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Editorial

Mieczysław Bazewicz

Motto:
"The type of architecture is not being established by the architect, but by the societies. The communities of the world determine, indeed, the goals, and assign to the architect the tasks of searching for means that will assure the acquirement of ethical values contributing to create social purposes of the evolving reality"
Encyclopaedia Britannica, Macropaedia, 1089."

This successive issue of SYSTEMS – Journal of Transdisciplinary Systems Science, presented to the Reader, contains a specific monographic work being focused on the improvement of research methods in creating projects of an environmental implementation of the architectural achievement. Systems research in that domain is concentrated on improving the creative skills of the architect in designing complex conditions of the environment, these conditions respecting the ethical values of the society in micro- and macro-scale of the evolving nature.

Revaluations of societal environments arising in the contemporary world are manifested by an increase of the human consciousness as well as by the development of social communication. The awareness of the sources and causes of imperfections appearing in the creative development of the nature and in the methods of designing social systems is also increasing. However, this increase of social consciousness and awareness presents also deep imperfections what concerns the design of architecture reflecting the complexity of integration of images of different social environments and communities of the XXI-century mankind.

The architecture of the system of an arbitrary social community expresses itself by a conceptualization of integrated images of the platform of the evolutionary nature of the reality, in a local and global scale. The architecture of a social system with any kind of nature integrates the conditions of ethical attributes and values that are the base of a social symbiosis and of the dynamics of functions in the development of the environment. Thus, architecture is a specific kind not only of interpretation of the system usefulness but, above all, of functions of morphological conditions being the base of evolutionary processes of the nature and of ethical revaluations of the complex nature, of various communities of the world.

In the course of her monographic investigations, the Author has undertaken a penetrating evaluation of the up-to-present scientific achievements, in creating

and improving social values serving to integrate various environments. She has also performed an analysis of creative values and conditions connected with the categorization of the creative architectural work. The role and importance of the adequacy of integrated images of the evolving reality are enhanced, e.g. of the method of environmental analysis and synthesis, of the morphological analysis of the multi-dimensionality of the environment, of the praxiological interpretation of the decision-making processes, as well as of the organization of actions and creative activity of designers in architectural environments and communities.

The scientific research carried on in the presented article is of a pioneer character, and it is original in the domain of the methodology of designing complex and evolutionary systems. Besides, the work is of a multidisciplinary character and of an extraordinary importance for the development and for the future of knowledge what concerns living systems of the surrounding reality. These reasons were, indeed, the cause of our interest in publishing this work in the international SYSTEMS Journal, as well as in promoting these research results in worldwide scale.

As usual, a list of selected conferences completes the issue.

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Morphology of the Architectural Achievement.
A Methodological Analysis of Selected Morphological Systems of the Natural and Architectural Environments

Aleksandra Prokopska*

I would like hereby to express my heartfelt thanks to Professor Mieczysław Bazewicz for his advices, suggestions and for his aid lent during the realization of this work, as well to all persons who contributed to the development of the work.

The presented work concerns the principles of knowledge acquiring in a methodological and systems way, as well as the processes of a morphological analysis of the architectural environment. It is dedicated to the methodology of analysis and synthesis in designing spatial architectural systems and assemblies. The object of the analysis and synthesis being carried on is the nature of the complex architectural environments and the level of the modern knowledge on architecture designing. In the considerations concerning the morphology of an architectural environment a trial was taken up to answer the following question: Can systems knowledge deriving from the theory of living systems, praxiology as practical philosophy, informatics and computer science, cybernetics and design methodology help in attaining a harmony and compatibility, as concordance of the natural environment with an artificial environment constituted by the architecture being designed?

As a result of such an approach, in the work investigations of architectural objects and of their design processes are presented with the use of a vocabulary applied in the domains of architecture, systems theory, design methodology, praxiology and psychology. Perhaps systems knowledge concerning the nature of the reality is needed, as it is useful for human beings so that their efforts do not so often appear to be vain, because such a knowledge leads to more precisely understanding and managing the environment that is given to us, in all its aspects, among them in the architectural aspect being analyzed.

The observations of the morphological features of architectural objects composing architectural environments result in referring the investigations being carried on to the Mendeleev's table (classification) of the elements that is an example, supported by documentary evidence, of regularities appearing in the nature, as principles composing the method being currently defined as the morphological analysis method. The periodic classification of the elements is a morphological interval, or one of many forms of morphological analysis, well known and used in technology, and partly intuitively used in architectural creativity.

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In this work a description of the structure of the multi-variant process of architectural design and of its elements has been presented, as a praxiological reconstruction of natural processes of architectural design covering the phases from inspiration to realization. These processes, being performed according to the architectural knowledge, are partly also realized according to the designer's intuition acquired during his/her design activity, e.g. the design of a great number of houses. The analysis has been undertaken in order to consider the possibility of a broader, more conscious use of the morphological method or of its parts in architectural design activities. The performed methodological analysis has been limited to selected, already historical architectural and painting achievements of Le Corbusier, and to his hand drawings of various types, as well to contemporary architectural works of F.O. Gehry that show morphological features. The practical purpose of the present scientific work is to confirm an order being read off in the realized achievements and in the design processes of selected architectural objects with morphological features. The general objective of this work is a contribution to improve designing and building social environments of the human being. A social environment can be designed in a greater accordance with the nature and can create a friendly habitat of the man thanks to the development of an evolutionary conception of the method of transformation of designing processes. The ampleness of forms being created according to the morphological method can permit architects to develop their creative activities in the future not for the technology-dependent mass customer, which has no cultural identity, but in conformity with their proper creative individuality and humanistic vision of a well-equilibrated development of the world. The existence of these possibilities has found a confirmation in analyses carried out in the presented work.

The application, in architecture design, of the existing systems knowledge and praxiological knowledge, and of the design methodology, does result in enlarging and liberating the creative possibilities of the architect-designer in design processes, also computer-assisted processes. This knowledge can be enriched, among others, by the method of morphological analysis as a design method being validated in practice.

The need of a harmonious coexistence in the system of the nature, a part of which we are together with our mind and creative possibilities, is reflected in the carried on in this work considerations on the morphology of the architectural environment.

1. Introduction

1.1. Assumptions and research directions

The presented scientific work has been taken up with a deep concern for the condition of the contemporary world, the equilibrium of which has been shaken, in various environments, i.e. natural as well as designed and realized environments by the man, not only architectural environments [10]. In this work, the direction of system-based and pro-ecological development of knowledge, of engineering and of architecture is indicated. The presented considerations concerning the morphology of an architectonic achievement (work) fall within the systemic and pro-ecological image of the environment architecture. The architectural environment, being an environment of human activity, constitutes a certain determined image. A base of differentiation of the systems description of images of the reality, from micro- to macro-scale, is the observed degree of complexity of the world and of the measures being used [128].

M. Bazewicz stated: "The past has introduced, in its achievements, numerous social and scientific divisions that favor tendencies to a fragmentation of the knowledge and the development of theory. This leads to a narrowness of the scientific specializations and to the growth of complexity what concerns categorizing measures of values of the transforming nature. The vision of a world that is divided, fragmentary and structural, is dimensioned by symbolism of static matter, theory and abstractive judgments and subjective truths. The reality is symbolically comprehended, and is a measure of psychological ideas or convictions that are not verifiable by the value of the evolutionary nature laws [16, p. 14].

When searching for foundations of a system- and methodology-based way of acquiring knowledge about the processes of a morphological analysis in designing spatial architectural systems assemblies, the existing scientific knowledge and intellectual instruments as well the proposed therein methods were applied, and particularly the knowledge on architecture, design methodology, systems theory and praxiology.

The present-day environment of the human being depends more and more upon designing and design methods. Architectural achievements (works) and common architectural realizations, as being carried out design activities, increase, to a higher or lower degree, the quality of the environment. At present, a number of possibilities exists that are not fully utilized to support the development of architecture by the existing computer science and informatic, methodological and systems sciences.

In this work, methodologies in architectural design are indicated, existing and being carried on according to the intuition of the designer and/or possible for development and realization. A base of the accepted considerations concerning the morphology[1] of the architectural achievement and architectural environment is the existing now knowledge concerning morphology of the nature, morphological analysis being applied in engineering, design methodology, architectural knowledge and systems theory, being derived from the analysis of systems processes concerning living processes, as well as ecology, psychology, computer science and informatics, cybernetics, philosophy of technology, practical philosophy-praxiology [11, 13, 16, 17, 18, 23, 25, 117].

The work concerns the scientific bases of the architectural design being in conformity with the nature (and with the nature of the human being) and its morphology. Morphological assemblies/arrangements appear in the nature, analogically to the system, in various forms. From the system- and methodology-based

[1] Morphology is the science on the forms and the external and internal construction of plants and animals. Among well-known examples of morphology, the morphology of a crystal, the morphological system of blood, the morphology of languages, expressions and their forms can be mentioned. See: Wielka Encyklopedia Powszechna (The Great General Encyclopedia), PWN, Vol. 7, Wydawnictwo Naukowe PWN Warsaw, 1966, Leksykon naukowo-techniczny (Scientific and Technical Lexicon), WNT, Warsaw, 1984, Nowa encyclopedia powszechna (The New General Encyclopedia), Vol. 4, Wydawnictwa Naukowe PWN, Warsaw 1996.

point of view, morphological methods of creating spatial assemblies in architecture manifest themselves through the form, i.e. through the comprehensively conditioned creative effect. One of these methods is the well-known method in technology and science, called morphological analysis. This is a method connected with the logic and style of design, also of the designer-architect. Morphology means methods of analysis and creation of designed systems, of their forms and their compatibility with the environment. Consciously or intuitively carrying on actions that are called the creative method of morphological analysis in the design of an architectural achievement (work) is not associated with imitation or duplication of architectural forms.

Thanks to the development of the present knowledge and the interdisciplinary communication, we are able to perceive more and in a more precise way. This remark concerns also the morphological features of the natural (inanimate and animate) environment, the designed environment and the human nature. Perhaps a so perceived environment (community) can facilitate the design of modern, more and more complicated architectural objects. Notwithstanding the differentiation of cultures and different social instruments, practices and skills, we are searching now for a confirmation of such specific human community, and of the resulting thereof responsibility of the architects in the present-day civilization. From the point of view of the architect, one of the barometers of this responsibility is the division and the shape of the existing and the being designed space – stated H. Skibniewska [5, 6, 116].

Natural systems constitute environments functioning as a whole that, after their decomposition, cease to work. An existing natural system, as a universe, is composed of functioning smaller wholes or subsystems. For practical reasons these subsystems are called systems. Natural and being designed architectural environments are composed, as subsystems, of various types of assemblies. These assemblies are composed of smaller, simpler subassemblies, and the latter – of further subordinate assemblies (some of these assemblies are decisive what concerns the properties of the used constructional, isolation and other materials). The being designed and realized assemblies and their subassemblies form artificial systems, among others the architectural environment. In that sense, one of many existing definitions of the system permits to determine it as an "assembly of assemblies" [53]. The so outlined image of the reality is more complicated. But this does not change the fundamental truth that the being designed, artificial architectural systems (e.g. urban agglomerations) are realized in a natural system and should be in conformity with its laws, principles [5]. Only in this way they can form a harmonious whole with it [6, 10, 79]. The question arises: how should this be done? This work is also an answer to this question. The problem becomes more evident when we realize that for building an artificial environment we use elements of system assemblies existing in the natural environment. These are e.g. building materials. These elements have their own morphology. That is a per-

manent feature of the animate and inanimate nature. A harmonious coexistence of these two systems (of the natural and artificial system), and as a result thereof an equilibrated development of the environment being designed, can be achieved through aiming at their compatibility. Perhaps is that possible to be attained through searching for and reaching common features of both environments, e.g. morphological features.

The present-day knowledge, particularly systems knowledge, and methodological and praxiological knowledge, creates practical possibilities of creating efficient system solutions covering many domains of human activity[2]. American scientists are characterized by an open, pragmatic look to the future, which is conditioned by the development of science and knowledge on the nature, and the symbiosis of the human being with the nature. In the mid-fifties of the last century in the USA, research works were initiated in the domain of theory and practice of systems science. This concerns achievements of these sciences in a world scale, in particular regarding sciences concerning social and economic systems.

An interpretation of the knowledge on systems is given in the research works of the American scientist K. Bolding (General Systems Theory: Management Science, 1956). This author, beside K.L. von Bertalanffy (who created cybernetics), is generally recognized as the creator of systems sciences. The paradigms of systems investigations of the nature, developed by L. Bolding, referred to humanistic sciences, particularly to social-natural and economical-organizational sciences [17]. The systems movement came into existence already more than fifty years ago, thanks to the development of numerous societies and assemblies that rallied scientists and practitioners having common scientific and professional interests. Among the scientific works that contributed to the development of this systems movement, the works of Prof. B.H. Banathy, the President of The International Federation of Research, played an important role. In Poland, it is The Polish Systems Society with Prof. Mieczysław Bazewicz as President that was the initiatory organization of the systems movement. The above-mentioned works are the main sources of development of systems sciences oriented to the knowledge on management and on the nature of information systems [13–16, 18]. The process of development of systems sciences is further continuing. There are no obstacles to continue, in a selected direction, creative thinking and the analyses that are connected therewith, according to the existing modern knowledge, particularly to the systems knowledge that liberate such creative thinking.

As a result of acknowledging the architect to be the unique humanist who is working among technicians, problems of designing and improving architecture,

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[2] The scientific works of M. Bazewicz [13–17], W. Gasparski [34–40] and H. Simon [112–115], demonstrate, among others, the possibilities of overcoming, by the notion of *architecture*, the disciplined limits and divisions, what can be equivalent in the future to passing towards an integration of the particular domains of knowledge. The present-day development of systems knowledge and of informatic and methodological knowledge permits to adapt the notion of *architecture* to new problems.

appearing in the area of humane and technical questions were selected [36, 38, 98, 99]. The present-day progress concerning technique (engineering), technology and organization of labor leads to the phenomenon of a collective coming into being of an architectural achievement, and the interdisciplinary process of architectural design is a process of shaping an architectural form that is conditioned in a many-sided way. From the system- and ecology-based viewpoint, the consideration of the process of architectural designing as an interdisciplinary process leads to strengthen in that process the creative role of the "architect taking sides with the human being" [116]. Such a point of view results in considering the being designed building as to be a designed whole, that simultaneously is a part of a greater whole or environment. On the basis of the theory of living systems that whole, being designed and realized in interdisciplinary collectives, can be considered as to be a functioning organism.

According to the opinions of W. Gasparski, S. Wrona, W.C. Dorosiński [27], systems knowledge is a peculiarity of the knowledge of the 20th century. These authors stated "the systems approach, in common with the increasing differentiation and integration of knowledge, accepts a lack of discipline barriers, the freedom in applying knowledge and technology gathered in one domain to problems appearing in another domain. That is a disciplined freedom of the unhampered intellect". The present-day development of systems knowledge has fully confirmed the importance and validity of these formulations. This knowledge assures new possibilities for a many-sided, because interdisciplinary, verification of the processes of architectural design, thus for an improvement of these processes. Perhaps it is a new knowledge, which can permit, to a higher degree, the mind to penetrate existence as a whole, and make possible to understand what we know and do not thoroughly understand. If this knowledge brings about such a chance, then how can we let that pass and how can we not undertake a trial for confirming or acquiring a greater certitude of the existence of such possibilities assured by this knowledge?

W. Gasparski, as engineer-methodologist, praxiologist and ethicist, asks and warns: "Does searching through the world for a technical and social complexity being more and more realized really must call as a support the Greek ideal of beauty and good?" [38].

Subject to investigations were the processes of designing architectural objects with morphological forms. Observations of morphological features of certain forms of architectural objects resolved to undertake deepened methodological analyses. Morphology appears in the nature, or in the system, a part of which is the human being with his/her intellect and creative possibilities. Perhaps it is worth to consider the causes and morphological relationships that can be practically utilized, as well as the scientific and philosophical consequences of the appearance of morphology in the nature and architectural creative activity. This opinion is reflected in the considerations presented in this work. The consider-

ation of morphological features according to systems philosophy[3] discovers the degree of complication of the relations of the nature and the designed environment.

The awareness of needs of a harmonious coexistence with the nature is reflected in this work through searching for laws and regularities that concern shaping the architectural form. The general purpose of the work is to indicate the possibilities of utilizing by architects the contemporary systems knowledge, praxiological knowledge, design methodology and modern technologies (in particular pro-ecological technologies) in the architectural shaping of the social environment as a friendly habitat[4] of the human being [5–8, 71]. On the basis of scientific works, among others of Z. Bać, it has been accepted that this present-day knowledge can be to a higher degree applied to shape a friendly architectural environment as the habitat of the man [5–8, 73]. Perhaps it is easier to attain this goal when thinking of the morphology of such environment.

The system-based and pro-ecological direction of research causes observing common features of the nature and the effects of architectural design. The presented methodological investigation of designing selected architectural objects was undertaken in order to search for methodological bases of acquiring knowledge about the method of morphological analysis and of its elements applied in the architectural design process.

Systems investigations of the behavior of the architect-designer were performed with the aim of understanding the design process and of a more objectivist description of the real architecture design. According to the contemporary knowledge on designing [16, 20, 35, 44, 61, 67, 88, 113, 117], it was recognized that objects being realized in concrete ways bear the stamp of the ways (methods) of their execution. The method of morphological analysis belongs to these observable realization ways and methods.

In order to deepen the knowledge about the ways and methods of behavior of the architect-designer and to accentuate the importance of experience and intuition of the designer, a morphological analysis has been performed of forms of concrete architectural objects. The awareness of the Author of the work was subordinated to ethical principles as well to the responsibility for a consequent, pur-

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[3] Philosophy is a knowledge aiming at cognizing the nature of the reality and the essence, structure and principles of being, as well as thinking and the most general laws governing the man, the society, the nature. Systems philosophy is an approach that is opposed to the analytical, reductionist, simple approach (based on the cause-effect principle) and mechanistic approach of philosophy in traditional sciences; systems philosophy introduces a reorganization of the ways of recognizing the perceived reality and thinking thereof. Systems philosophy has created a new Weltanschauung revealing itself in synthesis-based, expansionist, dynamic methods of thinking and research, where mutual and recursive multicausality is taken into consideration [22–24].

[4] A habitat is defined in this work as a " living system" and is a complicated set of factors and processes occurring in the environment. The characteristics of all natural and culture factors reflects the complexity of the habitat [5–8, 71]. In the most general sense, it is an environment [102] that coexists with the nature.

pose-oriented search for the truth about the nature and knowledge enriching the systems image of the architectural environment, this image being conditioned by the development of many other domains of knowledge [3, 11, 12, 18, 19, 20, 23, 25, 49]. This aspect expresses the methodological relation of the research being carried on to the science on the human being, his/her needs and his/her psyche.

According to the existing knowledge on design methodology, a system- and praxiology-based description of the structure of the multi-variant process of architectural design was performed. This description is a reconstruction of natural processes of architectural design of many architects-designers. The architectural objects and processes causing their coming into existence, selected for analysis, have system-based and morphological features. It seems that one can quote more examples of human creativity, among them technical activity, where elements of a subconscious systems thinking can be identified that are on a fuzzy limit between consciousness and subconsciousness, also in other domains of knowledge.

The architectural process being analyzed was interpreted as a tree of multi-variant possibilities, that means as one of possible forms of morphological analysis. The form is well known to the designing architect who searches for the unique proper solution among many variants.

Examples of methodological analyses of selected forms of architectural objects are a documentary evidence of possibilities of an efficient, practical application of the combinatory method of morphological analysis or of its elements in the architectural design process. Analyses have been performed on selected, already historical architectural and painting achievements of Le Corbusier as well as on contemporary architectural achievements of F.O. Gehry [42, 43].

The intention of this work is to enhance the consciousness of the growing now role and responsibility of the human being what concerns ethical problems of civilization development [14, 19, 24, 25, 114]. This responsibility, according to W. Gasparski, M. Bazewicz and A. Collen [13, 18, 23, 25, 36], is expressed in respecting the ethical values of the nature, which determine the activeness of the societies subject to transformation.

The presented methodological investigation of designing selected architecture objects was undertaken in order to search for and determine methodological principles of acquiring knowledge about the morphological analysis and the process of architectural design. To this effect, a systematic investigation of behavior of the architect-designer was carried on, with the aim of achieving a more objectivist description of the real process of architectural design.

A methodological investigation of designing architecture objects has to be connected with a system-based and pro-ecological direction of the undertaken scientific research. Such approach permits, to a higher degree, to avoid a schematic transfer of methods of technology to architectural design. Contemporary technologies often "create an environment in their own likeness, and not in the likeness of the human being" and of his/her needs [1, 5, 6, 101, 102].

In the architectural design, the designer bases him/herself on real possibilities resulting from the progress in science, art and technology. The architect accepts logistic technical solutions or logistic constructions, and – at the same time – overcomes them in a natural way. In such a manner the activities of the architect are connected with his/her creative artistic achievement, i.e. with the art and its laws.

This work is also a trial to answer the following question: Is it possible to describe the process of an architectural creative achievement, rising up in the imagination, in a more objectivist way than hitherto? For that purpose a methodological investigation of processes of architectural design of selected objects was taken up.

An ampleness of possibilities of shaping forms is resulting from the application of the morphological method in architecture. Maybe it will permit to architects in the future to create not for a technology-oriented mass spectator as a passive customer, but in conformity with proper creative individuality, feeling of cultural identity and with a humane vision of development of the world [102].

Research directions and methodological bases of the work

The general purpose of this work is to determine the principles, methods and ways of operation in the so important activity of architects, which is the creation of architecture and habitat as an environment required for the survival of the human beings on the Earth. This multidisciplinary work concerns shaping the bases of a systems design and the methodological ways of acquiring architectural knowledge. The object of the analysis and synthesis being carried on is the nature of complex architectural environments and the level of the contemporary knowledge on architecture design [86]. In the work, a search for laws and regularities that concern shaping the architectural form and the process of architectural design was undertaken.

The present-day results of systems knowledge, as well as methodological, praxiological and architectonic knowledge permits to describe, in a more objectivist manner, the real processes of architectural design [23, 25, 36, 39, 58, 84, 90, 115, 117, 126]. An investigation of features of the architectural style through an examination of the morphology of the forms being designed results in a more detailed comprehension of the processes of architectural design as intellectual processes [37, 98].

Among the goals of the research being carried on, the following have to be mentioned:

- discovering elements of creative artistic and technical activities, that were hitherto not described in an objectivist way, as intellectual activities of the architect,
- presenting possibilities of utilizing the existing knowledge, therein the knowledge on the morphological method, for improving the design so architecture

can contribute, to a higher degree, to preserve the equilibrium and harmony of the artificial environment, or between the designed and the natural environment,

- finding an order in conformity with the method of morphological analysis, being read off in architectural achievements and in being realized design processes of many outstanding architects. In the examples selected for the analysis, this order was identified as an order in conformity with the morphological analysis,
- observing and describing the method of morphological analysis or of its elements, used in he process of architectural design of selected achievements in the domain of architecture,
- aiming at recognizing the not explained aspects of the creative process of architectural design. This process is a complicated intellectual process compatible with the nature of the human being and with its discovered and not discovered laws [98, 100, 102],
- contributing to the improvement of architecture through improving the architectural design. This goal is connected with the sense of responsibility for a harmonious and balanced development of the civilization in the limited space of our environment on the planet.

J. Sołtan stated that an immense role in making architectural decisions is played by really hitherto unknown laws, being subject to presentiment, and being determined in architecture as design intuition acquired together with experience in designing [117]. Investigations carried out show that an important role in the architect's intuition is played by the morphological analysis. The utilization of design experience of architects-designers, which is connected with the use – to a higher or lower degree – of elements of the morphological analysis, can become a basis for purposely humanely oriented improvements of the architecture.

The systems research assumptions of this work, constituting the morphological analysis of an architectural achievement (work), concern a systems image of the reality and of the future of the architecture. This image is connected with a choice of ways of development of the reality, these ways being related to the development of the environment of the human being's life. The architectural environment is a part of this environment of man's life.

1.2. Systems image of the morphological reality

Systems description of images of the reality and of possible futures

The image of the reality and of the future is connected with human activity as well as with a systems perspective as a paradigm [16–20, 25], also with problems of degradation of the natural environment and enlargement of the designed-artificial environment, therein of the architectural environment. The architectural environment that is an environment of human activity constitutes a certain concrete systems image. A base of differentiation of the systems description of reality im-

ages, from micro- to macro-scale, is the observable degree of complexity of the world and the measures being used [12, 15, 19, 66, 68]. Perhaps the development of knowledge, therein systems theory, methodology and psychology overcoming the existing inside us psychological barriers and permitting a change of the point of view, will create new possibilities of comprehension of what we know, of an unification of scientific notions of knowledge and science, and of a systems description of the existing reality. From the architectural point of view and the present-day psychology, a great role in creative processes and in perceiving the surrounding reality is played by our psyche. One of the essential profits resulting from a broader realization of systems perceiving what concerns the surrounding reality could be to avoid many errors in the future development, maybe also future development of the architectural environment. Mistakes in the present and future development can result e.g. from a lack of systems analyses, from future relations of consequences (therein ecological and cultural consequences) of present decisions and activities. L. Gerardin stated: " Creative planning of many futures is, first of all, an attitude towards the future. However, the attitude itself is not sufficient" [41].

Relationships of the present and the future, as well as the dependence of the present on the past and of the future on the present are illustrated in fig. 1. The figure defines the always limited from the systems point of view, but existing possibilities of choice (being realized in decision making processes) of real ways of the future development. There exist system-based and multi-aspect dependences of the future on the present, and of the present on the past. From the systems point of view, well known and described systems assemblies, and the not known and not fully recognized subassemblies, as well as the connected therewith laws and regularities of the system of the nature, are decisive what concerns the properties of the human environment. For instance, laws of statics and structural analysis and the properties and qualities of materials assure determined possibilities of shaping constructional assemblies as supporting structures, thus architectural systems assemblies. In such a manner e.g. knowledge on the laws and material properties is utilized to a higher and higher degree in building the architectural environment.

Laws and properties of the system of the nature influence directly coming into existence of a range of forms, among them morphological forms in the nature. It happens that forms being realized in architecture, as forms being useful for the man, are also morphological. It happened so in the past and it happens in the present development of architecture. Figure 1 demonstrates once more that we all are in a continuous process of civilization transformations derived from the past as a process conditioned by past decisions and facts. These continuous transformation processes are possible and necessary in the future. Together with knowledge development, particularly with the development of systems theory, design methodology, informatics and computer science, and praxiology, a more systemic

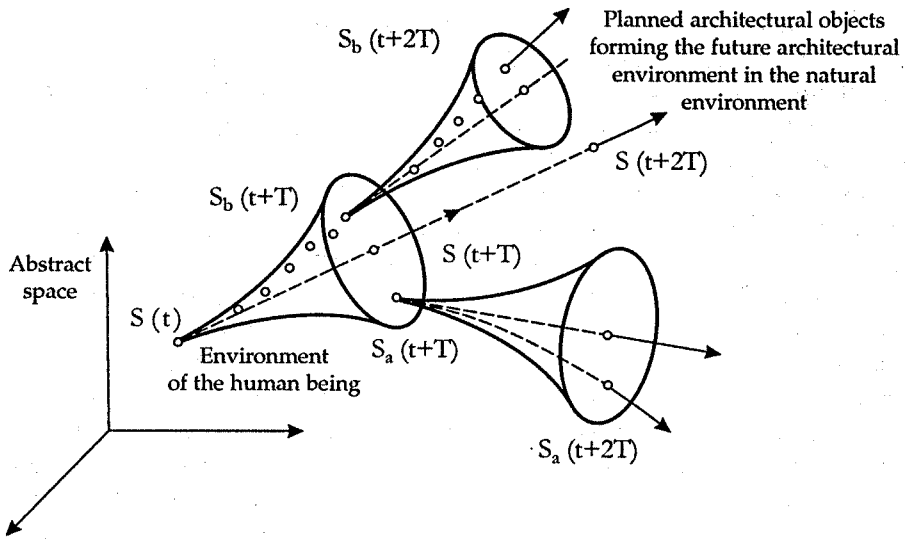

Fig. 1. Evolution of the system inside possible abstract spaces. According to Gerardin, these are scenarios of possible futures

description is possible to a higher and higher degree, and, perhaps, systems forecasting and management of these processes. Maybe is that possible, provided that – so as it results from experiences during the past societal development – it will be in conformity with humane goals of the man.

The awareness of needs for changing the being realized architectural systems follows the evolutionary aspect of the nature as a system – environment of human activity. From the point of view of the architect, the following question is essential: Can building and performing artificial systems by the man (so as it happens in architecture) take place without appreciating the fact that systems being realized are decisive, in their feedbacks, what concerns our possibilities of further activity, development and our further existence? This results from the fact that the reality being designed depends on ourselves, and the reality realized in conformity with the project, or the so-called built environment, does make us dependent upon it. The systematically enlarging so-called built environment, i.e. the architectural environment that comes into existence as a result of the growing up interdisciplinary designing and realizing activity of the human being, is decisive what concerns our present, and as a result thereof, what concerns determined possibilities of development and survival in the future. The so-called in architecture "lost spaces" are a negative example of that state of the matter, indicating the essentiality of the problem of environment degradation [6, 8,]. It seems that an optimistic future direction of development is the use in architectural realizations [81, 82, 87] of present-day pro-ecological technologies. These are, for instance, comfortable buildings equipped with systems solutions based upon pro-

ecological informatic (computer science) technologies. Buildings utilize e.g. the solar energy and, at the same time, economize this energy in different way [42, 43, 60]. It can be observed that in the mentioned pro-ecological solutions the applied technologies exert, to a higher or lower degree, an influence on shaping the architectural (cubic) mass.

It is possible, perhaps, to develop in the future a conception of the method of evolutionary transformation of architectural design processes for their improving, and as result thereof, improving the being designed environment of the man [5, 10, 11, 13, 14]. The present designing takes place according to the being discovered degree of complexity of the nature and the more and more conscious design process (fig. 2) [25, 37]. From the systems point o view, there are no obstacles to improve the being designed environment of the human being with maintaining his/her architectural and cultural identity. This process can be favored, among others, by a broader and more aware use of the morphological method that makes possible a relatively easy acquisition of multi-variant spatial solutions.

The continuity of cognitive and creative processes permits to perceive in a new perspective the problems of morphology of the natural and the designed environment. The present-day knowledge of methodology makes it possible to perceive, in the periodic classification of the elements, an example of morphology of the inanimate nature. The principles of the classification of the elements have been discovered as relationships existing in the nature. From the viewpoint of the architect, it has to been enhanced that this principle, as, perhaps, a law of the nature, concerns the human being and his/her products. The omnipresent morphology is observed in the living nature, and particularly also in the build of the human body, and some products of the human mind, e.g. architectural products, have morphological features. The question can be brought up whether this coincidence of morphological features is accidental or, on the contrary – whether in this juxtaposition of facts a regularity of the nature is manifested? Such regularity concerns the human being with his/her intellect, being a part of the nature. This problem remains unexplained, as not brought up earlier. However, the present comprehensively developing science and knowledge permits to take up the problem.

The validation, presented in this work, is a process of determination of the degree of correspondence, correctness and precision of the morphological method, and a process of determination of the degree of validity and purposefulness of the use of this method as an intellectual instrument by the architect-designers. Some of the architectural spatial solutions with beauty emanation have morphological features. The appearance of morphological features in some existing architectural forms was a cause leading to undertake a trial of retrieving this method or of its elements in the process of shaping architectural (cubic) masses, this process being conditioned in a many-sided way [94, 101]. This activity was carried

on according to the consideration that each change in an architectural project results in a change of the form. For example, a change of the properties of the used construction materials causes a change of sections of the construction being designed. This often influences the designed architectural form. According to the decisions knowledge on architecture and design methodology, all architectural decisions being conditioned in many-sided aspects influence the designed form. In the morphology of the architecture environment being analyzed a call was made to the bases of thinking of the architect-designer on the creation of the architectural form. When calling to the bases of the intellectual process of the architect, the existing at present intellectual tools were utilized. These tools are design methods and the connected therewith design methodologies, architectural knowledge, systems knowledge and knowledge on the contemporary practical philosophy – praxiology[5]. System- and praxiology-based analyses of selected forms of architectural objects with morphological features were performed. As composition is accepted to be one of the fundamental architectural notions, the method of decomposition in the analysis of the form of a concrete object was applied. A decomposition of the architectural form of the historical Villa Savoye and Ronchamp Chapel developed by Le Corbusier, and the contemporary achievements of architecture of F.O. Gehry was performed. A methodological analysis of elements of the architectural process was also carried out, according to acquaintance with design practice and on the example of the project of the Carpenter Center of Le Corbusier and of his carnet-like sketches.

From the point of view of the creative architect, the morphological analysis can become an inspiring method. This method facilitates, according to the creative individuality of the architect, coming into existence, i.e. generating varieties of architectural forms and their synthesis-based approaching. The knowledge and language of systems theory and design methodology make possible a systems description of the design processes, among them also processes of architectural design being conditioned in a many-sided way [83], as well as of their effects, e.g. buildings.

