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OSKAR VON MILLER'S CONTRIBUTION TO THE FORMATION OF THE GERMAN MUSEUM OF OUTSTANDING ACHIEVEMENTS IN NATURAL SCIENCE AND TECHNOLOGY

The German Museum of Outstanding Achievements in Natural Science and Technology in Munich was founded in 1903. For three years, its founder, electrical engineer Oskar von Miller (1855-1934), collected an extensive collection of historical and technical exhibits, and in 1906 the museum was opened to the public. The individual creative power of Oskar von Miller needed a certain social and cultural basis on which it could be realized. Miller's intentions were related to current problems in the country and his museum project corresponded to the interests of the national elite. The great popularity of the museum among the population and the concept of the museum itself is undoubtedly the merit of Oscar von Miller. The German Museum in Munich demonstrated for the first time that not only artists, but also technicians created masterpieces, not only philosophers, but also inventors had ingenious ideas, not only medieval objects, but also modern technology is a relic. O. von Miller formulated the most important motives and goals of the museum as follows: documentation of the role of technology for the development of society and culture; the implementation of an educational function in the presentation of

technology, the achievement of a national status. The didactic principles of organizing exhibitions in the museum served to popularize natural science laws, to visually demonstrate the functional application of technical inventions. The presentation of technical objects was qualitatively different from the exhibition principles of other technical museums. Demonstration of old technologies and historical machines in action was already the norm in museum work. O. von Miller set the task of the museum to explain the technology of manufacturing technical products, such as watches, fabrics, and so on, for which fragments of workshops and factories were reproduced in exhibitions. For the first time in a technical museum, in addition to the traditional chronological display of technical inventions, the principle of operation of machines and apparatus was explained by means of experiments conducted with exhibits by visitors and museum staff. This function was extremely new for the technical museum and was nevertheless carried out mainly by the public, mainly students and young people. The immersion into the environment and the public's participation in the technical process was Oskar von Miller's tremendous contribution to the technical exhibitions of all museums.

Keywords: *natural science, technology, outstanding achievements, technical museum, technical invention, exhibition, creative power*

ВНЕСОК ОСКАРА ФОН МІЛЛЕРА В СТАНОВЛЕННЯ НІМЕЦЬКОГО МУЗЕЮ ВИДАТНИХ ДОСЯГНЕНЬ ПРИРОДОЗНАВСТВА І ТЕХНІКИ

Німецький музей видатних досягнень природознавства і техніки в Мюнхені був заснований у 1903 році. За три роки його засновник електроінженер Оскар фон Міллер (1855-1934) зібрав велику колекцію історико-технічних експонатів і у 1906 році музей був відкритий для публіки. Індивідуальній творчій силі Оскара фон Міллера був необхідний відповідний суспільно-культурний ґрунт, на якому вона могла б реалізуватися. Задуми Міллера були пов'язані з актуальними проблемами, його музейний проект відповідав інтересам національної еліти. Велика популярність музею у населення і власне концепція музею, є, без сумніву, заслугою Оскара фон Міллера. Німецький музей у Мюнхені вперше продемонстрував, що не тільки художники, але й техніки створювали шедеври, не тільки філософи, але й винахідники мали геніальні ідеї, не тільки предмети Середньовіччя, а й сучасна техніка є реліквією. Найважливіші мотиви і цілі музею О. фон Міллер сформулював коротко так: документація ролі техніки для розвитку суспільства і культури; здійснення навчально-виховної функції в уявленні техніки, досягнення музеєм загальнонаціонального статусу. Дидактичні принципи організації виставок в музеї служили популяризації природно-наукових законів, наочному показу функціонального застосування технічних винаходів. Презентація технічних об'єктів якісно відрізнялася від виставкових принципів інших технічних музеїв. Демонстрація старих технологій і історичних машин в дії вже тоді була нормою музейної роботи. О. фон Міллер

ставив завданням музею пояснення технології виготовлення технічної продукції, такої як годинники, тканини тощо, для чого в виставках були відтворені фрагменти майстерень та фабрик. Вперше в технічному музеї крім традиційного хронологічного показу технічних винаходів пояснювався принцип дії машин та апаратів шляхом експериментів, що проводились з експонатами відвідувачами і співробітниками музею. Ця функція була виключно новою для технічного музею і здійснювалася все ж в основному публікою, переважно студентами і молоддю. Прийом «занурення в середу» та участь публіки в технічних процесах були величезним внеском Оскара фон Міллера в технічні виставки всіх музеїв.

