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Mikhail Ziegler, the First Professor of Metallurgy at Warsaw Polytechnic, and His Contribution for Developing our Knowledge about Steels

Abstract

The article presents results of research on the origin and development of scientific schools in the field of metallurgy in Eastern Europe at the turn of the 19th-20th centuries, associated with the scientific and pedagogical activities of the famous scientist Professor Mikhail Karlovich Ziegler in the higher technical educational institutions of Warsaw (Warsaw

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Polytechnic Institute of Emperor Nicholas II), Kharkiv (Kharkov Technological Institute of Emperor Alexander III), St. Petersburg (Petrograd Polytechnic Institute) and Moscow (Moscow Mining Academy).

The main facts of the biography of this scientist and university lecturer are given. The stages of formation of M.K. Ziegler as a personality and a scientist against the backdrop of occurring historical processes are shown. The Soviet period of his activity was considered separately.

The scientific achievements of Professor Ziegler in the field of steel metallurgy, in particular, in determining the strength of steels depending on the conditions of their crystallization, studying the diffusion of impurities in steels, which became the foundation for the development of continuous casting technology, i.e. one of the most important world inventions of the 20th century, are systematized and analyzed.

His organizational and educating contribution for the training of scientific and engineering personnel for the metallurgical industry is also estimated.

The article includes interesting forgotten and little-known facts from the history of metallurgical science and the training of the higher engineering and technical personnel in educational institutions located on the territory of modern Ukraine and Poland.

Keywords: *Mikhail Ziegler*, *Warsaw Polytechnic*, *metallurgical science*, *history of metallurgy*, *technical education*

Wkład pierwszego profesora metalurgii Politechniki Warszawskiej Michaiła Zieglera w rozwój wiedzy o stalach

Abstrakt

W artykule przedstawiono wyniki badań nad genezą i rozwojem szkół naukowych w dziedzinie metalurgii w Europie Wschodniej na przełomie XIX i XX wieku, związanych z działalnością naukową i pedagogiczną słynnego uczonego profesora Michaiła Karłowicza Zieglera w wyższych uczelniach technicznych Warszawy (Instytucie Politechniki Warszawskiej im. Cesarza

Mikołaja II), Charkowa (Instytucie Techniki im. Cesarza Aleksandra III w Charkowie), Petersburga (Instytucie Politechniki Piotrogrodzkiej) i Moskwy (Moskiewskiej Akademii Górniczej).

Podano główne fakty z biografii tego naukowca i pedagoga. Ukazano etapy powstawania M.K. Zieglera jako osobowości i naukowca na tle zachodzących procesów historycznych. Odrębnie rozpatrywano sowiecki okres jego działalności.

Usystematyzowano i przeanalizowano dorobek naukowy profesora Zieglera w dziedzinie hutnictwa stali, w szczególności w określaniu wytrzymałości stali w zależności od warunków ich krystalizacji, badaniu dyfuzji zanieczyszczeń w stalach, co stało się podstawą rozwoju technologii odlewania ciągłego, jednego z najważniejszych światowych wynalazków XX wieku.

Oceniono także jego wkład organizacyjny i dydaktyczny w kształcenie kadr naukowo-inżynierskich dla przemysłu metalurgicznego.

Artykuł zawiera ciekawe zapomniane i mało znane fakty z historii metalurgii i kształcenia kadr z wyższym wykształceniem inżynieryjno-technicznym w placówkach oświatowych znajdujących się na terytorium współczesnej Ukrainy i Polski.

Słowa kluczowe: *Michaił Ziegler*, *Politechnika Warszawska*, *metalurgia*, *historia hutnictwa*, *wykształcenie techniczne*

1. Introduction

Scientific research in the field of metallurgy started in Ukraine at the end of the 19th century. The development of scientific knowledge in the metallurgy and mining industry is associated with the activities of outstanding Ukrainian scientists, whose achievements have been recognized throughout the world. Among them, the special place belongs to Prof. Mikhail Karlovich Ziegler.

Mikhail Ziegler, the talented representative of the scientific school that was formed in Kharkiv at the end of the 19th century, was a student of the first educator of metallurgy at the Kharkov Practical Technological Institute, Apollon Fedorovich Mevius. Thanks to the persistent and tenacious work of Ziegler, metallurgical science was significantly expanded in promising areas, primarily in the production of steel and in improving its quality. Also, he managed to make the significant contribution to the training of scientific and engineering personnel in metallurgy. His students, whom he taught in Kharkiv, Warsaw, Nizhny Novgorod, and

Moscow, pioneered in new scientific trends and established research institutes. It is thanks to their work that the world steel production exceeded one billion tons by the beginning of the 21st century.

Studying the history of Ukrainian metallurgy requires an integrated approach, that is, identifying key events, in-depth study of scientific schools and biographies of famous metallurgists. In this work, the authors used the following methods: content analysis, historiographical analysis, chronology, historical and comparative analysis, biographical methods, and critical analysis based on historicism and objectivity. The scientific and educational activities of Mikhail Ziegler have formed an important page in the history of world metallurgy and we need to study them in detail. In addition, the personality and professional activities of Mikhail Ziegler have not yet been studied. A brief information about the scientist and the pedagogue has been already presented in numerous studies on the history of the National Technical University "Kharkov Polytechnic Institute" (NTU "KhPI") and the Moscow Mining Academy. However, these works had certain inaccuracies, and did not reflect the contribution of the scientist and the pedagogue to the history of world metallurgy. Moreover, there is no comprehensive study of the life and work of Mikhail Ziegler.

The sources of our study were the documents from the State archive of Kharkiv region, the State archive of the Nizhny Novgorod region, and the archive of NTU "KhPI".

This article presents the brief biography and detailed description of the Kharkiv period of Prof. Mikhail Karlovich Ziegler's life.

2. Biographical information

Mikhail Karlovich Ziegler was born on June 19, 1864[1] in St. Petersburg, in the family of the nobles Matilda-Eleonora Egorovna (in girlhood – Stukkey) and academician of architecture Karl Karlovich Ziegler.[2] His father was the architect of the court of The Grand Duke Mikhail Nikolayevich and one of the restorers of the building of the Old Hermitage.[3] Four children were born in the family. The older ones were

[1] SAKhR, f. 770, desc. 2, case 2120, p. 2.
[2] *Ibid*., p. 5.
[3] Blokh 2018, p. 406.

Matilda Karlovna (born March 19, 1857), who married Viktor Lvovich Kirpichev in 1876 and brother, Emily Karlovich (born September 18, 1859). The younger sister, Nina Karlovna was born April 26, 1866.[4] (Hereinafter, the dates are given in the old style.)

The godfather of the baby was The Grand Duke Mikhail Nikolaevich, the godparents were Dr. Eduard Stukkey and the widow of the provincial architect of Finnland, Amalia Ziegler.[5]

It would seem that everything in the family was good: father's fast career, prosperity was in the house. But suddenly, in December 1867, the mother, Matilda-Eleonora Yegorovna Ziegler, died.[6] The father remarried Francis-Emilia (Fanny) Ivanovna Snow. New children were born: a son – Maximilian Karlovich (born January 31, 1870) and Olga Karlovna (born July 15, 1875).[7]

Since 1891, the family used the name "Ziegler von Schaffhausen". By that time, the father had the title of the real state councilor, which corresponded to army rank of major general and gave the family the right to hereditary nobility.

