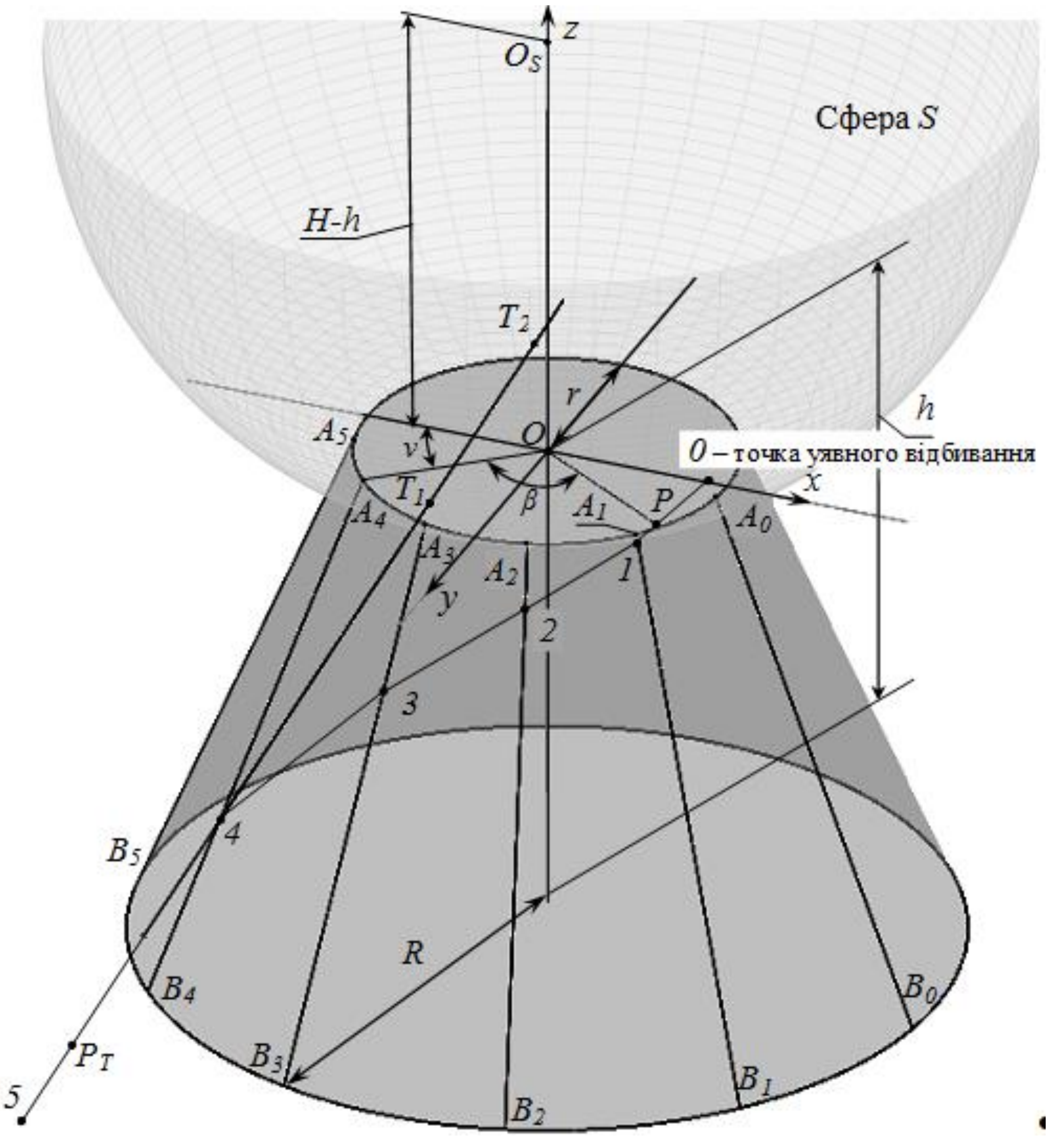

Fig. 2. Scheme of the US and the trajectory of the beam

3. By the method given in [6], check whether the beam passes through the school. On the sweep of the beam and its corresponding trapezoid (Fig. 3), determine the point of intersection of the scan of the direct output beam $4\,P_T$ with a circle of sphere S. If there is no intersection point, then such a ray does not pass through the shaft, and the brightness of the corresponding output beam is accepted $L_{вх} = 0$. If the intersection is, determine the coordinates of the point of intersection T_1 and we calculate

the number of reflections k as rounded to a larger integer angle ratio θ to the corner φ (Fig. 3). Rotate the chord A_4A_5 on the corner $k\varphi$ determine the position of the chord A_0A_1. Check if there is a crossing point (P_1)direct output beam $4\,P_T$ with chord A_0A_1, if there are no points of intersection, then such a ray does not pass through the shaft and the brightness of the corresponding output beam accepts $L_{вх} = 0$.

