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ON METHODOLOGY FOR DESIGNING ARCHITECTURAL LIGHTING OF PRODUCTION SITE INTERIOR PART III. RESULTS AND CONCLUSIONS

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ABSTRACT

This is the final, third part, on the presentation of Chapter 4 and the results of the Vladimir Voronov thesis [1], successfully defended at the Moscow Architectural Institute in 1985 and devoted to the author's method of designing architectural lighting for industrial interiors with three main upper lantern types of natural daylight and artificial lighting.

The method was developed on the basis of long-term analytical calculations and numerous experiments conducted according to all the laws of statistics in natural conditions and in the camera "Mirror-type artificial sky" created by the author using planar and volumetric (on mock-ups) light modelling with careful measurement of lighting parameters characterizing various states, qualities and options for luminance composition, light saturation of the interior space, contrast of lighting, etc.

The conclusions of the dissertation give a general picture of the research work performed, the main meaning of which is the belief that the design of lighting in industrial (and in any other) interiors is not limited to providing elementary normalized lighting parameters, but is a complex, sophisticated, and creative task of architectural design where the light – natural and artificial – is the main "actor", providing functional and aesthetic qualities to the interior.

Keywords: design method, architectural lighting, industrial interior, luminous image, luminance and luminosity similarity

The dissertation established that the solution to the urgent problem of designing architectural lighting for the interior, achieving a certain visual correspondence of the luminous image in a project that was carried out graphically manually in the recent past and in kind, can be achieved on the basis of the pattern of luminance similarity obtained in the course of experimental studies based on luminosity similarity. Although even today, with the availability and improvement of the digital computer calculation methodology and the visualization of its results, there is no full correspondence for the reasons indicated in [1] as the "ineradicable drawback" of any planar light modelling.

So, to implement the design plan of the architect (and now the lighting designer) without gross distortions in kind based on the research, a method for designing architectural lighting was developed that provides the functional and aesthetic quality of the lighting environment inherent in the project. It is worth noting that with the modern possibilities of controlling LED lighting, the medium can be not only traditionally light-stabilized, but also light-kinetic in a certain scenario.

The lighting design process according to the developed method consists of two stages. The first is the search for a solution and the expression of a conceived (predicted) luminous image using architectural graphics on paper (now possible on a computer screen). The second is the definition of methods for its implementation in kind [3].

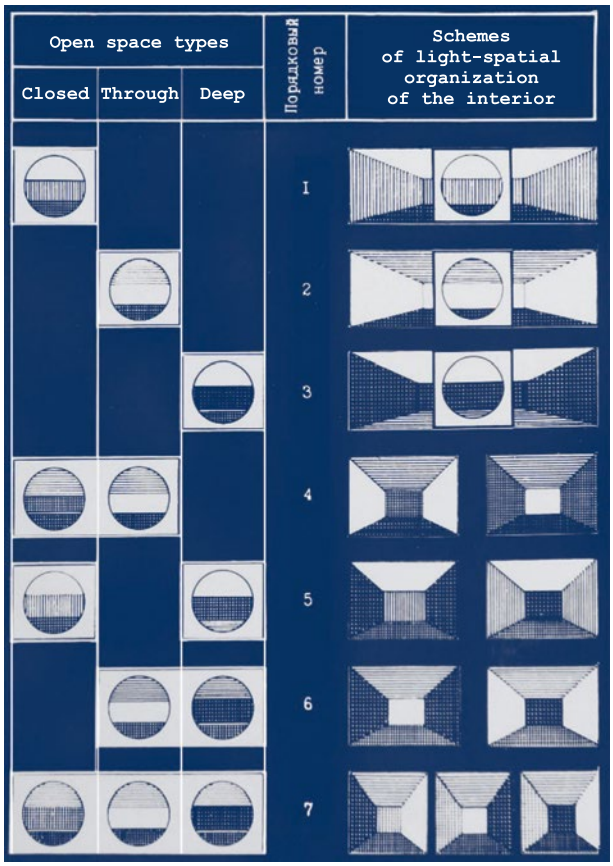

Fig. 1. Schematic diagrams of the light-spatial organization of interiors (see also Fig. 2 [1])