However, Mikhail Karlovich never used neither the full surname nor his middle name. His birth certificate indicates his name according to the Evangelical Lutheran religion: Mikhail-Eduard (obviously, he was named after his godfather, The Grand Duke Mikhail Nikolaevich and uncle, Eduard Stuckey).[8] But the name Ziegler alone appears in his diplomas, passports, and his articles. Either Mikhail Karlovich did not want to change all his documents, or he did not want to use his father's new surname, being offended by him or his stepmother, perhaps he did not want to use the same surname as the children born in his father's second marriage...

In 1876, Mikhail entered St. Petersburg first real school, which he graduated from in June 1883. The young man's favorite subject was chemistry, and his knowledge of this subject was rated excellent. It is not surprising, that in June 1884 he graduated from additional class in the chemical-technical department of the St. Petersburg first real

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[4] SAKhR, f. 770, desc. 2, case 2120, p. 12.
[5] *Ibid*., p. 6.
[6] Blokh 2018, p. 29.
[7] SAKhR, f. 770, desc. 2, case 2120, p. 13.
[8] *Ibid*., p. 5.

Fig. 1. The Coat of arms of Ziegler von Schaffhausen noble family.
Source: Anonymous$_3$ 1895.

school, which gave him the right to enter higher technical educational institutions.

Analyzing the grades of Mikhail Karlovich, we can assume that his older sister and her husband influenced the young man and helped him. Because, Mikhail finished the main course in the St. Petersburg first real school with average grades. His knowledge was rated 5 points in chemistry and history, 4 points in God's law, physics, drawing and mechanics, and 3 points in the remaining 10 subjects.[9] However, his grades in the additional class in the chemical-technical department in the same school were significantly higher: his knowledge of the God's law, physics, chemistry, mechanics and laboratory work was rated 5 points, his knowledge of history, general building art and accounting was 4 points. And only his knowledge of mathematics was rated with 3 points[10]. Yet, Mikhail Karlovich subsequently graduated from higher educational institution with the title of process engineer, that is, with honors!

He successfully entered the St. Petersburg Technological Institute in 1886, and then transferred to the Kharkov Practical Technological Institute (KhPTI).[11]

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[9] SAKhR, f. 770, desc. 2, case 2120, p. 3.
[10] *Ibid.*, p. 4.
[11] *Ibid.*, p. 1.

Why does a young man moves to Kharkiv, which in many respects was clearly inferior to the capital at that time? In the capital, there was his father's house, his friends lived, there were many attractive places for young men – a cinema, a park, many museums; balls and gala evenings were held. Most likely, he did not have a good relationship with his stepmother and this was why he decided to leave and study in another city. Moreover, his older sister, Matilda Karlovna, who lived in Kharkiv, was married to the first director of the Kharkov Practical Technological Institute, Viktor Lvovich Kirpichev. Moving from the capital was a difficult test for Matilda Karlovna: she had four children in her care, the eldest of whom, Vera, was 8 years old, and the youngest, Nina, was not even 4 years old.[12] She could not expect her husband's help, because he used to be out for whole days at work, used to go on numerous business trips, worked hard for the successful opening of the institute. And yet, the first summer in Kharkiv brought a lot of joy to the Kirpichev family. The change from the humid and cold seaside climate of St. Petersburg to the dry and warm continental climate of Kharkiv had the positive impact on the health of both parents and children. The abundance of fruits, vegetables, and dairy products, which Kharkiv fairs have always been famous for, has led to the fact that children in the Kirpichev family fell ill much less often. It should be noted, that Matilda Karlovna was also a good mother. She devoted all her time to her children and hardly participated in various events that she could attend as the wife of the director of the institute.

Arriving in Kharkiv, Mikhail Karlovich plunged headlong into his studies.

Sometimes he visited his four nephews: Vera, Evgenia, Nina and Mikhail. The elder sister, supported her younger brother as well as she could, realizing that he had to rely only on himself.

In the Kirpichev family, two future academicians bore the same name Mikhail – Mikhail Viktorovich Kirpichev and Mikhail Alexandrovich Leontovich, the son of Vera Viktorovna Kirpicheva (married Leontovich). Most likely, the nephew, Mikhail Viktorovich, was named after Mikhail Ziegler: Matilda Karlovna loved her younger brother very much

[12] SAKhR, f. R-1682, desc. 2, case 14, p. 35.

and tried to help him as much as she could. But in whose honor Mikhail Alexandrovich was named, it is impossible to determine. He could be named both in honor of his uncle, Mikhail Viktorovich, as well as in honor of his great-uncle, Mikhail Ziegler.

Mikhail Karlovich met his sister's expectations, graduating from the institute among the best graduates. His cohort, which graduated in 1891 (they were the second cohort, that graduated from the Kharkov Practical Technological Institute) was impressive: in the mechanical department, 20 students received the title of process engineer and 8 received the title of technician, and in the chemical department, 23 students received the title of process engineer and 12 received title of technician.

Fig. 2. Mikhail Karlovich Ziegler (1864–1922). Photo from the album of KhTI graduates of 1891 is in Public Domain.

In other words, 43 people graduated with honors and 20 without ones. In his cohort were: Nikolai Ivanovich Kartashev – a locomotive constructor, Grigory Fedotovich Burakov – a future professor and rector of the KhTI, Duke Alexei Akakievich Tsereteli – a well-known opera entrepreneur in the future, Joseph Abramovich Zektser – Kyiv architect, Mikhail Konstantinovich Chekurul-Kush – an architect of the city Chisinau, and others.[13]

[13] SAKhR, f. 45, desc. 1, case 989, p. 2-3.

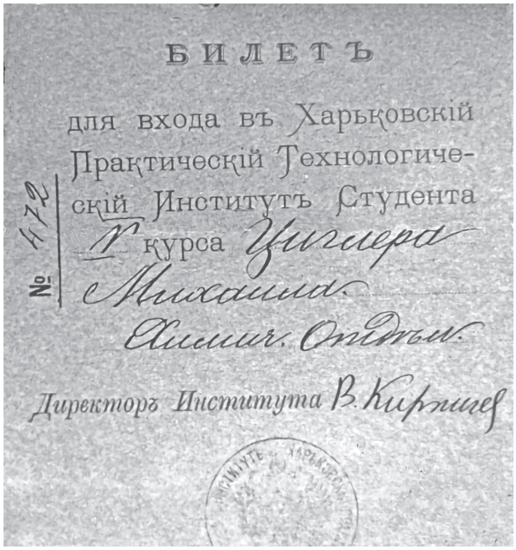
БИЛЕТЪ
для входа въ Харьковскій
Практическій Технологиче-
скій Институтъ Студента
I курса Циглера
Михаила.
Химич. Отдѣл.
№
Директоръ Института В. Кирпичев

Fig. 3. Mikhail Ziegler's student card. *Source*: SAKhR, f. 770, desc. 2, case 2120, p. 26.