***Ключові слова:** природознавство, технологія, видатні досягнення, технічний музей, технічний винахід, виставка, творча сила.*

Introduction. Since the 1850s, industrial museums have emerged in German countries with permanent exhibitions of industrial products in order to showcase examples of industrial achievements. The first was the Musterlager in Stuttgart, founded in 1850, followed by the industrial hall in Karlsruhe and the Bavarian industrial museum in Nuremberg. The next major technical museum in the world was the German Museum of Outstanding Achievements in Natural Science and Technology, which was created taking into account the experience of the first two museums (despite the lack of a clear classification of the composition of the collections in them). The Deutsches Museum in Munich became the largest technical museum of its time, organized according to modern scientific and exhibition principles.

The German Museum of Outstanding Achievements in Natural Science and Technology in Munich was founded in 1903. For three years, its founder, electrical engineer Oskar von Miller (1855-1934), collected an extensive collection of historical and technical exhibits, and in 1906 the museum was opened to the public.

Research methods. The aim of the article is to analyze the contribution of Oskar von Miller to the founding of the German Museum in the initial phase of its formation. Previous ideas about the origin of the museum were based on the formal result of the interaction of various ministries, commissions, unions and therefore were of a historical and institutional nature.

In this scientific study, the methodological basis of the study is the historical method of research, based on the study of the emergence, formation, and development of objects in chronological sequence, which achieves an in-depth understanding of the essence of the problem. In addition, a chronological method was used, which provides for the presentation of historical material in chronological order at all stages of the development of a historical phenomenon, the methods of bibliographic and source analysis used in the search, systematization, and processing of primary information. The principles of historical validity, objectivity, consistency, and complexity have also been applied.

Results and discussion. The individual creative power of Oskar von Miller needed a certain social and cultural basis on which it could be realized. Miller's intentions were related to current problems in the country and his museum project corresponded to the interests of the local, regional and national elite. The great popularity of the museum among the population and the concept of the museum itself is undoubtedly the merit of Oscar von Miller.

Oskar von Miller was born in 1855 in Munich, his father, Ferdinand Miller, was a famous bronzer who organized an exhibition of German and Austrian applied arts in 1897, where, along with new works, pieces of old masters were exhibited [5, p. 27]. Oscar von Miller inherited his ability to work and talent in organizing exhibitions and activity in popularizing knowledge from his father. In 1878 he graduated from the Technical University of Munich, where he studied civil engineering, specializing in the construction of railways, waterways and bridges. As a qualified engineer, he entered the public service, where he worked with construction contracts, and in 1879 he was transferred to the Ministry of Transport [1, p. 344].

Oskar von Miller received his first experience in museum and exhibition business as a Commissioner of the Bavarian Government at the International Electrotechnical Exhibition in Paris in 1881. A variety of European electrical equipment (telephones, motors), DC dynamos and Edison incandescent lamps were on display here. In Paris, he visited the Conservatory of Arts and Crafts and studied the collection of hydraulic machines. Having decided to use the knowledge gained in

practice, after returning from Paris, Miller began working in a new branch of engineering – electrical engineering and studying the possibilities of using the waters of the Bavarian Alps in the production of electricity [3, p. 77].

In 1882, Miller organized the Munich Electrical Engineering Exhibition, where he applied the experience gained at the Paris Exhibition. The exhibition demonstrated the transmission of electrical energy from Miesbach to Munich over a distance of thirty-five miles, while at this time the maximum distance for the transmission of electricity was considered to be a distance of one thousand meters. Thus, he proved the correctness of the French engineer Marcel Desprase, who argued the possibility of transmitting electricity over long distances [8, p. 52]. Miller paid the main attention at this exhibition to the pedagogical impact of exhibits on the public in order to popularize technical knowledge.