The development of disciplined sciences in the present informatic area is characterized by collaboration in interdisciplinary teams and by the today's expansive development of systems knowledge and praxiological knowledge. This leads to return to the considerations of Einstein concerning the possibilities and the need of unification of the language of science [29, 30]. The unification of the language of notions of science, of which he wrote many times, would permit an easier and more precise communication of specialists in many domains of knowledge, and an easier penetration of values of knowledge from one domain into another.

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[5] Praxiology, as practical philosophy, is a general theory of action, and praxiologists set themselves as goal the inquiry of the broadest generalizations with a technical character [31]. Praxiology is the science of standards and principles of an efficacy and efficient action. Praxia in psychology means a capability to perform purposeful movements (*Greek praksis, prakseos – action, act, praktikos – practical, active, diligent*).

In the future, it could be a language functioning in a global scientific system and could concern also architecture.

The values of achievements of the architectural knowledge, encoded in its specific language, remain to be relatively incomprehensible in other disciplines, and thus to be not easily accessible. Consequently, in this work notions belonging to systems theory, praxiology, design methodology, scientific architectural knowledge and architectural jargon being connected in an inseparable way with experience and professional practice of the architect, are used [2, 64, 65, 67–69, 77].

According to modern knowledge, particularly systems knowledge, and praxiological and architectural knowledge, all what is subjective, or e.g. an artistic experience, was separated in the considerations being undertaken from what is possible to be objectively recognized, such division being not forejudged in anticipation. The architectural knowledge is characterized by the fact, that it connects objectivist with subjective cognition and experience.

A particular importance was assigned to the being developed list of notions connected with the theme being undertaken. That seems to be a key to create a notional platform and a better communication between various communities.

The present expansive development of the systems knowledge, informatic and computer science and cybernetic knowledge as well as the psychology of creativity, and particularly psychology of architectural creativity, permit undertaking works concerning the creation of principles of the future system- and methodology-based creative architectural design in conformity, to a higher and higher degree, with the systems construction of the nature and the human being. Such a development is possible as a result of a continuous and successive enrichment of the architectural knowledge and of the "architectural" language by praxiological and methodological notions and formulations functioning in systems knowledge. Introducing systems notions and praxiological notions into the theory, teaching and practice of architectural design can contribute to a better communication of architects in an interdisciplinary collaboration and to a systematic discovery, in the future, of many unexplained aspects of the complicated intellectual process in the design of architecture.

2. Polymorphism and multi-dimensionality of the morphological analysis of the environment

Mendeleev's periodic classification of the elements as an example of systems morphological arrangements in the nature

Systems knowledge permits to carry on a logical analysis of the structure of the reality without taking into consideration the disciplined divisions introduced during the historical development of science and technology.

The carried on universal search for morphological features in the nature have led to a system- and methodology-based analysis of the Mendeleev's periodic classification of the elements.

Lothar Meyer (1830–1895, chemist) and Dymitr Ivanovitch Mendeleev (1834–1907, chemist) came by different ways in the years 1868–1871 to the discovery of a regular ordering of the elements, this ordering being based upon atomic masses and chemical properties. The classification of the elements is a real and independently discovered by the scientists as well as supported by documentary evidence example of morphological arrangements that can be found in the inanimate nature. This classification has a form of a morphological interval. Generally, the form of a contemporary morphological interval used in technique (engineering) is a morphological mathematical matrix. This form is destined in technique to define a full set of combinations of variants of features of a determined class of technical objects.

Beneath, the form of morphological matrix was identified and supported by documentary evidence as a form functioning in the nature, in the Mendeleev' classification of the elements. Mendeleev has documented this arrangement independently of the development of knowledge on the morphological method and other forms of morphology in the nature. The classification of the elements is a morphology concerning the structure of matter. At the same time, this form of record of morphological analysis is well known and utilized in science and technique [48, 134]. Morphology is a feature of the animate nature, concerns the human being with his/her mind and its products. The question arises: is that a pure accident?

Probably the creative mind of the human being applies methods to a higher or lower degree, particularly e.g. the morphological method that has been defined, among others, in technique, and by Mendeleev in the classification of the elements.

As a method, the morphological analysis has specific features, particularly multi-dimensionality and polymorphism. According to the present-day systems knowledge, therein informatic and cybernetic knowledge, morphology, particularly morphological analysis, has many possible forms of recording, and it appears in many forms in the animate and inanimate nature [98, 129, 132, 133]. Polimorphism of the morphological analysis as heuristic method is a specific feature of that method. Perhaps as a result of these features, polymorphism is difficult to be observed in the nature, the part of which is the human being with his/her mind and creative possibilities. The actual importance of the method of morphological analysis, called also morphological method, results from its numerous applications in technique, e.g. spreadsheets [41, 57, 109].

There are no facts available of documentarily evidenced intuitive application of the method of morphological analysis in architectural design.

The following question can be also asked: Does there exist a relation and what kind of relation does exist between the periodic classification of the elements, the

structure of animate and inanimate matter, and the creative mind of the human being, of course beside the evident relation consisting in the fact that the details of the classification of the elements, which are subject to further combinations resulting in creating morphological arrangements, are decisive what concerns the structure of animate and inanimate matter, together with the human being's mind.

These considerations are not exhaustive from the viewpoint of the description of multi-aspect possibilities of that method, as regularities of the nature.

Morphology as feature of architecture can be defined with the use of the notion "arrangements", e.g. morphological architectural arrangement or assembly. The method of morphological analysis being considered from the point of view of the architect can become an intellectual tool, with the aid of which the architect generates in an easier way various architectural forms, i.e. design variants. That method is equal to creativity, it assures possibilities of artistic creation, opposed to simple combinatorics. It can become an inspirational method for many architects-designers.

Heritage of the science of science conception of Einstein

Einstein stated, "If we care sincerely and honestly for the preservation of all people's talents and their unhampered, free development, we cannot resign methods leading to that goal" [72, 74, 124]. What concerns the scientific language and scientific method, he wrote that how a man can use this tool (scientific method) entirely depends on the character of the aims, which the mankind desires to reach. If such aims exist, the scientific method creates ways to reach them. But the aims themselves cannot be created by it [28–30, 74, 124]. In other words, he treats the method as an intellectual tool, by means of which the designated goal can be achieved. At the present-day phase of science development, this statement does not lose importance in spite of the passage of time.

The aims of the science will have always their aspect and ethical dimension, which cannot be created by the method itself. Analogically, the beauty of the architectural achievement cannot be created by the design method itself, but only by the creative man using the method as an intellectual instrument.

M. Bazewicz and A. Collen formulate the following ideas: "During our efforts to understand the arising images of the global complexity we realize more and more that the ethical dimension is the most important category of value and of our reasoning. Thus, the questions arise: does the individual activeness carry only local or also global consequences, and if so, what should the human being do in order to act in a more conscious way and to avoid disadvantageous influences upon the everyday activeness? Those are really questions with an ethical character" [18].

Einstein left a rich heritage of ideas on science of science (therein a not finished theory of unification of science notions), the elements of which can be found in his notes, letters and writings. In these considerations, a part of his opinions was compared with selected elements of the contemporary systems knowledge

and methodological knowledge. A particular trait of his scientific idea was the fact that there, where other people saw a unitary phenomenon, he perceived the manifestation of general principles. The world was for Einstein a uniform whole, wherein universal, omni-embracing principles are acting. According to modern knowledge of design methodology, a principle "grows up" from a manner, and a method – from a principle. The opinions of Einstein continue to be in conformity with to-day's knowledge, particularly with the ecological and systems knowledge. This feature of his mind is the base for treating Einstein as a scientist-specialist and science philosopher. Generally, the opinions of Einstein harmonize with the present development of systems theory, praxiology and design methodology, psychology of creating activity. These opinions are not contradictory also with regard to the philosophy of the method of morphological analysis. Maybe morphology is not a unitary phenomenon, but the manifestation of action of general principles of the structure of the reality.

Philosophy of the method of morphological analysis and of its pra-concept

The "pra-concept" of the method of morphological analysis is The Lull's Art[6] [41, 78], that reflects its multidimensionality, as well as the richness and continuity of the human thought in the course of history. This logician, philosopher, mathematician and astronomer has created the beginnings of the philosophy of the method of morphological analysis. Ramon Lull, called during the following centuries Raimundus Lullus, proposed – so he stated – a universal and infallible method of solving all thinkable tasks. In his dissertation "Ars magna et ultima" he presented the idea of realization of this purpose [41]. He constructed a "logic machine" that performed an automatic combination of notions. He assumed that through combining fundamental and general notions and predicates, all possible judgments could be obtained, and thus also new truths. The conception of Lull consists in systematic combinations of a concrete number of selected notions. These notions symbolized intervals on the orbits of "coaxially turning" circles [41]. Ramon Lull called his method "Great Art". Many intellectuals have recognized the Method of Lull as a base of their philosophy, among others Giordano Bruno[7] and Leibniz[8] [41, 78, 119]. Leibniz wrote appreciatively on that method in his "Dissertatio de Arte Combinatoria". So as Lull, he stated that thanks to the ars combinatoria (art of association) any cognition would become possible.

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[6] Ramón Lull (1235–1315) was a monk from Majorca, and the author of more than 150 scientific works.

[7] Giordano Bruno (1548–1600), Italian philosopher, defender of the heliocentric theory of Copernicus, the first systems theory. He has been therefore burnt at the stake.

[8] Gottfried Wilhelm Leibniz, German philosopher and mathematician, has created the philosophical theory of nomads as elementary components of the world. He aimed at the creation of the *mathesis universalis*, an idea the rules of which would define the way of operating on elementary notions treated as to be an alphabet of a universal language of science. See: F. Copleston: History of philosophy. From Bertham to Russel. Volume VIII, translation into Polish: B. Chwedeńczuk, Instytut Wydawniczy PAX, Warsaw 1989.

T. Kotarbiński, when writing on the philosophy of Lull, stated, " here we have the inception of an inferring machine" [69]. L. Gerardin stated that the conception of Lull plays an essential role in the method of morphological analysis as its pra-concept [41].

Present-day scientists have a strong tendency to base upon the results of the modern science. It happens so in technique (technology), but in philosophy is that neither simple nor evident [14, 45, 50, 51, 57, 75, 79]. Many of scientific notions continued to develop from pra-concepts that some time ago had no proofs being valid to-day[9]. The idea of Lull, connected with the philosophy of morphological analysis, is remained in mathematics as combinatorics, and in art – as the sporadically demonstrated "old" method permitting to obtain often-original figurative compositions, from the point of view of plastic art. These figurative compositions were achieved through accidental assembling combinations of figures being set on the planes of coaxially turning circles.

The contemporary astrophysicist F. Zwicky[10] was searching for morphological assemblies/arrangements in stellar systems [130]. The example presented in fig. 2, reprinted from a seventeen-century book, is a contemporary morphological structure. The Lull's art, was characterized by the danger, being perceived by many scientist, also by Descartes [11] [41,49], of a mechanization of thought, what was brought to mind in a changed form by the present omni-embracing computerization, for which the human mind becomes only en element fulfilling the expected requirements. Thus, a return to the considerations on Lull's philosophy, philosophy of technique and its applications is full of present interest.

F. Zwicky is the creator of the standard technical method, the morphological analysis. In this method, he utilized the essential feature of Lull's Art (fig. 2). In the idea of Lull and in the method based on this idea, that means in the morpho-

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[9] Ludvik Fleck (1896–19610 defines pra-concepts as to be directional lines of development of cognition. He writes: The Greek antiquity has donated to the modern atomic theory its pra-concept, that, in particular, Democritus proclaimed in his pra-atomic science. (...). Numerous motives of the present atomic science, being discovered in the theses of antique atomists, are continually amazing us: the meaning of association and separation of atoms; their mutual attraction and its consequences; effects of pressure and collision. It is analogical when it concerns other theories: the idea of the element, the idea of the chemical compound, the law of conservation of energy, the idea of spherical form of the earth and the heliocentric system" [32]. These facts are mentioned also by W. Tatarkiewicz, History of philosophy: Volume 1, Philosophy of the antiquity and middle age, Volume 2, Modern Philosophy until 1830, pp. 7–65, Wydawnictwo Naukowe PWN, Warsaw 1995

[10] The fundamental assumptions and directives of the method of morphological analysis have been developed by the astrophysicist F. Zwicky who applies with success this method in astronomy, (the pioneer of construction of reaction engines) and E.R. Herzog, in the years 1938–1945. The advanced method is used in many domains of technology [129–134].

[11] René Descartes (1596–1650), French philosopher and mathematician, representative of rationalism and cognitive skepticism, discoverer of the method of analytical geometry, postulated a method of thinking based upon mathematic reasoning. See: W. Tatarkiewicz: History of Philosophy. Volume 1. Philosophy of Antiquity and Middle Age, pp. 7–65, Volume 2. Modern philosophy until 1830, Wydawnictwo Naukowe PWN, Warsaw 1995 [121].

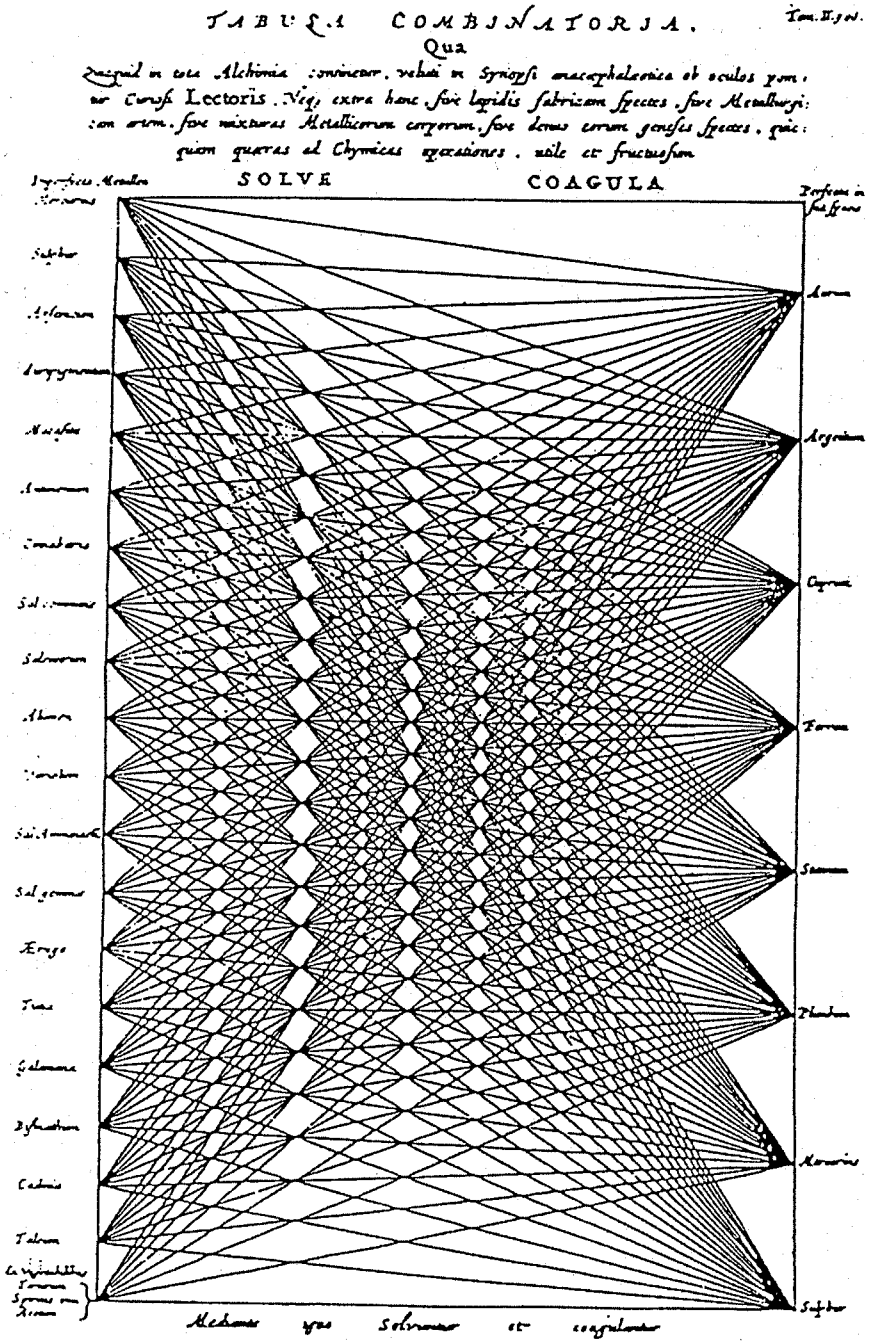


Fig. 2. Morphological structure, found in a book of the 17th century according to the work [41]. The most essential in this figure are not notions (words) but lines of division. These lines form a typical morphological structure. This structure can be associated with the being discovered degree of complexity of the nature.

logical analysis, it is possible to create (generate), by associating in a combinatorial way different elements (e.g. of the object being designed), an immense number of new arrangements and assemblies (among them real and unreal arrangements), and this task has always a finite number of solutions. Descartes defined in his "Discussion on the Method", some rows before the explanation of the four famous rules, the danger of the "blind action" of methods in the following way: "as I was young, I studied a little between philosophy and logic, (...) but after having studied them I think that logic, its syllogisms ... serve rather to explain things, that one knows, or even, as in Lull's Art, to speak without judgment on things, on which one does not know anything and which have to been learned". This idea, according to the opinion of Lull, assured to a man who used it, the possibility to solve all the problems of philosophy. As it is reduced to combining partial solutions, this idea constitutes the base of one of the contemporary heuristic method: the morphological analysis. Lull limited the number of notions subject to automatic combination to nine, and he wrote them in another form: in the form of a contemporary morphological interval (fig. 3). However, practical instruments Lull disposed of appeared not to be sufficient so the method could last out and develop, finding further applications. In course of time, this method was relegated to oblivion. The most important advantage of this pra-idea or pra-concept, and simultaneously of the based thereupon morphological analysis, as mathematical method, is the fact that – according to the definition of Zwicky – it leads to identifying and examining all the real combinations of features, e.g. of the ob-

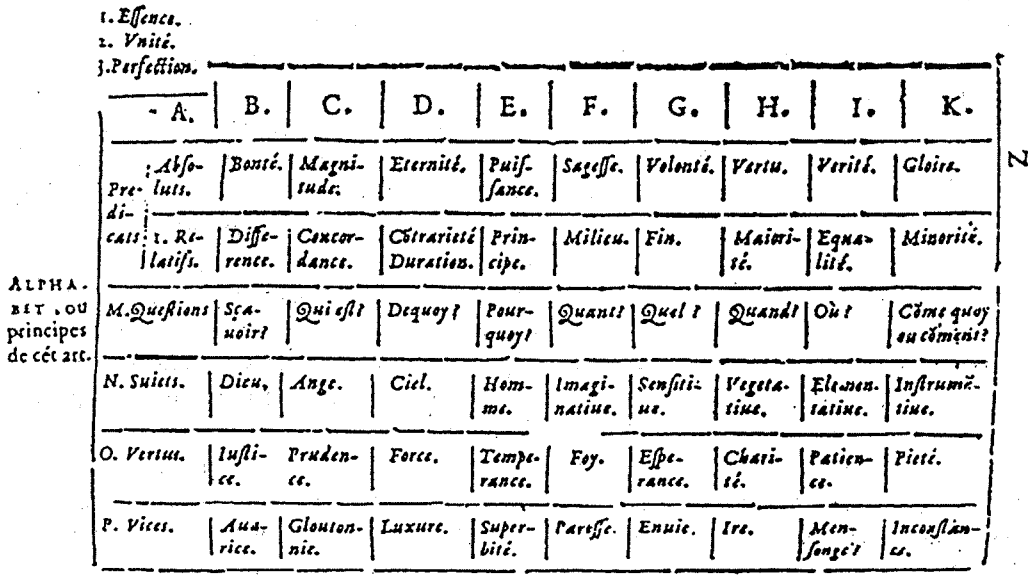


Fig. 3. The nine principles of Lull: example of a morphological interval constructed by Lull in the XIII century (reprinted from a seventeenth-century book) [14]

ject being designed. It happens so in the case of a regular definition of sets of main and detailed features.

When assuming, according to the opinions of contemporary intellectuals, that thinking takes place through juxtaposing and comparing even the most distant facts, then the method of morphological analysis, based on Lull's Art, gains in importance because it assures such a possibility. In fig. 2, the theoretical structure of the morphological method has been determined. This structure shows the possibility of easily obtaining, on its base, a great number of variants of solutions, what means that it enables to generate varieties. Actually this feature of the method permits to its use with computer assisting. The Lull's method, and simultaneously the morphological analysis, defined by Descartes as "the risk of mechanization of the thought" [41], was used in technique, in numerous computer-assisted applications of the method.

Considerations concerning the importance of the form

Einstein stated that we think by means of images (ideas), notions, but not by means of words, and that our thinking is of a subconscious character [28]. In the undertaken investigations concerning mainly morphological forms of the architectural achievement (work), and in the conclusions resulting from these investigations, the form has been recognized to be the indispensable feature of the nature and architecture. A. Cournet remarked, "independently of the object being concerned by our observations and investigations, the form is that what is the easiest for us to recognize, that means that is also connected with human being's nature"[12]. He accepted that, because this remark is of a universal importance, only on that account "the notion of form should be introduced at the heading of all lists of categories and sets ordering the basic and constructional notions of cognition" [122].

Z. Wasiutyński confirmed this opinion [122]. He refers the notion of form both to objects being perceptible only by reasoning, as well as to material, visible and tangible objects. Among numerous considerations of Z. Wasiutyński regarding the form, the following can be found: "...the forms of produced objects are dependent on forms of production activities. The properties transmitted to the produced objects reflect the way of action, thus the way of recognizing. These properties can only arise as a result of action and they can be adapted, as a whole or in a partly way, to the intended useful purpose, or they cannot correspond to that purpose. (...). The properties given to objects reflect elements and forms associated in cognition being the base of these actions. In the properties of the produced objects we can read off elements and forms given to the objects. Besides, we can associate many forms comprising visible properties". In other words, the form appears (otherwise, is created) in the feedback regarding the properties of the object.

[12] Antoine-Augustin Cournot (1801–1877). L'ordre et la forme – quotation according to the work [122].

Every shape created in space by the architect (i.e. every form), and the importance that this shape has for the observer-consumer or user, is a phenomenon of communication by means of spatial signs, or forms. In this process, different users incessantly complete those mental images (or forms) with complex combinations by introducing e.g. semiological values. The process of designing an architectural form is a process of spatial information processing.

The method of morphological analysis used in technique (engineering)

F. Zwicky, the author of the standard morphological analysis, has applied in this method the principle of Lull's Art, or a combinatory association of the particular elements (e.g. of an object being investigated or designed). The method of morphological analysis is also called the morphological method. F. Zwicky used the term "morphological analysis" for determining the standard constructional method destined to identify all possible means permitting to reach the goal, as a specific functional capability. He has formulated the method of identification, classification and organization of technical parameters of the construction of a technical device [129, 131]. The present mental processes, called the morphological analysis or morphological exercise, already do not correspond to the typical morphological analysis of Zwicky, limited to ordering technical factors. In the method of morphological analysis the value of the solutions is connected with the value of the analysis, and the solutions can be consciously examined and applied.

Zwicky considers morphology to be a perception of such an image of the reality, in which would be taken into account, in a transparent way, all the more important structural links between objects, phenomena, ideas and actions [131–134]. L. Gerardin and W.L. Wager state that the morphological analysis permits the imagination to work on a greater number of ideas than it were possible in the case of a classical approach [41, 119]. The value of the solutions in this method is consciously connected with the value of the solutions analysis [41, 45–47]. A.D. Hall defines the method of the morphological analysis as a generalization of a list and comparison of properties, by associating it strictly with the morphology itself. He accepts the denomination given by Zwicky as an accurate name, as the word "morphology" is connected with science concerning construction and form (from Greek *morphe* – shape and *logos* – *science).* He states that considering the construction and the form excites the intuition, and aids in formulating the problem itself [52–54]. This statement concerns the specificity of architecture designing.

A.D. Hall presents the procedure of that method being used in technique (engineering) as follows: begin from the possibly broadest formulation of the problem (i.e. analogically as it occurs in architectural design), elaborate a list of all the independent variables of the required system, assign one of the dimensions of the morphological map to every variable, calculate the values that can be taken by every variable. The total number of solutions of the problem is equal to

the product of numbers of values of each of the variables. In this method, the combinatory process increases according to the geometrical progression, and fast tens of thousands of solutions are obtained. Therefore it has to be explicitly distinguished what is a morphological analysis, and what is not [54].

Selected features of the morphological analysis

The importance of the discussed heuristic method[13] does not consist exclusively in obtaining an ordered way of recording combinations of values of the features of the object being designed. In this method that is being applied in technique, the values of the object being designed are comprised within a morphological interval (figures 4, 5). One of the main characteristic features of the morphological interval (one of the possible of forms of this method) is the mutual independence of parameter values. The most difficult element of the morphological procedure is to perceive the internal order among many variants of solutions in a thing that does not physically exist (that means to perceive an order in the complexity), and to determine the main features of the solution. In technique (engineering), in a situation where the number of features and their variants is considerable, it is comfortable to apply computer-assisted procedures [70]. Then the set of solutions of variants, obtained in this way, is subject to reduction. I this method the variants remaining after reduction form the required set of solutions, or they are subject to further evaluation and reduction. It is possible to reduce the set of solutions by searching for constraints, and also these combinations that seem to be unrealistic. When one wants to examine all the solutions obtained as a result of the analysis with regard to the values of different parameters, one has to define the morphological interval in such a way (fig. 5) as to obtain a number

	VALUES			
PARAMETER **A**	A_1	A_2	A_3	
PARAMETER **B**	B_1	B_2		
PARAMETER **C**	C_1	C_2		
--------	------			
PARAMETER **H**	H_1	H_2	H_3	H_4

Fig. 4. A typical contemporary morphological interval. Applied in technique, e.g. in spreadsheets [95]

[13] The author of heuristics was Georges Polya, a Swiss-American mathematician and methodologist of scientific discovery [66, 67].

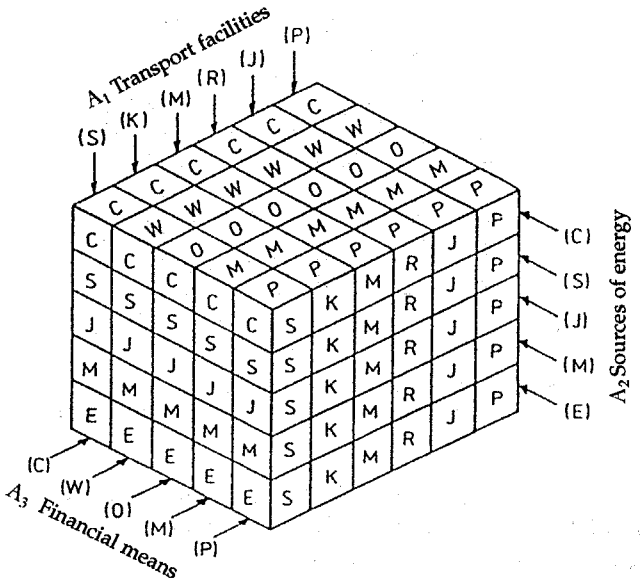


Fig. 5. Spatial morphological matrix, the so-called morphological box [95]

of different solutions that correspond to a rational time necessary to their examination.

In a morphological interval containing seven parameters, with three values for every parameter, 2187 solutions are obtained. In the case of seven parameters, with two values for every parameter, 128 solutions are obtained. This indicates the importance, in this method, of searching for constraints, which can exist in relation to the being considered solution variants. The morphological analysis that is used in technique (engineering) is a method of random error making. An example of methods of systematic and limited generation of space elements is the analysis performed by means of the morphological box. The morphological box (fig. 5), and the flat morphological matrix (fig. 6) can be supported by many manners and methods, e.g. by the method of random error making, method of determining the degree of probability, sequential methods, and other methods.

The procedure of the morphological analysis can be described in the following way [116]:

1. Formulating the task.
2. Selecting the domain of the solution and defining the limits of the solutions being searched for.
3. Structuring the task: determining its morphology.
4. Finding partial solutions.
5. Aggregating partial solutions into a set of integral solutions.
6. Evaluating and selecting the solution from the set of possible solutions.

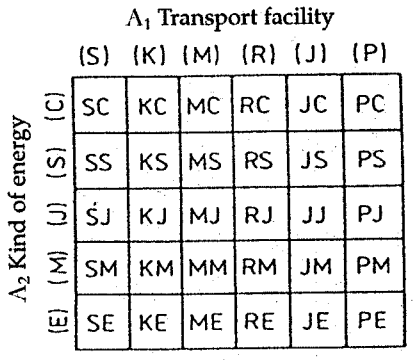


Fig. 6. Flat morphological matrix. A currently applied in technique form of morphological analysis [95]

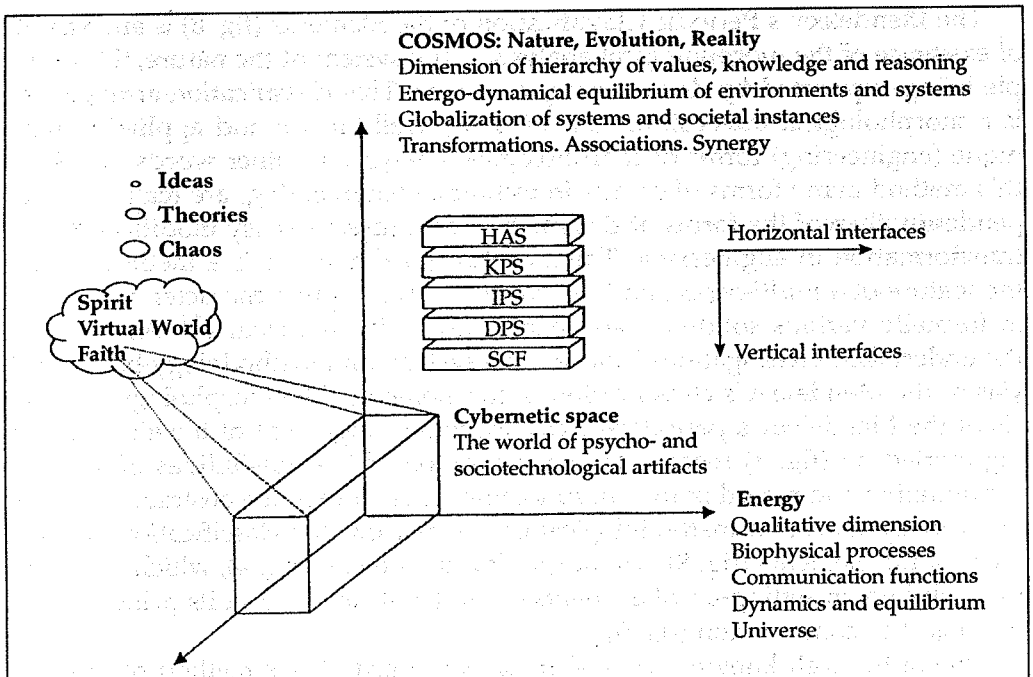
The features of the morphological method point out possibilities of description, by means of this method, of high-complicated structures as a result of the identification of their component elements.

In fig. 7, the most important structural links between objects, phenomena, ideas and actions have been taken into consideration in a transparent way. This figure presents an image of the morphology of the reality, containing values that form e.g. architectural environments. In the figure notions and principles can be found, put in a functional context of mutual connections. Such context refers also to the architecture environment. This environment is connected with space and psycho- and sociotechnological artifacts, as well as with evolutionary reevaluations.

Methodological analysis of the morphology of the Mendeleev's Periodic Classification of the Elements

Einstein stated: "Science must start from facts and end with facts irrespective of theoretical structures that it uses to combine them" [26]. This principle can be also directly referred to the morphological analysis. It is because this method starts from facts and associate them one with the other, forming theoretical structures, that means generates varieties called variants.

In considerations concerning morphological forms in the architecture and the classification of the elements, observations of the methodologist Z. Wasiutyński were accepted to be helpful; Z. Wasiutyński wrote that all what exists in the universe and in our consciousness appears (i.e. exists) through the form. In other words, there exists no "thing" that does not possess its form or shape [122]. The carried on discussion concerning the form leads to considerations concerning dependencies and relationships appearing in the nature and the science. These relationships are often observed through morphological features of the form, e.g. of an architectural object.



Matter: Quantitative dimension, physical structures, time-space and statics of the universe

The time-space of the nature of evolutionary values is characterized by a system and communication based integration through the intellectual-informational energodynamics of societal transformations. Reevaluations of the nature are categorized in three dimensions:

1. by creation and conceptual representation and categorization of knowledge,

2. by operative aspect of intellects and by reasoning in information processing,

3. (in the dimension of) functions of the energo-dynamics of interfaces and medial information and knowledge carriers.