3. The Beginning of metallurgical research in Ukraine

The beginning of scientific research in metallurgy in Ukraine was made by Apollon Fedorovich Mevius, one of the most educated mining engineers of his time, the former head of the Lugansk Mining District, and then the lecturer of metallurgy at the Kharkov Practical Technological Institute. He enriched domestic technical literature with fundamental works on foundry and ferrous metallurgy. He authored, for example, the printed course of iron metallurgy and many other scientific works of mining topics.[14] In total, A.F. Mevius was the author of about 100 printed works, including the first textbook on metalworking in Russian – "The cast iron foundry course" (for this work, published in 1859, the Russian Academy of Sciences awarded him the Demidov Prize 2-th degree), "The future of mining in the South of Russia" (1867), "Training course on metallurgy of cast iron, iron and steel" (1888) – the first textbook on metallurgy published in Ukraine, "Technical French-Russian dictionary" for 64 thousand words (1898), on which Mevius worked for the last 28 years of his life, and many others.

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[14] D.Yu. Zhurylo 2020, p. 170.

Fig. 4. The mining engineer, an Acting State Councilor Apollon Fedorovich Mevius (1820–1898). *Source*: A.G. Zhurilo 2013, p. 8.

After analyzing the transport conditions, as well as the labor and water resources in Donbass, Mevius not only outlined the basic principles and features of the design of metallurgical plants in the region, but also specifically identified 11 points, where it would be economically profitable to start building large iron and steel plants. It should be noted that, after 25–30 years, metallurgical plants were actually founded at number of these points (Yuzovsky, Makeevsky, Druzhkovsky, Olkhovsky and others).[15] It was thanks to his activities that it became possible to carry out large-scale railway building in Russia, the boom of which coincided with the end of the 19th century.

A.F. Mevius became the educator of metallurgy at the Kharkov Practical Technological Institute[16] from July 16, 1887. In addition to lecturing on metallurgy, he supervised *fifth year student* graduation projects on building metallurgical plants and their equipment, also supervised the manufacturing practice of the students' manufacturing practise at metallurgical plants, and edited the "Gornozavodskoy Listok magazine" published in Kharkiv.[17]

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[15] A.G. Zhurilo 2013, p. 12.
[16] SAKhR, f. R-1682, desc. 2, case 202, p. 2.
[17] *Ibid.*, p. 8.

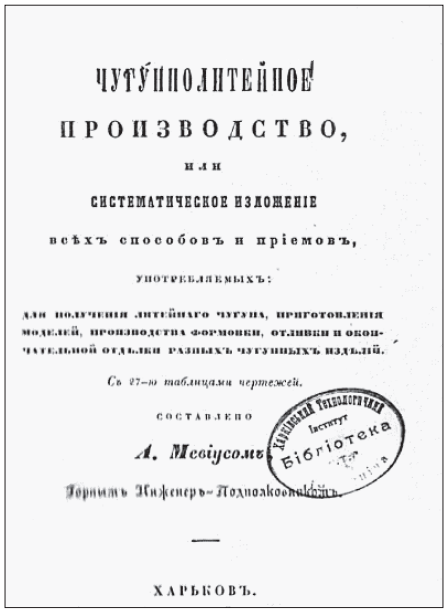
ЧУГУ́НОЛИТЕЙНОЕ
ПРОИЗВОДСТВО,
ИЛИ
СИСТЕМАТИЧЕСКОЕ ИЗЛОЖЕНІЕ
всѣхъ способовъ и пріемовъ,
УПОТРЕБЛЯЕМЫХЪ:
для полученія литейнаго чугуна, приготовленія моделей, производства формовки, отливки и окончательной отдѣлки разныхъ чугунныхъ издѣлій.
Съ 27-ю таблицами чертежей.
СОСТАВЛЕНО
А. Мевіусомъ,
Горнымъ Инженеръ-Технологомъ.
ХАРЬКОВЪ.

Fig. 5. Cover of the Mevius's book «Iron foundry». *Source*: D.Yu. Zhurylo 2020, p. 178.

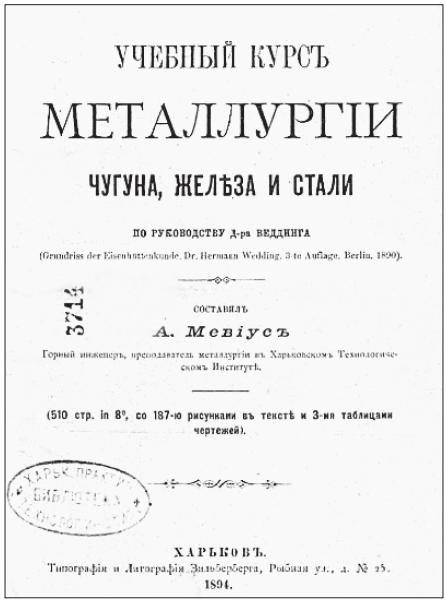
УЧЕБНЫЙ КУРСЪ
МЕТАЛЛУРГІИ
ЧУГУНА, ЖЕЛѢЗА И СТАЛИ
ПО РУКОВОДСТВУ Д-ра ВЕДДИНГА
(Grundriss der Eisenhüttenkunde, Dr. Hermann Wedding. 3-te Auflage. Berlin. 1890).
3714
СОСТАВИЛЪ
А. Мевіусъ
Горный инженеръ, преподаватель металлургіи въ Харьковскомъ Технологическомъ Институтѣ.
(510 стр. in 8°, со 187-ю рисунками въ текстѣ и 3-мя таблицами чертежей).
ХАРЬКОВЪ.
Типографія и Литографія Зильберберга, Рыбная ул., д. № 25.
1894.

Fig. 6. Cover of Mevius's book "Training course on cast iron, iron and steel". *Source*: D.Yu. Zhurylo 2020, p. 180.

Another outstanding Russian scientist and mining engineer, the founder of mining mechanics, Ivan Avgustovich Time, wrote:

> A.F. Mevius is one of the most educated mining engineers, who was the head of the Lugansk mining district and then professor of metallurgy at the Kharkov Technological Institute, who enriched Russian technical literature with fundamental works on foundry. He also published the printed course on iron metallurgy and the lots of other scientific works on mining topics.[18]

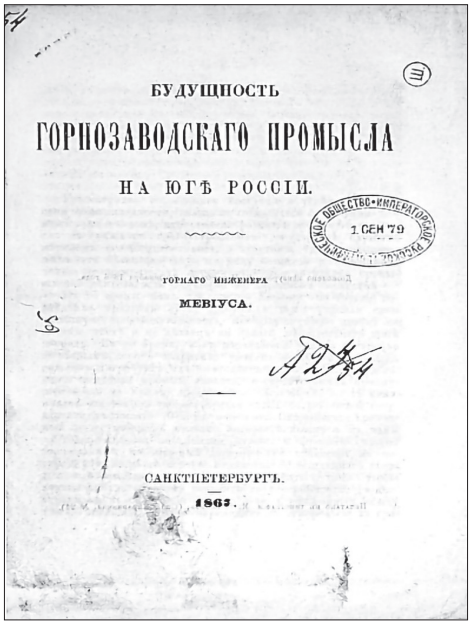
БУДУЩНОСТЬ
ГОРНОЗАВОДСКАГО ПРОМЫСЛА
НА ЮГѢ РОССІИ.
1 СЕН 79
ГОРНАГО ИНЖЕНЕРА
МЕВІУСА.
САНКТПЕТЕРБУРГЪ.
1863.

