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TWO SIDES OF SCIENTIST GEORGE KISTIAKOWSKY

The article is devoted to the analysis of problems related to the responsibility of scientists for the results of their activities. The development of science and using its results in practical life raises a number of questions related to this topic. An example for consideration of this issue can be the work of an outstanding scientist, physical chemist George Kistiakowsky. Despite the prominence of this researcher, his creative activity is explored insufficiently. It especially concerns native biography science. This is due, in particular, to the complicated scientist's biography. The paper deals with the study of the life path and scientific achievements of G. Kistiakowsky. The source base of the research consists of a biographical encyclopedic dictionary, and works of native and foreign authors. We have tried to reproduce as much as possible the way of a scientist's life in all its contradictions and determine his contribution to science. Special attention is paid to his family, which played a significant role in the formation of several talented scientists in various fields of knowledge. Being the author of many works in the field of physical chemistry, G. Kistiakowsky is nevertheless best known as a participant in the project for creating the first atomic bomb. However, the main attention has been paid to such controversial points that took place in scientist's life and work. Thus, as one of the developers of nuclear weapons, G. Kistiakowsky devoted his entire life to the struggle for peace, limiting developments in the field of nuclear weapons and preventing their use. The threat of nuclear war today requires considering the significance of some scientific discoveries for the future of mankind once again. And G. Kistiakowsky's position can be a typical example of a balanced approach in the consideration of scientists' responsibility concerning the results of their developments.

Keywords: scientist's responsibility, nuclear weapons, implosion, disarmament, international security.

Introduction

The study of the life and work of outstanding native scientists has always been important. But it becomes especially relevant in modern conditions. First of all, this concerns those scientists who, due to various circumstances, were forced to leave their homelands and continue their activities abroad. An analysis of the events from the first half of the last century gives us an opportunity to better understand today's global changes.

One of these representatives is outstanding scientist George Kistiakowsky, physicist-chemist, native Ukrainian, a member of the US National Academy of Sciences (1941), its vice president (1965-1972).

His scientific research and technical developments concern the physics of explosion and creation of the atomic bomb. He invented several types of explosives, including plastids, developed the hydrodynamic theory of explosion and nuclear ignition for the first American plutonium bomb, using an implosive detonation (atomic bomb of the implosive type). After 1945 G. Kistiakowsky opposed the using of nuclear weapons and their proliferation, took an active part in international meetings of scientists advocating for peace, disarmament and international security, as well as for the prevention of world thermonuclear war. He has made significant contributions to high-level disarmament negotiations between the United States and the Soviet Union.

G. Kistiakowsky is the author of more than 150 publications on the kinetics of reactions in the gas phase, the structure of polyatomic molecules and thermochemistry of organic compounds. For his scientific work and high professional achievements, the scientist has received the main awards from the American Chemical Society. Besides, he was awarded the Medal for Merit from President Truman in 1946, the Presidential Medal of Freedom from Eisenhower in 1961 and the National Medal of Science from President Johnson in 1967. Great Britain awarded him the King's Medal for Service in the Cause of Freedom in 1948. It is the person of G. Kistiakowsky who has met expectations of many Ukrainians that rights and dignity of our people will be properly appreciated.

The **novelty** of our study is the coverage of little-known aspects of G. Kistiakowsky's life and the analysis of contradictory moments in his creative activity. Great importance is also given to such issues as Responsibility in Science.

The **object** of our investigation is study of the biography, scientific, social and political activities of the Ukrainian origin American scientist G. Kistiakowsky.

Systematization and analysis of individual facts and aspects of G. Kistiakowsky's activity is **the subject** of our study.

Research methods

The study is based on the fundamental principles of historicism, objectivity and comprehensiveness, which determine the research methods, including comparative-historical, subject-logical, system-functional methods. Special techniques, such as problem-chronological, comparative, biographical methods are also engaged. We used the origin and archival approaches for analysis of the source base. The method of generalization and systematization of facts is employed in the preparation of conclusions.

Sources analysis

Despite the significant contribution of G. Kistiakowsky into world science, the figure of the scientist still remains insufficiently studied in native historiography. This is due to the fact that the scientific and organizational activities of the scientist took place outside of Ukraine. We can notice the works of V. Shenderovsky[1], S. Trofimenko[2], L. Depenchuk[3], biographical dictionary "Foreign scientists – natives of Ukraine"[4] and article of Yu. Khramov and M. Stankova[5].

Foreign sources include J. Watson's book "Avoid Boring People: Lessons from a Life in Science"[6], R. Rhodes "George Kistiakowsky's Interview"[7], F. Dainton[8], W. Lambers[9] and M. Specter[10].

Therefore, the **aim of the article** is the most complete description of G. Kistiakowsky's life, as well as two sides of his social and political activities.