In 1883 O. von Miller visited France, England, and the USA (here he became friends with T. Edison) to study the latest achievements in electricity. The richest collection of locomotives and machines in the South Kensington Museum made a huge impression on him and Miller later said that it was then that he decided to found a science and technology museum in Germany [3, p. 76].

After returning to Germany, Miller received an offer from Emil Rathenau, founder of the German Edison Society for Applied Electricity, to design and build a central power plant in Berlin. O. von Miller envisioned the creation of a hydroelectric power station in Munich, but did not find support in Bavaria. Miller's Berlin Central Station was the largest generating system in Europe and made him famous [4, p. 124]. Rathenau (AEG) becomes the world's leading organization in the field of electrical production (Allgemeine Elektrizitäts Gesellschaft), which later provided significant financial assistance in the organization of the German Museum. Despite a large salary at AEG, O. von Miller returned to Munich, where he organized his own consulting engineering firm. Miller's entrepreneurial activity developed successfully, after the construction of power plants in German cities and abroad, he created an energy system for Bavaria. It was one of the first structures of this kind in the world, which consisted of hydroelectric and coal-mining stations connected into a single system, which were

in the department of the state and supplied the whole of Bavaria with electricity and light. O. von Miller proved to be an engineer-entrepreneur, leading technical innovations and modernizing the industrial process as a whole. When implementing his technical projects, he brilliantly solved issues of ecology, preservation of social values, took into account political and institutional factors [1, p. 348].

In 1891, he was director of the Frankfurt Electrical Exhibition, which lasted six months and was visited by over a million visitors. Here were presented domestic historical exhibits, such as the Siemering telegraph in 1809, Hertz's radio apparatus, as well as the latest equipment from leading companies. It is also necessary to note the design of the exhibition in order to attract the general public and popularize technical knowledge – powerful night illumination of the square and pavilions, a full-size panorama of a transatlantic steamer, lectures, music, ballet, pantomime. Theatricalization in the demonstration of exhibits at industrial and technical exhibitions, which received more and more attention, was used to educate the public. The focus of the Frankfurt exhibition was an experiment with electric current, which repeated the Munich one, but more successfully. Here it was again proved that electric current can be transmitted over long distances quite economically and safely with alternating current under high voltage. This meant that the idea of electrical distribution networks serving long distances is quite feasible in practice [1, p. 344]. The machines on which the experiment was carried out are currently on display in the Deutsches Museum.

Miller's Frankfurt experiment was an engineering sensation and professionals from all over the world, especially the United States, visited Frankfurt to be convinced of an important discovery. On the basis of an experiment in 1896, a commercial line of 27 miles was opened between Niagara Falls and Buffalo [6, p. 16-17]. After the Frankfurt exhibition, O. von Miller's reputation as a courageous and trustworthy electrical engineer was established throughout the world.

The influence of exhibitions in the last quarter of the 19th century on the development of museums was enormous. Some exhibitions gave impetus to the formation of museums, building on the basis and deepening their concepts of their

expositions, as was the case with the Munich Electrotechnical Exhibition (as well as with the Nuremberg Bavarian Exhibition). The high attendance of industrial and industrial exhibitions in an age of developed industry reflected the general belief in the progress of civilization and admiration for technological achievements. The experience of the retrospective departments of commercial trade shows, illustrating the linear rise of civilization, was perceived by the German Museum in a consistent presentation of the technological development of machines, reflecting an evolutionary approach to the problems of technological progress.