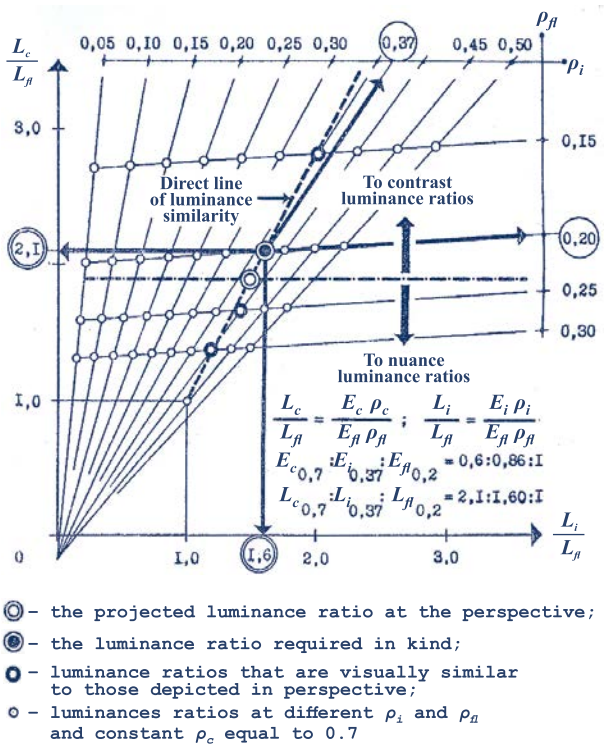

Fig. 2. Determination of the required ratios of luminance: L_c: L_i: L_{fl} and their ρ calculation and graphic method

The first stage includes:

– Selection of the scheme of light-spatial organization of the interior (Fig. 1);

– Achromatic image in the perspective of the predicted distribution of luminance in the interior;

– The luminance of the ceiling (L_c), interior elements (L_i), and floor (L_{fl}) and their ratios with respect to L_c determination.

The second stage includes:

– A graphical definition in daylight of the required ratios L_c: L_i: L_{fl} for nature, which is similar in visual sensation to images in perspective (Fig. 2);

– The choice of the relations L_c: L_i: L_{fl} for their implementation in kind and the determination of the absolute values of L_i and ρ of these surfaces;

– Determination of the quality class of interior lighting according to the quality assessment Table in [1] and the nomogram (Fig. 9 in [1]), in accordance with which (if necessary) the correlation is made L_c: L_w: L_{fl} in perspective (L_w - wall luminance);

– Assessment of the quality of interior lighting according to the luminance range, its harmony and frequency (Fig. 4 [1]);

– Determination E_h /E_z and N and determining their compliance with the required values (Tab. in [1]).

In the dissertation, many of the data mentioned and not mentioned here, provisions and factors of articles that did not fit into the volume, are given more convincingly and extensively. In four, fortunately preserved, but unfortunately not in the best photo quality, exposition tablets, the author's (Vladimir Voronov) method of designing architectural lighting for the interior in comments, graphic diagrams, and tables is more systematically presented (Figs. 3–6).

In those years in our country, an obligatory section of candidate dissertations was the evaluation of the economic effectiveness of the results. It is clear that today it is a completely different, but now rejected idea of this section in dissertations is detrimental to science and practice. By the existing in those time methodology, Vladimir Voronov faithfully found out that the reduced total cost of lighting was the smallest in production interiors with zenith lantern. Costs increase on average by 7 % for buildings with rectangular and 14 % for buildings with shaded lantern. But this does not mean that the shed lights are rejected. They are almost always in the interior according to the impression of the light

