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# AUTOMATED CONTROL LED SYSTEMS OF ARTIFICIAL SKYSCRAPER

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***Abstract***—*Considered the possibility of creating an experimental light environment (helioclimateron) for the study of natural, artificial and compatible lighting in the composition of the interior and exterior of buildings. The determined light, electric and optical patterns of the formation of light fluxes in a hemispherical model of skyscraper. Significant economic and operation advantages of LED systems of light for artificial skyscraper have been proven. Proposed schemes of computer control by LED cells, which form the distribution of light and color.*

**Index Terms**—LED cell; helioclimateron; controller.

## I. INTRODUCTION

The light environment, as an element of the general environment and its parameters, affects a great deal on the human body. It is determined by the light fluxes of light sources that are transformed as a result of interaction with the surrounding object environment, which is perceived by the distribution of light and color in space. The light environment in the premises can be formed in three ways. Firstly, through of natural light, in which the light environment is formed at the expense of natural sources of light - the sun and the sky. Secondly, due to artificial lighting, in which the light environment is created at the expense of artificial (created by man) sources of light. And thirdly, due to the combined lighting, in which insufficient natural light is supplemented by artificial lighting.

It should also be noted and the psychological role of light holes. They are the link between the surrounding space and the enclosed interior space of the room. In the presence of this link, a person in the building feels calm and confident, as many positive factors affecting a person are preserved. Transparent fences significantly affect the cost of a building, especially operating costs. And, finally, their great role in the energy balance of the building, because through the deaf parts of the fence passes heat two to four times less than through the glazed surfaces.

## II. PROBLEM STATEMENT

As can be seen, the significance and impact of the whole on the building of translucent fencing is large and multifaceted to the designers very hard and difficult to determine the rational area and the location of light gaps. Therefore, this problem requires a scientific approach. From this it follows that studies in the field of building lighting in Ukraine and improving its laboratory base are relevant both from an economic point of view and from a social one.

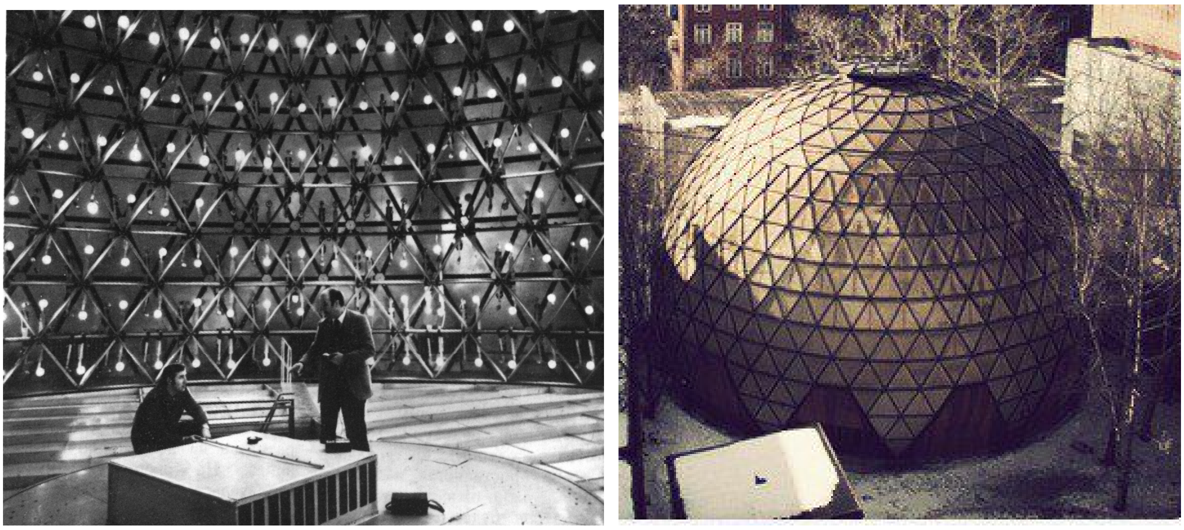
A significant amount in this case is occupied by experimental studies, for which a lighting laboratory is required. It is intended for the organization and conduct of experimental field and laboratory studies in the field of formation of optimal light-inflation environment in buildings, structures in urban structures.

Relevance of laboratory justified by the fact that theoretical studies in many cases difficult, time consuming, and sometimes impossible to consider the full range of operating factors on the process of distribution of light beams, particularly reflected from the light source in the room given point or area.