Source of systems transformations is the communicativeness of social environments and the integrality of conditions of a dynamic equilibrium in processes of evolutionary reevaluations of the universe and the nature of the world.

LEVELS OF INTEGRATION:

Infological System of Information and Knowledge Representation (KPS/IPS – Knowledge Processing System/Information Processing System)

Datalogical System of Data (DPS – Data Processing System)

Technological System of Communication Flows (SCF)

Systems of Human Activity (HAS)

Fig. 7. Axiological image of time-space and three-dimensional integration of values of the nature, which result from the energo-dynamical and evolutionary reevaluations of heterogeneous environments and from the development of systems of social communication. Flows of multi-medial communications as well as functions of horizontal and vertical interfaces of information processes are a base for a dynamic equilibrium in the development of integration of different social environments and systems. Transformations and reevaluations of environments as well as the development of social systems in a symbiosis with the evolutionary nature are grounds for hierarchical structuring the intellectual-informational levels of the nature of values and the globalization of knowledge [16]

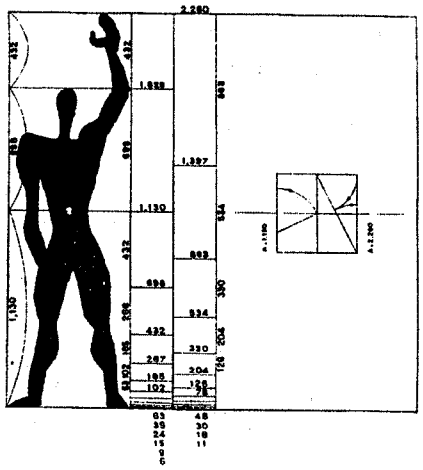
The Mendeleev's Periodic Classification of the Elements (fig. 8) is an example of existence of the morphological analysis in the system of the nature, this example being supported by documentary evidence. This classification-arrangement is a morphological interval, i.e. one of many well known and applied in technique (engineering) forms of morphological analysis. In other words, thanks to this method many forms of objects in technique (engineering) are realized. Independently thereof the forms of this method are subject to easy modification and transformation in engineering. The morphological analysis is a method having the feature of a multi-aspect and multiform (polymorphic) character, it can exist in formally various solutions, and hence results its importance[14]. As an effect, the undertaken investigations have led to a system- and methodology-based analysis of the Mendeleev's classification of the elements. The morphological analysis of the Mendeleev's periodical classification-arrangement of the elements being carried on (fig. 8) regards the consideration of the possibilities of a logical continuation and record of this morphological structure in the abstract space (fig. 9). From systems and methodological points of view, the classification-arrangement of the elements (fig. 8) is a morphological interval (fig. 4), which illustrates the well-known setting-up of elements of matter structure, and its principles can be subject to continuation (fig. 9).

One of the well-known forms of graphical record of this method of morphological analysis, being a mathematical method, is the morphological matrix, sometimes called a morphological box (fig. 5).

The number of dimensions of this matrix is equal to the number of main features of the solution, and every element of the matrix corresponds to a determined combination of features. This form (the morphological box) is met in solutions applied in technique (engineering).

The Mendeleev' periodic classification-arrangement of the elements (fig. 8) is a morphological interval that forms a particular case of a flat morphological ma-

[14] Perhaps the forms of this method can be found in the nature, e.g. in the morphological regularities of the build of the human body. Examinations of proportions of the human body, calculated according to the golden cut (set in Modulor), have been performed by the outstanding architect Le Corbusier, the creative achievements of which exerted a great influence on the development of architecture in the 20th century, about 1948. Modulor is the presented beside diagram of harmonious proportions. Le Corbusier joined passion of an objectivist approach to esthetics with the antique and renaissance world, with thinkers of the scale of Pythagoras and Leonardo da Vinci [117]. Le Corbusier did not join his considerations concerning the form with concrete elements of form of antique styles, but with proportions applied in the antique architecture. At present, it is the appreciated sculptress Magdalena Abakanowicz who is dealing with morphology of the build of the human body in the art.



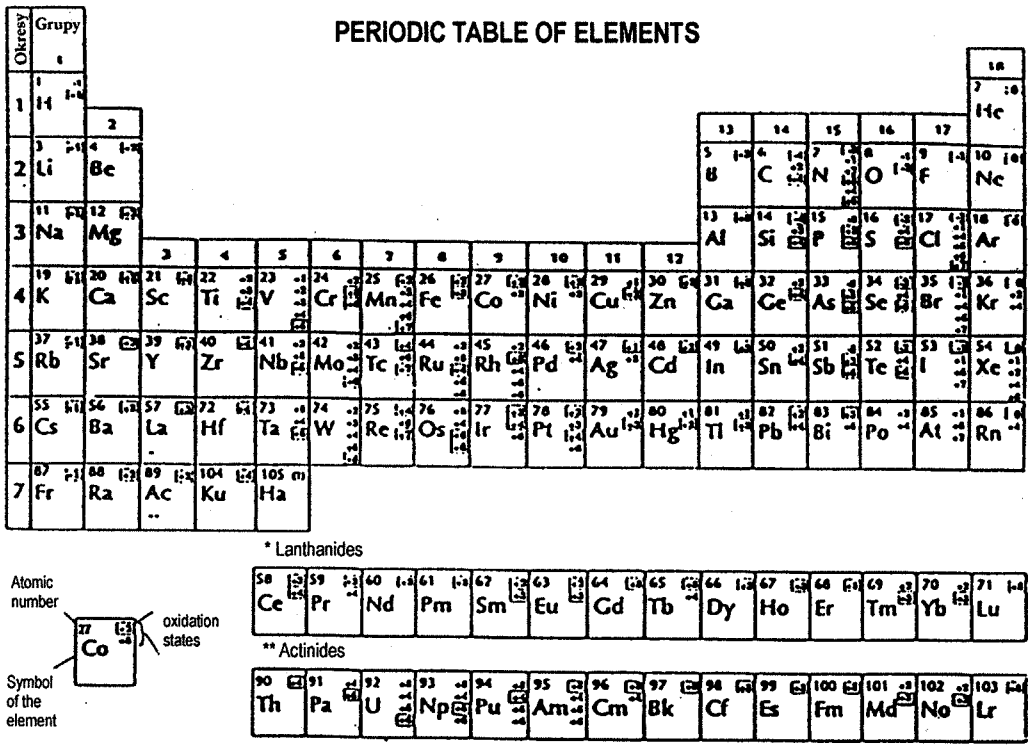


Fig. 8. It has been accepted that the structure of the periodic classification-arrangement of the elements is in conformity with the principles of a morphological interval. The Mendeleev's Periodic Classification of the Elements can be considered to be a flat morphological matrix

trix. This is one of many known records of the method of morphological analysis. If so, then is a continuation of that form of recording facts from the morphological interval of the Mendeleev's periodic classification-arrangement of the elements possible in the third dimension? The justification of asking such type of questions is confirmed in fig. 9. From the point of view of the present-day systems knowledge and methodological knowledge there exists such possibility. In fig. 9 such a theoretical possibility is presented. In this figure the record and assembling of facts, performed by Mendeleev, creating a structure of the morphological interval- periodic arrangement of elements remains in an unchanged form of a flat matrix. This identification was made possible thanks to the contemporary progress in systems knowledge and methodological knowledge. An extended form of this record has been proposed as its spatial, logical continuation in the form of a morphological box. The successive "layer" of the record of values would consist in a combinatory assembling of e.g. facts from, for instance, the "lower" layer of the morphological box, that means of the interval- periodic arrangement of the elements, in other words these would be arrangements of chemical molecules composed of elements. The successive layer in the opposite di-

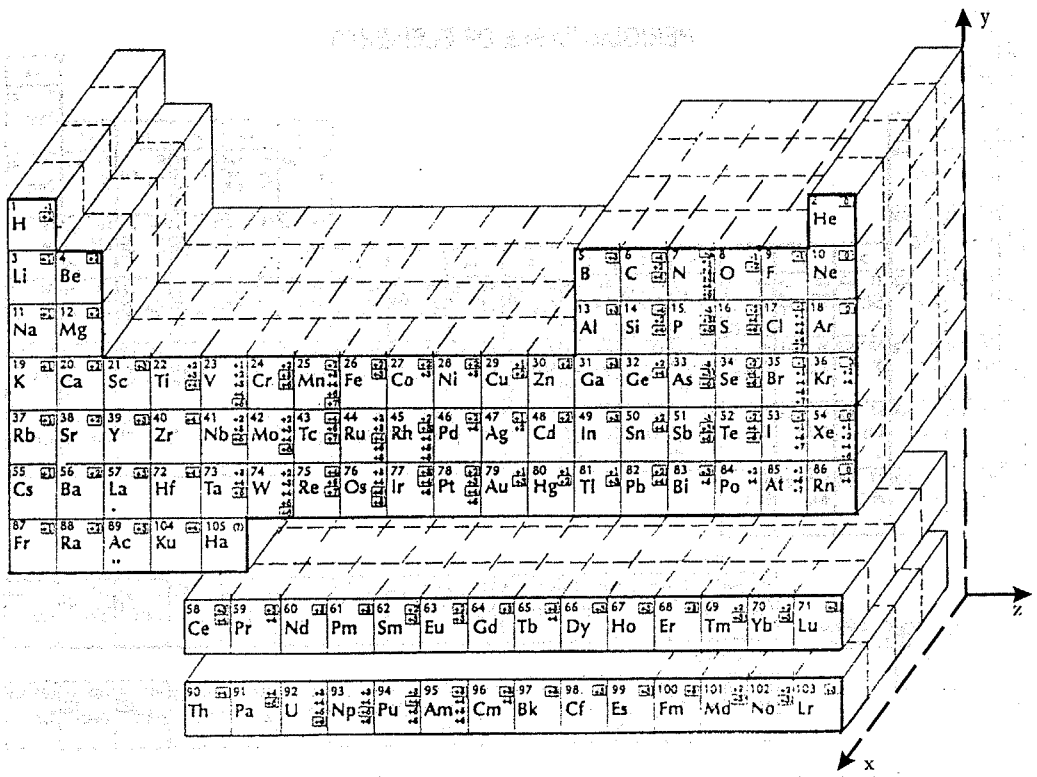


Fig. 9. The figure presents a theoretical logical continuation of the structure of the classification-arrangement of the elements, i.e. of matter structure. This structure is an example of the method of morphological analysis, being identified in the nature. The form of the morphological analysis in a three-dimensional, spatial structure is known as morphological cube. The Mendeleev's periodic classification of the elements, as an identified two-dimensional form of the method of morphological analysis, is analyzed, in the figure, in the abstract space. This form can be considered as to be a logical continuation of the real flat morphological structure. The possibility of carrying on the mentioned considerations is a proof of the immense cognitive possibilities of systems knowledge and methodology. This figure indicates the importance of morphological links existing in the space

tion could perhaps contain elements of the structure of the atom. The arrangement of the morphological box presented in fig. 9 is an arrangement that is logically simple and that maybe is joining the knowledge on the matter structure. The possibility of continuing the morphological analysis of the matter structure, presented in fig. 9, is not supported by empirical investigations. Perhaps there exists a practical possibility of an empirical confirmation and/or verification of the existence of structures being created in the figure, as theoretically possible or existing structures, because they constitute exclusively a logical continuation of the known fragment of the reality, described by Mendeleev. In fig. 9 the structure of the Mendeleev's classification-arrangement of the elements has been treated as a record of the morphological method, and thus the possibility appeared of

transforming and continuing this structure. The reasoning presented in fig. 9 was performed according to experience concerning applying, in technique (engineering), the method of morphological analysis, what shows that this method is fitted for examining objects with a high degree of complexity, and for solving problems the essence of which consists in associating a great number of elements in different ways. As a result of this consideration, and according to the contemporary systems knowledge, particularly with knowledge concerning the morphological analysis, the two-dimensionality of the Mendeleev's classification-arrangement of the elements (fig. 8) has been transformed into the three-dimensional form of the morphological box (fig. 9). The reasoning being presented in the form of the morphological box (in fig. 9) can be continued in the direction of the analysis of, existing in the natural environment and being realized in the artificial environment, combinatory assemblies of smaller structures into greater ones and of their mutual multi-directional connections. These are, among others, also architectural objects being realized by the man, that form the architectural environment covering more and more surfaces of lands on our planet. Such kind of consideration is based on the awareness that all forms exist in the reality through their assembling according to the laws of the nature from smaller forms. This reasoning can be continued in many directions, for instance by means of the question: have all elements composing the existing micro- and macro-structure morphological features? It seems that many among them possess these features.

Mathematical structure of the method of morphological analysis

Einstein was convinced that the description of the electron or of another elementary particle, equipped with mass, position and velocity, is a very naive image, and the scientific progress that has taken place in physics since Einstein's times has confirmed this opinion. There is a greatly complicated structure of field behind this image, added Einstein, this structure requiring carrying on further investigation. If we knew this structure, he wrote, then the apparent randomness of the elementary processes would disappear **in favor of strict causal conditions of all the events in the nature.** Einstein imagined this structure as a mathematical structure and he accepted it to be the only possible structure. He wrote also that the dialog with the nature can be carried on, and is carried on in the language of mathematics. Here it is maybe worth adding that in the initial period systems knowledge was called "new mathematics" and thus it was not expected to become an interdisciplinary knowledge [22, 24, 25].

The morphological analysis that belongs to systems knowledge is, among others, a mathematical method, and the periodic classification-arrangement of the elements is an assembly of facts or concrete solutions. In other words, fig. 9 presents a possible continuation of the morphological structure in the abstract space, in the form of a morphological cube, i.e. according to the mathematical method. The example of a morphological structure being recorded by Mendeleev in the form of a morphological interval as the classification-arrangement of the elements,

as well as all the known, various records of the method of morphological analysis, have a logical mathematical structure what cannot be passed over in silence.

L. Gerardin proposed to replace the definition of Zwicky with another, simpler definition: "the morphological analysis is a method of a systematic examination of all possible solutions of a given problem". In such approach that is in conformity with the morphological procedure, one can hope to discover a new solution when starting from the analysis of a known solution [41]. According to this definition, in the morphological analysis, the problem is examined from the possibly most general point of view so as to obtain the greatest probability of examination of all the possible solutions of the problem. The morphological structure in fig. 8 has been realized according to this principle. One started from what was already known, that means with the elements' interval. Then, the spatial morphological structure was defined as a continuation of what was known, thus the structure of the morphological box was recognized to be a possible, logical continuation of "known assemblies" of the classification-arrangement of the elements in the abstract space [42, 45–47].

Morphological processes

W. Gasparski presents the opinion that the present progress of civilization is connected with the acquirement of a new, surprising knowledge being the more shocking the more different it is from what "everybody knows", or different from common sense. This is a pursuit of cognition of the reality, whereof Einstein stated, that it was for him "one of the independent purposes, without which a conscious acceptation of the existence seems to be impossible for a reasoning man" [32, p. 21].

The goal of the contemporary morphological mental processes, irrespective of the fact, that it will be named decomposition into semantic factors, morphological exercise or method of morphological analysis is: "searching for more convenient and meaningful factors through the continuation of the analysis of partial terms connected with complex terms, and of complex terms comprising partial terms" [41]. The above definition is realized in these considerations concerning the morphology of the architectural work or achievement.

The definition of morphological analysis can be referred to architectural activities provided that for "meaningful factors" and "terms" e.g. meaningful complex and partial forms are accepted. Thus, one can search for morphological features in the forms of architectural objects. Such search can be induced also by the observation of the reality where there occur no changes in the real space without changes of the form and, inversely – there occur no changes of the form without changes in the real space. The shapes (forms) of the record of the morphological analysis, mentioned in the text in figures 2–8 are not exhaustive what concerns all possible forms of this method.

Form the viewpoint of systems knowledge investigations concerning the importance of the morphological analysis in the nature cannot be limited in anticipation to one or only some domains of knowledge. In figures 9–13, 17–18 the valuation by means of categories of the nature and the living world, connected with its morphology, is presented.

The nature and the living world, whereof our thoughts and reasoning are the products, remain to be indifferent to our disciplinary divisions, but do not remain indifferent to our actions and activity. The living world and the nature are not a conglomerate: they constitute a whole. Such whole can appear to be easier to describe and understand when we use therefore knowledge and a systems language of notions. For example, problems illustrated in figures 10 and 11 are the base of the method of morphological analysis and design of architectural objects. The figures 10–12 are connected with the methodology of analysis in processes of architectural design and with design strategies concerning asking questions and determining design aims [1, 20]. Problems presented in fig. 10 are problems being also undertaken and solved by the architect more or less consciously and efficiently. In the design (not only architectural design) the interest connected with the problem being undertaken is essential. Curiosity contributes in a natural way to a concentration of attention and often constitutes a source and inspiration of creative design processes. Design processes, also in architecture, are continued through asking successive questions and trying to segregate and verify these questions. For example, architectural design processes according to fig. 10 can be considered as successive questions and answers connected with aims of the activity. Spatial solutions referring to the existing position of the object being designed and to the situation being examined are the aim of these processes.

Architecture and architectural knowledge is of a timeless character, with a tradition of many centuries; from the practical point of view architecture derives

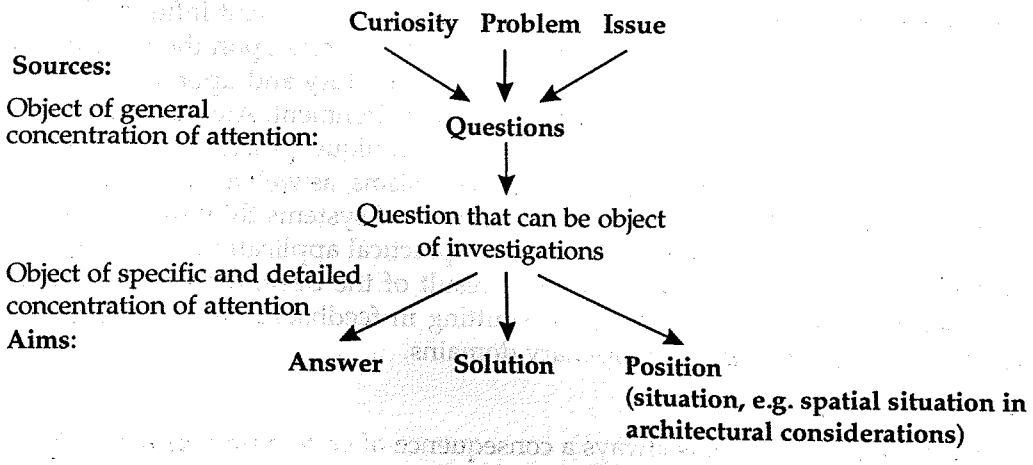


Fig. 10. Links between questions, sources and aims [18]

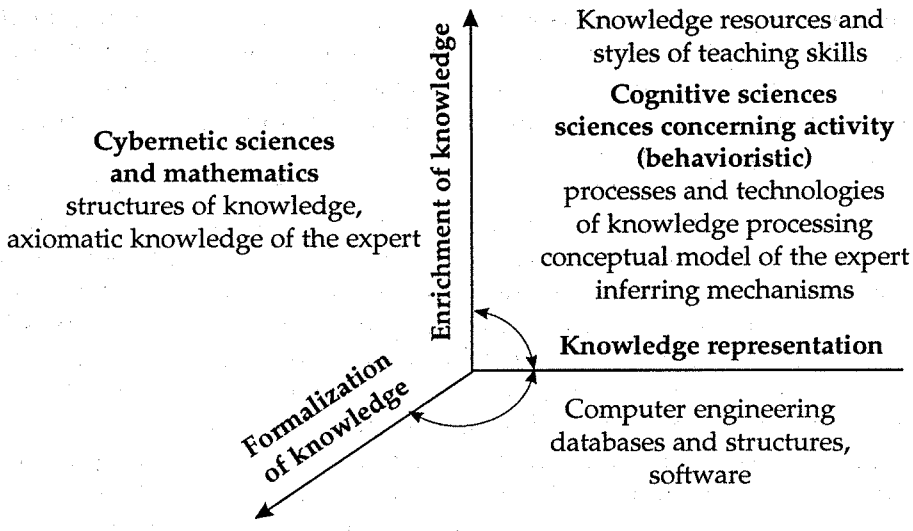


Fig. 11. Model of knowledge systems engineering [18]

from handicraft, thus is connected with the style of teaching skills to many generations of architects, who earlier were named also builders. The present-day architect-designer possesses a learned design skill as a result of having designed many houses [26]. For practical and theoretical reasons architecture and architectural problems fall within the model of knowledge systems engineering, presented in fig. 11. In this context one can also consider the possible future influence (also mutual influence) of the experience of architecture during many centuries upon further progress of the knowledge in the domain of methodology of design and systems theory. This is possible when accepting, by the architects, the apparently foreign (unfamiliar) knowledge and foreign (unacquainted) language. Regarding the consequences thereof, it can be analogical to the evident influence exerted by the knowledge of structural analysis and mechanics upon the progress of building engineering and architecture in the 19th century and upon the processes of design and realization of the architectural environment. Architecture is connected in an inseparable way with technology, technique, processes and technologies of knowledge processing, inferring mechanisms, as well as with formalization of knowledge. The intuitive use of elements of systems thinking in this domain is a proof of the existence of a broader, practical application of the existing systems knowledge in architecture. As a result of the development of systems knowledge, a possibility exists of transmitting in feedbacks values of architectural knowledge into other disciplinary domains.

Reality as universe

A law, as stated Einstein, is always a consequence of certain universal principles which are active in the universe and which demonstrate an internal logic pene-

trating the being as a whole [28–30]. If so, then a law as a consequence of principles refers to the being examined periodic classification of the elements, to the human mind and its products, as well as to the being realized artificial environment, e.g. architectural environment.

All actions of Einstein were controlled by a philosophical need of understanding. The violent contemporary enlargement of the range of scientific knowledge was for him rather a source of trouble than of courage. He wrote in 1900: "who could think that after fifty years we will know so much more and understand so less" [72]. The present-day knowledge permits not only to know more, but also to understand more.

Thanks to the multidirectional development of the present science, particularly of the omni-embracing informatics and computer science, cybernetics systems knowledge, praxiology and design methodology, we can perhaps not only know more but also understand more if we want – according to the sense of Einstein's considerations.

The considerations of M. Bazewicz can be declared to be a present-day continuation of above opinions; M. Bazewicz writes that the auto-reflective capability of the human being is a source and a hope of liberation of the man from ignorance and mental closeness, as well as of enrichment of his/her awareness [16]. In the cosmopolitan approach, the human being is paradoxically both moved away from the center of the universe and placed in that center. However, the new and central position of the human being, connected with the gaia-centric approach[15], will consist in a creative synergy for redesigning our education systems in order to face the challenges being set and categorized by global trends of world development and evolution. In figures 7, 12 and 13 evolutionary possibilities of the world as universe being in dynamic time-space equilibrium are presented.

M. Bazewicz and A. Collen write also that the evolution of the reality inspires the human consciousness to pass from images of the world, theory of psychology and virtually divided chaos to the time-space vision of the world of nature values of the globally integrated cosmos [18]. When treating the reality as a universe, as an area of our informational recognizing, disciplined information research (inquiry) oriented on inferring signifies a precise examination and description of the existing phenomena, e.g. the description connected with the question: what is? Such research constitutes a process of production of knowledge about all kinds of phenomena [86].

The disciplined information research (inquiry) (fig. 12) is the fundamental method of contemporary systems investigations. Disciplined research being intellectually associated with informatics and computer science consists in an active examination of the inquiry type and in the penetrating character of exploration carried on by means of questions [19] destined to acquire information about the en-

[15] The gaia-centric approach is connected with other approaches as a "hybrid of other approaches, enhancing the ecological aspect for the biosphere, and ecological ethics"

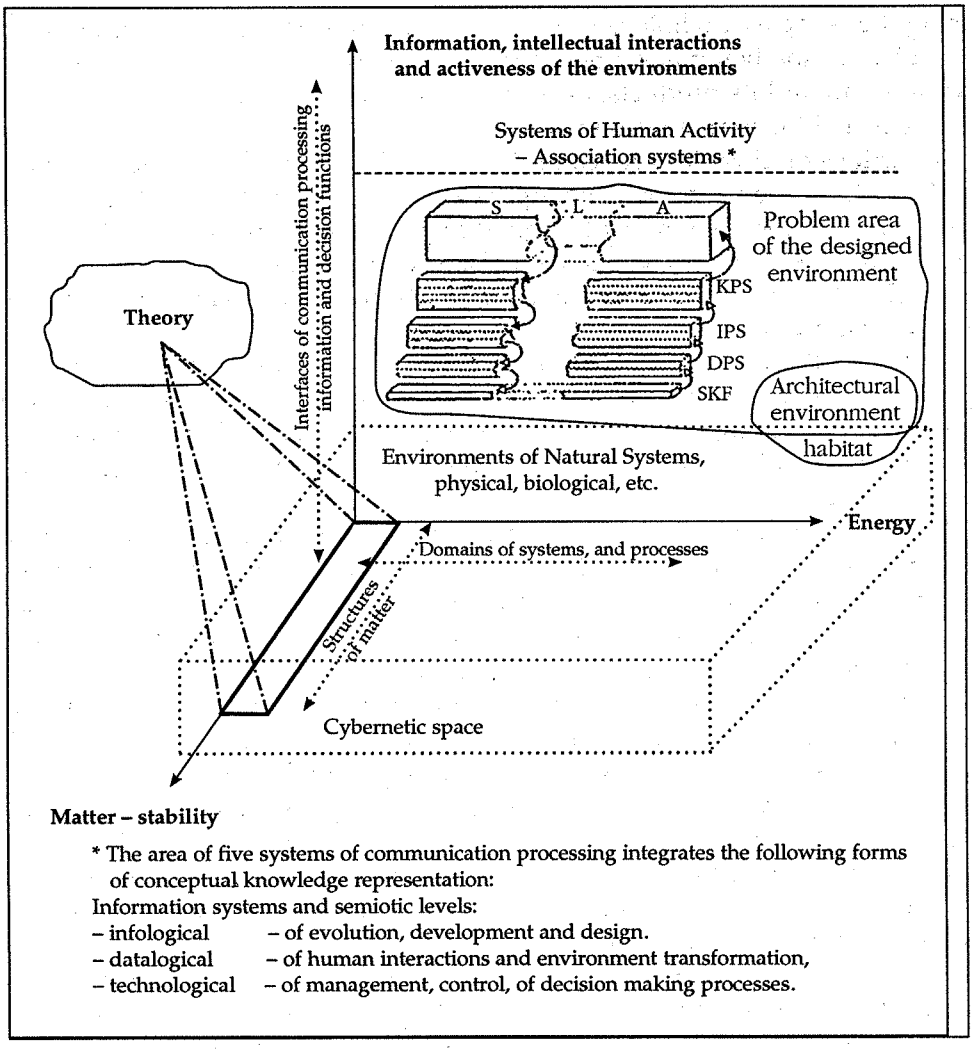


Fig. 12. Cybernetic theories and models of the reality [18]

vironment as a fragment of the system of the nature. The investigations of the architecture, being undertaken and presented, are oriented onto referring. They serve acquiring information on the architectural environment understood as a part of a greater whole or system.

Systems exist in many forms and in such a quantity the man is capable to imagine. Systems can be natural, artificial and conceptual and also be a compound of all kinds of hybrid forms [16, 23, 70, 109]. Thus, systems and knowledge about them become a powerful intellectual instrument for investigating, recognizing and understanding the reality, also the architectural reality. Systems thinking is not

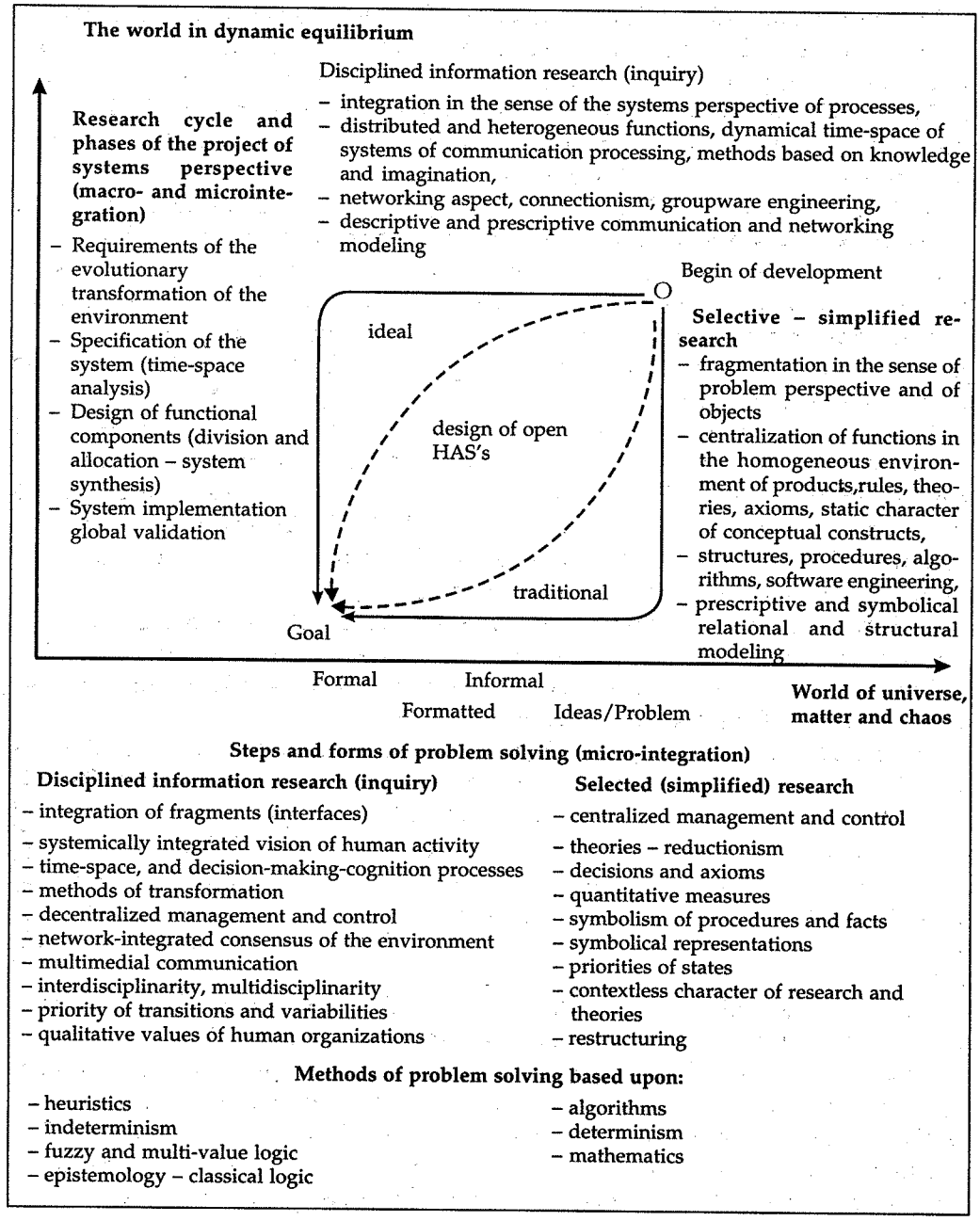


Fig. 13. Disciplined information research – research paradigms [18]

covered by existing schemes. The figures 9–13 are a proof thereof. The variety understood as polymorphism and multi-dimensionality of forms is a feature of the nature.

Polymorphism and multidimensionality of matter, occurring in the universe, e.g. being observed by scientists, astronomers, is so important that it can only bring to mind apparently the chaos, however the world as a whole is not a chaos. The usual reality is always richer than our cognitive possibilities. Perhaps the morphological form will become in recognizing this reality a "key" for better understanding and for a more efficient activity.

M. Bazewicz and A. Collen state:" The results of systems research show that an arbitrary environment can be in local and global scale subject to hierarchic categorization of levels of transformation of its nature of values, irrespective of heteromorphy and systems complexity. A particular role in designing environmental transformations and information systems is inherent in systems methodologies and cognitive methodologies of inquiry, and in dynamically developing information technologies [18, p. 201].

The process of designing a system, also an architectural system composed of arranged assemblies and subassemblies, occurs from the phase of systems analysis (comprehensive cognitive identification) and specific diagnose (identification) of the environment through a systems synthesis (multidimensional conceptualization) and morphological representation of the values of nature, up to the validation[16] of the efficiency of the systems solutions.

As it concerns many domains of knowledge, the architectural design of a concrete object of architecture occurs in an analogical way. However, it is a specific and individual process being subject to known and unknown laws, perhaps also to morphology of the nature, a part of which we are.

Figures 12 and 13 present an image of the system of the nature, i.e. of the system of the reality. This is a time-space and dynamic vision of the world. The image of the system arises in cognitive processes being inspired by the activity of human intellects and the capabilities of mutual reactions with the environment. The world is a universe where universal laws are governing. Perhaps morphology and morphological analysis belong to these universal laws. One cannot reject this possibility as well as other logical possibilities before their empirical verification.

