Technologies of Invention for Sustainable Development of Construction and Architecture

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Abstract. The article presents the original author's approach to the methodologies of invention in the field of construction and architecture and with consideration of specific examples of solving inventive tasks for various typological groups of architectural and construction objects. The "direct" and "reverse" ways of creating relevant inventive solutions for key sectors of the national economy in the context of aggravation of interstate competition in various fields of intellectual activity are considered. The conclusion is made about the need to develop the two considered topical counter methodologies in order to form other principal alternative ways of the innovation platform.

1 Introduction

Numerous inventive methods that currently exist are either very general or too particular in nature, correlating with a particular branch of science or industry. At the same time, in the scientific and technical literature, there is not enough description of the methods of invention in relation to architecture, with reference to relevant typical examples. Thus, the purpose of the article is to present an original interpretation of the two main inventive methods, summarizing the many years of experience of the authors' inventive activity in solving various innovative problems in construction and architecture. The approaches to invention presented in the article allowed the authors, for over 40 years of inventive activity, to obtain in total more than 250 patents of the USSR and Russia. Perennial experience of inventing convinced the authors of the coexistence of two fundamentally opposite methods for solving inventive problems, which they defined as the "direct" path and the alternative "reverse"
2 Results and discussion

The “direct” way of obtaining inventive solutions is well and fully covered in numerous publications on the methods of inventive creativity; it can be described by the following general scheme of three successive links:

1) formulation of a technical problem / problem statement;
2) selection and application of the algorithm(s) for solving it;
3) obtaining a specific patentable solution / group of solutions (in the examples below effective form of the object).

An example of the use of this approach is the modification of the outer contour support structure (peripter) of the Parthenon, formed by the trunks of vertical columns (Fig. 1a). The need to improve the external support systems of similar temples of Ancient Greece and Rome arose already in the process of their construction long before our era, when a great many buildings were destroyed as a result of earthquakes: structures made of vertical supports had a very low resistance to horizontal seismic effects.

After analyzing this technical problem, the original support structure of vertical columns was transformed into a rigid diagonal system located between the stylobate and the architrave (Fig. 1b), where adjacent supports are made inclined in opposite directions and join in the upper and lower sections along the entire contour of the structure, forming constructive lattice of triangular cells.

Fig. 1. The original contour structural structure of the peripter of the Greek temple of the Parthenon (a) in a modified form (b).

The result was a seismic-resistant composite structure, which, unfortunately, could not be technologically implemented at the turn of the first millennium of our era, but can be used in modern times using new structural materials.

In the considered example, the tasks of preserving the aesthetics of the building, ensuring that the resulting technical solution complies with the architectural order are deliberately not considered.
Also, the "direct" path may well be in demand when solving a large number of construction tasks in such areas as the development of new design or technological solutions. Consider an innovative solution to the following construction problem. In the manufacture of the ends of monolithic floor slabs, inventory removable formwork is used (Fig. 2a). The technical disadvantage of this solution is: low quality of the formation of the end of the slab due to wear of the formwork; the impossibility of obtaining a decorative surface of the end, for example, in the form of brickwork, to match the texture of the facade of the building. When solving this problem using the "direct" path technology, for example, using TRIZ technologies [1], it is possible to obtain a solution for a fixed reinforced concrete formwork for high-quality manufacturing of the ends of the floor slab, with the possibility of obtaining a decorative end surface.

Fig. 2. Structural solutions for forming the ends of monolithic floor slabs: (a) – removable formwork of the ends; (b) – connection of fixed formwork with the reinforcing cage of the ceiling; (c) – general view of the element of fixed formwork overlapping...
2) further, the establishment and study/analysis of the totality of its new qualities is carried out for their technical effectiveness; 3) based on the established qualities, the areas of its most effective use in the national economy are identified.

The essence and significance of the "reverse" path for inventive creativity is very accurately expressed by Edward de Bono: "We have advanced far in science and technology, but not in our behavior. In the last millennium, thinking has always been associated with the question "what is it?". This is thinking based on analysis, criticism and argumentation. And here is the thinking associated with the question "what could it be?" (with the creation of value), we are practically not developed at all. But it is precisely this kind of thinking that is creative and constructive. It is this thinking that helps in resolving conflicts and solving problems, designing forward movement."

The essence of the "reverse" path lies precisely in the ability to understand "what IT could be", i.e. where previously made developments can be used as efficiently as possible (and not only our own: in the categories of inventions there is an item "use of a known device, substance for a new purpose").