In 1909 O. von Miller became a member of the Upper House of the Bavarian Parliament and Commissioner for the Electrification of Bavaria. Skillful conduct of discussions, solution of complex technological problems in a clear form for everyone made Miller a recognized leader in wide circles of the population [4, p. 156]. After the revolution, he was appointed State Commissioner of the new Republic, at the end of the First World War he was a member of the German delegation at the Versailles Peace Conference. His high professionalism is evidenced by the list of his posts, positions and titles: Chairman of the Bavarian Branch of the Union of German Engineers, founder of the Research Institute of Hydroengineers and Hydropower, Honorary President of the World Energy Conference, founder of the Academy of Science and Technology, since 1925 Doctor Munich Technical University. From the post of President of the German Museum, he was re-elected a year before his death, in 1933, at the annual meeting of the Board of Directors at his request due to health conditions [1, p. 358].

O. von Miller's activity in popularizing technology reflected his belief in progress. He strove to demonstrate the importance of natural science and technology for the further development of the state. As the chairman of the Bavarian branch of the Union of German Engineers, he tried to show the role of the social stratum of engineers in economic well-being and social progress and thereby increase their social prestige and, in addition, graphically represent the interdependence in the development of natural science and technology.

Like many other engineers, O. von Miller saw himself as a politically neutral expert in purely technical matters. In the Charter of the professional organization of German engineers, the Union of German Engineers, it was declared a politically neutral organization, whose members occupied a position between dependent workers and self-employed entrepreneurs [5, p. 135].

The struggle of engineers for their position in society was directed against the imperial political system, they sought a new social status and inclusion in the changing economic and social structures. In this way, the technicians sought to become a real state power in the creation of general welfare.

The establishment of the museum was an important stage for the representatives of engineering science in the Union of German Engineers and the Technical High School on the way of their social recognition in the empire. In one of the main cultural institutions – the museum – their achievements in the field of technology and industry were to be evaluated, which meant recognition of their contribution to the development of culture, along with the merits of the long-formed third estate.

The German Museum in Munich demonstrated for the first time that not only artists, but also technicians created masterpieces, not only philosophers, but also inventors had ingenious ideas, not only medieval objects, but also modern technology is a relic.

In the implementation of the project of the German Museum, the Union of German Engineers, which consisted of 17,757 members from 206 branches, played a major role as one of the most influential unions in Germany [5, p. 155]. O. von Miller wrote a call for the formation of a museum as chairman of the Bavarian branch of the Union of German Engineers and linked the formation of the museum with the annual congress of the Union held in 1903 in Munich. Funding of the museum by the Union and the personal participation of many of its members in the commissions of the museum clearly show the common interests of the professional organization and the museum. The permanent chairmen of the museum until 1921 O. von Miller, W. von Dick and K. von Linde enjoyed the reputation of authoritative representatives of the

Union of German Engineers. In 1905, over half of the members of the museum's commissions were members of the Union [5, p. 155].

The first technical museums in Germany were opened in Nuremberg: in 1872 the Industrial Museum, in 1885 – the Railway Museum (since 1901 the Royal Bavarian Museum of Technology), but they did not receive a public response and remained at the level of private museums. The proposal to create a natural-scientific-technical museum in the capital of Bavaria was made in 1886, and then – in 1892 in Berlin. Both proposals remained unrealized [5, p. 129].

Miller formulated the need to create a museum of outstanding achievements in natural science and technology in his main theses in May 1903, which he sent to representatives of science, politics and economics for preliminary discussion. He pointed out the growing importance of industry and technical sciences and their growing influence on all spheres of culture. In this regard, Miller believed, a museum of technology and natural history should be established in Germany, modeled on museums in France and Britain, which would offer a rich material for scientific and technical education, the enthusiasm of young people in technology and for the glory of the fatherland. The collection exhibition was intended as a «hall of fame» for outstanding scientists and technicians. Miller emphasized that «the museum had to be different from industrial exhibitions in the same way as the national museum is different from the industrial museum» [5, p. 138].

O. von Miller formulated the most important motives and goals of the museum as follows: documentation of the role of technology for the development of society and culture; the implementation of an educational function in the presentation of technology, the achievement of a national status by the museum for competitiveness with Paris and London.