Fig 7. Cover of Mevius's book "The Future of mining in the South of Russia". *Source*: D.Yu. Zhurylo 2020, p. 182.

Simultaneously with teaching, Mevius supervised also the building of a metallurgical plant in Alchevsk. Due to the workload of factory affairs, Mevius had to quit work at the institute[19] in 1895. Despite the fact that Mevius left teaching, he did not leave work in the field

[18] A.G. Zhurilo 2013, p. 16.
[19] SAKhR, f. R-1682, desc. 2, case 202, p. 6.

of technical education, but he served as vice president of the Kharkov branch of the Imperial Russian Technical Society (the president was the director of KhPTI V.L. Kirpichev). The technical society was located in a house number 18–20 on Sumskaya street, where the Congress of Miners of the South of Russia was also located. In the last years of his life, A. F. Mevius was an honorary member of the Kharkov branch of the Russian Technical Society.

Mikhail Ziegler was also one of the members of the South Russian Society of Technologists, located at number 18–20 on Sumskaya street. Naturally, he would love to have personal acquaintance with such an outstanding specialist and extraordinary university lecturer in the higher educational institution, where he studied. In addition, Apollon Fedorovich was an exceptionally charming, a modest and benevolent person. Even at the celebration on the 50th anniversary of his mining career, he modestly noted that "his merits are too insignificant and he, to the best of his ability, tried only to fulfill his duties".[20]

4. Professional activity of Mikhail Ziegler

After graduating from the Kharkov Technological Institute, the young engineer begun work for the Ministry of Finance – as an assistant factory inspector in the Kharkov province. At the beginning of 1893, order No. 12 for the Ministry was issued, appointing him to the post.[21]

The system of factory inspectors in the Russian Empire was quite interesting. In each province, senior factory inspector was appointed, often with the rank of state councilor, to whom several district factory inspectors and assistant factory inspectors of various ranks and with various educations, from home schooled to university graduates, were subordinate. The factory inspectors were engaged in "supervision of the classes and training of young workers working in factories, plants and manufactories"[22], with the exception of injuries, for what today is called the parameters of the microclimate – temperature, humidity, illumination in the workplace. In fact, it was labor protection service. After the reform of 1861, a lot of former peasants moved to the city,

[20] Anonymous$_1$ 1890, p. 189.
[21] SAKhR, f. R-1682, desc. 2, case 356, p. 45.
[22] *Ibid.*, p. 62.

where they worked in variety of factories and plants. In some cases, 3 workers only worked at the «factory», in other cases, they were more than one hundred ones working. If there were some violations of the law, the factory inspectors could close enterprises until the violations were completely corrected. For example, due to the lack of permission, the factory inspectorate closed a forge[23], denied the opening of dyeworks[24]; a tobacco factory with 5 workers was closed due to dampness in Petrovsky lane of Kharkiv[25], and permission to arrange a bathhouse in Gymnasticheskaya waterfront[26] was denied. The decisions of the factory inspection were awaited, like in the case of the well-known merchant in Kharkiv, Vasily Pashchenkov-Tryapkin, who had asked for permission to install locomobile for lighting at his factory in Klochkovskaya street,[27] and another case, Nikolai Grebenshchikov, little-known in Kharkiv, who wanted to make soap in Voskresenskaya square[28]. All managers of enterprises were required to allow factory inspectors and assistant factory inspectors to enter the enterprises, to assist them and comply with their legal requirements. The inspector could come to the enterprise and verify at any time of the day.

Considering that the enterprises were located in different counties of the province and there were not many inspectors, the work involved not only knowledge of the basics of various crafts, but also multiple trips. The main requirement for factory inspectors was higher education. Technical education was appreciated above university one. The specialized higher chemical education of Mikhail Karlovich was in demand, and his single life allowed him to be on business trips for a long time.

Already in September 1893, Mikhail Karlovich received the rank of collegiate secretary[29], and in May 1894 he became the factory inspector in the Kharkov province. In March 1895, he was promoted to titular councilor.[30]. It was possible for him to stay in the service

[23] SAKhR, f. 45, desc. 1, case 1097, p. 54.
[24] SAKhR, f. 45, desc. 1, case 769, p. 42.
[25] SAKhR, f. 45, desc. 1, case 989, p. 29.
[26] SAKhR, f. 45, desc. 1, case 1097, p. 36.
[27] SAKhR, f. 45, desc. 1, case 9903, p. 162.
[28] *Ibid.*, p. 111.
[29] SAKhR, f. R-1682, desc. 2, case 356, p. 73.
[30] *Ibid.*, p. 74.

further on, receiving new ranks with the prospect of becoming a senior factory inspector, receiving the rank of state councilor or even a real state councilor...

Yet, in 1896 Ziegler started working in the KhTI as a laboratory assistant at the chemical laboratory.[31] His former superiors did not see any obstacles in the his transition to the new place of service, realizing that his income was low, and his demands, like those of most young people, high. Because as a factory inspector, Ziegler was paid only 800 rubles of annual salary, to which 600 rubles for housing and were added and another 600 rubles for canteens.[32] Of course, when traveling around the province, the inspector was also paid travel money, but their amounts were small. At the same time, the consolidation of factory districts took place and, for example, from 1897, on the basis of the Law of June 3, 1886, the number of senior factory inspectors for the entire Russian Empire was set at 26, and factory inspectors – 125 people.[33]

On May 26, 1896, the director of the institute sent a letter to Mikhail Karlovich announcing his acceptance to the position of a laboratory assistant with the payment of 800 rubles per year.[34] Zeigler settled not far from the place of working, on Theater square, near the Lutheran church, in the house number 10.

In 1898, Ziegler received the rank of collegiate assessor.[35] In August 1898, he took part in the Tenth Congress of Russian Naturalists and Physicians, which took place in Kyiv from August 20 to September 1, 1898.[36]

When a vacant position as a laboratory assistant in the laboratory of mineral substances appeared, Professor Valery Gemilian insisted that Ziegler took it. And, from June 1, 1899 Mikhail Karlovich was a laboratory assistant in the laboratory of mineral substances.[37]

On April 21, 1900, in the Society of Physical and Chemical Sciences at the Imperial Kharkov University, Mikhail Ziegler reported his first scientific work on the recovery of metals using the Goldschmidt

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[31] *Ibid.*, p. 2.
[32] *Ibid.*, p. 5.
[33] Anonymous$_3$ 1900, p. 17.
[34] SAKhR, f. R-1682, desc. 2, case 356, p. 9.
[35] *Ibid.*, p. 17.
[36] *Ibid.*, p. 80.
[37] *Ibid.*, p. 37.

method.[38] Professor Valery Alexandrovich Gemelian provided him with serious assistance in conducting further research. He also insisted on Ziegler's business trip abroad in June 1900.[39]

In February 1901, Mikhail Karlovich received permission from his superiors to marry,[40] and in April 1901 he married the daughter of a hereditary nobleman of the Tauride province (from Melitopol) Claudia Alexandrovna Rykova, who was the younger sister of his colleague at KhTI, Yanuariy Alexandrovich Rykov.[41] Subsequently, two children were born in the Ziegler family.[42]

Where Ziegler met his future wife, this is unknown. It can be assumed that he spent one of his vacations (in 1894[43], or in 1896[44]) in the Crimea, visiting his friend Yanuariy Rykov, who was engaged in construction of churches and other buildings in the Tauride province. In Ziegler's passport there is a note about his residence in the Crimea in the summer of 1896.[45] He could meet his friend's sister there. Besides, Ziegler's friendship with Rykov continued until the death of Mikhail Karlovich.