The system signifies a living environment of any nature and/or a morphologically and time-spatially ordered arrangement (assembly). The activeness of the system is characterized by the capability of maintaining an integral and energodynamic equilibrium respecting the laws of evolutionary coexistence, and a local and global integration of the system with the selected environment [18]. The considerations presented in figures 11–13 illustrate selected intellectual possibilities that are created by systems thinking and knowledge, particularly oriented

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[16] Validation – psych. – process of determining the degree of correspondence, correctness, purposefulness of a test, or of the validity, precision of a measuring tool (lat. validatus from validare "confirm", validus – "efficient, valid", lat. "strong" from valere). (W. Kopaliński, Dictionary of foreign expressions and foreign language idioms, Wiedza Powszechna, Warsaw 1999).

onto solving practical problems. These possibilities can be referred to architecture. The plurality of architectural conditions taken into account by the architect indicates the plurality of information items and their mutual relationships existing and being accepted in the design process. These information items concern different domains of knowledge and show the potential, and sometimes the intuitively used multidimensional conceptualization used by the architects. For example, such a conceptualization can concern an analytically examined, existing spatial environment (the so called environment of the object being designed) and a synthetic approach to the spatial architectural solution being created therein.

3. Methodological analysis of architectural processes

Thinking with the use of systems

The opinions being analyzed in this work continue the scope of problems concerning the phenomenon of human designing. Einstein stated that our thinking, wherein imagination is necessary, generally takes place without the need of using words, and besides, that it is to a great extent of an unconscious character [29]. This is a statement that is convergent to the practical activities of architects and to the opinions of present-day intellectuals: A. Collen, W. Gasparski, M. White, J.A. Wise, M. Bazewicz, Z. Wasiutyński, J. Sołtan, H. Skibniewska, and others.

The trial of a praxiological and methodological analysis, reconstruction and interpretation of a real architecture process of concrete architects was based on the opinions of: M. Bazewicz [13,19], W. Gasparski [1, 3, 34–40], S.A. Gregory [9, 42, 43], G. Nadler [88, 89], H.A. Simon [112–115]. These opinions indicate the fact that the design processes being applied influence the results of designing.

The method of morphological analysis is a creative method of design that may support architectural design. This work presents a trial of an objectivist description of the process of architectural design according to the contemporary interdisciplinary knowledge. The fact of renouncing the possibility of using the notion of model in the favor of a decision graph representing the organization of decision activity of the design-creating process[17] of the architect results from the fact there are no models in the nature. This fact is satisfactory to resign this notion during the analysis of design-creative processes of the architect in the favor of the notions *process* and *method*.

The nature to which we belong does not "use" a model or scheme. In such sense, the nature "uses" perhaps a method. This method being visible (observable) in this sense in the nature has been supported by documentary evidence in the above-discussed periodic classification of the elements, in its multi-variant solutions of the structure of matter.

[17] According to praxiology [34], unitary design-creative actions of the architect compose sequences of actions, which form creative design processes or, in other words, design-creative processes [36] with their complete specificity.

Independently of the justification of the above observation concerning a lack of models in the nature, and the undertaken systems description of the organization of the process of architectural design, the architect used, uses and probably will use models in his professional activity. For example, in the creative achievements of Le Corbusier[18], a French architect of Swiss origin, and Gaudi[19], a Spanish architect, these were paper or pasteboard models. At present, an architect builds models of architectural solutions with the use of a spatial computer simulation. In this aspect of practical realization, the use of models in architecture is fully justified and assures positive results. However, this has nothing to do with searching for models in the nature.

In technique (engineering), thinking with the use of models makes for many years its way of progress. As a result of arisen and being arising ecological destructions connected with a concrete development of technology (particularly industrial technologies), the question arises concerning the compatibility of technical thinking with systems of the nature. Together with the development of systems theory, informatics and computer science, as well as praxiology, the possibility appeared of making a choice, e.g. between "thinking with the use of models" and "thinking with the use of systems-arrangements".

In the architect's profession, the concrete practical usefulness and efficiency in solving the given problem situation should be decisive for the selection of one of these possibilities.

Problems of formulating needs in architecture

The professional responsibility charges architects to take their stands at the side of the human being [116] and of his/her various needs. The needs result from the human nature, among them from the psychical and physical nature, as well as from the development of technique and technology, mainly connected with building engineering, however not only with this domain.

Considering the needs in the process of architectural design, from the system- and ecology-based point of view, leads to confirming in this process the creative role of the architect being on the side of the man and his/her various needs. Architectural needs concern artistic emotions, useful qualities connected with the comfort of the future user of the (cubic) mass being designed, and its many-sided conditions. For example, designed spatial solutions should not exist without the fulfillment of technical and technological conditions. In the process of architectural design, being conditioned in a many-sided way, a correct determination

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[18] Charles Edouard Jeanneret, named Le Corbusier (1887–1965), was born in Switzerland. French architect, town planner, painter and sculptor. One of the most outstanding creators and theoreticians of the modern architecture. Coauthor of purism in painting, representative of functionalism and constructivism in architecture.

[19] Antonio Gaudi (1852–1926) readily used the morphological form in his architecture, among others in shaping the apartment building Casa Milá in Barcelona. This building is an example of the Catalonian secession.

of the needs [33, 88, 91, 98, 102] influence the active attitude of the designer towards the new problem situation. The new problem situation is connected with the appearance of new needs. The active attitude of the designer towards the architectural problem being solved and the new needs appearing therein is decisive to a high degree for the correctness and level of the later spatial solutions.

Searching for elements of a methodic order in architectural achievements

The theory of Fleck [32], dedicated among others to problems of knowledge methodology and sociology, shows the impossibility to delimit the scientific cognition and the sphere of emotions and values. This justifies carrying on considerations and analyses concerning the creative design activity of the architect. That is an activity being satiated by artistic emotions on the one hand and by objectivist thinking on the other hand. L. Fleck, basing on the theory of Kuhn [71], indicates the conditions in the scientific fact rising and developing. He treats the cognition act as a result of a historical development of thought. According to his views, each discovery requires a change of mental style. Also the use of systems knowledge and methodological knowledge in architecture requires such a change.

The development of scientific cognition in the 20th century is characterized by the fact that more and more attention is paid to ways and methods of scientific activity [14, 15, 33, 37, 80, 88]. Le Corbusier wrote: "one of the greatest treats of the human mind is to perceive the order of the nature and to measure one's proper participation in the arrangement of things: a work of art seems to us to be a work of ordering – a masterpiece of human order". He stated that each law, existing and experienced in the architectural space is nothing else as the statement of an existing order [58, 59, 76, 90]; perhaps is that a morphological order. It is possible that this order often influenced the architectural style of Le Corbusier.

Components of the architectural style

According to H.A. Simon, the components of the architectural style of an architectural object can objectively result from three sources: from a direct description of the finished object, from the processes applied to produce it, and from the processes of designing it, being fundamental for the features of the object being designed. Simon remarks also that, at present, a movement of the attention of the artist takes place from developing works of art to developing design processes [115]. Le Corbusier engaged a lot of time to deal with the processes of architectural design. However, he had not at his disposal the present knowledge on designing.

The scientific design, analogically as the methodology of design, is a systematic, rational reconstruction of proceeding of the architect, and discovers its complexity. On the base of practical and theoretical knowledge on the complexity of the object being designed, the architect-designer has a chance to make creative and more correct decisions. From the methodological point of view, the designed

architectural form can be considered as a whole composed of partial forms, or fragments, and be treated as a solution of synthesis. Actions undertaken by the architect in the design process can be accepted as to be a mental, combinatory composition, or aggregation of solutions: functional and constructional arrangements/assemblies, spatial forms, architectural details, spatial smaller or simpler solutions, etc., into a whole. The whole is e.g. a building that function and fulfill its tasks, analogically to an organism or system. Architects-designers apply in the design process elements of the morphological analysis, calling them a combinatory analysis (combinatorics) of forms. The combinatory analysis itself is a reproductive assembling. The morphological analysis is its higher, creative step, connected in architecture with a spatial artistic creation. The morphological analysis or its elements are more or less observable in creative achievements and processes of many architects. The being connected with this method processes of architectural designing performed by concrete architects, influence the design results, that means influence, as an effect, the architectural form.

4. Organization of design activities in architecture

Organization of the architectural process

The presented in this work organization of decision-making design activities in architecture is connected with problems of techno-social complexity [24, 25][20]. The organization of decision-making design actions of the architect, presented in fig. 14, is a scheme of actions of the multi-variant process of architectural design, having a form that is called a decision graph in design methodology and cybernetics (fig. 15). The proposed decision graph is one of the forms of morphological analysis. An extended form of the decision graph is the table of the tree of solution variants (fig. 16) [37, 113, 116).

The graph, presented in fig. 14, reflects the organization of activities of the architect during the design-creative process. It was formulated on the base of earlier experiences of the professional practice of the Author of this work, and of methodology-, system- and praxiology-based observations and analyses of the existing knowledge in the domain of psychology of creation [19, 25, 41, 48, 50]. It is connected with investigations concerning the architectural process presented in earlier works of the Author [91–102]. This graph presents the systems complexity and the hierarchical categorization of levels of transformations of the spatial environment being designed (e.g. referring to spatial arrangements/assemblies in town planning and/or to the architectural (cubic) mass).

[20] The multi-variant process of architectural design, proposed as a decision graph, is a not ethical process but not an anti-ethical one. This graph does not refer directly to the ethical aspects of designing and realizing objects of architecture. Ethics is being introduced from outside into the architectural and economic activities, and can be declared to be one of the criteria that limits the area of possible decision making actions.

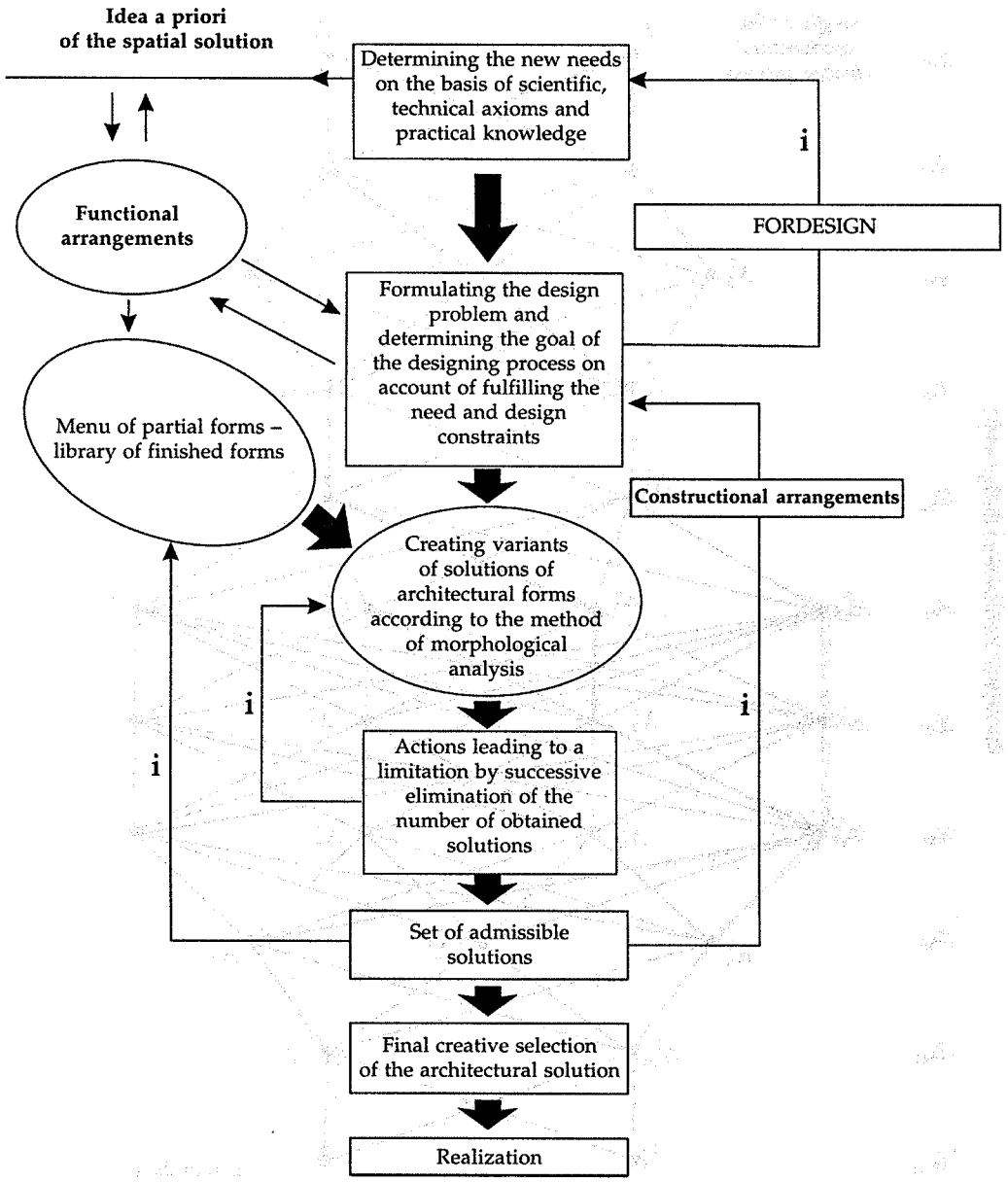
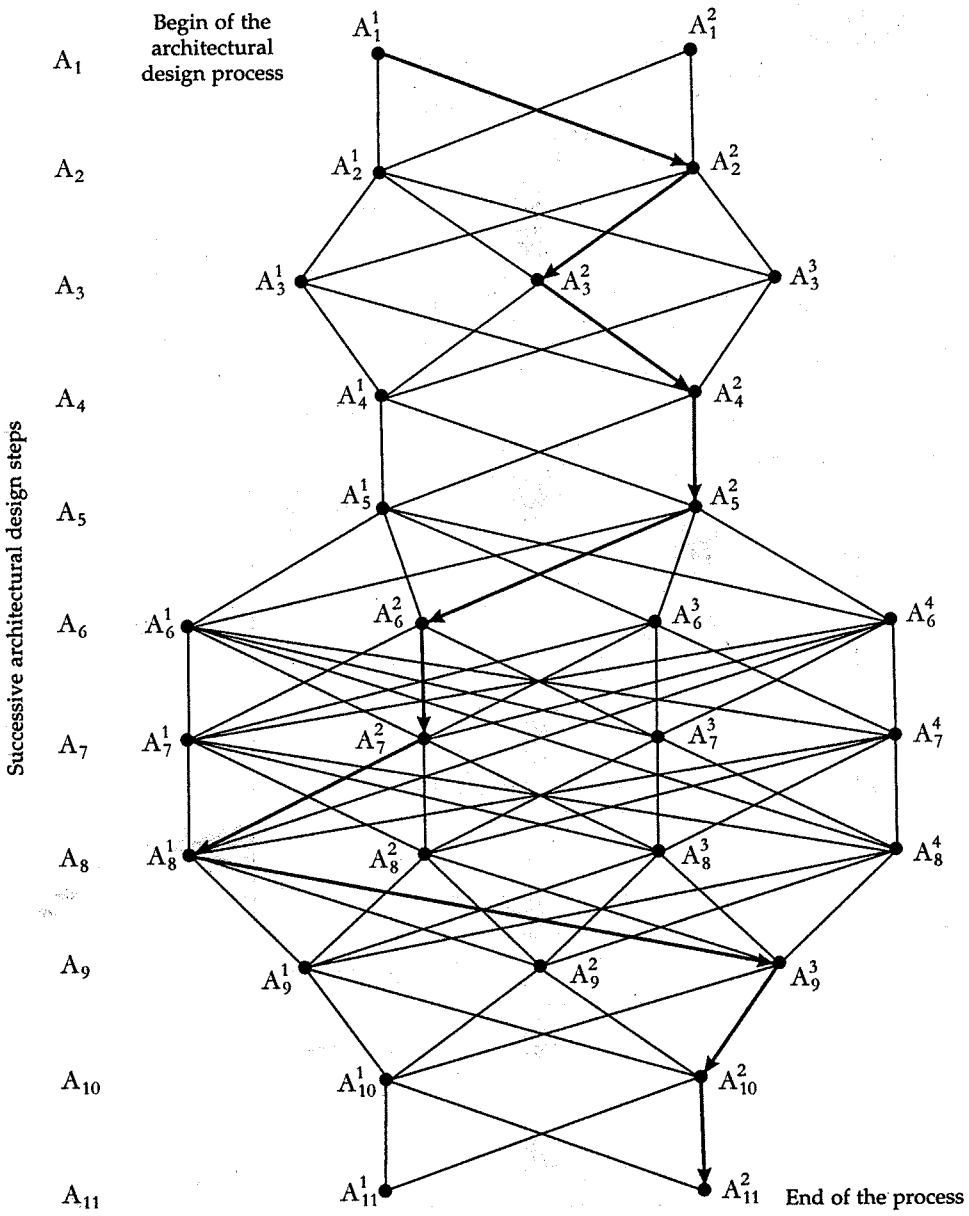


Fig. 14. Decision graph of the process of architectural design: i – iterations and feedbacks

One design decision has been determined in the decision graph by one operational action, and illustrated by the transition from one to another graphic point. Thus shaping (forming) the architectural object takes place, in the process of ar-



Number of paths (e.g. solutions of the architectural problem being undertaken) = 36864

Fig. 15. Cybernetic decision graph – form of morphological analysis used in technology

chitectural design, in successive designing steps (defining the decision making process) being undertaken by the architect, a group of architects or an interdisciplinary group [89, 95, 97].

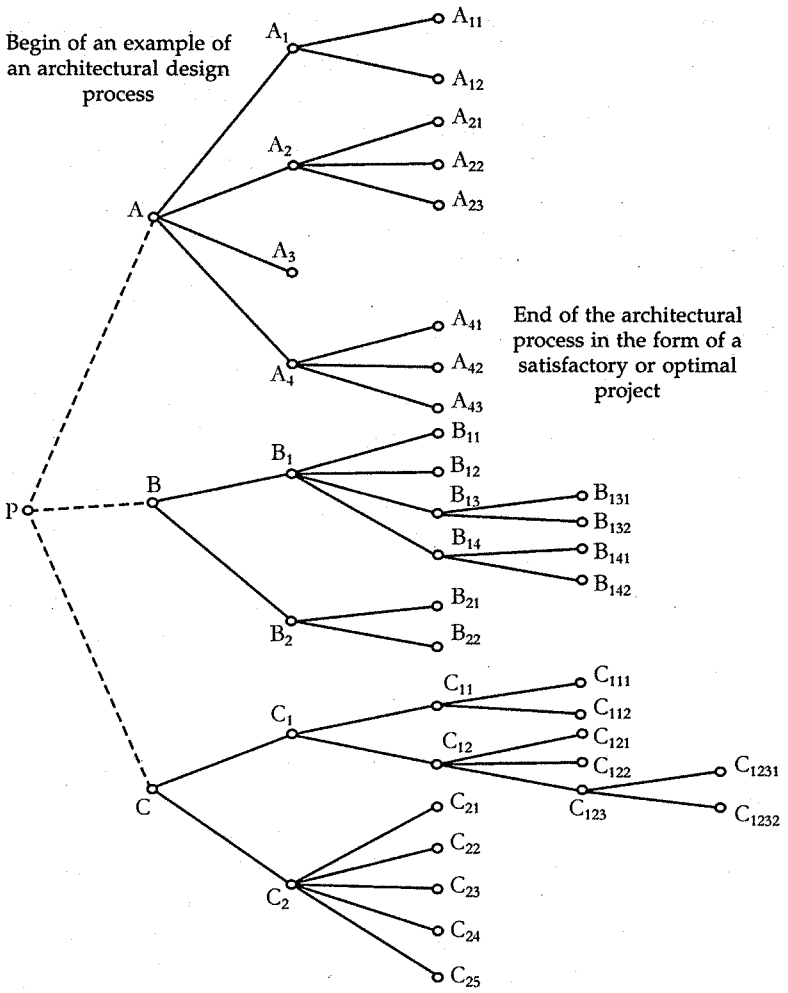


Fig. 16. Table of the tree of multi-variant possibilities of design solutions referred to architectural design [107, 116], one of the forms of morphological analysis. This table is referred to architectural design because the feature of multi-variant character of the solutions is a constant of the design processes in architecture.

According to the existing praxiological and systems knowledge, the following features and actions in the organization of the process of architectural design can be distinguished:

- formulating the task, examining the needs and design conditions,
- creating the ideas of the whole solution as a solution being accepted in anticipation, or a priori (it is generally the first draft of the architectural solution),
- taking into account the multidimensionality regarding the complex and interdisciplinary problems of architecture,

- analyzing the spatial solution as a solution that is possible to be divided into partial solutions, connected with generating and selecting variant solutions arising according to the will and the need of the architect,
- searching, through a formal modification, for satisfactory partial solutions that can lead to a modification of the earlier accepted solution idea,
- determining the being designed architectural form, covering basic functional problems, construction problems, installation problems and other problems, this form being elaborated in the final phase as the technical design project.

The process of architectural design is by nature a multi-variant process. It contains many spatial design variants arising in the imagination of the architect, these variants being considered as possible to be accepted.

In the real and theoretically considered architectural process (fig. 14), the decision graph can permit the architect to better penetrate into the design-creative actions and technical details of the designed solution, and to manage this process according to the current design need. Applying other methods can support the organization of the decision process in conformity with concrete design conditions and with the creative will of the architect-designer. This organization is presented in fig. 14. The graph shows multi-variant design-creative decision processes, possible to be realized, these processes being compatible with the method of morphological analysis.

Structure of the architectural process

The proposed on the graph above decision processes assure a possibility of modification. Modifications of the designed architectural form can result e.g. from taking into account additional information, the so-called inserted information, being obtained during the design process. This graph has been constructed according to the truth consisting in the fact that the process of architectural design is a dynamical process. The use of the graph based on the method of morphological analysis leads to better understanding and easier teaching architectural design.

The decision process enclosed in the proposed structure of the tree of multi-variant possibilities can occur in conformity with the will of the designer in a different way. The described decision process has no characteristics of a technical technological process because it is a creative process. The decision graph, according to the therein-accepted morphological method, indicates real possibilities of selecting different design **ways and paths**. These ways and paths are marked on the graph by arrows. They form a tree of multi-variant design possibilities. This is a today's acceptable systems approach to the problem, in conformity with the real aspects of architectural design. The structure of the multi-variant architectural decision processes, defined on the decision graph (fig. 14) permits to perform successive choices according to the vision of the architect-designer. The design process, chosen in such a manner by the designer, will influence the design results (4, 8, 9, 18, 84–88). In the proposed multi-variant decision graph of

the process of architectural design **iterations and feedbacks** have been marked. Such actions are applied in a general way in architectural processes. The structure of the proposed architectural process assumes and permits transferring the attention of the designer from the broader context onto a small detail of the solution of the designed architectural form, and inversely, i.e. so as it happens in the practice of architectural design. This permits the designer to think alternatively by analysis and synthesis what favors appropriate design decisions. During the design process, the architect examines many possible design decisions, and subordinates their selection to his/her proper creative personality, knowledge and design intuition, achieved by designing many houses.

In the practice of architectural design, the definition of the task on the base of problem formulation appears as the (first) phase I and leads to a preliminary determination of the fordesign. Fig. 14 constitutes a trial of a system-, praxiology- and methodology-based reconstruction and interpretation of the architectural process. The design decision process, described by the decision graph, can in practice start in any arbitrary point, chosen by the architect. This should take place after having determined the fordesign, that means after having considered and examined the conditions of the design problem. The decision design process was determined through successive actions according to the direction of the arrows and the marked feedbacks and iterations, and has been presented in the form of the tree of multi-variant possibilities. This tree is illustrated in fig. 16.

Methodological considerations of the organization of the architectural process are included in broader interdisciplinary considerations. Figures 17 and 18 concern processing of different information about architectural processes and systems perspective. They present the relation between method, conceptualization and theory, as well as the cyclical and interactive character of disciplinary information investigations (inquiry).

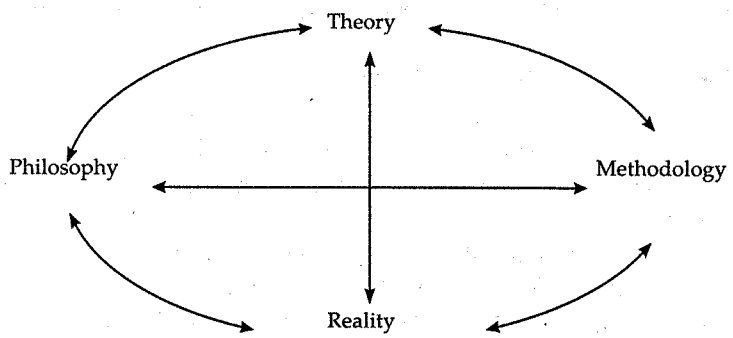


Fig. 17. The architect-designer incessantly considers relations between method, conceptualization and theory during designing. Architecture forms spatial frames of differentiated functions of the human activity and technologies realizing human needs and functions [18]

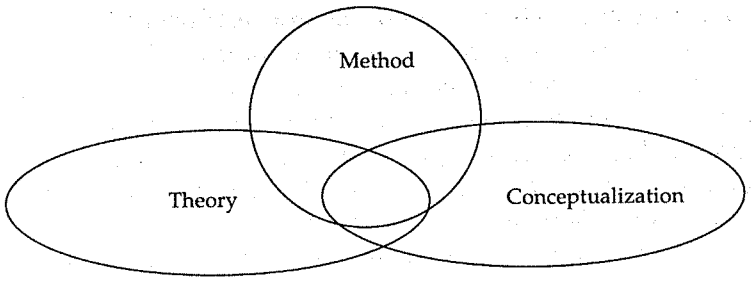


Fig. 18. Cyclic course of the interactive character of disciplined information investigation (inquiry) [18]

Conceptualization is one of the highest forms in the hierarchy of functions of human activity. From the notional point of view conceptualization means: inventiveness, images, rational conception (of something), intellectual representation of a given object, e.g. object of architecture [18, 23, 24]. An intellectual representation is connected with mapping or determining specific features from the viewpoint of the purpose. These are fundamental features in the creative activity of the architect.

Systems relations illustrated by these figures can be referred to the problems of architectural design being considered. Explanations concerning figures 17 and 18 are the base of methods of morphological analysis and design of architectural objects.

Different cognitive and conceptual processes characterize every creative architectural design. The aim of these processes is to obtain a multi-contextual function representation; the architectural form can be recognized to be such a representation.

5. Praxiological, decision making architectural process

Decision making actions of the architect

The present-day expansive development of architectural, systemic, praxiological, informatic, cybernetic and psychological knowledge shows the possibility and the justification of undertaking a trial of reconstruction and praxiological and methodological interpretation of the process of architectural design [23, 24, 25]. The presented reconstruction and interpretation of the process of architectural design can become useful in architectural designing and teaching.

In order to compose the design-creative actions of the architect, as intellectual actions, the existing knowledge and methods have been applied as intellectual tools of the contemporary science, as well as an objectivist language of notions of systems theory, praxiology and design methodology. Elements of design-creative actions of the architect have been presented as a scheme of the multi-vari-

ant creative process, being determined as the decision graph. In the presented graph, one architectural design decision has been defined by one operational action and illustrated by an arrow indicating the transition from one to another graphical point (figures 14–16). In this way the architectural object is shaped in the decision making process of architectural design based on morphological analysis, in successive design steps (that determine the decision making process) undertaken according to the vision, the possibilities, the knowledge and the skill of the architect. The presented decision graph of the architectural process is in conformity with the practice of architectural designing and has the form of a tree of multi-variant solutions. The multi-variant character of solutions is an almost permanent feature of the creative-design activity of the architect. The process of architectural design, being conditioned in many-sided aspects (therein, among others, in technical and psychological aspects), starts from the appearance of a determined need.

Determination of the needs and of the design purpose in architectural designing

In the specific process of architectural design, the determination of the needs takes place on the base of scientific and technical axioms as well as practical knowledge, and influences the formulation of the problem being solved and the design purpose, and a formal description of the fordesign of the investment.

The determination of different needs, among others spatial, economical, social, technical needs, permits to formulate the architectural design problem. This formulation describes the design purpose. The design purpose, being formulated in a general way, is subject to detailing in practice (what is indicated on the graph) on account of the fulfillment of the design needs and limits being determined in a more detailed way.

In the design of architecture, renouncing the **objectivist description of the needs** [22, 55, 91, 98] in favor of e.g. a purely intuitive description is not possible. During the design process, the designer performs his activity simultaneously on different decision levels, concerning e.g. the technical detail being elaborated, that is included in the general form and function of the architectural object and environment being designed. The designer uses alternatively in the design cycles analysis type thinking, e.g. concerning the technical detail, and synthesis type thinking concerning the whole of the solution. It's the decision graph of the architectural process that permits to perform such type of iterative actions.

The architect-designer takes into account many conditions of a concrete process, concerning in a more or less indirect way the concrete architectural problem being solved. Architectural designing, perceived as a capability and art of shaping the space of our environment, starts from assumptions concerning an integration of contradictory factors, and is functioning as a multi-criterion system. The arrangement of the criteria being accepted in this process is an ordered

presentation of requirements and constraints, i.e. a formal description of the needs the object or/and architectural environment being designed has to fulfill.

Determining and examining the needs is a complex action in architecture, variable in time, and hence the problems of needs contain forecasting elements and are connected with the theory and practice of planning investments as well as with psychology of creative activities. In such designing, the objectivist determination of the needs is an indispensable element permitting to perform the further designing process.

The determination of the set of needs, and as an effect, their hierarchical ordering being understood as their complete analysis, can protect the designer against design errors. In architecture and building engineering, a systems determination of the needs in connection with the formulation of the design problem being undertaken protects against wrong investment decisions. The architectural project is a function of the relation "creator – need". Such project arises as a result of acceptance of the necessity of realizing the technical means, on account of the fulfillment of the need or a set of needs being identified by an appropriate measure. The need is felt by the individual as a state of frustration because of a lack of a good with material or mental character.

When examining the bases of motives of the activity of the human being or of a community, one can accept that the existing unbalanced state or state of tension of the individual or of a community causes a determined behavior called action. This is a process of an aware change of the state considered to be undesirable or unsatisfactory because of a lack of fulfillment of a determined need, into a state where this need is fulfilled. In particular, this become evident in the case of fundamental needs, e.g. the need of habitation connected with the feel of security, i.e. in architecture and building.

Determining the fordesign in the praxiological decision graph

The determination of architectural design assumptions (fordesign) of the architect in the presented praxiological decision graph results from the destination (connected with the function) of the object being designed, from its environment and from many other conditions, wherein technical, constructional, material, functional, technological, financial, ergonomic, ecological, as well as social and environmental conditions in the culture, psychological, semiological sense etc.

In the practice of architectural design, the project comes into being in successive phases of development. The development phases can be connected with discussions during a group design activity, with the standards being in force, with the applied technologies, materials, agreements, verifications and modifications. During the design process, the variety of conditions of this process is taken into account to a higher or lower degree. The determination of the design assumptions is an indispensable element in real architectural designing, this element orienting and ordering to some degree this process in a formal way.

Idea *a priori* of the architectural solution

The main idea of the architectural solution often appears suddenly, *a priori,* in the architect's mind. It can be called an idea appearing by the so-called insight. This main idea becomes an idea being accepted in advance (being assumed), and used in the starting phase of the process. It is useful as a synthesis type aspect of earlier examined, basic design problems connected with the needs and goals of the enterprise (fig. 14).

The creation of ideas of a spatial solution is connected with designing functional arrangements/assemblies and formulating the design problem. Creating this idea is indicated in fig. 14. Iterations and feedbacks assure a practical possibility of a multiple modification and verification of the form according to the current need. These are actions in conformity with the design practice. The *a priori* idea can arise also in the mind of the architect-designer not only after having considered the functional arrangements or/and design constraints resulting from the accepted technology of the object, but also under the influence of artistic emotions. This idea can be an element of the design-creative process connected with design intuition of the architect.

Library of forms

In the proposed architectural design process, a possibility has been assured of a creative application of a broadly apprehended library of forms, or a menu of forms. This broadly apprehended library often is "in the designers' mind" and is connected with his/her psyche, his/her earlier design experiences and with artistic experiences and inspirations.

Problems of the form do not exhaust questions of complexity of the architectural object and environment. However, there is no possibility to perform any changes in an architectural project without change of its form. This principle refers also to the nature and its forms. An assumption made in the graph was the fact that the library of forms is formalized and contains **morphemes** (or partial forms). These are forms being earlier selected and assorted by the architect-designer. Then, these morphemes can be modified according to the artistic inspiration and the creative will of the architect-designer. The library is composed of "ready to use architectural forms", in contradistinction to ready to use building elements. It is assumed that individual creative predispositions, tastes and interests of the architect-designer will be decisive what concerns the assortment of its contents (i.e. partial forms – the so-called morphemes). This library is an element that supports the proposed creative architectural design process. Partial forms can be assorted form the library and modified according to the current need and creative imagination of the designer. They can be used e.g. to "building round" the scheme of functional arrangement and/or result from the being accepted idea of spatial solution. The library of partial forms came into being according to the example of what Le Corbusier was doing in his architectural design processes.