Results

George Kistiakowsky was born on November 18, 1900 in Kyiv in the family of the famous lawyer and sociologist Bohdan Kistiakowsky. Bohdan, together with his brother physical chemist Volodimyr, was elected

[1] Шендеровський, В. (2006). *Він створив її і добився її заборони. Нехай не гасне світ науки: у 4-х книгах*. Київ, *2,* 117-123.

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[5] Храмов, Ю.О., Станкова, М.Д. (2021). Видатний фізико-хімік Джордж Кістяківський (18.11.1900–07.12.1982). *Наука та наукознавство, 3 (113),* 121-130.

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member of the Ukrainian Academy of Sciences in 1919. G. Kistiakowsky studied at a private gymnasium in Moscow, but finished last year of study in Kyiv, where he moved to in 1917.

The young George could not avoid the political fever and unrest of the time after the Revolution of 1917. According to Dainton[1], Kistiakowsky's youth in Russia ended with a whole series of hair-raising narrow escapes as a soldier in the White Army. He was given up for dead with hundreds of other typhus victims, and then fled the Red Army on a French ship. After a short stay in Turkish captivity Kistiakowsky lived in France and then in Germany, where he entered the University of Berlin in 1920. He completed his undergraduate and graduate work in record time, achieving his Ph.D. and was appointed assistant to Max Bodenstein, who had supervised his thesis work on the photochemistry of chlorine monoxide and ozone. For the first third of the 20th century Berlin could be justly described as the cradle of physical chemistry. Its alumni frequently founded or led pioneering departments all over the Western world, and from time to time some would turn to their old master Bodenstein for advice on able persons whom they might recruit[2].

On the Bodenstein's advice Kistiakowsky took the post of International Education Board Fellow. The scientist held this position for two years. In 1926, the scientist moved to the United States, where he became a professor at Princeton University, and on 14 April 1927, he was appointed Research Associate and DuPont Fellow with the rank of Instructor. At that time Kistiakowsky worked on the problems of adsorption and catalysis, at the same time starting work on writing a book on photochemistry.

The publication of a monograph on photochemical processes made Kistiakowsky more widely recognized as an expert in photochemistry, and this was reflected in his promotion to the rank of Assistant Professor on 25 October 1928.

He had thus successfully placed his foot on the bottom rung of the academic ladder, ready as a gifted experimentalist and a fertile, intuitive thinker to carve out a distinctive niche for himself in reaction kinetics and mechanisms. Two years later came the call to Harvard, whither he moved with his Swedish wife, the former Hildegard Moebius, whom he had married in his first year at Princeton and by whom he had a daughter Vera, now Professor of Physics at Massachusetts Institute of Technology.

Since 1930 Kistiakowsky held the position of professor at Harvard University in Boston, and in 1940-1943 he headed the laboratory of the National Defense Research Committee.

With the start of the Second World War, Kistiakowsky was engaged in the Manhattan Project, a nuclear program. One of the problems connected with the functioning of an atomic bomb is the assembly of the component parts of the critical mass. These have to be rapidly propelled into position. As a member from 1941 of the National Academy of Sciences Committee on Atomic Energy and the country's leading explosives scientist, Kistiakowsky was appointed head of the Explosives Laboratory at Los Alamos (New Mexico). He held this position in 1944-1945, in particular, directing the development of detonators for the first American atomic bombs.

Seth Neddermeyer, who also worked at the Los Alamos Laboratory of the Manhattan Project, was one of the first supporters of implosion techniques development for the assembly of a critical atomic bomb mass. Although the explosion was proposed by Richard C. Tolman in 1942 and discussed in introductory lectures in Los Alamos, S. Neddermeyer was one of the first to give it full development, presenting in April 1943 the first substantial technical analysis of implementation. R. Oppenheimer considered it as the beginning of an implosion study in Los Alamos and appointed him as a head of a new group of E-5 implosion tests. Cannon-type nuclear weapons were considered the best method, but implosion research was a backup. S. Neddermeyer began an intensive series of experiments to test the cylindrical implosion, resulting in a series of distorted shapes. Later members of his group H. Bradner and J. Tuck devised explosive lenses, in which cumulative charges were used to focus the force of the explosion. However, unsolvable problems with the shock wave of uniformity forced to pay attention for implosion. By September 1943, Neddermeyer's team had grown from five to fifty persons. J. Neumann also worked in Los Alamos at the request of R. Oppenheimer. Working with E. Teller, he made a number of proposals and was impressed by the concept of implosion, which allowed him to create own mathematical model and significantly expand research programs. In this regard, E. Macmillan and I. Rabi recommended G. Kistiakowsky, who had special knowledge in the field of high-precision explosives, and could help and participate in the program. In February 1944, G. Kistiakowsky took up the assistant position of W. Parsons, who was Associate Director at the research laboratory at Los Alamos, which dealt with development using implosion.