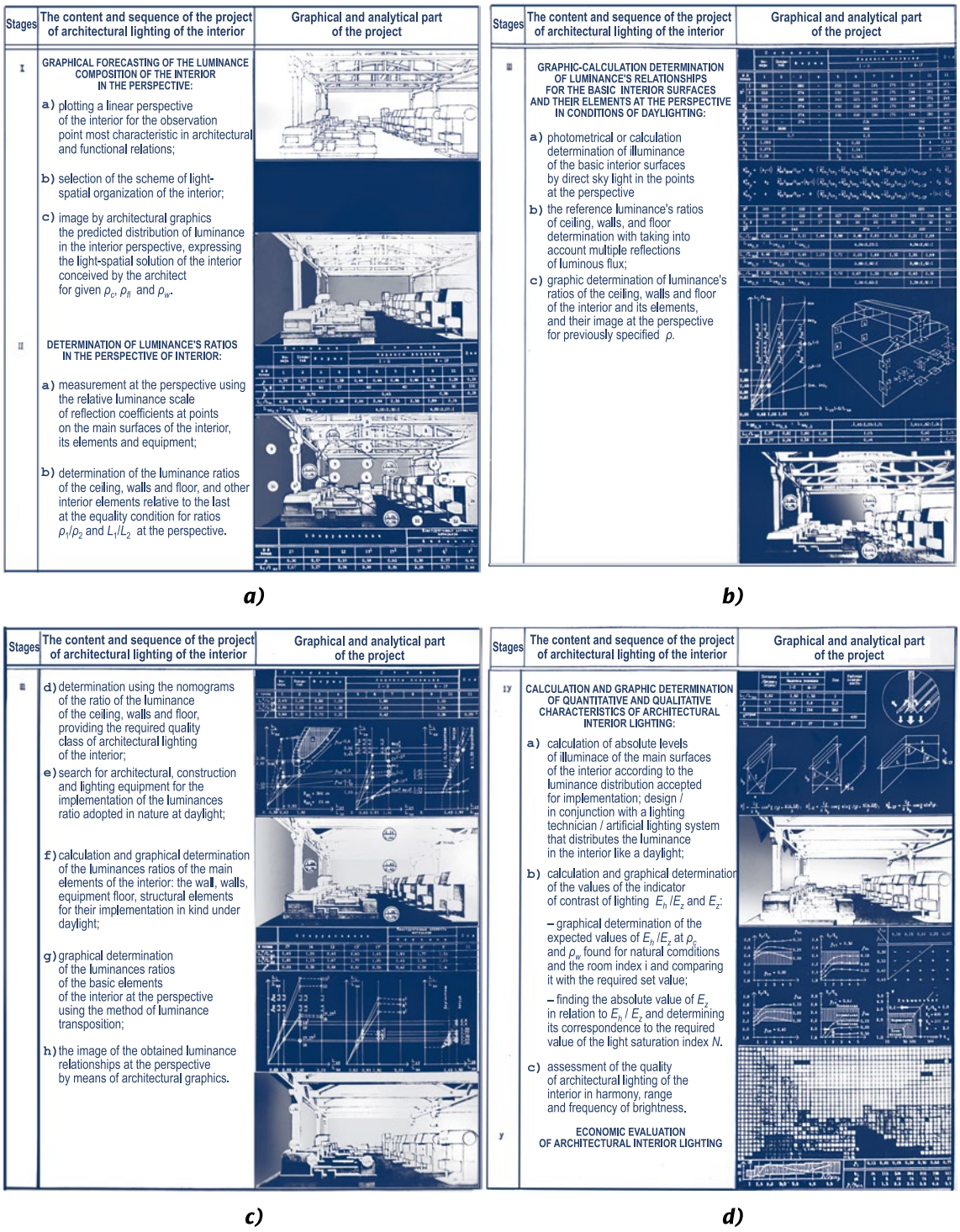

Fig. 3–6. A brief graphic presentation of the method of designing architectural lighting for the interior (stages I–V)

composition aesthetically preferable to others, and for a number of productions in appropriate climatic conditions they can be rational and economical. At the same time, the lump sum costs for daylighting (DL) were determined by the cost of covering the building and for artificial lighting (AL) – by the cost of the originally installed illumination systems (IS) with light sources and their assembly.

The reported costs for the IS were calculated by the VNISI method for the general lighting system (GLS), which in the evening provides a distribution of luminance in the interior that is close to that adopted in daylight. The value of the costs for the light sources ranged from 26 % to 38 % of the total cost of lighting (at the norms and tariffs that were in effect in those years) and depended on the cho-

sen system of light-spatial organization of the interior. Under equal conditions of weighted average luminance ratios of the main surfaces of the interior at DL and light saturation in workshops with shed, rectangular and zenith lamps, the reduced costs for the IS were different. This is due to the fact that the main surfaces of the interior, due to the peculiarities of the light distribution of the lanterns of the upper natural light, are not lit equally during the day. The equality of their weighted average luminance ratios at DL (to achieve a comparable aesthetic effect) is achieved through the use of different internal surfaces $\boldsymbol{\rho}$, which, when calculating the IS, lead to a different amount of illumination devices in the IS. This important circumstance should be taken into account not only as a factor determining the quality of architectural lighting of a production (as well as any other) interior, but also as an important condition for the economic evaluation of a particular illumination installation option.