The main institute in the field of building physics in the former USSR was the Scientific-Research Institute of Building Physics of the State Construction Board [1]. The Institute is a complex of buildings and structures in which branches are located in different scientific areas. The main experimental installation of light engineering and insulations is located in the "sky-sun-earth" block. This unique complex of equipment differs significantly from the existing ones, where possible, with experiments, size and design. This is a separate structure in the form of a hemisphere with an internal diameter of 16 m (Fig. 1).

Ways of development of the experimental base are not limited to laboratory installations. All that is obtained as a result of laboratory tests must be tested in field trials (especially with regard to subjective visual perception research).

It should be noted the rich laboratory of the Ukrainian Lighting Institute in Ternopil, in which there are various devices and installations (photometric bench, photometric ball, brightness, etc.). Under certain conditions, many of these devices can be used for research on natural and artificial lighting [4].



(a) (b)

Fig. 1. Installation "artificial skies" – helioclimateron: (a) is the inside look; (b) is the look out

## III. PROBLEM SOLUTION

Today, with the use of semiconductor light sources (LS) – light-emitting diodes (LEDs) binds to the future of a number of industries.

LEDs are the most promising direction of the lighting in all its applications – from lighting facilities and utilities industries, alarm, light display and advertising to manufacture mobile devices and displays.

The main attractive feature of LEDs is the potentially elevated level of light transmission, which leads to a range of economic and social benefits, the most important of which is a radical reduction of energy consumption for lighting, accounting for about 14% of the total electricity generated in Ukraine.

The criterion for assessing the variable natural light is the coefficient of natural light (CNL), which is the ratio of natural light $E_m$ created at the point M at a given (working point) surface inside the room light of the sky (directly or after reflection), to the simultaneous value of the external horizontal illumination under the open sky $E_n$. Coefficient of natural light is expressed as a percentage. The participation of direct sunlight in the determination of $E_m$ and $E_n$ is excluded. The value of CNL, denoted by the formulas as $e$, is from the expression:

$$e_m = \left(E_m / E_n\right)100\% \tag{1}$$

Along with the CNL, in the calculations of natural light, a geometric CNL is used, which is denoted by $\varepsilon$. It differs from e in that it does not take into account the effect of glazing and indoors processing, as well as the uneven brightness of the slope. The geometric CNL is determined by the law of the projection of the cortical angle [4].

The total value of the CNL for one or another point of the premises is determined by the following components: the proportion of natural light created by the direct light of the sky and evaluated by the value of the geometric CNL; The proportion of CNL, due to the side lighting reflecting light facades of confronting buildings and lands.

With the participation of direct sunlight in creating the brightness of the reflective surfaces is excluded (Fig. 2).

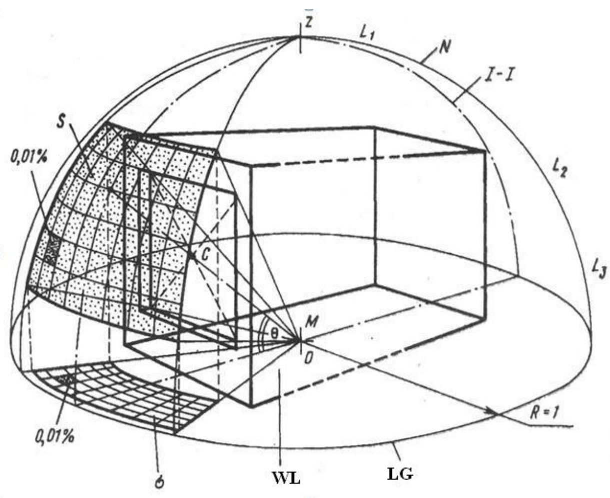



Fig. 2. Graphic skyscraper model. Scheme to the law of the projection of the cortical angle (axonometry and section I-I) : $L_1 = L_2 = L_3$ = const; $S$ is the area of the sky, visible from the point $M$; $N$ is the skyscraper; $\sigma$ is the area of the projection of the sky, illuminating the point $M$, on the work surface (WS); HL is the Horizon line; $\theta_0$ – Angular height of the middle of the light transmission; $z$ is the above the horizon (zenith); $O$ is the center of the sky, connected with the studied point $M$; $L$ is the brightness of the skyscraper, cd/m$^2$; $B$ the basis of calculation and modeling of natural lighting of premises are two laws

The CNL fraction due to the reflection of light from the interior surfaces of the room.

To assess the distribution of natural light in the room rate applies uneven lighting (on a given surface), which is the ratio of minimum to medium or minimum to maximum CNL.