In June 1901, the Ministry of Public Education sent Mikhail Karlovich on a business trip abroad. In 1895, the metallurgy university lecturer Apollon Fedorovich Mevius had resigned from the institute, and another educator, Nikolai Petrovich Klobukov, had died on October 27, 1900.[46] So, there was no full-time university lecturer on this subject. And it was decided to prepare Ziegler for a professorial rank. He was awarded a scholarship from the Ministry of Public Education in the amount of 2,000 rubles per a year from January 1, 1901 to July 1, 1902.[47] Later, the scholarship was extended until January 1, 1903.[48]

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[38] SAKhR, f. R-1682, desc. 2, case 356, p. 25.

[39] *Ibid.*, p. 22.

[40] *Ibid.*, p. 32.

[41] Yanuariy Alexandrovich graduated from the mechanical department of the institute a year earlier than Ziegler, in the first cohort of engineers with the title of technician. SAKhR, f. R-1682, desc. 4, case 480, p. 1.

[42] Blokh 2018, p. 30. However, the birth of children in the Ziegler family is not noted in archival document – see CANN, f. 2082, desc. 2, case 321, p. 160.

[43] SAKhR, f. R-1682, desc. 2, case 356, p. 5.

[44] *Ibid.*, p. 16.

[45] *Ibid.*, p. 94.

[46] SAKhR, f. R-1682, desc. 2, case 145, p.116.

[47] SAKhR, f. R-1682, desc. 2, case 356, p. 30.

[48] *Ibid.*, p. 87.

During the business trip, it was planned to visit the Freiberg Mining Academy, in order to study iron metallurgy under the guidance of Professor Karl Ledebur[49]. It was planned to study mineralogy and crystallography with Professor Julius Weisbach, geology and microscopic studies of minerals – with Professor Friedrich Beck, electrometallurgy – with Professor Wilhelm Borchers.[50] It was noted that it was desirable to have the practice of performing thin sections with Professor Adolf Martens, and refractory production – with Professor Herman Seger.[51] The preparation was planned to be very serious, affecting all aspects of the ferrous metallurgy of that time – from theory to practice, from determining the quality of ores to chemical and metallographic studies of the melted metal.

Letters of recommendation were written in French and German with the request to assist scholarship holder of the Ministry of National Education Mikhail Ziegler. Interestingly, in the German certificate Ziegler's position (laboratory assistant) is indicated as "assistant", but crossed out and "associate professor" is written on top.[52]

The letters were sent to the number of domestic factories, for example, to Yuzovsky and Dneprovsky, which indicated the need for laboratory assistant Ziegler to visit laboratories, production shops of "our best factories" and asked management for assistance.[53]

Unfortunately, there is no report on the trip abroad in Ziegler's personal file. But the main milestones of his can be restored from his printed works. One of them was co-authored with the classic of metallurgy, Henri Le Chatelier (inventor of the pyrometer, metallographic microscope and author of the famous Le Chatelier thermodynamic principle). The article was titled: "Iron sulfide, its properties and state in molten iron".[54] And it was also translated into English.[55] It is interesting that the future metallurgist Ziegler, while still studying at the fifth year of KhPTI, specialized not in metallurgy, but in sugar beet production.[56] This was not

[49] *Ibid.*, p. 26.
[50] SAKhR, f. R-1682, desc. 2, case 356, p. 27.
[51] SAKhR, f. R-1682, desc. 2, case 356, p. 27.
[52] *Ibid.*, p. 36.
[53] *Ibid.*, p. 28.
[54] Le Chatelier 1902.
[55] Le Chatelier 1903.
[56] SAKhR, f. 770, desc. 2, case 2120, p. 28.

the only case. For example, the world's first doctor of science in the field of aviation, who defended his thesis at the Sorbonne, George Botezat, being a student at the Kharkov Technological Institute, defended his diploma in the design of power plants.[57] This once again testifies to the exceptionally high engineering training of specialists, who were taught in higher technical educational institutions in the Russian Empire in the late 19th and early 20th centuries.

In 1902, Ziegler was promoted to the court councilor.[58]

After returning to Kharkiv, M.K. Ziegler began to teach metallurgy and conduct practical classes in chemical technology at his alma mater with the year salary of 1600 rubles[59] from January 1903. He was allowed to live in the state-owned apartment on the site of the institute. Using his advice, after his return, the Institute purchased a Curie analytical balance at the cost of 500 francs; installations and devices for electrolysis at the price of 340 francs; Siemens and Buchers arc furnaces at the price of 270 rubles; an electric drilling machine at the price of 147 rubles, rheostats and measuring instruments at the price of 168 rubles. An electric current was conducted to the laboratory of mineral substances and installations for electrolysis and electric furnaces were made.[60] And the total expenses for the laboratory in 1903 amounted to 1500 rubles.[61] Using this equipment, classes were held with students in metallurgy under Ziegler's guidance. Thus, Mikhail Ziegler can be considered one of the first researchers of electric melting of metals in Ukraine.

From February 20 to February 28, 1903, Mikhail Karlovich was on vacation in St. Petersburg,[62] where, thanks to the connections of his older brother Emil Karlovich, he determined his future.[63] Because Kharkov Technological Institute of Emperor Alexander III did not have a department of metallurgy, it was impossible to get a professorship, or an associate professorship. Following his brother's advice, Mikhail Karlovich wrote a petition addressed to the director of the Warsaw

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[57] D.Yu. Zhurilo 2022, p. 74.
[58] SAKhR, f. R-1682, desc. 2, case 356, p. 57.
[59] *Ibid.*, p. 54.
[60] Anonymous$_6$ 1904, p. 54.
[61] SAKhR, f. R-1682, desc. 2, case 356, p. 61.
[62] *Ibid.*, p. 56.
[63] Blokh 2018, p. 30.