In the context of both "forward" and "backward" paths, inventors often have cases of insight when a solution to a technical problem suddenly comes under the influence of some external factors, conditions or situations/events that prompted them to an inventive solution (a vivid example is the invention of the electric arc lamp by Russian scientist P. N. Yablochkov in 1876). Such qualities as the ability to create absolutely innovative solutions, as well as to recognize the rational use of any known objects in a new, previously unknown purpose, distinguish a true inventor from an ordinary techie, whose work results fall under the definition of results "conventional design."

With the "reverse" method of invention, the complete process of creating and filing patentable solutions looks like a chain of such sequential operations:

1) analysis of any available own form - creative development in order to detect patentable qualities in it – qualities of technical efficiency;
2) selection from the list of similar solutions of the corresponding prototype - object that is closest to the patented solution in terms of the totality of essential structural features;
3) identification of the criterion(s) of patentability in the process of comparative analysis of the new solution and the prototype;
4) the formulation of the essential features of the restrictive and distinctive parts of the formula of the proposed solution;
5) identification of solutions (if any);
6) drawing up a description of the application and abstract;
7) production of images of the declared object with designations;
8) filing an application for an invention/utility model;
9) obtaining a patent.

It is obvious that the "reverse" method of invention is possible and effective if two main conditions are met:

a) the presence of a wide information system base of known technical solutions of any typological groups of objects, among which solutions are contained that are similar in function and structural features to the proposed proposals (information Block 1: register of possible analogues/prototypes);

b) the presence of a wide system base of their own abstract form - creative solutions, allowing them to be compared with the known solutions closest in terms of structural and constructive essential features according to a number of technical criteria for patentability in order to identify their own patentable solutions (information Block 2: register of own patentable developments).
Obviously, Block 1 can only be created on the basis of many years of research and selection of relevant patent information from state and private departments on intellectual property in various countries, as well as relevant technical solutions set forth in special technical literature.

At the same time, Block 2, equivalent in volume, is created in parallel with Block 1 on the basis of the implementation of many years of special experimental and search own creative work (including by arbitrary variable shaping – random or purposeful manipulation of the main geometric parameters of the object shape).

It should be noted that, acquiring patent status, previously innovative, and now patented solutions from Block 2 are automatically moved to Block 1, replenishing the register of known technical solutions and themselves can serve as analogues / prototypes for future developments, incl. the same author or co-authors.

A comparative analysis of the development obtained by the author with an analogue is carried out on the basis of the patentability criteria for architectural and construction objects. Let's consider an example of using the "reverse path".

As a result of search shaping experiments, a composite shell was created, including autonomous coaxial surfaces of revolution, located with a narrow slot gap relative to each other. Analysis of the shell geometry made it possible to assume its possible effective use as an original industrial heat exchanger tower – a cooling tower. The proposed hydraulic structure contains an exhaust tower, as well as a drainage basin located inside it with a sprinkler made in the form of an axial vertical distribution pipe, along which coaxial hollow shells in the form of compartments of rotation surfaces are located with a gap relative to each other. The exhaust tower is made in the form of separate coaxial annular tiers located with a narrow slotted gap relative to each other along the vertical distribution pipe; at the same time, each annular tier of the tower is formed by an outer hollow shell of rotation and is associated with the corresponding inner coaxial hollow shell of the sprinkler, which has an opposite spatial orientation (Fig. 3).

![Diagram](image-url)
Fig. 3. Architectural solution for industrial cooling tower:
(a) prototype of a patented industrial cooling tower solution; (b) patented industrial cooling tower solution; (c) type of industrial cooling tower

An analysis of similar solutions presented in Block 1 made it possible to identify the cooling tower structure closest in terms of the totality of structural features to the new solution, containing a hyperbolic exhaust tower, as well as a drainage basin located inside it with a sprinkler made in the form of an axial vertical distribution pipe, along which coaxial hollow shells are located with a gap relative to each other in the form of compartments of surfaces of revolution (prototype – Fig. 3a).

3 Conclusion

It should be noted that the inventive approaches presented in the article (“direct” and “reverse” ways) can serve as a methodological basis for the development of both new effective methods of architectural and technical creativity for scientific, design and production organizations - on the one hand, and frontier educational and pedagogical technologies and practices of teaching the basics of innovation and industry - specific inventions at universities, on the other.

It should be emphasized that the above counter methodological approaches are universal in nature, they are acceptable for creating the entire range of patentable technical solutions aimed at ensuring the sustainable development of construction and architecture. At the same time, the authors are convinced that the essence of diverse inventive creativity is far from being exhausted by two fundamental approaches.

References


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