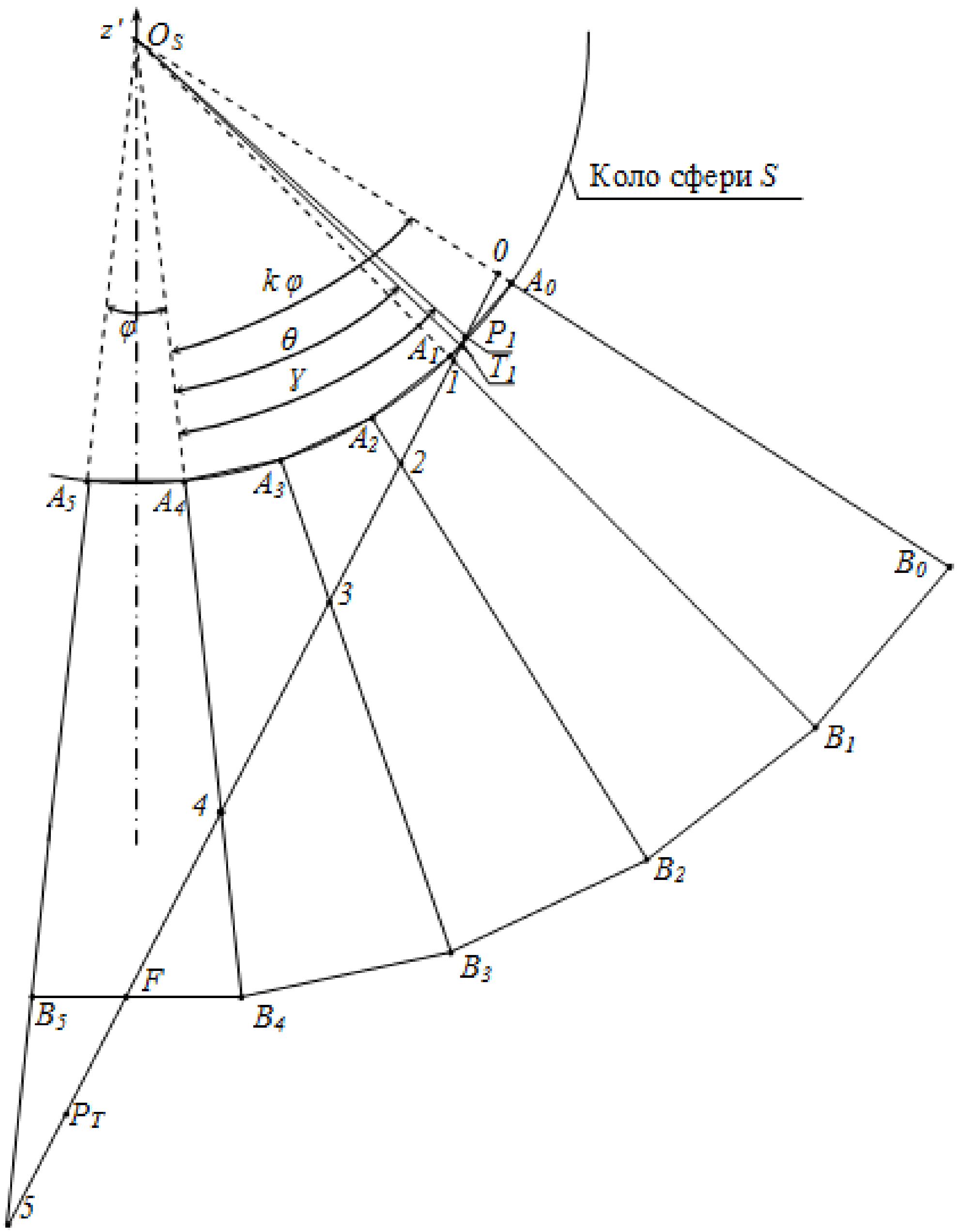

Fig. 3. Scattering of the beam and its corresponding trapezoid to the beam of the beam $4\,P_T$