*The law of the cortical projection.* Graphically, the law is illustrated by the following construction: let's draw from the point $M$ the hemisphere of the firmament with a radius equal to one, and denote the brightness of the sky through $L$ (Fig. 3). Determine the illumination at the point $M$, created in the room through the window section of the hemisphere $S$, which can be taken as a point source of light, by the formula (1). Expressing in it the force of light 1 section of the sky $S$ due to the brightness of $L$, we obtain:

$$E_m = LS\cos\alpha.$$

Another law is the law of lighting similarity (Fig. 3). The illumination at the point of the room is created through windows, the brightness of which is $L_1$ and $L_2$. Various brightness can be created, for example, using different grades of glass (transparent, dairy, contrast, matte, etc.). However, with different window sizes (I and II), but with the same glass, the illumination at the point is created by the same bodily angle with the vertex at this point.

The practical significance of this law is that it allows you to solve the problems of natural light using the modeling method, that is, to evaluate the lighting conditions of the premises on models. To do this, models are made at a scale of at least 1:20. At the same time, all geometric and lighting parameters (processing, proportions, details, etc.) of the interior are carefully observed.

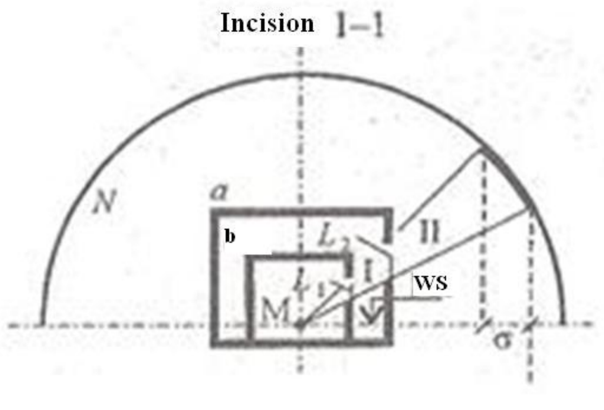
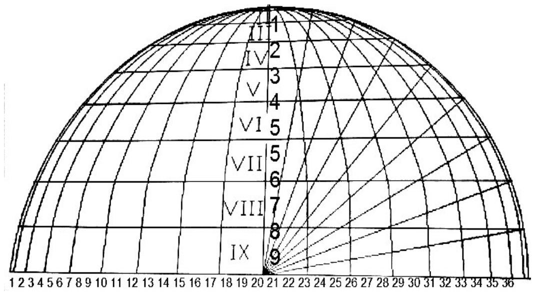


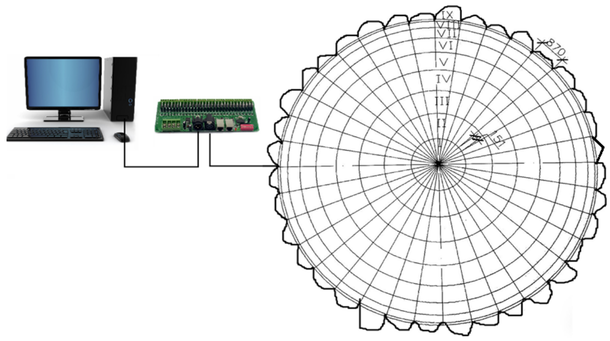

Fig. 3. Schemas to the law of lighting similarity. Models of the room on a scale of 1:10

First of all, in this hilly helioclimateron, large-scale modeling is possible, which greatly enhances the reliability of the research results and, first of all, opens the possibility of introducing a human-observer model. It is provided by the size of the skyscraper and models of buildings to (4 × 4 × 3) m. Such models can conduct comprehensive research on natural and combined LED lighting, insolation, sun protection, translucent materials and structures, color solutions of the interior, facade plastics, visual workability in the light-color environment characteristic of different climatic areas. Such possibilities are provided by four main factors of the LED equipment of the skyscraper: modeling of cloudy and clear skies, "the sun" with different coordinates, the surface of the "earth", rotating and shining mainly by the surface. Almost such a skyscraper with an automated LED lighting control system provides the research needs of all lighting laboratories.

Figure 4a shows the sectoral-cellular model of a hemispherical helioclitromagne with a diameter of 10 m, that is, a height of 5 m. The dimensions of each cell are (10 × 10) angular degrees. Figure 4b shows the switching control circuitry of 324 LED cells connecting through the LED series controllers to the central server, the software environment of which controls the brightness of the glow of LEDs in the cells themselves.




(a)



(b)

Fig. 4. 36-sectoral model of helioclitromagne with 324 LED cells (a) and (b) control circuit for its illumination

Figure 5 illustrates the electrical circuitry of managing thirty LED cells (panels) from one LED series controller.