The results of the dissertation research can be considered, at a minimum, that [1, 2]:

– The theoretical foundations of the light-spatial organization of the production interior with the upper natural and artificial light have been developed, including a relatively universal classification and system of types of interior space, as well as schematic diagrams of its light-space organization;

– Author's methods of objective and subjective assessment of the quality of architectural illumination (AI) of interiors with upper light in natural and laboratory conditions are presented, which showed that it is mainly determined by the light saturation and the distribution of luminance in the interior space;

– A nomogram ("butterfly") was created to assess the quality of AI interior by the distribution of luminance in its space, which is proposed as a tool for controlling light-composition decisions at the design stage and in kind;

– The indicators of quantitative and qualitative assessment of the light saturation of industrial interiors with upper light were determined, characterized objectively by the values of hemispherical ($\boldsymbol{E_{2\pi}}$) and cylindrical ($\boldsymbol{E_{cy}}$) illumination, as well as the contrast of lighting through the ratios $\boldsymbol{E_h / E_{2\pi}}$ and $\boldsymbol{E_h / E_{cy}}$ and subjectively – the author's indicator of light saturation $\boldsymbol{N}$;

– The pattern of luminance similarity was established, on the basis of which an architectural method was developed for the transposition of luminance relations from a planar graphic image of the interior perspective to natural;

– A schedule has been developed for assessing the quality of AI interior according to the range of luminance, harmony and frequency of its series, which allows us to evaluate the luminance composition of the interior at the micrometric level and to differentiate it by categories of monotony, nuance and contrast of lighting;

– It was proved that the permissible (preferred) ranges of luminance ratios in interiors with DL and AL practically coincide, which indicates the subjective desirability of a person to ensure a relative constancy of the luminance distribution in the interior when switching from DL to AL in order to maintain the quality of AI and the constancy of the visual-psychological atmosphere if it is comfort and aesthetic;

– A design method for designing industrial interiors with overhead lights has been developed that is applicable in other typological groups of buildings and allows one to determine the means for realizing the author's design in kind under natural, artificial and combined lighting, ensuring the required quantitative and qualitative characteristics and evaluating their economic efficiency.

All of this is not so little if we talk about the candidate dissertation.

P.S. From the co-author

By his thesis, Vladimir Voronov thoroughly "penetrated" his evidence base into the technical field of lighting engineering, which is little known and obscure in architectural theory and practice.

As far as possible, we, architects from the Department of Architectural Physics, Moscow Institute of Architecture (S.S. Alekseev, N.M. Gusev, V.G. Makarevich, N.V. Obolensky, V.V. Voronov, N.I. Shchepetkov, V.I. Zherdev, G.I. Chirkin, E.V. Sangina, A.G. Batova (Prikhodko), G.S. Matovnikov, etc.), as well as from the NIISF (O.A. Korzin, V.V. Ivanov, A.I. Panurov, Yu.A. Volkov, and others) for decades have tried and have been trying to the best of our abilities and capabilities with our works to expand the range of worldview problems associated with light in architecture and affecting professional tasks – strategic, practical and, at least, operational. Applied lighting, in our opinion, is designed to solve some of the tactical and operational tasks of creating a comfortable, artistically complete, environmentally friendly, and energy-ef-

ficient natural and artificial light architectural environment in the interior and exterior in terms of more accurate criteria-based assessments and methods for their determination.

It is unlikely that it claims to be a separate "science for science", as there once existed the historically failed trend of "art for art", although extreme examples of it still exist today. It makes no sense to argue that a competent architect should formulate strategic tasks in this area – he designs the material-spatial and figurative basis of the anthropogenic environment. And there is practically no productive contact between them today. Few architects who are scientifically engaged in the problems of light, at best, determine some current trends in the development and artistic qualities of this environment, including in the form of ratios of lighting values, without setting the ultimate goal to obtain mathematically accurate results. This is not their area and path. It is here that a productive, systemic, interdisciplinary scientific continuity could be established: professional and important architectural tasks were set, and "narrow specialists" – lighting technicians, on a broad front, are looking for means and methods for solving them.

These are the dreams of an architect who has long plunged into lighting engineering.

Unfortunately, according to the experience of episodic peer-reviewing in recent years, lighting dissertations of applicants at the NIISF, MGSU, MPEI, as well as publications, including in the journal "Lighting & Engineering", I see how fragmented, unsystematic, and partly small-scale research topics are in applied building lighting, and in essence – in light in architecture. It seems that not a single dissertation refers to the works of architects in this area. I don't know what such "caste" isolation means – ignorance, disrespect or, God forbid, contempt for attempts, perhaps not always convincing from their point of view, to use the "outsiders" knowledge of an adjacent respected science. I'm probably mistaken in something. You can consider these estimates as an invitation to discussion.

The dissertation and abstract of V.V. Voronov will be presented on the journal site after converting them to digital form.

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