[1] Dainton, F. (1985). George Bogdan Kistiakowsky (18 November 1900-7 December 1982). *JSTOR, 31,* 376-408.
[2] Ibid, 380.

In April 1944 tests of the first plutonium sample produced with neutrons in a nuclear reactor showed, that the reactor plutonium had concentration of 5 times less than cyclotron-made specimen. This unacceptable isotope spontaneously decayed and produced neutrons providing a pre-explosive challenge without sufficient speed to collect critical masses. It has become clear that only implosion works in the practice of plutonium bombs. Until then a powerful pistol could not be built small enough to be used on an airplane, and plutonium-240 would be even harder to separate from plutonium-239 than uranium isotopes, which caused difficulties in the Manhattan Project. Plutonium was unusable if the implosions did not work, but only plutonium could be produced in quantities that would allow regular production of atomic bombs. Thus, the method of implosion became the key to the production of nuclear weapons.

In June 1944 a report by G. Kistiakowsky and R. Oppenheimer on the detailed dysfunction of implosion led to the exclusion of S. Neddermeyer's experiments and his resignation from the post of group leader, but he remained a technical consultant to the implosion program with the status of group leader. In August 1944 the laboratory in Los Alamos was reorganized, and the group was renamed to X-1, led by N. Bradbury. S. Neddermeyer used the implosion method in the first atomic bomb dropped on Nagasaki. This method was later used in almost all modern nuclear weapons.

On returning to Harvard (in 1961) G. Kistiakowsky devoted himself with enthusiasm to teaching, research and administration, serving as departmental chairman for 3 years and initiating new lines of research in enzyme kinetics, reactions in shockwaves and active nitrogen[1].

Working at the US National Academy of Sciences, G. Kistiakowsky created the Federal Council for Science and Technology. Within the Academy of Sciences in 1961 he was appointed chairman of a special committee on relations with the government, and in 1963 this committee became the Committee on Science and Public Policy headed by G. Kistiakowsky. The task of this committee was to provide basic information and plan to support science in the long run.

G. Kistiakowsky died on December 7, 1982, but the scientific dynasty of his family did not end. His daughter continued father's natural science research.

Discussion

G. Kistiakowsky's life was full of contradictory moments, as well as his activities. It demonstrates two sides of his personality: on the one hand, as a scientist, and on the other, as a citizen and politician.

First of all, it should be noted that G. Kistiakowsky, being of Ukrainian origin, spent only the first 20 years in his homeland. The total subsequent period, including education and research, took place abroad. In total his life could be divided into four periods[2]: the first twenty years he grew and learned in gymnasium, the second twenty year period was devoted entirely to chemistry, the next twenty year were divided between chemistry and the creation of weapons, succeeding in chemistry, and even more in the creation of weapons. And the last twenty he mostly fought against nuclear weapons (not forgetting the chemistry).

As F. Dainton noted in his memoirs[3], G. Kistiakowsky did not accept the October Revolution of 1917, because he considered the Bolshevik's cause as completely authoritarian. As a result, he immigrated to Europe and eventually settled in Germany. It seems the future scientist found political asylum in this country. But the paradox of his biography is that the further direction of his scientist's activity was directed against the political system that was established in Germany in the 1930s. He was promoted Associate Professor in 1933, when he also became a U.S. citizen and became full Professor (holding the Abbott and James Lawrence chair) in 1938. Not yet 40 years old, he seemed set for a successful and distinguished career in one of the most prestigious chemistry departments in the world. But outbreak of World War II changed that prospect significantly. Although the USA did not enter the war until Pearl Harbor in December 1941, President Roosevelt was well aware of the need for scientific preparedness and had established the National Defense Research Committee in June 1940. One of the founder members of this Committee was J. B. Conant, Professor of Chemistry and, since 1933, President of Harvard. He headed Division B concerned with chemistry, including explosives and other munitions. No doubt at Conant's suggestion, Kistiakowsky was appointed to this committee and in that capacity accompanied Conant to London in 1941 and 1942. He was made chief of Division 8 (explosives) and held that post until he became leader of the explosives Division of the Manhattan Project working at Los Alamos in New Mexico. Later G. Kistiakowsky claimed that it was the fear of domination in the world of Nazism that forced him to take up this work.

[1] Dainton, F. (1985). George Bogdan Kistiakowsky (18 November 1900-7 December 1982). *JSTOR, 31,* 384.

[2] Шендеровський, В. (2006). Він створив її і добився її заборони. *Нехай не гасне світ науки: у 4-х кн*. Київ, *2,* 117-123.

[3] Dainton, F. (1985). George Bogdan Kistiakowsky (18 November 1900-7 December 1982). *JSTOR, 31,* 380.