Well-known figures of science, politics and industry invited by Miller, among whom were Professor V. K. Roentgen and engineer R. Diesel. O. von Miller in his speech declared that the main task of the German Museum was to show the development of science and technology and the influence of inventions and technical progress on the history of human society. He reiterated that instruments and machines

will be displayed in a museum in the Pantheon or Hall of Fame, dedicated to the creations of leaders in science and technology [5, p. 138].

The Charter of the German Museum, developed later, was an expanded concept of O. von Miller. The task of the German Museum has been designated as «presenting the historical development of natural research, technology and industry in their interaction and reflecting the main stages of this development through the display of outstanding and typical inventions of masters» [2, s. 45]. The inventions of the masters were understood as the result of the interaction of scientific research, technical implementation and industrial application. At the same time, historical and technical development and the social consequences of technical progress remained in the background.

Miller emphasized that the museum would be created for the benefit of all of Germany and sought support from government, industry, universities, scientific and professional organizations and individuals. Miller's concept was accepted and prior to the construction of the planned building, the Kingdom of Bavaria and the city provided the museum with temporary premises in the Old Bavarian National Museum on Maximilian Strasse. The locomotive manufacturer Georg Kraus donated 100 thousand marks to the museum [1, p. 350].

By analogy with the British Museum in London and the German National Museum in Nuremberg, the museum was called the «Deutsches Museum», which emphasized the national character of the institute. At the same time, the title did not imply an exclusion from the scope of showing the contribution of foreign inventors, scientists and technicians in the corresponding sections of the exhibition.

On June 28, 1903, in the ceremonial hall of the Royal Bavarian Academy of Sciences, under the chairmanship of Prince Ludwig, who took over the protectorate over the museum, the establishment of the museum was announced [5, p. 141].

The titled administration of the museum, headed by the German Chancellor, included the German Minister of the Interior and the Bavarian President-Minister and Minister of Education. At the suggestion of the Minister of the Interior, O. von Miller, W. von Dick and the engineer and industrialist K. von Linde were elected as

chairpersons of the museum. They formed the so-called small executive committee, to which the real power belonged. A. Rippelt, Professor V. K. Roentgen and W. von Siemens, which assumed their scientific, technical and formal leadership. By 1913, the Board of Directors and the Board of Advisers numbered 102 people, of whom 63 were appointed by the German and Bavarian governments and 39 by the General Committee of 575 members – leaders of German science, technology and industry. The Board of Directors met annually, members of the General Committee held scientific consultations for museum staff and, if necessary, provided financial assistance to the museum [1, p. 350].

The cost of the new museum building was 7 million marks. In addition, the funding for the construction of a new museum building, completed in 1913, shows how persistently O. von Miller attracted the industrial and political elite. Personal merit of O. von Miller was also the participation of Emperor Wilhelm II in the solemn laying of the foundation of the museum. Thus, the museum was demonstratively raised to the state level and the issue of funding from Berlin was resolved [9, p. 38].

The new museum, designed by Gabriel von Seidl, consisted of exhibition rooms, a library and a collection, a hall of fame, a lecture hall, a central power station, a restaurant for visitors, management rooms, industrial premises and apartments for employees. More than half of the cost of the new building was contributed by the German and Bavarian governments, Munich, Berlin, Hamburg city authorities and German industrialists and their numerous associations. Many industries provided building materials free of charge, which were also transported by rail free of charge. The rest of the sum was made up of membership fees, honorarium, public sale fees [10, p. 68].

After the legal recognition of the formation of the museum, Miller immediately began work on acquiring the collections. The collection was based on the Royal Academy of Sciences collection of physics and mathematics instruments. O. von Miller immediately showed his authoritarian approach in dealing with museum issues. The transferred meeting was supposed to be exhibited by the higher

institutions in the same order. However, Miller decisively refused this and defended in the Ministry of Culture his own exhibition principles and the right to an autonomous decision in matters of exposition construction. He did not object to individual labels and display cabinets and allowed the ministry to use them in the design of their collection. He made concessions in minor details, but in controversial issues defended his position and the exhibits in the departments obeyed his irrefutable exhibition concept. Miller believed that only firms for the objects donated by them could dictate exhibition principles. Miller viewed the museum as his own project in which his performances were carried out and was convinced that the management of the museum should be in your own hands. One of the chairmen of the museum's board of directors, K. Duisberg, said that he could only be considered a friend of Miller by adhering to his point of view and that Miller's unwritten rule in the museum was that «everyone here will do what I want» [8, p. 57]. His sensitive reaction to the social and economic situation in the empire and acting in accordance with state interests helped in the implementation of all his decisions.