Polytechnic Institute of Emperor Nicholas II, Alexander Evgenievich Lagorio, with a request to accept him "to one of the existing chairs of metallurgy at the Mining Department".[64] The Warsaw Polytechnic Institute of Emperor Nicholas II was in its infancy at that time. At the time of opening on September 3, 1898, it had three departments: mechanical, chemical, and civil engineering. The Institute was temporarily located in a building donated by the prominent Warsaw manufacturer, Jan Bloch.[65]

And, in 1902, the mining department was also opened.[66] The Warsaw Polytechnic Institute was given, thanks to the Polish citizens and the city authorities, a beautiful seat, built during two years according to the design of two academicians of architecture: Stefan Schiller and Bronisław Wawrzyniec Rogoyski. It is interesting that in 1915, B. W. Rogoysky used the project of institute buildings again for the Don Polytechnic Institute in Novocherkassk.[67]

The Warsaw Polytechnic Institute had been given the plot of land, almost 5 hectares in the area of Polna, Koszykowa and Nowowiejska streets and the city forest nursery. There, the main building, as well as chemical and mechanical pavilions were located. As conceived by the architects, the single complex of buildings formed "a cross inscribed in an irregular pentagon". In the center of the main building, there was a large hall covered with a glass roof and surrounded with several galleries. Nearby, two residential buildings with 24 apartments for the administration and professors were built, providing the staff with state-owned apartments, according to the standards of that time.[68]

In January 1904, the director of the Warsaw Polytechnic Institute of Emperor Nicholas II, Alexander Evgenievich Lagorio, sent a secret letter to the director of the Kharkov Technological Institute of Emperor Alexander III Nikolai, Nikolaevich Schiller, asking him about Ziegler's "moral and service qualities", any possible obstacles to his transfer and copy of his service record.[69]

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[64] CANN, f. 2082, desc. 2, case 321, p. 1.
[65] Blokh 2018, p. 12.
[66] *Ibid.*, p. 13.
[67] Rybiev 2007, p. 16.
[68] *Ibid.*, p. 15.
[69] SAKhR, f. R-1682, desc. 2, case 356, p. 59.

Fig. 8. The main building of the Warsaw Polytechnic. *Source*: Anonymous 1901, p. 12.

The Warsaw Polytechnic Institute of Emperor Nicholas II belonged to the Ministry of Finance of the Russian Empire, and not to the Ministry of Public Education, like the Kharkov Technological Institute of Emperor Alexander III did. Therefore, the transition from one higher educational institution to another was, in fact, transition to another ministry and required time for various bureaucratic delays.

The director of the Kharkiv Technological Institute of Emperor Alexander III, Nikolai Schiller, in his response letter indicated that "process engineer Ziegler has good moral and service qualities".[70] The Professor Schiller's only condition was that Ziegler's transfer should take place no earlier than June 1904. So, on July 1, 1904, Mikhail Ziegler was transferred to the Warsaw Polytechnic Institute of Emperor Nicholas II to the post of university lecturer of metallurgy with the duties of an extraordinary professor.[71]

As soon as he moved to Warsaw, Mikhail Ziegler filled out the application for supplying equipment for metallurgical laboratory at the Warsaw Polytechnic Institute of Emperor Nicholas II.[72] Not knowing the new address of the educator, the supplier, T. Plevinsky, sent the

[70] SAKhR, f. R-1682, desc. 2, case 356,, p. 60.
[71] *Ibid.*, p. 65.
[72] CANN, f. 2082, desc. 2, case 321, p. 26.

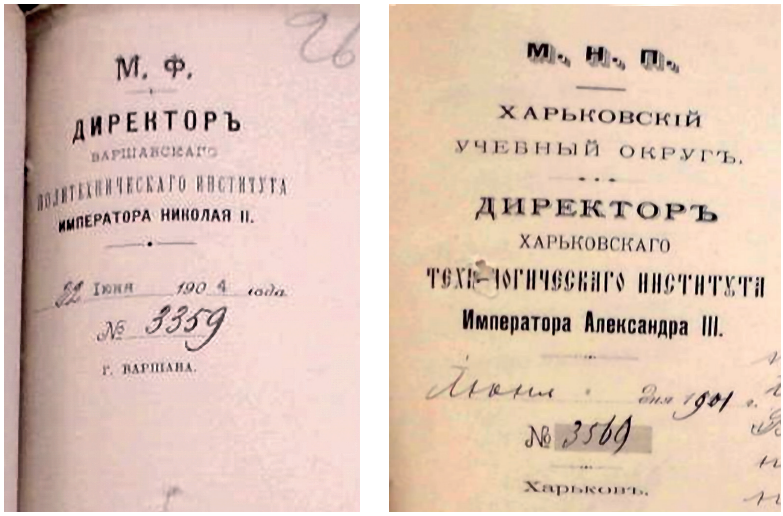

Fig. 9. Corner stamps of institutes. The affiliation to the ministries (finance and public education) *is indicated* at the top. *Source*: SAKhR, f. R-1682, desc. 2, case 356, pp. 37; 59.

letter to the office of the Kharkov Technological Institute of Emperor Alexander III with request to indicate the address of residence of Mikhail Ziegler[73] in February 1905. He was answered that Ziegler's address was unknown to them.[74]

After moving to Warsaw, Ziegler was quite active, self-educating, supervising coursework and graduation projects. The Warsaw Polytechnic was also being developed. Already in the 1904/05 academic year, the number of students exceeded 1,000. In this academic year, 14 professors and 32 teachers taught at the institute, some of whom worked part-time.[75]

The Warsaw Polytechnic Institute of Emperor Nicholas II did not belong to the Ministry of Public Education, therefore, the names of employees, their positions, marital status, awards received and salaries were not published in the relevant proceedings. As we mentioned above, the Warsaw Polytechnic Institute belonged first to the Ministry of Finance, and then to the Ministry of Trade and Industry. However,

[73] SAKhR, f. R-1682, desc. 2, case 356, p. 69.
[74] *Ibid.*, p. 70.
[75] Anonymous$_5$ 1903, p.314.

in the proceedings of «All Warsaw» for various years we could find some data about its educators and staff. For example, in the proceeding for 1905 it was noted that the acting process engineer court adviser Mikhail Karlovich Ziegler was the acting extraordinary professor of metallurgy.[76]

But, in January 1905, a revolution broke out and the Institute was transferred to Novocherkassk. Meanwhile, Mikhail Karlovich, who was granted a leave,[77] continued his experiments, and in December 1907, he took part in the 1st Mendeleev Congress in St. Petersburg, where he reported on the results of his research, including those carried out earlier in France and Germany. Interestingly, in the capital, Ziegler lived in the apartment belonging to his older brother, Emil Karlovich, at Konnogvardeisky boulevard, house number 19.[78] In 1908, the Warsaw Polytechnic Institute of Emperor Nicholas II resumed operations in Warsaw, and M. K. Ziegler, like other teachers, resumed educating there. In 1908, Mikhail Karlovich began to publish toms of his book "Investigation of alloys of iron with sulfur and the phenomenon of hot-brittleness of steel". Interestingly, the 3rd tom was first published, partially reported at the Mendeleev Congress, and just in 1912, the 1st, 2nd and 4th toms were printed. Today, any metallurgist says that sulfur has the greatest influence on the hot-brittleness of steel. But how many do remember the author of numerous studies on this issue – Mikhail Ziegler?