And on July 16, 1945, G. Kistiakowsky took part in the test of the first atomic bomb with plutonium. But whatever the actual words he uttered, there is no doubt he recognized that the event was a cataclysm in the history of war and therefore in the future would dominate international relations and diplomacy. After pondering this matter for 23 years he came to a fateful decision significantly changed the direction of his activities.

But the contradictions in G. Kistiakowsky's life did not end after creation of the first atomic bomb. Awareness of the dangers related to his own developments forced the scientist to change the direction of his activities once again. It was typical that most scientists, including G. Kistiakowsky himself, after the completion of the so-called "Manhattan Project", devoted their lives to the fight against its consequences.

There are other facts that characterize G. Kistiakowsky not only as a scientist, but also as a citizen who deeply comprehends the significance of his activity. His strength as a researcher was not only that he was a gifted experimentalist but also that he had a broad synoptic view of physical chemistry and a strong sense of scientific opportunism. If he saw a problem in any part of physical chemistry where he thought that his superior experimental skills could be deployed to make an advance he would tackle it. And it was significantly that 23 years after the testing of the first atomic bomb, he decided to leave all his advisory positions at the Pentagon, which allowed him to freely criticize government policy in the field of strategic control of nuclear weapons and mobilize public opinion against it.

Although Kistiakowsky always sought the advice of his scientific colleagues and was willing to listen to all points of view, he did not succumb to the temptation of becoming the advocate with the President for every new program that came along. He did not restrict his attention to new military weapons but took a major interest in nuclear arms control as well. He was the co-chairman of the US delegation to the 1958 Geneva Conference on Reducing the Hazards of Surprise Attack. He also pursued as Science Adviser many programs within the US government designed to control nuclear weapons, paying considerable attention to proposals for agreements to stop nuclear weapons testing.

His next step was quite natural for G. Kistiakowsky, when he resigned on January 20, 1961 and returned to Harvard. There his disappointment with government policy intensified, and he became increasingly involved in the affairs of the National Academy of Sciences, serving on its board from 1962 to 1965 and as vice president from 1965 to 1973. He was the first chairman of the Academy Committee on Science and Public Policy and the Report Review Committee[1].

In early 1968 in protest against the Vietnam War, G. Kistiakowsky broke off his commitments to the Department of Defense and devoted all his energy and time to preventing a global nuclear catastrophe. He became an active member of the Pugwash Conferences on Science and World Affairs (a movement of scientists advocating for peace, disarmament and international security, for the prevention of world thermonuclear war and scientific cooperation).

The essence of his views was expounded in characteristically vigorous prose in an interview he gave on his eightieth birthday[2]. Reading these words one cannot fail to be moved by his courage and determination to go on fighting the just cause (as he saw it) of a rational arms policy, despite the fact that he was suffering from the cancer from which he was to die two years later (in December 1982) and, as the Editor of Chemical and Engineering News noted ironically (1982), on "the day the House of Representatives voted to delete initial funds for deploying 100 MX intercontinental ballistic missiles. This vote may not represent Congress" final disposition of this matter. But it is the first time since World War II that either house has voted to deny a President a major new arms programme[3].

Conclusions

Investigation on the activities of scientists and research teams is important not only to determine the historical heritage of the country, but also as a source of unique material for the formation and transformation of new knowledge, analysis of the evolution of scientific trends and the heritage of scientists.

In summary, G. Kistiakowsky has made a significant contribution to various fields of chemistry and physics. In particular, his developments in the field of explosives were of great importance for the creation of the atomic bomb. In addition, the scientist is a recognized specialist in the field of chemical kinetics and catalysis, as well as photochemistry. G. Kistiakowsky is also known as an active opponent of the using and proliferation of nuclear weapons, a participant in the movement for disarmament and international security, the prevention of world thermonuclear war and supporter of scientific cooperation.

[1] Dainton, F. (1985). George Bogdan Kistiakowsky (18 November 1900-7 December 1982). *JSTOR, 31,* 386.
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It is worth noting the position of G. Kistiakowsky, who believed that the creation of scientific and technical knowledge depends on the financial support of the state of the best scientists, whose voice should be listened to in various areas of national needs. This approach can be an example of awareness of the responsibility of the scientist for the results of their activities.

America became G. Kistiakowsky's second homeland, but his native Ukraine has always remained in his memories and was part of his sphere of activity. It may be confirmed by the fact from his life that G. Kistiakowsky, together with his friend from Harvard University J. Bardeen, (twice winner of the Nobel Prize in Physics), supported morally and financially construction of a monument to Taras Shevchenko in Washington.

Of course, the achievements of every scientist belong to all humanity, but we should know and remember our compatriots who were forced to leave their native country due to various circumstances. And in this aspect the life and activity of our countryman G. Kistiakowsky, an outstanding scientist and public figure, deserves further research.

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