In order to maintain a transparency of the main arrangement of design actions in fig. 14, the possibility of modification of the graph resulting from the use therein of other supporting techniques [94] – to which can belong e.g. the strategy of ideal solution – has not been indicated.

There is always an excess of solutions obtained by the morphological method used in technique/engineering; not all the solutions fulfill the expectations, or goals and needs. The method of morphological analysis is a creative method, and by applying it in architectural activity, one can stimulate the spatial imagination of the architect-designer there where one wants it to do and consider it to be right, by creating e.g. sets of forms fulfilling determined formal, functional and technical requirements. Solutions obtained with the use of the library of forms can be in conformity with the being earlier assumed and examined idea of spatial solutions, with the accepted material, functional arrangement, construction and technology.

When being supported by the library of ready to use partial forms (menu of forms), the designer can create, in an easier way, variants of the design problems, modify and improve them.

Creating variants of solutions and successive elimination of variants

Analyzing solution variants is a permanent feature of the process of architectural design. The proposed process permits to obtain many variants of the solution. The further action that is repeatedly performed in the design process is a **successive elimination of variants**, taking place after their earlier development. That is an action being in conformity with the creative individuality of the designer. The elimination results in determining a limited set of **admissible solutions** and **selecting the optimal solution** (understood in architecture to be the best from among the admissible solutions). In the multi-variant process of architectural design **iterations and feedbacks** result in changing the solution through its modification. The elimination of solution variants can be performed in such a way as it is used to be in the design practice, through searching for and respecting more and more detailed conditions, e.g. material, technical, esthetic, conditions that eliminate previous solutions as well as details of these solutions.

Many architects do not abandon the first idea (or the *a priori* idea), and improve this idea or define precisely and modify the form, searching for detailed, better solutions. Such course of behavior has been marked in the decision graph as possible to be realized.

A final selection of the design solution in this proposed methodic design process (fig. 14) is not necessary if we accept that there is no solution being possible to be chosen and realized. In that case, the design has to be started form an arbitrarily selected action proposed on the graph of the design process.

It is possible to shape an architectural object in the described way, in successive design steps composing the proposed decision process [49, 61, 63, 92], because it is in conformity with the nature of human designing.

During the real design, the architect considers many times variants of solutions being possible to be accepted and realized. In such a way he/she intuitively constructs an individual decision structure of the design process. In that sense, the graph arises from practice of architectural design.

The praxiological description of the architectural design can assist the creative activity of the man, but does not replace his/her knowledge and talent. This description serves to improve design processes, and thus to improve the effects of the architectural design and the architectural environment. It creates new possibilities of better understanding and teaching as well as computer-based assisting the creative architectural processes [1, 12, 99, 110].

6. Methods of validation of the morphological analysis of selected architectural objects

6.1. Premises of systems investigation as well as methodological investigation of the architectural form

The existing and expansively developing systems knowledge concerning living systems, as well as the design methodology, are closely related to humanistic aims of the development of architecture. When undertaking the task of validation of the design method being accepted, concrete objects of concrete creators-architects were chosen. Here the proceeding was in conformity with what stated W. Gasparski, namely: " When searching for generalization, the individual item is ignored (...). A scientists, technocrat, bureaucrat, organizer – they all look to have nothing to do with the individual, unless considered in categories of types, medium cumulative quantities" [37, p. 95]. It has been accepted that observations of the general character of morphological features of the nature in many shapes (forms) are a base for searching for these features in certain forms of architectural objects being designed according to the individuality of the creator.

A building being designed is a designed whole [56] that is simultaneously a part of a greater whole, i.e. architectural environment. From the system-based and architectural point of view, values of an architectural achievement (work) as an architectural whole cannot be reduced to a simple sum of parts. According to the theory of living systems, the architectural whole can be considered as a functioning organism.

Morphological forms are recognized as forms that are relatively easy to be modified and subject to multi-sided conditions that should be fulfilled by an architectural object. These are, e.g., spatial, constructional, technical, technological, psychological and other conditions. All the mentioned conditions, and other ones, influence the architectural (cubic) mass to be designed.

The architectural form is a result of acceptance and realization of a great number of general and particular conditions, criteria, needs, possibilities and constraints. In order to obtain a faithful character of the undertaken investigation of

the architectural design, it has been accepted that the existing knowledge on design should be applied, this knowledge representing achievements of many intellectualists in different domains of science and knowledge about facts concerning real processes being performed by concrete architects-designers [4, 16, 26, 105].

As the morphological analysis was judged to be an intellectual instrument that is possible to be generally applied in designing and teaching architectural design, its validation has been performed, i.e. the determination of adequacy, correctness and usefulness of its application in architecture. Morphological analyses were performed through a decomposition of spatial forms of selected architectural objects [90, 93, 99], searching for an application of the morphological method (or of its elements) in the process of their creation. The performed in this way empirical investigations of concrete architectural mass forms having morphological features are a verification of the application of the morphological method of or its elements in real processes of architectural design.

The decomposition method is a method that is accepted and applied in many domains of knowledge. In processes of architecture designing and modeling, designers use alternatively composition and decomposition in a natural and easy way.

The methodological analyses being performed concern:

- the decomposition of architectural forms of selected achievements (works) of Le Corbusier [58, 59, 61–63, 76, 90] showing morphological features,
- the documentation analysis of drawings of design processes of Le Corbusier [62, 117],
- the methodological analysis of contemporarily realized architectural objects of F.O. Gehry [42, 43] with morphological features,
- the use of knowledge on design processes and theory of architecture [38, 41],
- the application of architectural knowledge resulting from the experience of the architect-designer.

What is the difference between science and skills?

Vitruvius stated in an amazing and right way, in conformity with the contemporaneous experiences and knowledge, that builders who did not possess theoretical knowledge are capable only to reach mechanical achievements and that they do not influence other people by their inspiration. And those who base only on exact knowledge seem to follow a shade and not the reality. Only those who had mastered precisely both theory and practice are in possession of an efficient arm to achieve, with a general appreciation, the goal they had traced out [127].

Beside knowledge, skills play an important role in the process of architectural design. In scientific analyses of practical architectural problems, it is worth returning to the question that can be found in the considerations of W. Tatarkiewicz: " What is the difference between science and skills?" First, a separate accurate observation and single true theorems and statements are not sufficient to constitute a science. A general awareness that things appear to be so or so does not

constitute a science. This awareness has to be analyzed and expressed in the form of theorems by means of notions. Finally, it is not enough to know something, but it is necessary to prove and demonstrate it to be so. In other words, knowledge being possessed by the man must be ordered, analyzed, proved in order to be acknowledged as scientific knowledge. Else such knowledge is just only skill and not science. Generally speaking, science requires not only "to know" but also "to understand." The aim of science is different with regard to the aim of skills. The aim of science covers also truths being interesting by themselves, when in skills the question concerns only valuable truths from the practical point of view [121].

Figures 16–18 present a continuation of these considerations from the systems viewpoint. These figures concern the relations between context, method, conceptualization and theory. Problems that are discussed there can be referred to the problems of architectural design. Methodological analyses that were carried out, together with the mentioned figures, are a proof of a high degree of complication of architectural creative processes and the connected therewith degree of recognition of design problems in conformity with praxiological, methodological and systems knowledge.

In this work, a trial was carried on of connecting the theory of architectural design with the practice of that design according to systems knowledge and analysis of the design-creative activity of the architect. The investigation of the design process was undertaken through an analysis of its effects, i.e. of selected objects of architecture.

The design process as a source of artistic successes of the architect

In the design process in architecture various problems of the human being in space are solved, and divisions of the process are performed. In these divisions are taken into account, for example, technical, technological, ergonomic, psychological requirements as well as the relations between them. The influence of such conditions can be found in the architectural form being designed, i.e. in the building.

Among the formulations of G. Nadler, the following are worth mentioning: "It is beyond dispute that the process applied in design influences to a high degree the results. Engineers and professional designers should abandon the traditional schemes and begin to apply multiple approaches, what is required by design in the reality. Continuing investigations on design processes permits to obtain better methods than the method we have at present" [88]. Le Corbusier spent much time and paid a great attention to elaborate multiple descriptions of his design processes. He considered the sketches from his design processes (and not only the concrete realizations) to be particularly valuable and worth studying in the future [61]. A part of the critics of his creative works followed his design process and searched there for the sources of his artistic successes. It was mainly with that end in view that the presented analysis of the design process was car-

ried on in the first period of methodological investigations [96]. As a result the method of this architect has been discovered.

Method of architect's working

Z. Giedion, who belonged to the scientists in the domain of synthesis of the 20th century, and historian of art, engineer, stated: "The present-day problem is not to popularize science. In our period, it is considerably more needed to reach an understanding and a general opinion on the dominating methods in various domains of human activity. Through an increasing similarity of methods, different fields of activity in our times are convergent so as to form one multi-thread culture" [44]. Such a possibility is assured by the contemporary progress of praxiology, methodology and systems knowledge.

Le Corbusier paid a great attention to the processes of arising of his works and achievements being conditioned in a many-sided way, namely conditioned technically, technologically, according to the most modern trends and achievements of the development of technique (he applied, for example, the most modern achievements what concerns the use of reinforced concrete constructions), and independently conditioned by the environment, that means not only by spatial features of a concrete environment of the building being designed, and by user's needs of different nature (e.g. of a student passing through a being built up site between studies carried on in not very distant pavilions, that means so as it takes place in the Carpenter Center). In his not conventional processes of reaching the conception of the project, he elaborated the method known in engineering as the method of morphological analysis.

The conception of a project is developed in the first phase of the design process, and then, in the further phases it can be technically elaborated. This approach, and the method that arises from this approach, is reflected in the morphological construction of the form of his architectural works. He considered he got to the bottom of the sense of architectural logic: **" I have discovered the fundamental principle: the architect creates words** –we will see". (Etude sur le mouvement d'art décoratif en Allemagne. La Chaux-de-Fonds 1912, according to [60]). When treating, according to the praxiological and systems knowledge, the expression of Le Corbusier "**principle**" as **a method of working**, one can discover in his creative achievements a creative method and its traces of reaction on the form of the architectural work" [61]. For example, architects often underline that in the Ronchamp Chapel[21] (fig. 19), the ceiling floats above the walls, and that the ar-

[21] The pilgrim church (Chapel) in Ronchamp (1955), built on a hill in the Vosges Mountains, on the place of a church destroyed during war hostilities. The reinforced concrete construction forms an architectural sculpture having morphological features. It is an example of an organic architecture. Users and visitors often compare this building with a mushroom. In this building, Le Corbusier assigned an important role not only to the form but also to the light. Le Corbusier has not leveled the surface of the ground being naturally corrugated so that, when walking inside, one feels distinctly the shoulder of the hill under feet [73]. The bent arch of the hill is a form being repeated in the building, in different modifications. This is also proved by the carried out decompositions of its architectural projections.

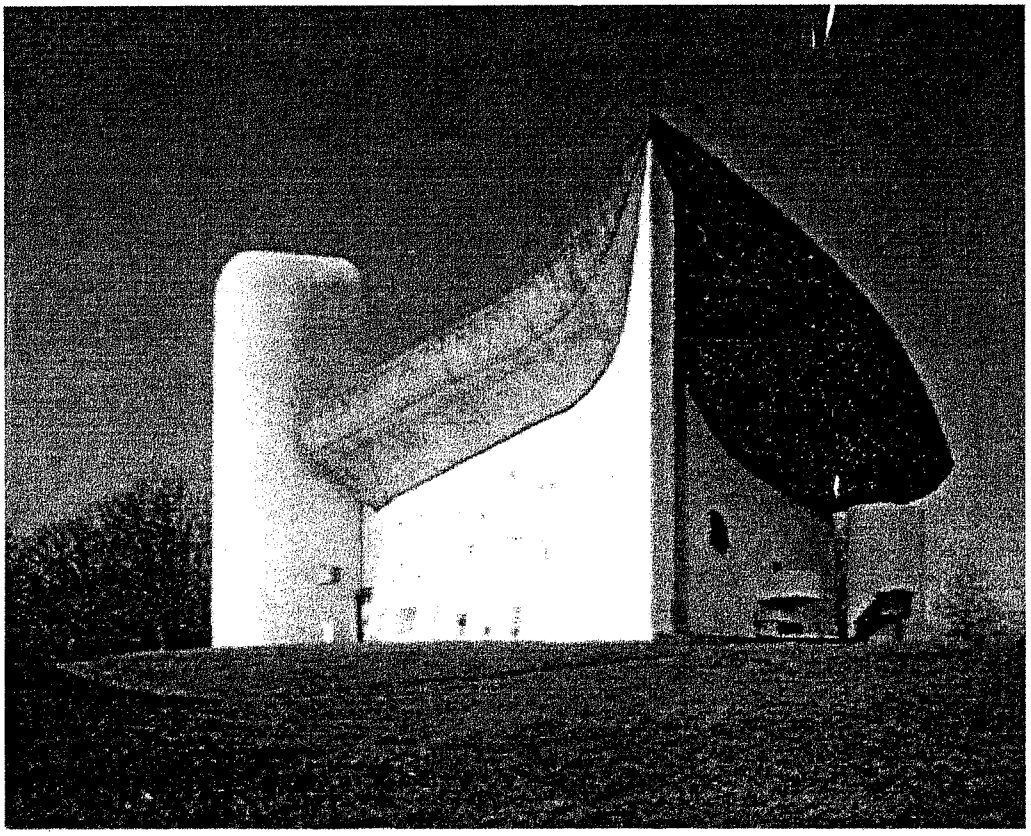


Fig. 19. The pilgrim church in Ronchamp, of Le Corbusier, view. The (cubic) mass has morphological features showing relations to forms of the nature. [Encyklopedia Powszechna PWN , 2000]

chitecture of this building is a metaphoric story about overcoming the (force of) attraction. The question arises: by which means the effect of an artistic experience of the observer is obtained? This effect can be seen and found in the achievements of many other architects [57–59]. When treating concretely the notion of *means* as *method*, and accepting that the method arises from "means", then it can be certainly confirmed that many architects, and among them Le Corbusier, had and have their proper ways and methods of designing. The method is a bridge between architectural theory and practice.

According to Ch. Jones [63], all the so numerous facts of searching for new methods suggest that we collectively search not only for new procedures, but also for new purposes and for another level of achievements. It is possible to reach this level thanks to the development of the present knowledge and science, particularly thanks to methodology (namely design methodology), systems and informatic (computer science) knowledge.

6.2. Morphological construction of the architectural form of the Ronchamp Chapel

Reconstruction of the behavior of the designing architect

W. Gasparski remarks: "A praxiologist realizes that an active human being takes his/her choice between different possibilities, by preferring one of these possibilities to the others, and that he/she performs it not in words being thought or pronounced, but in manifesting it by his/her actions" [38, p. 82]. These words and actions referred to designing, form the structure of the design process, which influences the (cubic) mass of the building being designed [39].

Scientific designing (also in architecture), analogically to the methodology of sciences, is a systematic, rational reconstruction of the behavior of the designer. Such reconstruction requires, according to Z. Wasiutyński [122], "a previous reflection on the handicraft of the designer" and a due consideration ordering the design experience (thus know-how knowledge [26, 64]) based on a methodological knowledge. From the methodological point of view, it is the effect of a complicated and conditioned in a many-sided way intellectual process. In the present developing systems knowledge as well as praxiological and methodological knowledge, there exist notions, ways (means), strategies and methods by means of which intricate and complicated particular architectural actions can be described. It results from such description that elements of the morphological analysis are intuitively used in complicated architectural processes of many creative architects [101, 102]. The decomposition method can be helpful in proving this thesis and the methodological reconstruction of the design process of a concrete architectural form. A decomposition carried out for a selected form, e.g. for the form of the Ronchamp Chapel, and its methodological analysis, reveal the use of the morphological methods or its elements in the architectural process. This concerns also other architectural (cubic) masses being selected for performing methodological analyses. As a result of the progress of the contemporary multi-disciplined knowledge, particularly knowledge on systems theory and methodology, a new notional situation is observed in science and engineering. As a result of this progress, a methodological analysis of the construction of architectural forms has become possible [132, 135].

Assumptions of the methodological analysis and decomposition of the architectural form

The following assumptions constitute a starting point in the being carried on methodological analysis and decomposition of the architectural form:

1. The principle of Lull's Art [41, 78, 90] is the pre-concept of the method of morphological analysis, which is a purely mechanical assembling.
2. The morphological analysis is a creative method [41, 56, 129–134], it results from a conscious selection and thus it has nothing to do with purely mechanical assembling.

3. The successive selection decisions in the design process of Le Corbusier result from many architectural conditions of the being realized architectural aim.
4. The process of architectural design, based upon the method of morphological analysis, is a decision making process and can be performed according to systems knowledge.
5. The process of composing the selected architectural form can be determined and identified by a decomposition of the form into component elements.

The aim of the methodological analysis and decomposition of the form of the Ronchamp Chapel is to determine the basic partial forms composing the architectural form being analyzed, this determination leading to the identification of actions of the process of its designing.

Methodological analysis and decomposition of the architectural form of the Ronchamp Chapel

The most difficult task in applying the method of morphological analysis, in particular in its applications in technique (engineering), is to determine the morphology of the solutions. The quality of results of the method depends upon the correctness of such determination [41]. This is a heuristic action, solved by Le Corbusier by "assembling" the architectural form from partial forms, being visible among others in his previous painting and architectural works. Thus, it results that he used the formal division of the architectural (cubic) mass.

In the decomposition of the architectural form of the Ronchamp Chapel (figures 19, 20) [76], a division into partial forms (morphemes) was performed, which are present e.g. in the purist painting of Le Corbusier (fig. 21) [25, 60, 90] and in his architectural artistic achievements (fig. 22) [58, 76].

The decomposition of the horizontal projection and of three façades of the Ronchamp Chapel (fig. 3) was performed in a precise way so that it was possible to reassembly the obtained elements into the original whole (fig. 24). The division was made according to the selected partial forms that were judged to be imposing forms. Fig. 24 is a documentary evidence of the obtained in such a way sets of partial forms. After having performed the decomposition of three façades and of the horizontal projection into partial forms, the obtained forms were assembled to create three sets.

The oval-like partial forms obtained as a result of the decomposition, or their small modifications form **set I** (fig. 24). These forms can be confirmed in the purist painting of Le Corbusier (fig. 21) or, for example, on the town development plan of Algiers (fig 22).

Set II of partial forms (fig. 24) is composed of forms of the same type, that means of arcuate lines set up under a sharp angle. Theses forms or their modifications are visible on the presented and analyzed works (figures 21, 22).

Set III is a set of partial forms being fragments of a rectangle or its parallelogram modification. In this set, partial forms belong to forms that are currently

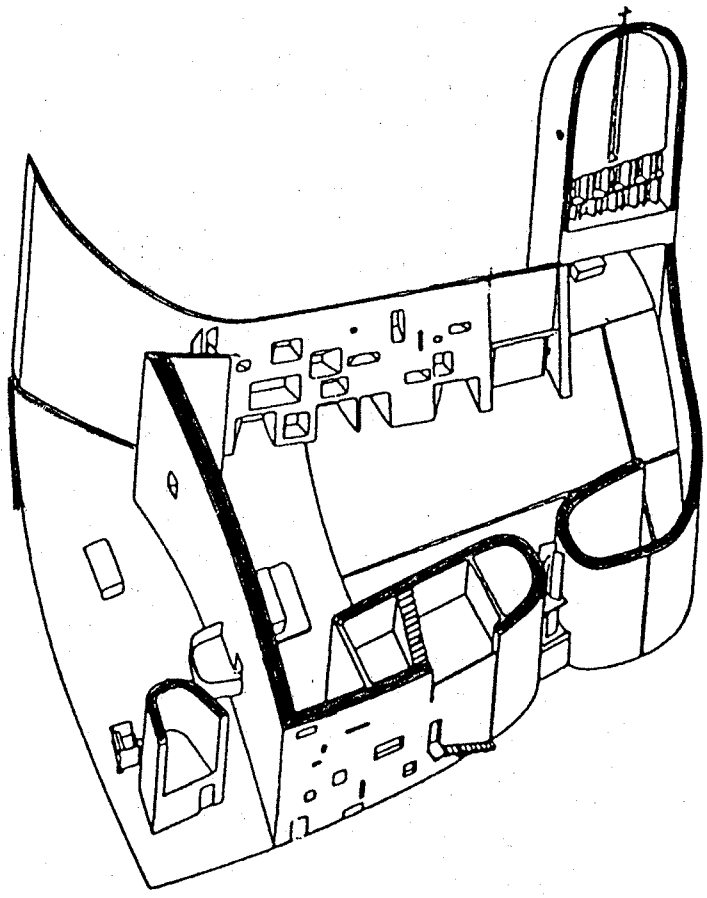


Fig. 20. Axonometric view of the architectural mass form of the Ronchamp Chapel of Le Corbusier, and its relations to the forms of the town development plan of Algiers (see fig. 22). The black thickened forms accentuate the morphological construction of the form of the object

used in the architecture. This subset arose after having removed the forms of the sets I and II.

In the method of morphological analysis, used in architecture, many divisions from different points of view, not necessarily formal points of view, can be performed [112, 115, 130].

Critics of the artistic achievements of Le Corbusier stated that a lack of full consistency, notwithstanding easily determinable and "perceptible from the plastic art viewpoint" principles, is a feature that is characteristic and visible in his creative works [90]. The aim of decomposition is, among others, to find these "plastically perceptible principles".

The decomposition of the architectural form of the Ronchamp Chapel was performed by its division into partial or simple forms, on which the "Le Corbusier's

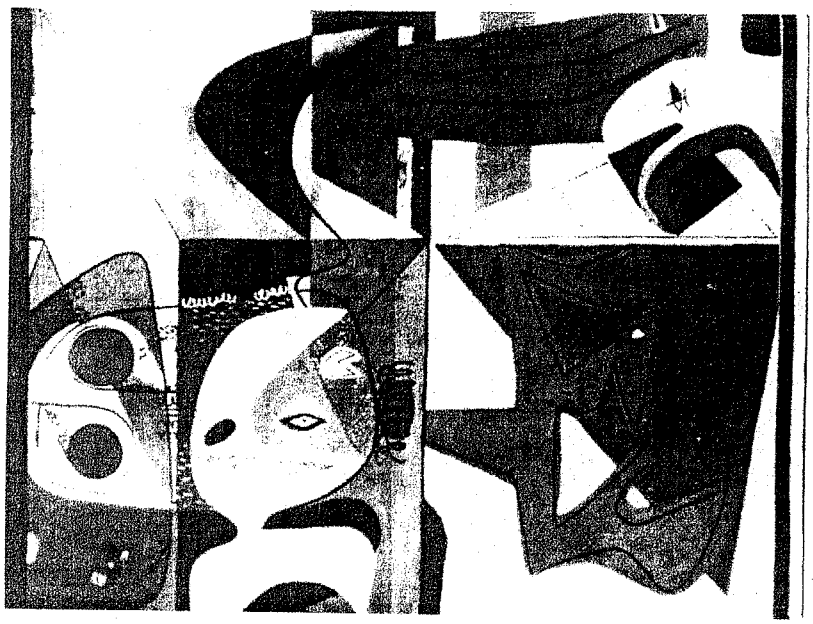


Fig. 21. Le Corbusier, Taureau XV (1957) with exemplary, marked forms x_1, x_2, x_3, the modifications of which can be found on the view of the plan of Algiers [60]

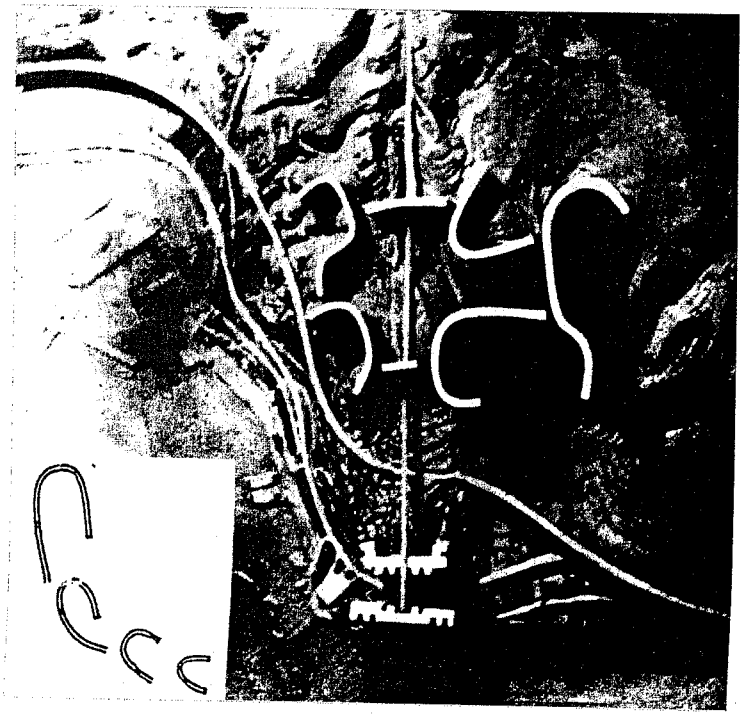


Fig. 22. Le Corbusier, Plan of Algiers (1930)

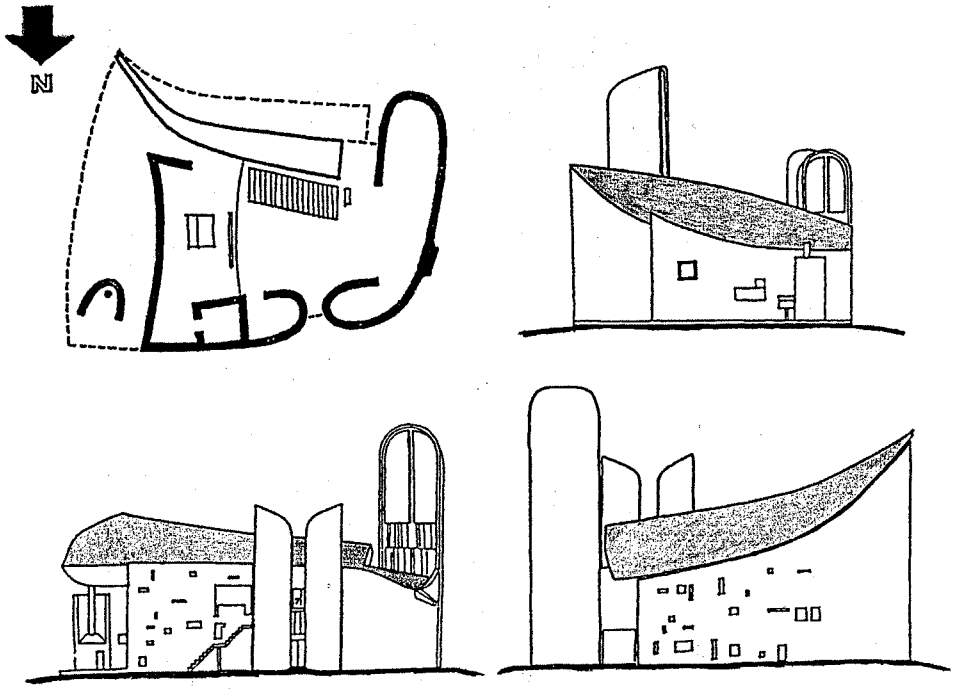


Fig. 23. The pilgrim church in Ronchamp. Three façades, among them the south façade with the main entrance, and the scheme of the horizontal projection. Architectural drawings

painting and architectural creative works do live". From the viewpoint of possibility of use of the method of morphological analysis in the architectural creative process, it is important that sets being obtained after decomposition demonstrate a limited number o form types. Thus, the conclusion is that these are forms obtained by selection or a conscious choice, and that the analyzed architectural form of the Ronchamp Chapel was obtained by assembling forms, preceded by a previous selection connected with verification. This assembling that results in the coming into being of an architectural (cubic) mass with a concrete construction, this form fulfilling many conditions and constraints of the creative process, is a creative choice. The conclusion is that assembling partial forms leads to assembling the complete, final architectural form and results from a creative assembling of parts into a whole. This constitutes an essential element of the method of morphological analysis.

The morphological character of the forms of the Ronchamp Chapel results from the characteristic feature of this method and is a proof of the use of this method by Le Corbusier in the design process being analyzed. The carried out decomposition shows that this sacral building was designed in conformity with a method where the value of the solutions is connected with the value of analysis. Those are features of morphological analysis.

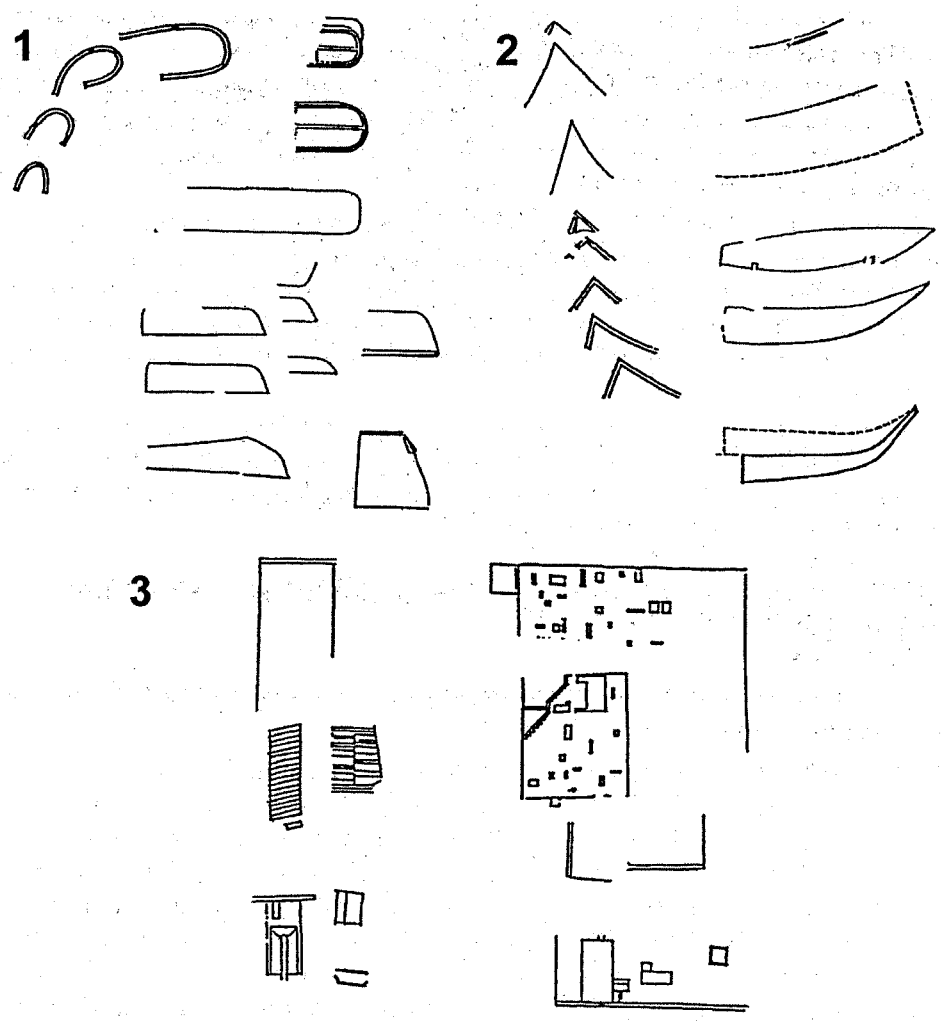


Fig. 24. Decomposition of forms contained in fig. 23. Three subsets of oval-type partial forms, approximate oval-type forms and rectangle fragments forms

The principle of Lull's Art, consisting in a pure assembling, could not be sufficient for Le Corbusier as designer, because his projects are strongly acting by their living form and logic of contents and result in coherent, formally logic wholes. Forms assembled into the architectural (cubic) mass constituting the whole, fulfill many architectural, constructional and other conditions, and it is difficult to declare them to be an accidental agglomerate of forms.

The carried out decomposition proves the application by Le Corbusier of the morphological method in the design process of this sacral architectural form and confirms the thesis that the number of partial forms being used there has been limited to three types.

The analysis of the process being realized by Le Corbusier leads to the statement that it is a methodic architectural process. This assures the possibility of a further, more general use of these experiences for applying the method of morphological analysis in architectural design. The comparative analysis of his creative achievements, performed by J.Ch. Jencks [61], G. Nagy [90] and R. Kellett [64] appeared to be helpful in this inquiry.

It cannot be confirmed that Le Corbusier used the morphological analysis in a fully aware way, as he never mentioned this method in his books and numerous writings. However, one can speak on an intuitive use by him of systems thinking in the process of design of architecture. In the outstanding mind of Le Corbusier, this creative systems thinking was concretized to the form of the morphological analysis.