Miller was extremely active in acquiring machines, apparatus, instruments and other exhibits for the museum. His petitions were sent to ministries, institutions and enterprises, to other museums and to individuals and, as a rule, brought results. He requested objects from the governments of neighboring Bundes states – in Hesse, Baden, Württemberg, Bremen, Hamburg, as well as Switzerland, and constantly repeated that the museum represented every part of Germany and indeed received support from the central and northern lands.

In cases where he could not make a request on his own behalf, he acted with the help of the Bavarian Ministry of Foreign Affairs. So, in letters to the Ministry, he asked to subscribe objects from Japan [5, p. 145]. Emperor Wilhelm II, after one of his meetings with Miller, presented a model of a steam ship to the museum, satisfied with the conversation about the design of the model. The basis of the domestic contribution to the museum collection was the collection of the Bavarian Transport Administration, a collection of old instruments of educational institutions in Bavaria, as well as models provided to the museum by the supreme building supervision of

Bavaria. Among the private donors in the field of large industry, the Krupp steel plant in Essen, the Siemens and Halske electrical company in Berlin and the Karl Zeiss optical plant in Jena [10, p. 27]. The most interesting exhibits in the museum were: the first steam engine used at the Krupp plant in 1835, the first electric locomotive from Siemens-Halske, the first gas engine in Germany produced by Deutz, the Reichenbach water mill, which brought the salt from the Berchtesgaden salt mine to the saltworks Reichenhall [10, p. 27].

The first departments of the museum were opened to the public in 1906 in the building of the old national museum, in 1909 – in the former barracks on the Isar River. Participation in the opening ceremony of the German Emperor, Prince Regent and Crown Prince of Bavaria, as well as the decoration of nearby streets and squares, turned the opening of the museum into an event of national importance [1, p. 351].

When planning the departments, the collections of the museum were divided into 36 groups (with internal classification) in accordance with the special taxonomy of engineering and natural science, in 1904 the number of groups exceeded forty [10, p. 34]. Miller reflected his main ideas later in the article «Technical museums as centers of education» (1929), where the collections were divided into forty topics according to the main sections of transport and industry.

However, due to the lack of space available in the old national museum, the originally conceived classification was significantly changed. There were departments of geology, metallurgy, hydraulic motors, electrical engineering, mathematics, astronomy, mechanics, optics, acoustics (with an extensive collection of musical instruments), photography and others [5, p. 168].

Criticisms were expressed regarding the accepted classification of groups aimed at creating additional departments. O. von Miller accepted the proposal to create a Department of Technical Hygiene, since the founder of scientific hygiene Max von Pettenkofer worked in Munich and the basis of the museum collection from the Bavarian Academy of Sciences was named after him, but abandoned the Department of Physiology and Descriptive Science due to the fact that they did not have an impact on the development technology and industry and went beyond his concept of

visualization of the stages of technological progress. Further proposals did not affect the established division of the collection and were directed only to classification within technical taxonomy. For example, R. Diesel spoke in favor of dividing the departments of windmills and hydraulic motors, which met with the approval of O. von Miller, since it did not extend to the sphere of social history [5, p. 168]. Obviously, all the criticism expressed did not touch upon the fundamental principles of the exhibition.

The departments were headed by the referents selected by the committee, who were, as a rule, prominent specialists in their fields of knowledge and held the positions of professors of technical schools. By 1907, 57 referents were working in the museum [10, p. 117]. They compiled lists of exhibits necessary for the most complete demonstration of the development of individual branches of technology.