In the proceeding "All Warsaw" for 1906, it was noted that the acting process engineer court adviser Mikhail Karlovich Ziegler was the acting extraordinary professor of metallurgy, and he lived at Koszykowa street, 63.[79] However, in March 1906, he received the rank of collegiate adviser.[80] In the proceedings "All Warsaw" for 1907–1912, there were no changes regarding to the status and the place of residence of the scientist and educator.[81]

Interestingly, other educators, who acted as extraordinary professors, also lived at Koszykowa street, 63: Alexander Yakovlevich Kasmin,

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[76] Anonymous$_6$ 1904, p. 403.

[77] CANN, f. 2082, desc. 2, case 321, p. 40.

[78] *Ibid.*, p. 46.

[79] Anonymous$_8$ 1905, p. 278.

[80] CANN, f. 2082, desc. 2, case 321, p. 89.

[81] Anonymous$_9$ 1906, p. 319; Anonymous$_{10}$ 1908, p. 241; Anonymous$_{11}$ 1909, p. 249; Anonymous$_{12}$ 1910, p. 250; Anonymous$_{13}$ 1911, p. 261.

Mikhail Ivanovich Lisyansky, Ivan Feodosievich Chorba and educators, for example, Viktor Adolfovich Bernadsky, Georgy Iosifovich Erchikovsky.[82]

Fig. 10 The educators of the Russian Warsaw Polytechnic. Seated from left to right: Prof. Ivan Ivanovich Bevad, Prof. Alexander Nikolaevich Kugushev, Prof. Ivan Feodosievich Chorba, Prof. Viktor Iosifovich Deutsch, Director of the Institute Vladimir Prokhorovich Amalitsky, Prof. Nikolai Konstantinovich Tolvinsky, Prof. Vasily Andreevich Solonina, Prof. Volodymyr Ivanovych Luchitsky. Standing from left to right: unknown, Prof. Ivan Romanovich Braytsev, unknown, Prof. Alexander Leonardovich Vasyutynsky, unknown, Prof. Dmitry Dmitrievich Mordukhai-Boltovskoy, educator Petr Alexandrovich Fedders, unknown, junior laboratory assistant Pavel Vasilievich Naberezhnov (?), senior laboratory assistant Vladimir Andreevich Vanyukov (?), Prof. Mikhail Karlovich Ziegler. The photo is from 1913 and is in Public Domain

In October 1908, M. K. Ziegler was elected the Secretary of the Mining Department.[83] He was also granted a title of a Knight of the Order of St. Stanislaus, 3rd class.[84]

Mikhail Karlovich was not an armchair scientist. He traveled a lot to various metallurgical plants of the Russian Empire – from the Urals

[82] *Ibid.*, p. 249.
[83] CANN, f. 2082, desc. 2, case 321, p. 51.
[84] CANN, f. 2082, desc. 2, case 321, p. 75.

(including the Zlatoust plant), where he visited in 1910[85], to the plants in the Kingdom of Poland, which he visited in June 1914, before the start of the First World War.[86]

Visiting the Ural factories was a serious tour for Ziegler. For example, Mikhail Karlovich visited: Kochkar and Miass gold mines, Nadezhda steel plant, Nizhny Tagil and Lunevsky plants, Kyshtym mining plants, Perm cannon plant, consulted with the Chief Manager of the Ural mining plants mining engineer Pavel Petrovich Boklevsky, with the mining head of the Zlatoust mining district mining engineer Anatoly Alexandrovich Zelentsov, mining chief of the Goroblagodatsky mining district mining engineer Alexander Stepanovich Levitsky. Ziegler's sociability and noble origin allowed him for making useful contacts and obtaining a large amount of necessary information.[87]

In 1915, Ziegler visited factories in the north of the Russian Empire – Konchezersky and Olonetsky. During each trip he learned something useful and mastered his technical skills, his ability to teach metallurgy. Also, he collected ideas and topics for his course, as well as ideas for his students in regard of their diploma dissertations.[88]

For example, having visited Zlatoust, he simply fell in love with damask steel – the most famous steel in the history of metallurgy. Using the methods developed by the brilliant Russian metallurgist Pavel Petrovich Anosov (1799–1851), Mikhail Ziegler managed to obtain cranked damask steel in 1911.

Based on the results of his research, Mikhail Karlovich published the paper «Ueber Damast» («About Damask Steel»), published in the journal «Metallurgie» in 1911. Mikhail Karlovich obtained the damask steel in order to prove that the Anosov's technique, when implementated carefully, allows any metallurgist for obtaining this most famous steel.

M. K. Ziegler was the author of the original theory of directional solidification of steel, which was partially confirmed only in the fifties of the 20th century with the development of continuous casting steel in the USSR.

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[85] *Ibid.*, p. 84.
[86] *Ibid.*, p. 129.
[87] *Ibid.*, p. 85.
[88] *Ibid.*, p. 138.

In 1911, the 200th anniversary of the birth of M. V. Lomonosov was widely celebrated, and director of the Warsaw Polytechnic Institute of Emperor Nicholas II, V. P. Amalitsky, prepared the speech for the celebrations entitled "The Significance of Lomonosov's Works on Mineralogy, Geology, Metallurgy and Mining Art".[89] In 1912, it was published as the booklet with small articles by several educators, including M. K. Ziegler. His 4-page article was called "Iron and its production based on the book by M. V. Lomonosov «The first foundations of metallurgy, or ore affairs»", published in 1763.

On May 21, 1912, M. K. Ziegler defended his thesis at the Mining Department of the Warsaw Polytechnic Institute of Emperor Nicholas II on the topic "Investigation of iron alloys and the phenomenon of steel hot-brittleness"[90], and on May 31, 1912, he received the title of adjunct and the post of extraordinary professor.[91] In May 1913, he became an ordinary professor with the rank of State Councilor.[92]

In 1912, the teaching of metallurgy at the Warsaw Polytechnic Institute of Emperor Nicholas II was expanded. The university lecturer of general metallurgy was the process engineer Vladimir Yakovlevich Mostovich, the senior laboratory assistant of the department of general metallurgy was the process engineer Mikhail Fedorovich Ortin, the junior laboratory assistant of the department of iron metallurgy was the process engineer Pavel Vasilyevich Naberezhnov.[93]

It is not surprising that in April 1913, the delegation of 11 representatives of the Warsaw Polytechnic attended the Second Congress on Mining, Metallurgy and Mechanical Engineering in St. Petersburg.[94] Honored Professor V. L. Kirpichev presided at the congress. Naturally, Mikhail Ziegler, as the close relative, was a guest of the Kirpichev family. Unfortunately, this was the last meeting that Mikhail Karlovich and Viktor Lvovich had, because, V. L. Kirpichev passed away in the autumn of 1913.

In April 1913, Mikhail Ziegler was decorated with the Order of St. Anna, 3rd degree.[95]

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[89] Amalitsky 1912, pp. 1-12.
[90] CANN, f. 2082, desc. 2, case 321, p. 98.
[91] *Ibid.*, p. 107.
[92] *Ibid.*, p. 120.
[93] Anonymous$_{13}$ 1911, pp. 251-252.
[94] Rybiev 2007, p. 16.
[95] CANN, f. 2082, desc. 2, case 321, p. 137.