It results from the performed methodological analysis of the architectural project of the Ronchamp Chapel that Le Corbusier used to apply such design principle that, in the present-day interpretation, is in conformity with what is called the method of morphological analysis.

6.3. Morphological construction of the architectural form of the Villa Savoye

Methodological analysis and decomposition of the architectural form of the Villa Savoye

Villa Savoye[22] (fig. 25) has been chosen to another validation of the method of morphological analysis. This building contains morphological features. The project of the villa is considered to be one of the more precise projects being realized by Le Corbusier. The description of the form of the Villa Savoye, carried out by means of the method of decomposition, appeared to be a surprising precise description, as it was exact, clear and verifiable. This confirms the use of the method of morphological analysis in the process of architectural design, which derives its origin from painting. It constitutes the proof of precision of the method of morphological analysis being applied as an intellectual instrument in the architectural process.

There exist, in the rich artistic achievements of Le Corbusier, such painting works of art that chronologically precede the selected here architectural works

[22] There are two villas that are characteristic for the purist period of Le Corbusier: in Garches (1927) and in Poissy (1929–1931) near Paris. The Villa Savoye in Poissy has been raised as a luxurious weekend house. These villas present regular spatial mass forms where elements are freely disposed, as in a purist painting. In the project of the Villa Savoye, Le Corbusier proceeds with a geometrical consistence. The Villa Savoye is a "box on columns" [61]). The white mass form, "suspended" above a green field is even to-day a shocking achievement. To this villa one rides up along a way that runs round the ground floor of the building between supports and forms a bend determined by the turning radius of a car. From the ground floor where are the servants' rooms and the economic accommodations, further access is assured by a ramp running through the entire building or by a stairway.

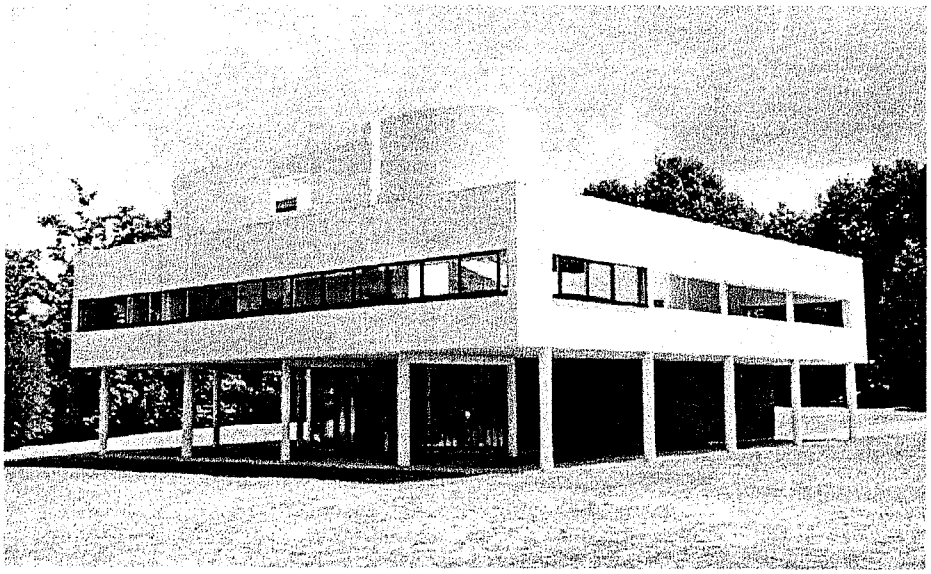


Fig. 25. Villa Savoye in Poissy (1929–1931), view. [Encyklopedia Powszechna PWN, 2000]

and that show many common elements of form. It is possible that it happens analogically in the creative achievements of many other architects. Le Corbusier-architect is not the only designer who considered architectural designing to be a complex process, not subordinated, for example, to one parameter. His spatial solutions fulfill many functional constructional, material and esthetic criteria. Design decisions taking into account a number of different aspects, thus being an aggregation of partial evaluations resulting among others from the method being used, are characteristic for the process of architectural design of Le Corbusier.

In this context, it was accepted that this creative work being selected for analysis and decomposition shows morphological forms. The horizontal view of the roof terrace of the architectural project of the Villa Savoye (fig. 26), being analyzed by decomposition[23], demonstrates plastic-art relationships of form, thus formal relationships with the purist composition "Still life with a heap of plates" (*Nature morte á la pille d'assiettes)* of 1920 (fig. 26). When comparing the painting with the selected architectural horizontal projection, one clearly sees a visible repetitiveness of a characteristic form in its different modifications, visible on the architectural view. This form can be found on the purist painting presented in the upper part of the figure. On the painting, this form is composed of objects

[23] The higher floor of the Villa Savoye is surrounded from all sides by band-form windows, being later often used not only by Le Corbusier. It constitutes the residential part of the building and is of an "L" shape, with a terrace on one side.

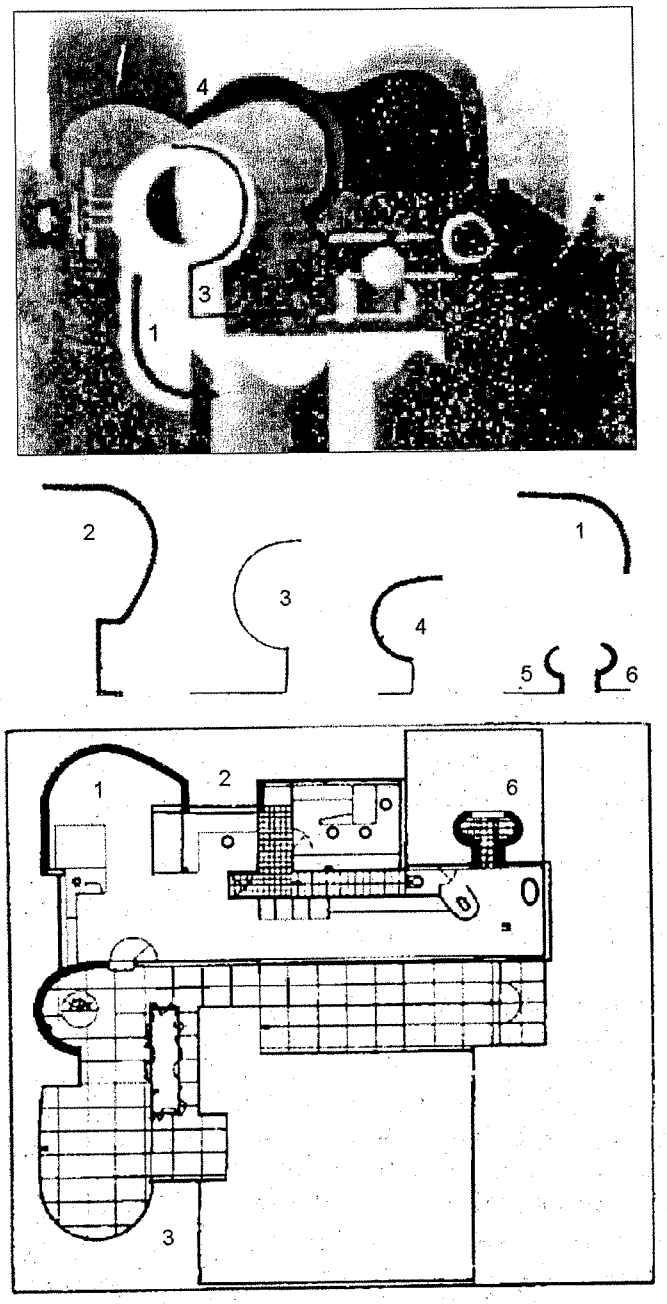


Fig. 26. Methodological comparative analysis (performed in earlier versions with computer assistance) of forms found in the painting of Le Corbusier "Still nature with a heap of plates" (1920) (top of the figure), and in the horizontal projection of the Villa Savoye (bottom of the figure). These forms have been black accentuated on the painting and the horizontal projection, and assembled together in the middle of the figure

together with the painted shadow thrown by these objects. The dominating form in this purist composition is repeated in some modifications on the horizontal projection of the Villa Savoye. It results from this reasoning that the discussed painting composition being discussed was an experimental laboratory for Le Corbusier

Originally, the analysis and decomposition of this architectural work were computer-assisted by an IBM PC 486 with graphic card VGA and with the use of the Turbo Pascal 6.0 system [94, 96, 99], and the Curb 1 computer program of the Author. In the undertaken methodological analyses, the dominating form on the painting composition, presented in its different modifications in fig. 26, was identified with a geometric precision as a form composed of three simple forms (oval, circle and rectangle fragments). These forms "appear to be true" with regard to the plastic art aspect.

It results from the carried out methodological analysis of the Villa Savoye that Le Corbusier applied in this project the design principle which in modern interpretation is conform to what is called the method of morphological analysis.

The buildings of Le Corbusier call forth artistic emotions of the users and observers; their architectural forms are internally coherent. These buildings constitute compositional wholes. The notion of *whole* is used when defining a system: systems are wholes that stop functioning after their decomposition. There is no need to prove that the beauty emanating from a coherent architectural whole is really acting upon the receiver-user.

Application of the morphological method in the creative process of Le Corbusier

In the creative design process being realized by Le Corbusier, this process deriving its origin from his proper painting compositions, the setup (assembling) of forms and their reduction through a creative selection, is the result of conscious design decisions[24].

When proving the application of the method of a system-based and systematic, conscious assembling of smaller parts of forms into greater forms in architectural design, one demonstrates, to say the least, the use of Lull's Art. It is difficult to consider the creative achievements of Le Corbusier to be a conglomerate of forms, and it is difficult to search there for chaos. Therefore, it has to be accepted that Le Corbusier made his creative option among possible, further assembling actions and formal modifications, and that constitutes the main feature of morphological analysis. Such creative process does not result from mechanical assembling smaller forms into greater ones. The decomposition of the Villa

[24] When constructing his first definitions, Socrates stated that, if we do not know "what it is", we should ask "What it's not, what we are examining" [121], that means that he used a principle in his philosophical inquiry. The sets of answers realized according to this principle in the so-called Tables of Socrates are a testimony thereof [121].

Savoye proves that it was designed according to a method where the value of solutions is in relation to the value of analysis. These are morphological features. This leads directly to the conclusion that it is the method of morphological analysis.

It results in particular from the comparative analysis and decomposition of the two creative works of Le Corbusier, chosen as exemplary achievements, that:

- for Le Corbusier, the painting artistic achievements were an experimental laboratory where a study of construction of the form was taking place,
- his architectural creative activity is conditioned by the painting creative activity, particularly of the purist period,
- the painting composition "Still nature with a heap of plates" has been used, in the process of architectural design performed by Le Corbusier, as a set or menu of forms or, in other words, as a library of forms. Le Corbusier drew partial forms from this painting for the architectural project of the Villa Savoye. These forms were identified as three basic types of form, named in the methodological analysis simple (partial) forms. It was proved that these forms in certain of their modifications were assembled into the architectural form of the horizontal view of the roof terrace of the Villa Savoye, with a geometric precision being confirmed by previous computer assisted investigations [96, 102].

A methodic decomposition and a comparative analysis of the creative works of Le Corbusier demonstrate the thesis concerning the application of morphological analysis in the process of architectural design being performed by this creator.

6.4. Morphological forms of the Energy Forum in Bad Oeynhausen and of the Guggenheim Museum in Bilbao

Architectural forms of F.O. Gehry, having morphological features

Compared with the classical description, the present knowledge and language of praxiology and systems theory assures new possibilities of an objectivist description of the problems of the architectural environment. For example, an architect who designs an architectural form considers mutual relationships and conditions of the spatial reality, e.g. location [23, 24, 52, 67, 116, 117]. As an effect of such reasoning, the architect searches for mutual proportions between the parts of the whole being designed: the architectural form and the existing environment. According to systems knowledge and design practice, many morphological divisions into parts can be performed in the imagined or designed architectural work or building, depending upon the knowledge about architectural handicraft, creative vision and fascination of the architect e.g. by art and technique (engineering) and their mutual relationships. Architecture is an environment with applications of many traditional and modern technologies [103–105, 108].

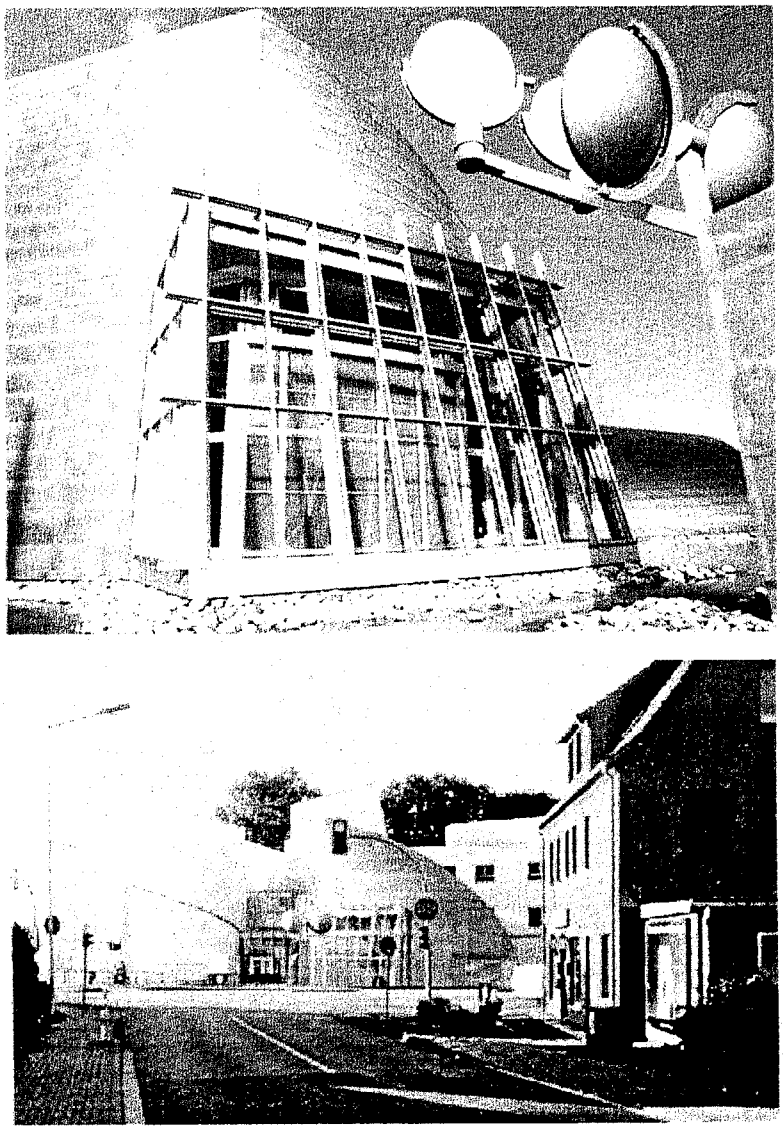
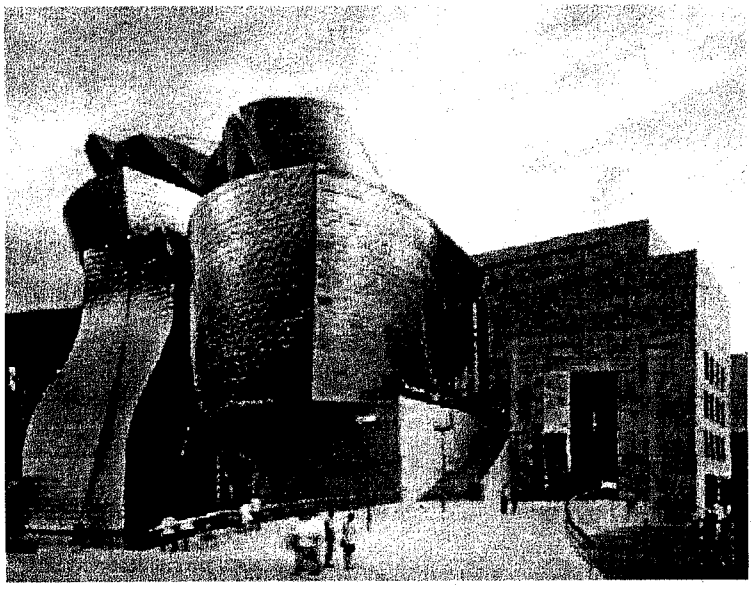
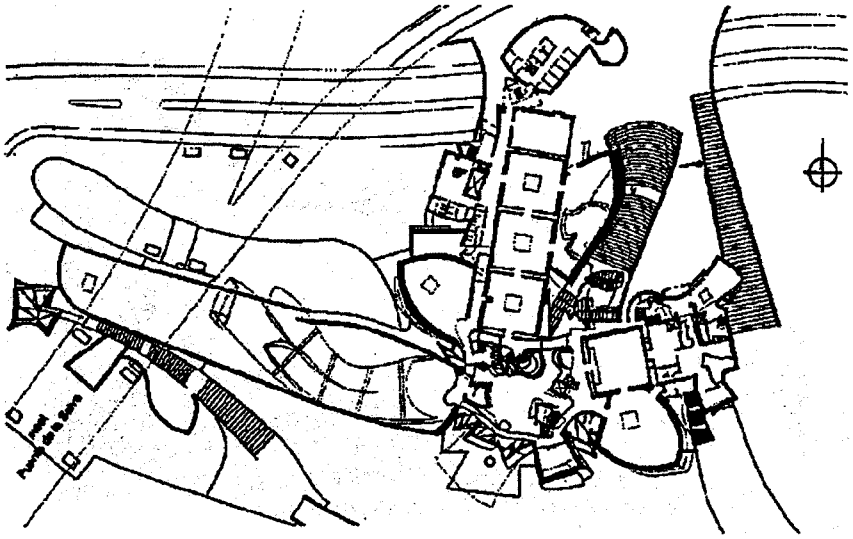


Fig. 27. View of the building of the Energy Forum [43]. The (cubic) mass of the building is characterized by morphological features [info@energie-forum.de]

The forms of G.O. Gehry[25] in the buildings of the Energy Forum in Bad Oeynhausen (Germany) and of the Guggenheim Museum in Bilbao (Spain) are morphological forms. The architectural form of the Energy Forum in Bad Oeynhausen (head office of energy network service) (fig. 27) and the Guggenheim Muse-

[25] F.O. Gehry – chief designer of the architectural conception of both objects. American architect, Canadian-born.





Projection of the 1st floor; scale 1: 1750

Fig. 28. a) The building of the Guggenheim Museum in Bilbao [42]. Morphological features showing connections with forms of the nature characterize the (cubic) mass of the building is. b) Development plan

um in Bilbao (fig. 28), the New York Branch of the R. Solomon Office – of F.O. Gehry as chief designer – shows, analogically as the Ronchamp Chapel of Le Corbusier (figures 19, 20), plastic art perceived morphologically features. These objects are examples of future-reaching architectural solutions with spectacular forms [96, 101, 105].

When discussing the creative process of architectural design of the Energy Forum in Bad Oeynhausen [42, 43], F.O. Gehry presents an illustration of the Ronchamp Chapel of Le Corbusier. The building being designed by him belongs to objects connected with informatic and computer science technologies of the 21th century [10, 12–14, 19, 53, 55]. The architectural forms being designed by Gehry are characterized by coherence, and they have morphological features. The characteristic fine form of the building has its proper original language of forms. These are morphological forms that permitted to adapt the buildings to the specific requirements of the used therein technologies. The architectural form of the Guggenheim Museum in Bilbao, viewed in sunset light, is called to be a sculpture [9, 125]. The building of the Guggenheim Museum has been realized during the years 1993–1997. This building has become an identifying mark of the town of Bilbao. When asked what this building does symbolize, many people would certainly answer: the future.

The Building of the Energy Forum in Oeynhausen (fig. 27), designed by Gehry, is a particular example of architecture. The building, satiated by modern and pro-ecological and informatic technologies, has been realized in Germany during 1993–1995. The form of the Energy Forum in Bad Oeynhausen results from the function and from the used modern economic solutions, e.g. technical, informatic, material solutions. This building has an attractive form being composed within the traditional environment of the town. Two pairs of round mirrors, placed as a heliostat at the main entrance, constitute a sculptural accent-element of the architectural form of the building. These electrically controlled mirrors (with a diameter of 1,6 m), direct the sunlight to the exposition rooms. The glass-equipped roof of the auditory has been executed as an "energetic system" associating some different functions: production of electrical energy in solar cells, uniform additional illumination of the interior with scattered light and protection against excessive heating. The Energy Forum, with its system-based control installations, is one of the first realizations where the hitherto independently applied systems of automation of the building, the electrical installations and devices, and the systems controlling heating, ventilation and air conditioning have been integrated. This assures a sweeping elasticity what concerns managing the network, and replaces the classical electrical installation with determined connections. As a result of such systems solution, the realization of the installation has been simplified, e.g. a smaller number of cables were necessary, and further changes and extensions should not cause important problems, according to the opinion of the authors of the project. The being used systems control, with a high precision and in an individual way, energy production and distribution in the building, thus contributing to energy saving and to improve the comfort of using the rooms and accommodations. On the south wall, a transparent additional heating has been executed.

From the methodological point of view, with reference to the architecture objects, the being applied automation systems as sub-solutions (subsystems) are as-

sembled in the building with other subassemblies (e.g. with installations as spatial architectural elements, as it is assured in the case of installing mobile mirrors).

An interdisciplinary approach to the multi-disciplined design problems, that were undertaken in a professional way and creatively solved, characterized the designers of this building (F.O. Gehry with his team). The performed design process influenced the building form shaping, with observable morphological features. A particular feature of the building is the fact that the applied there modern technological solutions do not subdue the human being. In their assumptions and observed consequences, these technologies are subordinated to the various needs of the man. This influenced shaping the architectural form.

Methodological analysis of the architectural form of the Energy Forum in Bad Oeynhausen

The architectural form of the Energy Forum in Bad Oeynhausen (fig. 27) shows morphological features in a visible form. The methodological analysis and de-

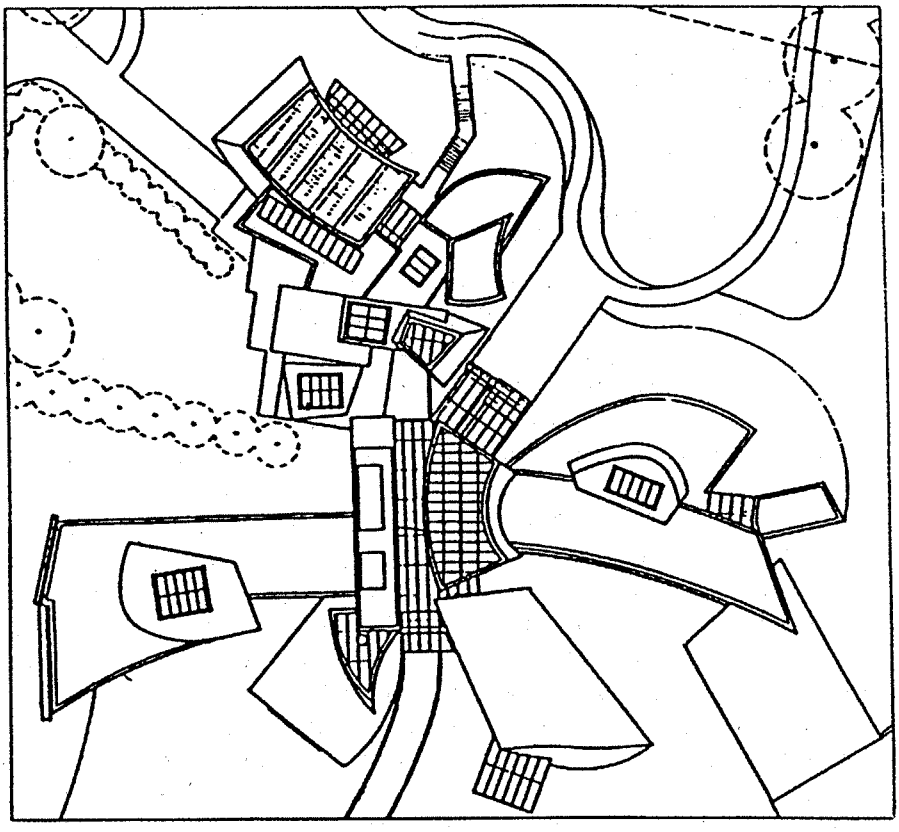


Fig. 29. Horizontal projection of the roof of the Energy Forum [43]

composition of the form of the horizontal projection of this building (fig. 29) aimed at discovering the use of elements of the method of morphological analysis in the design process. These considerations were undertaken, considering the fact that the morphological analysis is a method of assembling architectural solutions from parts, e.g. from partial problems. There is no obstacle to consider, in conformity with logic, the functional arrangement of the building being designed, or its constructional arrangement as to be partial solutions composing the designed whole: the architecture work (achievement), in a may-sided way (in the constructional, technological, material and other aspect) [26, 56, 57, 89, 106, 107].

In architectural designing, there is no change in the project made by the designer, which would not result in a change of the form being designed. These changes are conditioned by different requirements, among others spatial, psychological, material, constructional, technical requirements.

In technique (engineering), creatively assembling partial solutions (in other words, sub-arrangements) in this method leads to obtain solutions being in conformity with the need that defines the aim of the undertaken actions, with the

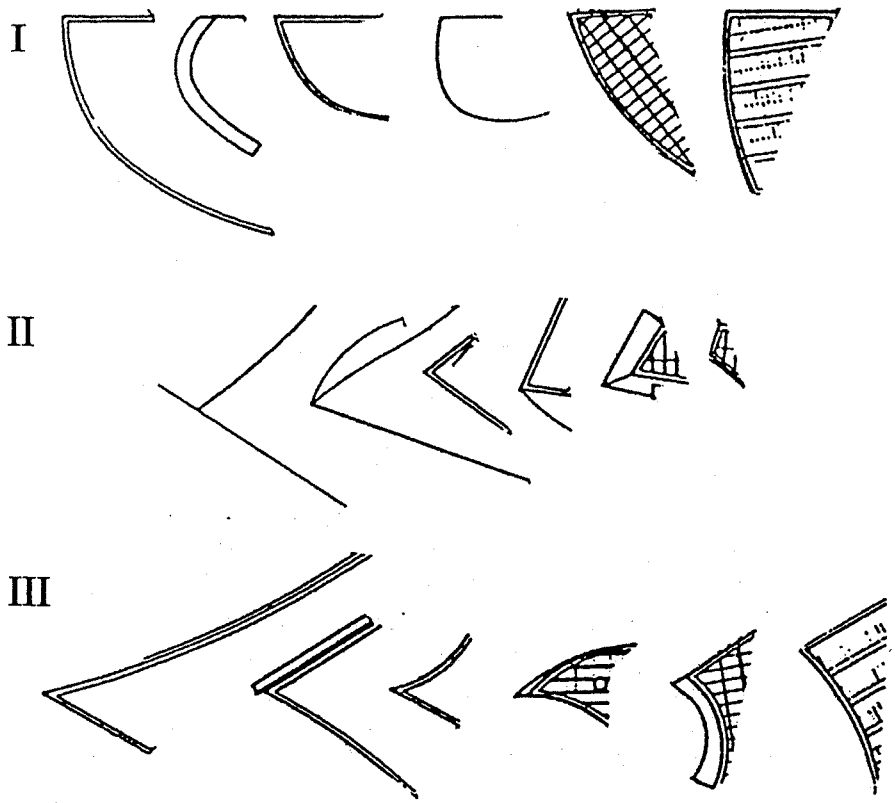


Fig. 30. Three types of partial forms on the horizontal projection of the roof of the Energy Forum

technical possibilities, and with the skill of the designer (of the designing team). Perhaps it can be analogical in architecture, with regard to the form of the architectural (cubic) mass being precisely analyzed in space by the designer.

A decomposition of the architectural form of the horizontal projection of the roof of the Energy Forum reveals repeating types of forms used in this project. In fig. 30 presenting the decomposition of the horizontal projection of the building of the Energy Forum, some types of partial forms composing this project can be found. Three types of partial forms are assembled in this figure into three groups of forms. The first group contains forms resulting from assembling an arc with a straight-line segment. The second group of forms contains acute angles composed of straight-line segments and their modifications leading to form an obtuse angle. The third group of partial forms results from assembling, in successive modifications, arc lines with straight-line segments. The other forms appearing on the horizontal projection of the roof of the building, after having subtracted the mentioned above three groups of partial forms, are parallelograms and trapeziums of different size and their fragments. The presented methodological analysis by decomposition does not exhaust the possibility of continuation of these and other analyses and spatial divisions of the (cubic) mass of the Forum being examined.

The possibility of isolating the partial forms (morphemes) used in the being analyzed project of F.O. Gehry intuitively suggests an application of elements of the morphological analysis in his architectural design process. That is the basic conclusion, drawn from the performed methodological analyses of his achievements. Perhaps this process as well as other creative architectural processes and projects, where morphological analysis or its elements were intuitively applied, are easily adaptable to differentiated requirements and modifications obtained by means of computer-assisted technology.

Computer assisted creative architectural process

The Guggenheim Museum in Bilbao (fig. 28) has a characteristic form of the roof, called by visitors a "metallic flower". The roof is covered with titanium plates. The building consists of several irregular masses, and has been composed within the surrounding nature. The realization of these irregular, different and dynamical shapes of the building was possible because F.O. Gehry used the Catia computer program, developed by the NASA. This program was created for the needs of the space program in the center of space research of Boeing. The Catia program is destined for a three-dimensional binary designing, for a precise mapping of corrugated surfaces. This permitted the designer to control the creative design process or the process of coming into being of the project in an interdisciplinary team, as well as to execute the designed construction according to its geometric regularities, selected materials, building engineering techniques and technologies.

According to the description of the architect and the handmade sketches, wooden and paper models were executed in different scales. These models were scanned and introduced into the computer. The Catia program controlled the machine work and permitted the designer to modify the form and cut out the appropriate model. The model, being elaborated with computer support in the creative process, became the optimal solution selected by the architect-designer. Then the project was stored in a numerical form. Starting from this design phase, the project constituted the main set of data, being the base for producing elements made of steel, stone etc. Gehry positively pronounced on the application of the Catia program in his design processes. He stated that, in the past, too many phases separated the original sketch from the finished architectural work. Gehry defined the use of computer support with the Catia program in such words: "My own feeling was always that something of my project was getting lost before the project reached the contractor, and now it appears as I spoke another language, and suddenly the craftsman began to understand me. The computer does not dehumanize, but is an interpreter of my will" [19].

In other words, this program has been performed according to the humanistic vision of the development of technique and technology that will not "dehumanize" but will be an "interpreter of the will" of the human being.

Possible directions of continuing systems investigations of the morphological features of architecture

Maybe there exist and/or can exist in the future architectural solutions having morphological features contributing to such a progress, where the human being will not be subordinated to such a progress of technique (engineering and technology) that is blind what concerns its consequences. Architecture being realized according to systems knowledge and praxiology can develop in the future, among many different conceptions, tendencies and styles, in conformity with the possibilities and needs of the human being, together with his/her need for experiencing beauty and harmony. Perhaps such architecture, realized according to the developing systems knowledge, will be able to more easily accept many various forms, e.g. morphological forms, depending on the cultural context and the technical progress, particularly on the expansively developing pro-ecological technologies. Maybe these architectural solutions having morphological features are more easily adaptable to complicated conditions, among others systemic, technical and utilitarian conditions and, at the same time, continue to be attractive regarding form and functions.

More examples showing morphological features can be found and analyzed, e.g. in the creative achievements of A. Gaudi, L. Wright, Calatravy. Many beautiful contemporary architectural buildings contain such morphological features.

6.5. Methodological analysis of selected elements of the process of architectural design

Preliminary phase of the architectural design process

The preliminary phase is the phase that precedes the development of the conception of the spatial solution. It decides to a high degree on the future useful and technical values as well as artistic values of the future spatial solutions. It constitutes an indispensable element of the creative process of the architect. It is characterized by an analytical approach to the problem being solved and by a synthesis-based handling thereof. Such handling is often documentarily evidenced in this phase by a hand made drawing.

The validation (trustworthy making) of selected elements of the process of architectural design of Le Corbusier was performed on examples selected from the professional activity of this architect. Drawings and considerations subject to analysis and concerning this design process have been judged valuable from the methodic point of view [26, 34, 40] and relatively richly documented [62, 64, 76, 90]. Le Corbusier wrote: " if future generations will pay some attention to my work as architect, then a deeper importance should be really assigned to these unknown works (it means to drawings from design processes, thus also to the creative design processes themselves)" [61, 117].

The existing rich methodological knowledge permits to describe the preliminary phase in the architectural creative-design process. In architecture, this is the phase connected with the coming into being of the conception of artistic creation[26]. It is of great importance for finding the appropriate synthesis-type design solution [22–24, 26, 49, 102].