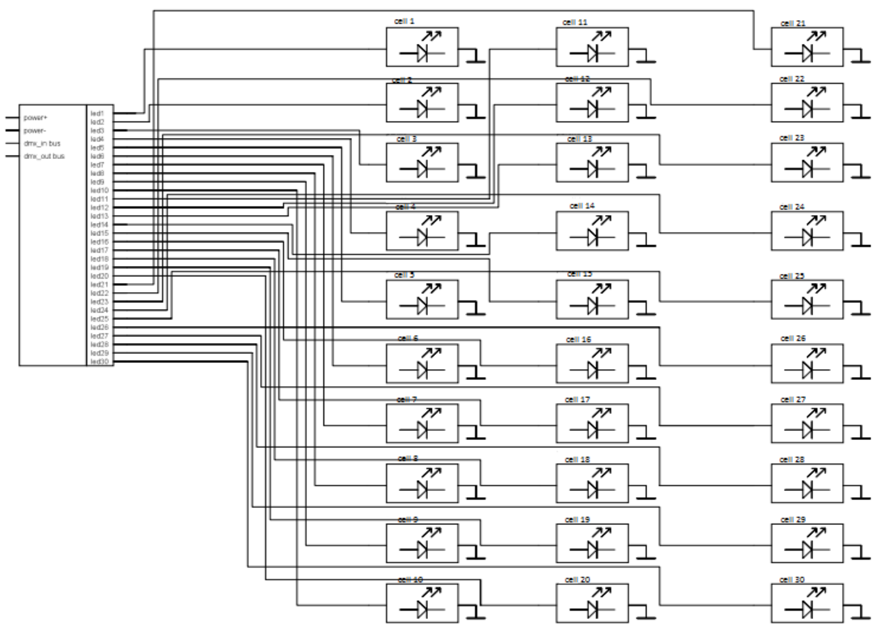


Fig. 5. Electrical control circuit of 30 panels from one controller

## V. CONCLUSIONS

Considering the importance of the development of artificial light environments for modeling the influence and perception of light and color in space, proposed a model for lighting control in the artificial skyscraper. Helioclimateron is used as an object of research on modern problems of optimization of light color environment of cities. Sets of experimental models and designs allow you to investigate the influence of world-tech effects and insulations.

## REFERENCES

[1] V. K. Litckevich, edited by N. V. Obolensky, Architectural physics. Moscow, Stroyizdat, 1997. (in Russian).

[2] V. O. Yegorchenkoov, M. B. Yatsiv, A. M. Yugov, and R. I. Kinash, Estimated and experimental methods for assessing the natural light environment of premises: A manual for architectural and construction specialties. Lviv, "TzOV Space M", 2008, 111 p. (in Ukrainian)

[3] DSTU B V.2.2-6-97 (GOST 24940-96). Buildings and structures. Methods of measuring light. Kyiv, Ukrarhbudinform, 1998, 22 p. (in Ukrainian)

[4] Natural and artificial lighting. DBN V.2.5-28-2006. Change No. 2. Kyiv, Ukrarhbudinform, 2012, 36 p. (in Ukrainian)

[5] DBN V.2.5-28-2006. Natural and artificial lighting. Engineering equipment of buildings and structures. Kyiv, Minbuild of Ukraine, "Ukrarhbudinform", 2006, 76 p. (in Ukrainian)

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**О. С. Мельник, Є. В. Поляков, А. О. Косов. Автоматизоване керування світлодіодними системами штучного небосхилу**

Розглянуто можливість створення експериментального світлового середовища (геліокліматрона) для дослідження варіантів природного, штучного та сумісного освітлення при формуванні композиції інтер’єру та екстер’єру будівель. Визначено світлові, електричні та оптичні закономірності формування потоків світла в напівсферичній моделі небосхилу. Доведено суттєві економічні та експлуатаційні переваги світлодіодних систем освітлення для штучного небосхилу. Запропоновано схеми комп’ютерного керування світлодіодними комірками, які формують розподіл світла і кольору.

**Ключові слова:** світлодіодна комірка; геліокліматрон; контролер.

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**А. С. Мельник, Е. В. Поляков, А. О. Косов. Автоматическое управление светодиодными системами искусственного небосвода**

Рассмотрена возможность создания экспериментального световой среды (гелиоклиматрона) для исследования вариантов естественного, искусственного и совместного освещения при формировании композиции интерьера и экстерьера зданий. Определены световые, электрические и оптические закономерности формирования потоков света в полусферической модели небосвода. Доказаны существенные экономические и эксплуатационные преимущества светодиодных систем освещения для искусственного небосвода. Предложены схемы компьютерного управления светодиодными ячейками, которые формируют распределение света и цвета.

**Ключевые слова:** светодиодная ячейка; гелиоклиматрон; контроллер.

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