4. Determine the coordinates of the points of the incoming beam $1\,P_1$ in a flat coordinate system and return to the output spatial coordinate

system. Point coordinates *1* calculate on creature A_1B_1, which we get by turning creature A_4B_4 on the corner $(k-1)\nu$ (Fig. 4). Angular coordinate point P_1 calculate according to the formula:

$$\beta = \nu \frac{\gamma}{\varphi}, \tag{2}$$

which emanates from the equality of the chords on the upper base of the SS, formed by successive points $A_0, A_1, \ldots, A_4, A_5$, as well as the equality of chords with each other on the corresponding scan (Fig. 3).

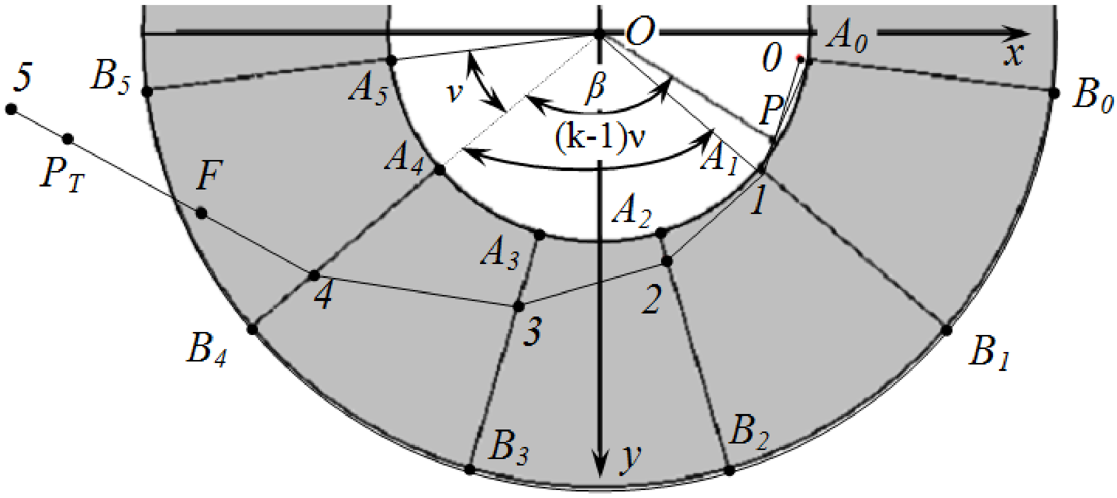

Fig. 4. Orthogonal projection of the school and trajectory of the beam on the plane of the original basis

Conclusions. The developed beam tracing algorithm and its program realization make it possible to determine the brightness of the reflected rays from the inner surface of the light shaft for standard types of relative brightness distributions [3], and to simulate the illumination created by reflected light at and out of the light shaft. Further development of research may be aimed at simulating the efficiency of light mines in the form of a cut-off direct knife cone and natural light from them.

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АЛГОРИТМ ТРАССИРОВКИ ЛУЧЕЙ В СВЕТОВОЙ ШАХТЕ В ВИДЕ УСЕЧЕННОГО ПРЯМОГО КРУГОВОГО КОНУСА

Зданевич В.А., Кундрат Т.Н., Литницкий С.И., Пугачев Е.В.

Разработан алгоритм трассировки луча в световой шахте в виде усеченного прямого кругового конуса с зеркальным отражением света от внутренней поверхности и горизонтальными верхней и нижней основами.

Ключевые слова: световая шахта, трассировка светового луча, зеркальное отражение, распределение яркости небосвода.

АЛГОРИТМ ТРАСУВАННЯ ПРОМЕНІВ В СВІТЛОВІЙ ШАХТІ У ВИГЛЯДІ ЗРІЗАНОГО ПРЯМОГО КОЛОВОГО КОНУСА

Зданевич В.А., Кундрат Т.М., Літніцький С.І., Пугачов Є.В.

Розроблено алгоритм трасування променя в світловій шахті (СШ) у вигляді зрізаного прямого колового конуса з дзеркальним відбиванням світла від внутрішньої поверхні.

Ключові слова: світлова шахта, дзеркальне відбивання, трасування світлового променя, розподіл яскравості небозводу.