Le Corbusier made a study of the many-sided design conditions. Such analyses led to the right determination (creative, unconventional determination) of design assumptions (fordesign). He assigned a great importance to the preliminary phase of the architectural process [39, 59, 73], this phase lasting sometimes for many months. A proof thereof is, among others, his statement: "It is necessary to start from zero. A definition of the problem is necessary (...). If the problem is good defined, the problem itself will indicate the solution" [61]. And he wrote: "I know by experience that the conception of a building comes then, when it is ready" [61, 107, 108, 111, 114, 117, 122]. He employed much time to examine the conditions which the problem was subordinate, e.g. with regard to its environ-

[26] Le Corbusier's words evidence the existence of a relatively long preliminary phase in the architectural design process. These words can be determined as to be an architectural design jargon: "Silence is gold, according to a proverb. At this moment I am storing in my "telephone exchange" (in my brain) the constraints of that problem. I am performing a model on the base of measurements round the building site". Important in this formulation are not the words but the values being transmitted by the words, as well as the sequence of actions of the architect-designer. These words indicate a free and thus, in consequence, a creative analysis of design conditions.

ment, function, construction. R. Keller writes that, what concerns Le Corbusier, many months passed between the acceptance of a demand, the first contact of the architect with the customer and the appearance of any material witness of the design process [61].

Le Corbusier modified a suddenly appearing solution idea (or the *a priori* solution) with the use of e.g. techniques applied by architects: i.e. paper models. This is a way of designing through building the *a priori* conception in the preliminary phase, and then by modifying it so as to obtain a concretization. This way is proposed in the decision graph (fig. 14).

Importance of the language of forms in the creative process of the architect; case of the creative activity of Le Corbusier

Independently of denominations used, the extra-language reality is always the same without regard to the type of language. Nevertheless, we perceive this reality just by means of the language. We divide the reality, group and classify the surrounding things. The reality constitutes an infinite continuum, where, by means of our semantic system, we place limits in determined points. However, the variety of semantic systems cause that these limits have a different course for different people.

According to the opinion of many intellectualists, we are thinking using forms [118, 120–124], thus the mentioned "limits in determined points" can constitute a base of the division into tangible or only mental forms, and into their component parts. The architectural form is a form that is conditioned in a many-sided way.

Critics wrote about the creative activity of Le Corbusier that he used the language of forms in his works. Le Corbusier was a creator, who exerted a great influence on the progress of modern architecture; he twice changed the "architecture language" (or the language of forms of architecture), as historians state [61, 62]. The denomination *architecture language* seems to be accurate with regard to the problem of systems architectural design. This expression means that the architectural design is a systems way of thinking. Perhaps this systems way of thinking has led to coming into being of the language in man's culture, that means the oldest system used by the human being. Hence it results that the utilization, in a natural way, of values and possibilities of the communicating system is not a novelty, besides the technique.

Le Corbusier appreciated the value of design processes and architectural sketches, that means of forms he was readily modifying. A proof hereof is the fact that he described many times, with passion, his architectural design processes and that he supported them by documentary evidence in the form of conserved sketches concerning the design processes.

Ch. Jenks [61] writes on the architectural dictionary of Le Corbusier: "The words in this dictionary are forms", and Le Corbusier creates from single "words"

complex architectural forms (that means according to the carried on methodological considerations concerning forms-morphemes). This comparison has a logic, morphological and systems sense.

In the creative achievements of Le Corbusier, the force of his plastic art expression and functionality of forms (forms-morphemes) was the reason of the fact that other builders used them within a considerably broader scope. These forms became "morphemes" of the modern architecture – semantic particles of the language of architecture – as wrote E. Nagy [90]. It is possible that this methodic ease of dividing architectural masses of his works into component forms (partial forms) or morphemes became the cause of the fact that forms of the Ronchamp Chapel appeared e.g. in buildings of banks in Los Angeles.

The dictionary of forms-morphemes (or the library of forms or menu of forms) is being gathered by the architect, often exclusively in the imagination and personality of the artist, in conformity with his/her creative individuality. This is connected, for many architects, e.g. with the need for traveling and extending in this way the creative imagination. Following in Le Corbusier's wake, in this work an architectural design process has been proposed that supports in a methodological way the individual imagination of the designer who disposes of a set of possibilities of creative activity. The proposed dictionary of forms (menu of forms) or, in other words, the library of forms permits such a methodological support. Simultaneously, this dictionary is an element of the proposed decision graph assisting the creative architectural process (fig. 14).

The *a priori* synthesis-type artistic vision in the activity of the architect; case of the Carpenter Center

A synthesis-type artistic vision of a spatial solution being accepted *a priori* (i.e. according to assumptions) appears as an element of the proposed graph of the architectural decision process (fig. 14). This element of the creative process (synthesis-type vision of the *a priori* solution) can be found e.g. in the sketches concerning the Carpenter Center of Le Corbusier (fig. 31).

An inconvenience of the method of morphological analysis is the fact that the creator has to imagine the solution already at the moment of starting, or *a priori.* This is in conformity with the opinions of many authors carrying on considerations on the creative process of Le Corbusier and with the existing documents in the form of sketches from design processes. Le Corbusier self left the mentioned sketches that were purposefully elaborated, for future architecture inquiry, so he stated. After the first stage of "incubation" (as he called it himself) [64], or the first phase of the design process, Le Corbusier started the design process by sketching the synthesis of the solution, i.e. from the synthesis-type artistic vision. This vision was preceded by e.g. studies of he relief and the environment, where the concrete object should be designed.

In the project of the Carpenter Center, Le Corbusier made a lay-out drawing of the preliminary *a priori* spatial conception (fig. 31), he improved it and adapted it in a more and more detailed way to the design needs and conditions being analyzed. In this project, this is a form that is drawn for the first time as a circle-type form. The following handmade sketches, starting form the synthesis-type form close to a circle, cover the whole of design problems. They are the first real proof of undertaking the design processes by Le Corbusier [64, 67]. This form, and the following forms have been sketched in the context of the existing environment, what means that they were drawn in scale, on the horizontal projection of the square together with the buildings surrounding the square. In this design process, the first synthesis-type form and the successive forms are subject to transformations. According to the assumed function and the technical possibilities, Le Corbusier transformed and improved the spatial solutions being designed, i.e. he changed their parameters.

The preliminary conception or the *a priori* vision appears suddenly in the mind of the architect after preliminary studies and considerations, sometimes lasting several months. Le Corbusier made more detailed layout drawings of this preliminary conception, improving and adapting the conception to more and more detailed, analyzed design needs and conditions. These forms were modified according to the assumed function and the technical possibilities. Le Corbusier never abandoned the original idea until the end of the design process; he improved and precisely stated it, applying techniques of collage and paper models, adapting the idea to real aspects. R. Kellett confirms the fact of carrying on these actions in an independently performed documentary analysis [64]. An example of sketches of the architectural process, presented in fig. 31, argues the appearance of the *a priori* solution in the design process of Le Corbusier and the importance of this fact. This solution has to be understood as a synthesis-type solution accepted by assumption, but after preliminary universal investigations of the design problem.

Besides elements of the morphological method, Le Corbusier applied the generally well-known strategy of improvement, being a strategy of searching for proper solutions. During his designing actions, he remained in the same set of selected partial forms being subject to modifications.

Design actions consisting in selecting an appropriate synthesis-type architectural form can be called actions leading to a plastic-art improvement and coherence of the form of the architectural work being designed. In the creative process of Le Corbusier, these actions are running simultaneously with the determination of any other architectural conditions, among them technical, material, organizational and spatial conditions of the design problem being solved. That is possible thanks to the morphological method being used by Le Corbusier as a method of creative activity.

a)

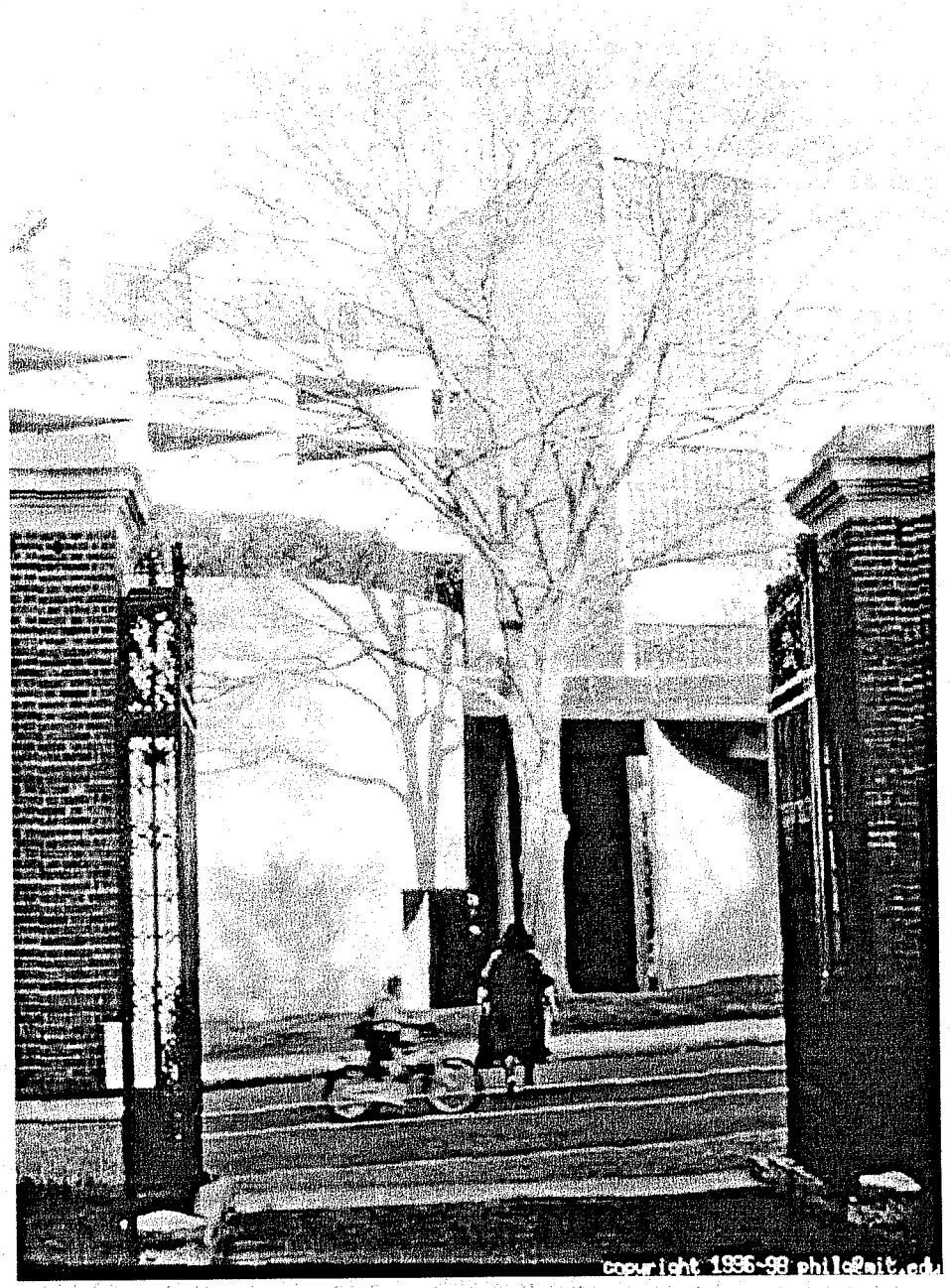
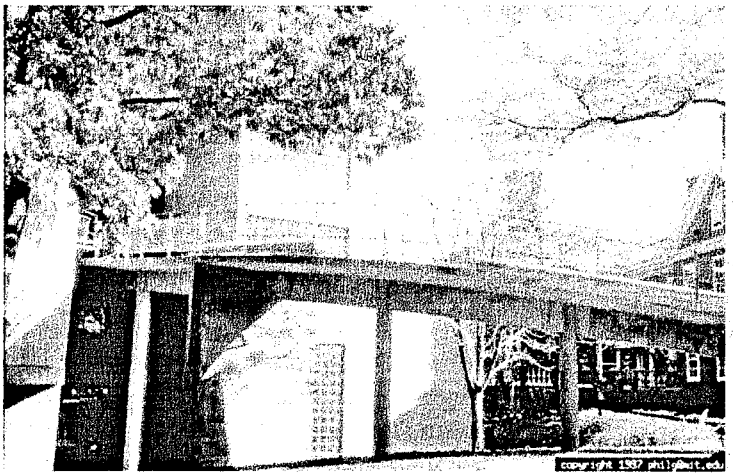


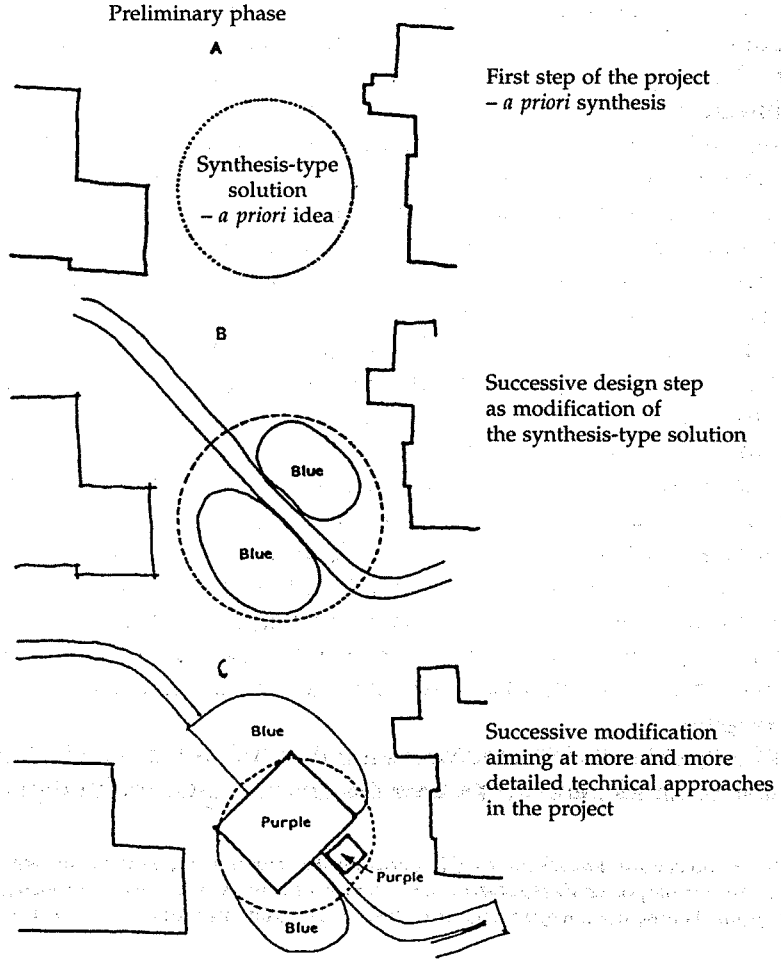
Fig. 31. The Carpenter Center of Le Corbusier, a), b) façade, c) Methodological interpretation of the sketches to the project of the Carpenter Center of Le Corbusier. These sketches present successive modifications of the original conception of the spatial solution. It is an example of the *a priori* design solution idea as a solution accepted by assumption, and then modified according to the needs and possibilities, among them to technical and spatial needs and possibilities

b)



Preliminary phase

c)



Importance of the carnet-like drawings of Le Corbusier for creating forms

The conserved sets of forms in carnet-like drawings[27] are another proof of the use by Le Corbusier of elements of morphological analysis. Forms taken from the sets of carnet-like drawings and purist painting were transferred to architectural projects. Le Corbusier carried on these actions according to an existing need, e.g. an accepted design command. The pocketbooks containing carnet-like drawings form an open set of "stored" forms in carnet-like sketches. These forms served Le Corbusier to perform a creative research. Beginning form his youth, he created sets of carnet-like drawings as a kind of travel associations. He assembled fragments of these handmade drawings and used them, often after several years. This formed a kind of library of "stored forms", documented by the architect, this library contributing thus to carry on methodological analyses. He considered these handy sets of forms [60, 61] to be interesting from his proper point of view. Ch. Jencks wrote about these sets of forms: A rigorous technical determinism was connected to a certain degree with a broad interest in the form, the shape of which he was elaborating by dipping into his earlier sketch blocks. This differentiated approach (to design problems) permitted him to create a whole repertory of new forms – architectural signs, which resulted from the technique of this method [60].

For architects-designers the fact is important that these forms are different and rich what concern their significance. In his sketchbooks, Le Corbusier gathered such a number of these original signs-forms that this permitted him to solve even complex functional problems. In some sense, a whole town can be designed with the use of only these signs-forms, which Le Corbusier created or, at least, improved. These signs-forms or morphemes can be modified. That is a museum that does not come to an end, states R. Kellet [64]. The town plans of Le Corbusier are full of these graphical signs-forms (for example fig. 22, The Plan of Algiers).

R. Kellet [64] describes in his documentary analysis of Le Corbusier's design means the way of creating these forms, or rather of their gathering and assembling on the carnet-like sketches. These carnet-like drawings are a specific **menu of forms** or, in other words, a library of interesting forms of Le Corbusier with regard to plastic art. In the course of years, Le Corbusier developed in these pocket books his proper style of carnet-like drawing. R. Kellet writes thereof as follows: "A preferred means was there a handmade drawing in India ink, with hurriedly placed remarks or, sometimes, color decorated or underlined" [64]. Carnet-like drawings are a proof of the fact that Le Corbusier was dealing with searching for and registering forms.

Many of Le Corbusier' collaborators call to mind different versions of the essentially same scene: the architect walked off for an instance, he dipped in the

[27] Many sketches of Le Corbusier are sketches of historical architecture, among them of the Ancient Greece and Rome. A documentary analysis concerning the means of creative activity of Le Corbusier, performed by Kellett [64], presents also the documentary analysis of assembly drawings, the so-called carnet-like drawings.

pocket of his coat and he pulled out one of his little notebooks, then some moments of intensive concentration followed during which certain accentuated features of the scene, the building or sometimes an enterprise were registered, the sketch block being "held towards inside of the palm" [64]. For example, a performed in 1960 carnet-like sketch presents a person in a turban looking through the balustrade of the ramp of the Carpenter Center, and refers to the problem of icing in winter. There an idea of a groove-based drain is recorded, inspired by a detail which Le Corbusier registered in the form of "a notebook drawing in one of the minarets in Suleiman 50 years ago, and then recalled" [64].

These carnet-like drawings witness the fact that Le Corbusier was dealing with searching for and registering simple schemes (forms), possible to be stored in this way for future using. Often he intentionally took out these graphical schemes from the context, connecting on one page of his notebook a current analysis with the developed image of another place, and "decorating it with his remark". Thus, these are associating drawings. These drawings were a means of "bringing out new significances and understandings" [64] from the common and apparently accidental synthesis of so stored notions, principles. This common and apparently accidental synthesis of notions and principles is a fundamental feature of the creative method: the morphological analysis. And that what in the quoted consideration of Kellet was named "means of designing", was a part of the design method and constitutes an element of the design process presented in fig. 14 as a menu of forms, that means as a set of forms being possible to be used. These facts not only assure a documentary evidence of design means, but also describe actions in conformity with the method of morphological analysis. R. Kelett did not deal with methodology and he did not write about this method. In this connection, one can consider his documentary analysis to be objectivist and impartial, because being without the subjective approach and handling of elements of this method used by Le Corbusier. The described assembling actions of forms is only "apparently "accidental, in reality they are conscious design decisions, and the so described actions constitute elements of the method of morphological analysis.

On his carnet-like drawings, Le Corbusier assembles different forms taken from different places, in different time, form the surrounding spatial reality. That "regrouping" of the stored words (as elements of the "architectural language"), pictures and schemes into "unexpected configurations", is nothing else than the use of Lull's Art and the resulting thereof creative method of morphological analysis.

Importance of painting in architectural creative activity

Analogically to many other creators-architects, Le Corbusier exploited an inspiration by painting forms, in particularly his own painting, and transferred it in the architectural space.

In the purist period, Le Corbusier started painting in the morning (when light was the most favorable), and drawing, as he determined, or architectural designing in the afternoon. He even proceeded in this way at the cost of direct contacts with the design team. It was a permanent, characteristic element of his creative work. This style of working assured a possibility of transferring the form being elaborated and verified in two dimensions, into the third dimension. In this way, he stimulated the process of designing the architectural form. In his architectural creative process, like in his purist painting, Le Corbusier led to a preliminary reduction of forms. Then, he created a methodically reduced set of architectural variant solutions being possible to be comprehended by the mind, thus to be verified. That is an important thing in the method of morphological analysis applied by Le Corbusier. According to the reality, we are not capable to comprehend by our mind in one moment a too great number of solutions what, obviously, make the design process difficult. Le Corbusier solves this problem by reducing the sets of partial solutions, or by reducing the number and kind of basic elements (partial forms) subject to assembling and analysis [102]. This can be seen in the design of the Villa Savoye and the Ronchamp Chapel, as well as in many other projects. Those partial solutions are "previously verified" in painting. The described actions of this type improved the innovation processes, characteristic what concerns his creative architectural activity. Le Corbusier treated painting as a specific experimental laboratory where he developed and "verified" assembly arrangements of partial forms. He used a creative assembling of partial forms being not borrowed from or repeated after existing examples. Le Corbusier searched for inspiration in antique architecture. He transferred into his own architectural solutions ancient proportions, but not antique forms. As a creator, he searched for principles of architectural proportions and for universal truths and regularities concerning architecture.

As purist painter, Le Corbusier emphasized the necessity of linking art in the current of important transformations of the scientific and technical civilization. He wrote that architects and artists-painters have to be equivalent partners of men of technique and technology. This statement is a proof of the fact that he did not acknowledge the domination of technique over art [61, 62]. This had nothing to do with an underestimation of progress of technique and engineering, it was quite the contrary. Le Corbusier is considered to be the "father" of prefabrication. In the project of the Villa Savoye he realized, as one of the first, the use of reinforced concrete skeleton constructions in an apartment building. In the work [43] concerning the design process of his above analyzed buildings, F.O. Gehry presents pictures of abstract painting that excited the imagination of himself and of the designing team. He confirms in this way the stimulating importance of painting and art in the architectural creative activity. This is a tendency being observable in the creative activity of many contemporaneous architects; it does not concern only the examples being analyzed.

J. Sołtan, collaborator and friend of Le Corbusier, states that the true art, to which belongs architecture, develops on the basis of affirmation an not of negation [117]. This is also the conviction of Le Corbusier.

A common feature of the examples being analyzed in this work is the fact that, irrespective of the morphological features of their form, the function and architectural construction form a conditioned, in a many-sided way, coherent architectural whole, perhaps as a result of their multi-aspect conditioned morphological features.

Relationship of methods applied in design of the architecture to the fulfillment of the needs of future users

From the accepted system- and methodology-based point of view, architecture expresses values of the living and evolutionary environment [16, 23], where building engineering, techniques and technologies are a tool for creating the architecture. The multi-aspect social needs (requirements) of the human being express values of complex architectural environments. Images of selected architectural objects, being presented in the figures of this work, signalize these values, and the presented decompositions of their forms confirm them.

In this work considerations are carried on concerning possibilities of use in architecture of achievements of science, technique, technology and art for realizing a morphological architecture organizing in a system- and methodology-based way the space of the human being's life in conformity with his/her needs [5, 24–26, 38, 53, 88, 93]. In designing the architecture, the fulfillment of requirements of the man using the architecture achievement is connected with aims, conditions and accepted criteria. On this account, the arrangement of criteria being every time set up by the architect-designer, is an ordered presentation of design needs and constraints.

At present, a system-based, systematic and methodological analysis of successive phases of the architect's creative process is possible. This concerns also the phase of determining the needs.

The application of the method of morphological analysis in architecture design assures potential conditions of coming into being of a plurality of architectural design solutions in the preliminary phase of this process. This leads to a possibility of a selective choice of the optimal solution, or of the solution that meets possibly the best determined needs of the human being functioning in the given surroundings, i.e. spatial environment.

It is possible that the use in architecture of the method of morphological analysis together with other methods and strategies, can assure an elasticity of reacting to future expected and unexpected needs, as well as to the inevitable changes of man's environment. The criterion of elasticity in utilizing is important when long duration objects are designed, so as buildings, towns or institutions [115, 116, 128]. This problem has, in architectural design, an economical, technological

and organizational aspect; towns, buildings are subject to continuous processes of expensive transformations and reconstructions.

The contemporary knowledge and science, particularly the architecture knowledge and science, is connected with the progress of information technologies, modern psychology and social communication. Together with the development of societies, science being the source of this development, the achievement of a fulfillment of needs of social groups and particular individuals becomes more and more difficult, and appropriate actions aiming at the fulfillment of the arising new needs become more and more complicated. The question arises how to realize a balanced development and to meet man's needs [116, 118] included in this development?

M. Bazewicz, A. Collen and AW. Gasparski persuasively state in their scientific works that a fundamental and strategic component of human activity systems are methodologies and modern technologies of processes of gathering, verifying and representing systems knowledge [16, 18, 38].

6.6. Summary of validation works being carried out

In order to prove the application of the morphological analysis or of its elements in architectural design in the past, methodological analyses of already historical objects of modernist architecture of Le Corbusier, and of contemporaneous architectural objects were undertaken. The present, rich knowledge in the domain of systems theory, praxiology and design methodology disposes of many methods, which can serve as intellectual tools. Those design methods with the whole existing knowledge can be used in conformity with the creative goals of the architect [23]. The presented in the above chapters of this work methodological analyses and decompositions of architectural forms confirm the legitimate character of the carried on systems considerations, the aim of which was e.g. to find actions and effects of the use of the morphological method or of its elements in architectural achievements of Le Corbusier and F.O. Gehry. Perhaps intuitively used elements of systems thinking as well as elements of the method of morphological method can be found in achievements of architecture of many authors-creators, being not presented in this work. It has been proved on the base of selected examples of architecture that, by means of this method as an intellectual tool, it is possible to create a differentiated, beautiful and useful architecture.

A great number of architects believed and believe in the sense of creative actions, in not transient values, in the sense of openness to all what is true and new [82, 116, 117]. Maybe future applications of this method will create new possibilities of development also of computer assisted creative processes of architectural designing[28].

[28] The Author of this work, in cooperation with a group of computer science specialists, has elaborated programs of a computer assisted creative architectural design process based upon the morphological method and upon partial forms.

The praxiological and methodological analyses carried on prove the significance and precision of the morphological method and of its elements as an intellectual instrument applied in architectural design.

The present-day architecture, strongly connected with science, art and technique, is evolving in the direction of artistic rationalism. It is a contemporary modernism adapted to present needs and cultural, technological and scientific possibilities.

The undertaken architectural considerations partially are close to the already forgotten or rejected tendencies of the so called "enlightened modernism"[29], preferred among others by Le Corbusier and his collaborators. In the 20th century, the awareness of social tasks of architecture, being at the beginning a creative factor of the modernistic avant-garde, later became a charge [116, 117]. At this time, architects being close to Bauhaus looked with expectation in the direction of physiologists and psychologists. Advanced architects searched for an objectification of human needs. A group of architects being aware of difficulties and obstacles, tried to direct progress in another way [117]. At present, J. Sołtan and many other intellectualists, e.g. bridge constructors, prefer such ways of thinking where logic and imagination, rationalism and intuition play an important role (these are independently appeared convictions, but in conformity with Le Corbusier's convictions). According to the opinions of J. Sołtan and A. Skibniewska, collaborators of Le Corbusier, we are returning, in the development of architecture, to these tendencies as they assure new chances for a balanced progress [116, 117, 120].

Maybe it is now the turn of a "modernism with human face", as wrote L. Corbusier and J. Sołtan, as a return to a humanistic vision of architecture development. At present, these tendencies are continued among others in an architectural search for the identity of the architecture. The existing systems knowledge concerning living systems, praxiological knowledge, is close to and/or compatible with the goals of the "modernism with human face" in architecture. This knowledge could become, perhaps, useful in a rational, creative and more secure management of the space where we are living.

The accepted fundamental research assumptions and directions of this work concern possibilities of development of the present-day architecture in conformity with the natural environment, with its discovered and undiscovered laws, with the human psyche and with the humanistic vision of the world.

Perhaps the present and future artistic rationalism of architecture as an architectonic direction aiming at a balanced progress and, simultaneously, accepting previous experiences of modernism, can accept and use the interdisciplinary

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[29] Representatives of this direction of art, preferring values connected contemporarily with aiming at a balanced development and progress were, among others: W. Gropius, Le Corbusier, as well as Polish collaborators of Le Corbusier: J. Sołtan, Z. Skibniewski (called Ski), H. Skibniewska (cooperation at the project of the Garches villa in the neighborhood of Paris, realized in 1927).

knowledge, particularly knowledge on design, methodic approach and methodology of design, systems knowledge covering knowledge about the morphology of the architectural environment.

The validation carried on in this work is a proof of the fact that there exist possibilities of improving the creative activity of the architect, which are not fully utilized. Those possibilities are connected with an increasing role of systems science and methodological sciences in teaching architecture, and in the architectural practice.

Systems sciences, applied in the future in architectural design, not only in such a way as in the presented examples i.e. intuitively and fragmentarily, but fully consciously, assure new possibilities of integrating the natural environment and the artificial environment i.e. the architectural environment at the level of micro- and macro-structures of these environments. Maybe this will be possible in the future in the architectural design of morphological spatial systems and arrangements thanks to the integration of systems knowledge and values of the nature.

7. Annex

Vocabulary and language of communication concerning the nature of architectural values

Problems of interdisciplinary knowledge and vocabulary considered form the point of view of the architect

The development of scientific knowledge can be reduced to the investigation of artificial languages and logic calculations. The language of notions of praxiology, design methodology and systems theory is such an artificial language. Research activity concerning systems and development activity creates a climate for a continuous change and increase of organization of activity as well as of languages connected with discipline divisions. The use of methods in designing excites towards efforts aiming at meeting requirements of the permanently and dynamically changing environment.

A. Einstein stated: If we really care for preserve all people's talents and their unhampered development, we cannot resign from methods leading to this aim [21, 29, 30, 31]. As he worked during several years on the theory of unification of notions of science, he was convinced of such a necessity, he wrote thereon many works and papers at different opportunities. During almost thirty years, he was elaborating the theory of unification of the language of notions of the science – a theory that he never terminated. He stated that, at a time, it will be possible do achieve that in further phases of the progress of science.

Problems of unification of the language of science, and the creation of a metalanguage of science, as problems of future progress, require a long-term effort,

and maybe multiple verification of notions of science, to be performed from different points of view, as well as a continuous development of science. Architectural knowledge, expressed among others by the language of systems theory, design methodology, praxiology, can contribute to this development. Architectural problems could be better solved and understood in the future, in many domains of knowledge, as these problems are of an interdisciplinary nature.

It seems that the architectural knowledge can absorb many systems notions and actions. As an effect, future development, being oriented in such a way, can contribute to a progress of methodological, praxiological, systems knowledge as well to the development of a metalanguage of the science.

The contemporary architectural objects are more and more often an effect of an equivalent collaboration of an interdisciplinary team where cooperate: the architect, constructor, installation specialist, building physics specialist, and computer scientist.

Architecture objects, being realized in space and forming the spatial framework of man's life (e.g. urban agglomerations or urban complexes) can be treated and considered as systems-organisms of smaller or greater size, which are subject to transformation, metamorphoses, adaptations, structural changes. A continuation of this approach is to search for their morphological features. At present, a large number of methods and manners, principles, rules of description of the system exist, serving to present properties of auto-organizing systems, with a broad scope and degree of complexity. These properties, existing notions and value areas of knowledge are the cause of the fact that the variety of aspects of the carried on investigations becomes very rich and sets the architects in the face of an essential challenge.

In the present-day interdisciplinary scientific research, an objective scientific language becomes more and more necessary. L. Gerardin stated that, if we contented ourselves in interdisciplinary research with intuitive definitions, a complete confusion would take place within a very short time, because these definitions used by different persons would be different. Everyone would believe that the others should understand him, while languages used by these people should be different [41].

It is the language of systems knowledge that is the useful language, possible to be universally applied, and simultaneously assuring a precise communication during carrying on architectural investigations and making design decisions. The language of systems knowledge and design methodology, as language of objectivist and coherent notions, can be used to describe and examine the processes of architectural design of concrete creators-architects. The existing notions of systems knowledge and design methodology permit to present and map many values of architectural knowledge being conditioned in a many-sided way. Today a rich and precise vocabulary of systems knowledge and praxiological knowledge exists, to which have contributed more than twenty knowledge domains.

Selected notions

The selected notions of methodological, praxiological and systems knowledge have been considered here with regard to multi-aspect conditioned architectural problems.

Adaptation is an interaction of the environment-system type being performed by a process, where a system (e.g. an architectural system, subjective to "moral ageing", so as the technique, as well as to physical ageing) adapts itself to changes occurring in the environment.