O. von Miller consulted with members of the General Committee on the search and acquisition of genuine exhibits (as well as making models). To help the referees in the creation of departments, Miller attracted students and candidates for the position of teachers, for whom the working time in the museum was counted as study shifts. They worked on the lists compiled by referents, students in the form introduced by O. von Miller wrote letters to various authorities with a request to transfer certain exhibits to the museum. He checked and signed all correspondence personally, despite the fact that the number of letters sometimes reached two hundred a day. Detailed projects of departments with emphasis on the most important points, in fact thematic-exposition plans, existed long before the acquisition of exhibits and exhibition equipment [5, p. 168].

The staff of the museum at the time of opening was about 35 professional workers – administrators, engineers, architects, technicians [5, p. 169]. Obviously, in the formation of the staff for O. von Miller, the main factor was the person's agreement with his concept and loyalty to him personally. Among the staff members of the museum and community assistants, he wanted people from whom one could not expect significant criticism. The involvement of students, freelance teachers and employees of their firm in museum work confirms this assumption.

The didactic principles of organizing exhibitions in the museum served to popularize natural science laws, to visually demonstrate the functional application of technical inventions. With these targets, objects could not be displayed in showcases without accompanying materials. The Statute of the Museum stated that in order to accomplish the tasks set, a collection of original instruments, apparatus and models «which are exhibited in the museum visually organized and explained for general inspection» [2, s. 43], as well as an archive and library for research work.

Conclusions. The presentation of technical objects was qualitatively different from the exhibition principles of other technical museums. Demonstration of old technologies and historical machines in action was already the norm in museum work. O. von Miller set the task of the museum to explain the technology of manufacturing technical products, such as watches, fabrics, and so on, for which fragments of workshops and factories were reproduced in exhibitions.

The main thing in the exhibition concept of O. von Miller was the demonstration of technical achievements as applied natural science, which excluded the demonstration of the application (use) of technical innovations in the industry provided for in the Charter.

The Deutsches Museum in Munich, the largest and most visited museum in Germany, was in its initial phase a model for the presentation of natural science and technology. As the main technical museums of the time, the South Kensington Museum in London and the Conservatory of Arts and Crafts in Paris, the Deutsches Museum was a kind of encyclopedia of science and technology, but significantly surpassed them in terms of exhibition space in its new building on Colin-Insel (building more than 30,000 square meters and a pavilion of 3,000 square meters) [10, p. 159].

It showed a panorama of historical machines and presented processes illustrating the development of science and technology. These objects, together with an extensive library, aroused particular interest among industrialists, engineers, workers. Observing the exhibits and analyzing the materials related to them, this category of visitors applied the acquired knowledge in practice.

For the first time in a technical museum, in addition to the traditional chronological display of technical inventions, the principle of operation of machines

and apparatus was explained by means of experiments conducted with exhibits by visitors and museum staff. This function was extremely new for the technical museum and was nevertheless carried out mainly by the public, mainly students and young people. The immersion into the environment and the public's participation in the technical process was Oskar von Miller's tremendous contribution to the technical exhibitions of all museums. Curator of the South Kensington Museum and founder of the Pioneer Society, H. W. Dickenson said of Oscar von Miller: «He made so many innovations in museum technology that he fundamentally changed the public's attitude towards museums – museums are now perceived not as distant and closed institutions, but as living and stimulating public places» [3, p. 76].

The German Museum was the first to show the ways and forms of application of technology and at the same time remained a science museum, the purpose of which was to trace the connection between the exact sciences and technology, between purely scientific research and technological application. The demonstration of the technology was based on the scheme proposed by O. von Miller, which consisted of three parts: raw materials, energy, information.

The didactic concept of the exhibition of technical artifacts was completely new for the beginning of the 20th century. The main role in the founding of the museum was played by the educational purpose of the museum. For the first time, the educational function was recognized as a priority in relation to the collecting and custodian function of the museum. This approach led to a new understanding of the museum and its role in society and was an innovation in the history of general museum work.

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