The **analysis of systems processes** is based on the theory of living systems: it permits to penetrate problems of pathology of systems as a result of the use of a methodology of evaluating the performance of systems in many dimensions [19]. This notion, applied in architecture, will signify a possibility of penetrating in multi-aspect architectural problems, their solving not only in three dimensions but with reference to an analysis in time-space. This is compatible with the reality, where architectural systems (e.g. urban agglomerations) are subject to continuous changes in space and time, e.g. to reconstruction and development. As a result of such an approach, new possibilities are obtained of description and thus of management of complicated processes of architectural design. The possibility is also obtained of indicating imperfections of this process and/or imperfections of concrete architectural spatial, functional and other solutions.

The **analysis of the cost-benefit index** signifies the determination of the kind of costs (resources, works) that can be (or should be) borne or utilized in order to achieve results being considered to be advantageous for the system and/or the environment. Economical problems of that kind are undertaken at the formulation of architectural design assumptions (fordesign).

Architecture expresses values of the living and evolutionary environment. The notion of architecture is perhaps evolving as a result of relationships with the living and evolutionary environment. Examples of such evolution are the following notions: architecture of the system, architecture of computers. The *architecture of the system* is a conceptual image of the morphological platform of the nature of the reality [6]. This opinion refers to architecture. This statement shows that the contemporary development of systems theory, and particularly the development of knowledge on living systems, design methodology, cybernetics with computer science and informatics, assures new possibilities of investigations of the architectural knowledge and of architectural achievements. This development is possible as a more secure development as it is connected with present-day knowledge of praxiology and ecology. According to present knowledge, scientific designing as well as methodology of sciences, is a systematic, rational reconstruction of procedures of the designer. Such reconstruction requires, according to the methodologist Z. Wasiutyński [122], a civil engineer, a previous reflection on the designer's craftsmanship, and a consideration ordering design experience

supported by methodological knowledge. Independently, free formulations appear: e.g. architect of social and political systems".

The *architecture of computers* is a domain of architecture and technology of information systems.

The *notion of architecture* accentuates attributes of a dynamic and developmental system, as functions, usefulness, design methodology and morphological aspects of the nature [19]. At present, many definitions of architecture exist, definitions that are parallelly accepted. Architecture is characterized by timeless values; it practically derives from handicraft. The *contemporaneous definition of architecture* can be formulated in the following way: architecture is an art of organizing and shaping the space of environment of the man's life. The present-day architecture of a determined community is often searching for cultural identity. *Architecture is an art or science on building engineering and built things.* It concerns the structure and organization of space, the style of building and the construction. An architect is a creator (a creative man), i.e. a designer of buildings with a complex and complicated construction. Engineering and building techniques (technologies) are only an instrument of the architect in creating forms of architecture.The oldest definition of architecture is the famous triad: *utilitas, firmitas, venustas,* or usefulness, firmness, beauty. This triad constituted for several centuries the base of any theoretical considerations in architecture. The conviction results from this definition that the unity and harmony of these three fundamental factors of form, function and construction are the basis of the value of an architectural achievement (work) *M.P. Vitruvius* [127], a Roman architect, in the year 70 before J.C. has formulated this triad. Vitruvius, as architect, builder of water clocks and war machines, theoretician of architecture, asked, in the antiquity, the following question: *Who is called to build architectural theories* that, by nature, concern also constructions: *whether only the practitioner* who deduces from practice a general theory, *or the theoretician,* who knows how to operate notions in a regular way and who adapts his general theory to practice, *or, perhaps,* the theoretician of art, an aesthete? This question remains full of present interest notwithstanding the time passed. The definition of Vitruvius has not lost its significance in spite of the time passed, of the progress of knowledge and of the existence of many simultaneously used and accepted definitions of architecture. Each architectural solution is a synthesis of many factors.The *definition of architecture of Z. Giedion* is as follows: Architecture remains and will remain for a long time in the future a domain being suspended between two poles of human thinking – objective and subjective thinking, between different types of exact sciences where the recognizing process proceeds fast forward, and the hitherto unknown and less objectively investigated world of intuition and emotion, until now named artistic intuition and emotion" [44]. *Architecture is an image of the epoch* where it arises. Architecture is a processing of information on the nature of the human being into spatial information and/or information shaping the space of the man's environment. Architecture illus-

trates the complex needs of the man and the existing (in a given epoch) possibilities of their realization. *Architecture is conditioned* by a concrete phase of technical, social and civilization development, by the surrounding system or the natural environment, as well as by a broadly determined tradition and search of the man for his/her identity. The architecture being created is connected with psychological and cultural aspects of the epoch when it arises, as well as with the feeling of beauty. *A new, more open-type definition of architecture* (together with the interdisciplinary character of architectural processes) covers by its scope many domains, and thus methods and formal languages. Architecture is perceived to be a dynamic art. Architectural environments are subject to continuous transformations (development, modernization, restoration, renovation, etc). Ordering complicated and different architectural conditions can appear to be more efficient in a systems aspect, particularly in the aspect concerning living systems. This does not wreck anything of the transmitted architectural expression, of the creative possibilities in building beauty and spatial order of the man's environment. Architecture expresses itself by the form. At present, the notion of architecture appears in the context of science, in abstraction of direct, traditionally perceived artistic and plastic art values.

The **architectural environment** is considered to be the architecture created by the realized architectural objects, together with the site development and the natural environment. This notion is strictly connected with the notions of *ecosystem* and *habitat* of the human being.The *habitat*, referred to *architectural arrangements (systems and assemblies)*, is derived of the Latin words: *habitus, habito, habitatio,* which determine: the external appearance, the set of features, the position and orientation, the human behavior what concerns sojourning and residing. The habitat is an arrangement of all factors of the environment: animate and inanimate, material and immaterial factors, which influence living organisms and are subject to changes under the influence of the latter [5–8, 73]. This notion is connected in our considerations with the ecosystem of the man and of the nature. *Investigations of the environment* cover, in the language of systems notions, an actively undertaken research of the environment, aiming at recognizing the environment characteristics and requirements regarding the system [19]. Referring to architectural problems, that signifies e.g. environment investigations, or investigations of conditions of this environment and of their influence upon the object being designed. The architect carries on an investigation of the environment before starting designing (performing a concrete project), i.e. during the first preliminary phase or fordesign phase. The whole architectural project constitutes, in some measure, a transfer of the interpretation of the influence of implication of the environment upon the system being designed, i.e. upon the architectural object being designed, as a new element of this environment.

The **architectural project** is carried out in successive design steps, in many phases and actions, also in *feedbacks*. These actions result in corrections and mod-

ifications taking into account e.g. design conditions appearing during the design process.

An **architectural system** is, according to the knowledge of the domain of theory of living systems, a whole being designed and realized, which can be considered as a functioning organism. The *architectural system* is a functioning whole (e.g. a set of assembled architectural elements) that does not function as a system without any of these elements, thus does not fulfill its goals (the stated technical, functional, formal and other requirements) in that case. From the systems point of view and in conformity with logic and needs of research being carried on, many *subsystems* can be isolated in an architectural achievement (architectural work).

Control decision systems can be automatic control systems, or systems of management and guidance of e.g. the creative-design process. In this case, the participation of the man is necessary as a decision making factor on the particular levels of hierarchy.

The **design process**, particularly the architectural design process is characterized by cyclic repetitions, or *iterations* resulting in successive modifications of the architectural conceptions being developed. The *process of architectural design* is a sequential process where certain actions are repeated, thus an iterative process. It is possible to distinguish in this process characteristic actions appearing repeatedly in its different phases, e.g. the phase of evaluation and validation. The *process of architectural design* is comprehensively conditioned, and in this sense, it sometimes oversteps the technical logistic arrangements, thus permitting the architect to carry on considerations in many aspects, particularly in the physical, ergonomic, psychical, cultural, artistic, intellectual and other aspect. From the system-based, ecological and technical point of view, the process of architectural design is an *interdisciplinary process*, leading to consider the designed building as to be a designed whole, this complete entity being simultaneously a part of a greater whole, or environment. The notion of *interdisciplinary character* concerns the penetration of values of knowledge between disciplines of science and art. The *interdisciplinary process of architectural design* is a process of shaping an architectural form conditioned in a many-sided way. When considering canons of beauty in architecture. J. Sołtan stated: "*architecture is building engineering* elevated to the level of art, it is building engineering that causes emotional feelings" [117]. This statement indicates the importance of interdisciplinary problems in architectural design. The present-day progress of engineering technique and technology, of organization of labor, results in the phenomenon of collective development of architecture achievements (works). *The necessity of designing architecture*, as an art of shaping the space, results from the needs of the human nature. The recognition of a need is a condition for formulating the design problem and for proceeding to the process of designing. The aim of the so comprehended design process is to fulfill a need. This need is to be considered as an element of the

creative process that defines the purpose of design actions. A feedback appears between the definition of the needs and the design purpose, as an aim of the design process is to make possible the fulfillment of the need.

Designing is the optimal (possibly best) modeling of the reality, a fragment of which has to be realized in the future.

Designing and planning research is based on techniques of information gathering.

Expansionism, as opposite to reductionism, is a process during which we are searching for significance and comprehension by intensifying the research and extending its scope [18]. It occurs also so in architecture. The architect applies alternatively expansionism and reductionism in the whole design process by searching during the design process for more and more appropriate purposeful solutions.

The notion of **form** refers both to objects being perceptible only by means of reasoning, and material, visible and tangible objects– states Z. Wasiutyński. As methodologist, constructor in bridge engineering, Wasiutyński wrote, according to A. Courotte [121] that the *notion of form* should be inscribed in the headings of all juxtapositions, categories and sets ordering the fundamental and constructional notions of recognition.

The **hierarchy of values and needs** manifests itself only in real aspects of activity. These hierarchies, as scales, exist independently, in abstraction from the effective behavior of individuals. The only source from which rises our knowledge on these scales is the observation of human actions [37, 38, 39]. Each action remains always in a perfect conformity with the scale of values or needs because these are nothing else than an instrument of interpretation of human activity.

Imagination is a psychological construct connected with the intellect of the man in the human activity system [19]. It is the capability to describe what can or could appear, as well as the capability to associate and recognize through analysis or by means of metaphors. The fact of communicating to the man what might appear, contributes to a high degree to the activeness of the system. Imagination constitutes a factor permitting the system to evolve. It is a fundamental value in architecture design.

Information is a certain portion of knowledge, a certain message, which influences the course of activity of the architect. In other words, if the designer did not dispose of a determined information, he would proceed otherwise than after having received it. Information can be treated as a semantic quantity, and its most essential feature is the carried contents.

A **jargon** is a special variant of a general national language being used by particular social and professional groups, with a different, specific vocabulary. It is a language that is not in conformity with standards. This language remains incoherent with regard to any professional language of a given domain. At the same time, a jargon being used in a given discipline completes the professional lan-

guage. In architectural design, the jargon is currently applied in the context of the architectural drawing and, only in this context, is fully comprehensible for the communicating parties. It is applied for a fast and efficient, thus precise communication taking place between designers in the design process, during which processing of design information is performed. In practice, a jargon is used in the context of updated architectural sketches or drawings and of their modifications with taking into consideration e.g. new information flowing in. The fact of an efficient and general use by architects of the architectural jargon shows that architects utilize in the design process values, which do no always refer to officially functioning notions in architecture. Perhaps, the jargon can fill gaps in the official language of notions. The architectural jargon "bursts" in a sense the officially functioning notions, as it does not fit therein. The existence of the architectural jargon shows the limited possibilities of the official language of architectural notions (among them the description of complicated intellectual processes of the architect-designer). If the official language was sufficient, the jargon should not appear or should disappear. This is an evidence what concerns needs and possibilities of the development of the language of architecture notions. A permanent use of the architectural design jargon in practice is also a proof of the degree of difficulty in transmitting contents and values concerning the complex multi-aspect intellectual process of the designer. Moreover, the fact cannot be ignored that jargons exist and are efficiently functioning by analogical, practical reasons in other domains of knowledge, what shows their importance.

A **method** is a selection and arrangement of component actions joined by a purpose.

Methodology means systematic investigation of scientific practice, principles being the base thereof and research methods being used in this practice. It means also the set (the whole) of methods and techniques in a determined domain, a composition, arrangement or construction of methods or method components, being used for teaching, commenting as well as for the needs of scientific and inquiry research. The methodology refers to the complexity of an object, e.g. an architectural object or to the investigation subject. Besides this definition, at least some convergent definitions exist of the notion of methodology. The *design methodology* is a scientific discipline dealing with a systematic reconstruction of the designer's proceeding. Design methodology deals with methods, procedures and techniques of design-creative behavior. From the praxiological point of view, *methodology* is a mapping and description of real design actions. *Design methodology* can be compared, in some sense, to surgery applying mechanical interventions with the use of physical instruments. However, the design methodology manages intellectual instruments. These are the mentioned methods, procedures, design strategies, etc.

The *methodology of architectural design* is based on praxiology and concerns decision actions of the architect, being made by the architect in the architectural design process.

Morpheme (linguistics) – the least indivisible semantic part of a word.

Morphological analysis concerns the nature and the differentiation of its forms.

Morphology signifies methods of analyzing and creating designed environmental systems, their forms and their compatibility with the environment. In the Concise Oxford Dictionary, the following definition of morphology can be found: morphology is a study on forms of things; in the biological sense, it is the study on forms of animals, plants and on the ways of their spacing and propagating, and valuing by categories of the nature and the living world. In design methodology, *morphology* means the living environment (e.g. habitat), the architect, the design method and the validation of design solutions.

The **perspective** of a **systems vision of the world** is referred to knowledge deprived of any disciplined divisions and reductionist simplifications in perceiving fragments of the reality [16, 18, 27].

A **system** is called a set of elements and of the relations between these elements, where:

– elements are determined (abstract) properties of material parts of the object,

– relations are relationships (formal and descriptive) relationships between the elements, these relationships describing dependences.

One of the many existing **definitions of the system** is as follows: the system is comprehended as a group or set of objects connected by a certain form of regular cooperation or interdependence in order to perform the required function. *In the nature, systems are wholes* that, after decomposition, thus after disturbance and/or interruption of the relations, dependences between its component parts, stop functioning.The term of *system* is used as a denomination of a certain construct. *The systems knowledge, and the science on methods and ways of systems comprehension of the reality constitute an intellectual phenomenon of the cultural progress of the 20th century.* Systems sciences become a factor of motivation of the human awareness in actively overcoming the barriers of recognizing the complexity of the world, and they serve to fix cultural foundations being necessary for the evolution of the systems movement [7]. A basic value of systems knowledge is *an increase of the role of human interactions and associations of human behavior in environments of living systems, an increase of activeness of systems, and of the cultural and ethical awareness in motivations of transformation and societal evolution of environments of human organizations.*

The **system's image** [16, 23] is a time-space and dynamic vision of the world. The system's image appears in cognition processes being inspired by the activeness of human intellects and by capabilities to mutual reactions with the environment. The being shaped images of the environment are destined to categorize the evolutionary, integral and dynamic equilibrium of system behavior. A system signifies an environment of any nature or a morphologically time-space ordered arrangement. The activeness of a system is characterized by the capability of maintaining the integral and energodynamic equilibrium that respects laws

of evolutionary coexistence and of local and global integration of the system and the environment.

Systems analysis has several contextually different meanings.

1) Systems analysis can concern investigations of component elements of the system and the way of construction of the system, what permits to perform a systems description.
2) In a systems analysis, it is possible to evaluate the system by asking the following question: how is the system functioning as a system, or how efficient is this system from the viewpoint of the determined criteria?

These questions, referred to architectural design, are particularly justified. Architects ask themselves this kind of questions during the design process; these questions being reformulated into the architectural language, are questions concerning the correctness, thus the efficiency of architectural solutions [14, 23, 24, 38].

The *systems analysis can be a part of systems design* in architecture, constituting e.g. the preliminary investigation or, in other words, the front investigation, as it is named in other domains of technology (e.g. in computer science and informatics). A preliminary investigation is the base for formulating the problem situation in the process of architectural design. The preliminary investigation is connected with the preliminary phases of architectural design. The term *systems analysis* can be referred to the design process and to the designed architectural object. *Systems analyses* are carried on in architecture with the use of a differentiated language of notions and concern the investigation of selected problems and/or component elements of the architectural system. *Systems analyses* concern the conditions of the spatial arrangement/assembly being designed. These analyses are undertaken in the considerations of the architectural environment of the human being, which is also named the "built environment".

The **systems perspective**, particularly also the **systems architectural perspective**, implies a holistic conception where properties and behavior arise as a result of the interactive-integral activity of the system. Systems of human activity, particularly architectural systems, as wholes, are subject to auto-organization to the form of systems of higher order, analogically to every system that is organized by a connection of its proper set of subsystems. For example, in a designed architectural object many subsystems-arrangements can be distinguished, e.g. constructional, installation-type, functional subsystems-arrangements. Symptoms of resulting properties concerning the intellectual, communication and information aspects, constitute – especially with regard to human activity systems – the proof that the given system exists and is functioning. This concerns also human activity in the domain of designing and realizing architecture, the architectural environment.

The **systems point of view in architecture** leads to consider the building being designed as a designed whole, which is, at the same time, a part of a greater

whole: the environment or system. Such whole, or the architectural (cubic) mass, being designed and realized in interdisciplinary teams, can be considered, according to the knowledge of living systems theory, as a functioning organism or system. This designed architectural whole is more than a simple sum of elements of the whole.

Strategy. On the ground of the **methodological attitude** in the design process, the **incremental strategy** and the **ideal solution strategy** can be applied.

The *incremental strategy* is currently used in design, also in architectural design, and consists in improving the already existing solutions. It assures an evolutional development of the conception, however limited by the preliminarily accepted assumption. A change of this assumption is not possible without abandonment of the whole solution. This strategy describes the currently accepted traditional procedure. From the historical point of view, an older procedure is the procedure that is called in the literature as the *trial-and-error method*, being a characteristic method for the behavior of a routine artisan, this procedure consisting in improving verified solutions. An example of application of the incremental strategy is the evolution of construction in building engineering and, as a consequence, the evolution of forms of architecture caused by successive changes and improvements being introduced in the course of time (beginning from the antiquity) by different creative authors; such strategy led to the present-day solutions acknowledged as to be the optimal ones. Examples of these solutions are logically formed constructions of arch, bell, vault (e.g. buttresses of gothic buildings, their hardened deep foundations). These constructions have passed a long and expensive way of successive improvements.

The *optimal solution strategy* consists in searching for an ideal solution (as a solution that fulfills a complete set of criteria) and then in searching, through successive departures and concessions (from the ideal), for a real solution. The purpose of such activity is to direct, in a conscious way, knowledge about means and particular aims on the achievement of that, what, according to the ideal solution, is worth of being obtained. This is an adaptation of the ideal solution to requirements and constraints through possibly successive departures from the ideal. G.S. Alstszuler [2] and G. Nadler [89] are considered to be independently creators who propagated the ideal solution method. In Poland, W. Lenkiewicz, B. Machowski (The Lemach method) and others dealt with this question. The notion of an ideal solution has a heuristic power; it determines the direction of research, what contributes to an ordered thinking and positively influences invention rousing. The optimal solution strategy assumes aiming at the achievement of the goal determined by present interest needs, that is the ideal solution, but does not assume the achievement of this goal. This strategy accepts that the ideal solution is impossible to be realized because such solution has a complete set of criteria. This is an internally contradictory system. Aiming at the ideal solution is a fundamental assumption of the theory of inventiveness, developed and

realized in technique (engineering) by G.S. Altszuler. In the process of architectural design an abstraction is justified from the conventional way of thinking, typical for the strategy of improving. One of the possible ways to achieve this goal is a search for the ideal conception [94]. Actions of creating the conception of the ideal solution can run by two ways:

- in a rational way, based on logical premises, on information about solutions of such problems or analogical problems, according to different methods functioning in systems with different structures,
- in an intuitive way when the conception arises spontaneously, appearing suddenly in the architect's mind.

These problems concern, to a certain degree, the design of architecture. The ideal solution method, as a method supporting other design methods and strategies, can appear to be useful in architectural design. This strategy can particularly support such methods that require the creation of a synthesis-type vision of the spatial solution before starting the design. The method of morphological analysis belongs to these methods.

The *choice of strategy in architectural design* should depend upon the kind of the design task, upon the designer and the designing team, upon his/her/their qualifications, talent, experience, predispositions, upon possibly to bear financial and time costs etc., that means upon concrete needs and possibilities. It is possible to apply simultaneously both these strategies (of the ideal solution and of improvement). Thus, one cannot create or postulate a rigid list of actions, particularly in the process of architectural design.

Structure means the complex of relationships between elements and the whole, being considered in a determined respect, e.g. the spatial respect.The *structure of a process* signifies the order of actions of the process, distinguished with regard to a determined criterion [19].

Transdisciplinarity is a notion characteristic for architectural design, it is based upon the conceptual centralization of the position of people or of the human being, and the investigation of all the kinds of relationships between disciplines is a source of new improvements, of extension and integration of experimental methods [16]. All that can serve the improvement of the designed environment of the man.

Valuing [39] signifies assigning a value to something. Thus, it is some kind of actions, namely such actions that consist in evaluating events by a subject acting with the aim of realizing the valuable character of the event being estimated.

8. General summary and conclusions

The present work is oriented towards the future. The conviction has been advanced and judged to be valid that it is impossible to stop mechanisms of societal progress, and that looking in the face of the truth without fear is necessary, unless the civilization has to disappear [16].

According to the present-day scientifically and experimentally documented knowledge, the periodic classification of the elements is an example of regularity of the structure of the reality. The periodic classification of the elements is shaped in conformity with principles, which we call to-day the method of morphological analysis. Thanks to the existence of this documentarily evidenced example of the nature and the contemporaneous knowledge, particularly the systems knowledge and methodological knowledge, we can inquire further logic consequences of the state of things [128] (fig. 32). The carried on considerations concern the existing morphological regularities of the structure of the inanimate nature as well the regularities of design processes of the architect as natural thinking processes, thus, in consequence, their effects, i.e. architectural objects.

In this work, logical searching for the method of morphological analysis and/or for its elements in the structure of the matter, in micro- and macro-scale, i.e. in the creative activity of the human being, for example in the architectural activity, has been recognized to be possible. The reason of this search is the morphology of features of the animate and inanimate nature, particularly the independently described morphology of features of technical products of the man, e.g. the morphology of surfaces, such morphology being observed and supported by documentary evidence in its variety by many domains of science and technology. These facts indicate the increasing importance of problems of morphology in the present and future development of science and technique.

This work was elaborated as a result of searching for the truth on the creative process in architecture, this process being considered from the systems point of view. This inquiry was undertaken in conformity with the existing contemporaneous knowledge and with the accepted interdisciplinary approach to the being considered general and particular problems.

The present-day systems knowledge, so as life and architecture, does overcome the bounds of particular knowledge domains. The architect shapes the spatial framework of the man's life, and the common purpose of science is to protect life. This point of view had a decisive influence on the interdisciplinary approach to the problem of morphology of the architectural environment.

A systems-based, pro-ecological, praxiological and methodological way of thinking, as a multidirectional way of thinking transferred to architectural problems, can create new possibilities of a better comprehension and utilization of the gathered and being gathered knowledge, particularly knowledge about architecture, in conformity with the nature and its morphology. This problem is connected with the use – for describing architectural creative activity – of a system-based, methodological and informatic language of notions that does not destroy anything of values of knowledge, technology and art.

The architecture o the 20th and 21st centuries was and is designed in interdisciplinary teams. As architecture uses contemporaneous possibilities of technique, technology and science, it can be realized to a higher and higher degree in har-

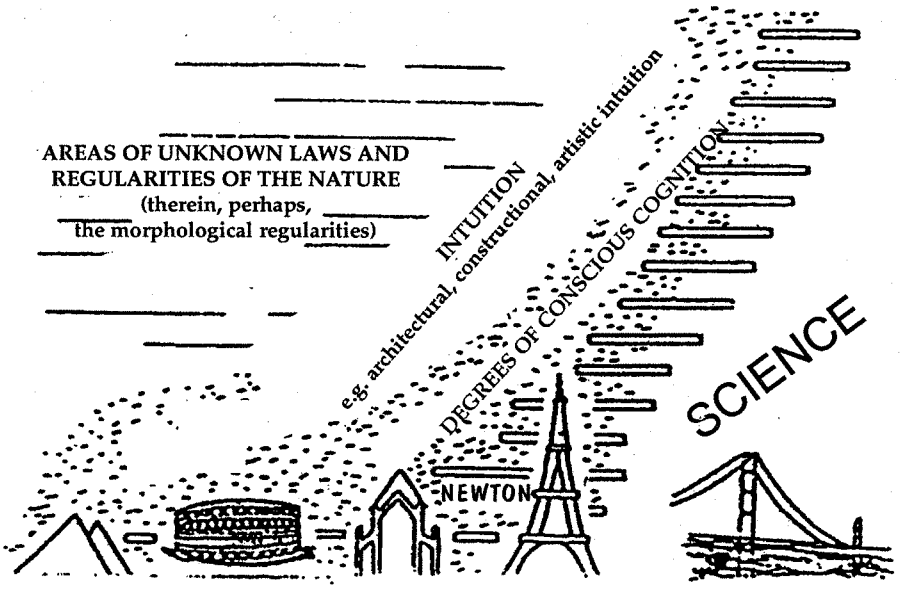

Fig. 32. This figure advises the possibility of inquiry of further multi-thread, logical consequences of the present state of the art in science, technology and architecture. Figure performed on the base of the drawing of W. Zalewski [129]

mony with the natural environment, with its micro- and macro-structure and with the nature of the human being. Systems knowledge and methodological knowledge together with their language of notions can become practically helpful in a better, more precise and faster communication between specialists of different domains of knowledge for solving problems of the necessary interdisciplinary cooperation, on condition that a familiarity with the system- and methodology-based language of notions will be generalized.

The carried on considerations on the morphology of an architectural work (achievement) treated as to be an organism, or system, mainly fall within the area being limited by the most largely comprehended problems of the man's needs, particularly needs concerning architecture, art, ethics, ecology and logic. Processes of designing architectural objects with morphological forms were subject to methodological investigations and systems descriptions. Morphological forms are features often being common features for the natural and designed environments.

A usefulness of the future processes of architectural design where will be used, in a fully aware way, the method of morphological analysis, will result also from the degree to with these processes will permit to understand, teach, and easily perform architectural design. This concerns also computer assisted architectural design.

According to present-day knowledge, buildings can be examined and shaped in interdisciplinary design processes, these buildings being treated as to be wholes

or systems composed of particular assemblies/arrangements or, in other words, as to be organisms. Such approach is observable in contemporary, being analyzed objects of architecture, as well as in many other objects that were not analyzed. The contemporaneous development of knowledge, praxiology and design methodology and of systems theory permits to analyze the process of architectural design as a coherent and simultaneously interdisciplinary decision-making process being conditioned in a many-sided way.

The selected and analyzed in this work examples of contemporary architecture present an architecture with morphological features, and thus present elements of practically applied by architects-designers intuitive methodical, methodological and systems thinking. One can find more such objects in the surrounding reality. The undertaken systems research of the morphology of architectural achievement serves the search for integrity of theory and practice in designing the architectural environment. It serves also the creation of a coherent image of the reality where the architectural environment has its fundamental place.

The system-based, pro-ecological and morphological image of architecture has been presented in conformity with the contemporaneous knowledge on architecture, systems theory, informatic and cybernetic knowledge, as well as with design methodology and praxiology. By basing upon knowledge from these domains, investigations were carried on of architectural system arrangements with morphological features, and of the processes of their design.

The carried out investigations show that an adaptation is possible, to the theory of architectural design, of the method of morphological analysis, which or the elements of which are intuitively applied in the design process. The use of the method of morphological analysis in architecture leads not to a limitation, but inversely, to an extension and liberation of the natural creative capabilities of the architects-designers.

The application of the method of morphological analysis or of its elements in practice and theory of architectural design can result in a development of architectural and methodological knowledge. If we accept that the human being with his/her intellect is a part of the nature, we thus accept also the fact that his/her intellectual process is subject to known and unknown laws of the system of the nature, also during architectural design. Our architectural products and processes of their producing bear the traces of such relationships, laws and regularities.

In the work, a praxiological description of the organization of activity in the process of architectural design has been presented. The proposed praxiological and methodological description is in conformity with real, multi-variant thinking processes of the architect-designer. A methodological description of the multivariant process of architectural design has been presented in the form of a decision making graph. This graph represents the architectural process as a tree of multi-variant design possibilities. The proposed record is one of many forms of the method of morphological analysis, well known and applied in technique (en-

gineering). The record of multi-variant design processes, performed in the decision graph, which is a form of the method of morphological analysis, indicates the importance of this method in the being described and discovered systems image of architecture.

In the carried on validation, the adequacy, correctness and purposefulness of the use of the method of morphological analysis have been determined, this method being in conformity with natural thinking processes of the man, and being an intellectual instrument of the designer in processes of designing architecture.

It results from the performed considerations that we can, at present, investigate in a system-based, methodic and methodological way, the process of architectural design and its effects, namely architectural objects. Methodological analyses of selected architectural systems and arrangements having morphological features were carried out when searching for the use of the method of morphological design or of its elements in architectural processes. The undertaken analyses concern the Ronchamp Chapel and the Villa Savoye from the thirties of the 20th century, created by Le Corbusier, as well as contemporaneous architectural works (achievements) of F.O. Gehry from the nineties of the last century. Investigations of selected architectural objects of the creative activity of Le Corbusier and F.O. Gehry showed that they are characterized by an architectural form that proves the use of principles, which are called at present the creative method of morphological analysis or its elements. The performed decompositions of the selected architectural forms demonstrate the fact that Le Corbusier and F.O. Gehry were applying the method of morphological analysis in the process of architectural design, and that the effect thereof was a morphological architectural form. Analyzing achievements of many other architects can continue investigations of this type.

Forms and their construction in the nature and architecture, particularly morphological forms, are a manifestation of laws and regularities that permitted their arising and continuing. The periodic classification of the elements, and strictly speaking its principles, are decisive to a measurable degree what concerns forms appearing in the reality. It has been accepted that those principles, laws and regularities, being manifested by every real form, perhaps were partially documented and illustrated by Mendeleev and his predecessors in the morphology of the structure of the matter, that means in the morphology of the classification of the elements. From the point of view of the modern systems science and methodological science, the periodic classification of the elements is a methodic example of generating morphological features and forms of the nature. The undertaken considerations point out its new systems meaning. According to the present-day knowledge on methodology and systems theory, the classification of the elements is a form of the method of morphological analysis (it is a morphological interval), i.e. a form of regularities to which we are generally subordinated together with our products, not only architectural products.

The being presented methodological, pro-ecological and systems image of the nature and architecture can contribute to the development of knowledge about the process of architectural design and to the development of real creative possibilities of a system-based and systematic improvement of the environment of human's life being designed, as artificial environment, perhaps being in conformity with the natural environment to a more high and high degree.

The empirical investigations carried out were recognized to be a verification of the possibility of a more general, not only intuitive use of the morphological method or its elements in present-day pro-ecological, systems solutions of spatial architectural arrangements. These investigations can be continued on examples of other objects of other architects-designers, which were not selected to be analyzed. It is possible that one can found elements of the method of morphological analysis in the creative architectural activity of F.L. Wright, A. Gaudi, Kenza Tange or of his disciple Arata Izosaki who dealt with system architecture, of S. Calatravy and other present-day outstanding architects. However, that exceeds the scope of this work.

The undertaken system- and methodology-based considerations concerning the morphology of an architectural achievement (work) can be used to improve the design and to teach architectural design, thus to improve spatial solutions of architectural arrangements/assemblies and of the being realized architectural environment. Rendering architectural designing and teaching more efficient can be realized, for example, by a practical application of the method of morphological analysis or of its elements.

The presented considerations can constitute an inspiration to carry on further search for the conception of systems improvement of the environmental functions of architecture.

The undertaken and presented investigations of architecture were associated with informatics and computer science. These investigations serve acquiring information on the architectural environment being understood as to be a part of a greater whole, i.e. of the system of the nature.

The fact of carrying on the presented system- and methodology-based considerations shows the immense possibilities of systems knowledge and research methods, particularly of the morphological method, as modern intellectual tools.

The inanimate and animate environment have morphological features and, at the same time, the realized products of the mind, to which belongs, among others, the architectural environment, selectively possess also such features to different extent. Maybe an analysis of these features will appear to be a key to improve the products, particularly the architectural products of the man. As an effect, this can lead to design an environment that will be more compatible with the natural environment, as a friendly habitat, prolonging the man's life, and it can lead as well to a balanced development, with maintaining cultural identity, therein the cultural identity of architecture. From the point of view of systems

knowledge and methodological knowledge, one should have perhaps recourse in these considerations to problems running from the micro- to macro-structure of the environment of the man and of the whole of the system, a part of which is the human being together with his/her creative possibilities. It is possible that systems knowledge, by its multiple relationships with all domains of knowledge and with the reality, will aid to join scientific discoveries that germinate in distant domains of science into a whole that will correspond, to a higher degree, to the complex reality.

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References

In the case of Journal Article:

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