In the proceedings "All Warsaw" for 1913, it was indicated that the extraordinary professor of metallurgy was the process engineer, adjunct of the institute, State Councilor Mikhail Karlovich Ziegler, who lived on at Koszykowa street, 75.[96] The university lecturer of general metallurgy was the process engineer, court adviser Vladimir Yakovlevich Mostovich, who lived on the at Polna street, 54.[97]

In 1914, Ziegler's official position and place of residence did not change, and chemical engineer Vladimir Andreevich Vanyukov, who lived on the at Polna street, 46a,[98] was indicated as an university lecturer of metallurgy, the senior laboratory assistant of the Department of General Metallurgy – process engineer Mikhail Fedorovich Ortin, the junior laboratory assistant of the Department of Iron Metallurgy – the metallurgical engineer Pavel Vasilievich Naberezhnov.[99] Subsequently, V.Ya. Mostovich, V.A. Vanyukov, M.F. Ortin and P.V. Naberezhnov would benefit development of metallurgy a lot more…

In 1915, the Ziegler family spent their summer holidays in St. Petersburg. They stayed in the apartment belonging to the doctor of medicine Vladimir Ignatievich Voyachek and his wife Nina Viktorovna (Ziegler's niece, the youngest daughter of Viktor Kirpichev).[100]

The Warsaw Polytechnic Institute worked as usual until August 1915, then its staff, educating materials and equipment were evacuated first to Moscow and then to Nizhny Novgorod, where they were the basis for creating a local technical school. However, the confusion, numerous relocations, unsettledness of educators and, especially, students, did not have the best effect on the professors and employees of the institute. In March 1917, the Director of the Institute, Honored Professor Vladimir Prokhorovich Amalitsky, was retired for health reasons. Alas, on December 17 (30), 1917, he passed away.[101]

Ziegler family's property was left in Warsaw. We see that Mikhail Karlovich was noted in the proceeding «All Petrograd» as «a state councilor who lived in Tsarskoye Selo, along on Bezymenny lane,

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[96] Anonymous$_{14}$ 1912, p. 250.
[97] *Ibid.*, p. 251.
[98] Anonymous$_{15}$ 1913, p. 254.
[99] Anonymous$_{15}$ 1913, p. 263.
[100] CANN, f. 2082, desc. 2, case 321, p. 139.
[101] Rybiev 2007, p. 84.

a member of the Petrograd Zemstvo-City Regional Commission for Supplying the Army».[102] In 1916, by the end of the First World War, Mikhail Karlovich returned to the institute.

5. The October revolution and the fate of the scientists

On October 25 (November 7), 1917, the October Coup took place, which was called the Great October Revolution 10 years later. Already on March 30, 1918, the decision was made by the local authorities to close the Nizhny Novgorod Polytechnic Institute (previously Emperor Nicolai II Warsaw Polytechnic Institute). It was supposed to became a part of the Nizhny Novgorod University.[103] On May 22, 1918, Mikhail Ziegler was offered the position of Dean of the Faculty of Mining and Engineering[104] there. On August 30, 1918, at the opening meeting in the Mining and Technical Faculty, he was elected a dean. M.S. Zbyshevsky was elected a secretary; a mining engineer, and later specialist in the production of cobalt Efim Isidorovich Yelitenko was appointed the university lecturer of mining mechanics.[105]

Mikhail Ziegler was well aware that it would be impossible for him to work successfully with the new government because of his noble origin. At that time, in Russia, mainly careerists and rogues came to local leadership. They just enjoyed power and used it in their own interests, which were far from noble, and usually against interests of others. Representatives of the new government did not report to anyone and were not going to do this, and any timid attempts to protest against the deliberately wrong decisions of the authorities were declared counter-revolution. Moreover, the titles of professors, academic degrees, scientific pensions upon reaching 25 years of work and much more were all abolished by law at the state level. Engineers and educators of higher educational institutions, military officers and industrialists, officials and free professionals had to be satisfied with the word "former".

Just the day before, they could afford to keep servants and buy real estates, help the needy and go on vacation, be honored and respected,

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[102] Shashkovsky A. P. 1916, p. 785.
[103] Rybiev 2007, p. 111.
[104] CANN, f. 2082, desc. 2, case 321, p. 173.
[105] *Ibid.*, p. 180.

they were addressed by "Your Excellency" or "Your Honor" and much more. However, the absolute majority of the "formers" had always considered honor, patriotism, family, knowledge, personal libraries, experience and professional skills as their main achievements in life, not only their position in society, their spouse's jewelry and money in bank accounts.

Mikhail Karlovich, after talking to the local authorities, concluded that it was necessary to move closer to the capital – to Moscow or St. Petersburg. There he still had an opportunity to work, to purchase equipment for laboratories, and experience and knowledge were still appreciated there rather than a loud voice and impertinence.

In addition, Mikhail Karlovich had been the owner of real estate in St. Petersburg for many years. He owned the house at Podolskaya street, together with his maternal relatives, the Stukkeys, and his younger sister Nina Karlovna (married Orfenova, then Lomshakova)[106]. Most likely, the house went to Mikhail Karlovich by inheritance. Giving it away was not a part of the plans of the nobleman Ziegler. And when the new dean of the Mining Faculty in Nizhny Novogrod, D.K. Artemiev, began to move the entire faculty to Moscow, Mikhail Karlovich supported him. And, by hook or by crook, in the autumn of 1918, by the decree of the People's Commissariat of Education, the Mining Department of the former Warsaw Polytechnic Institute was transferred to the Moscow Mining Academy. Until the end of 1918, the professors and the leading educators of the faculty moved there, and in the spring of 1919, the assets and numerous collections of laboratories and classrooms[107] were transferred.

In Moscov, Mikhail Karlovich participated in the foundation and development of the regulations, plans and programs of the Moscow Mining Academy together with Nikolai Mikhailovich Fedorovsky, Dmitry Nikolaevich Artemyev, Georgy Vasilyevich Klyuchansky and Yan Yanovich Enslen. By the end of 1919, Ziegler had been the leading university lecturer of the academy, the dean of the metallurgical department, the head of the chair of metallography, general metallurgy and the general course of iron metallurgy, which in fact were three chairs.

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[106] Yablonsky 1897, p. 1119.
[107] Rybiev 2007, p. 134.

The inability to provide laboratories with equipment, the impossibility of carrying out research work, in which Ziegler was major specialist, led him to the decision to leave the Mining Academy. Mikhail Ziegler, man of honor and dignity, patriot and nobleman, was extremely painful to see the struggle for power among the leaders of the academy, who were the people of minor moral qualities. Intuition did not deceive him. Two of the co-founders of the academy (D.N. Artemiev and Ya.Ya. Enslen) did not return home from business trips abroad at the first opportunity. Two others were subsequently repressed by the new government (G.V. Klyuchansky was shot)...

And Mikhail Ziegler himself was totally forgotten as the founder of the Academy and as the head of actually three chairs, for more than 90 years.

The last notion of Ziegler at the Mining Academy was from September 24, 1920. He took part at the meeting of the educational section.

From Moscow, Mikhail Karlovich moved to his native Petrograd, taking the post of professor at the Petrograd Polytechnic Institute. This institute was built by his elder brother, Emil Karlovich; Viktor Lvovich Kirpichev was a member of the building committee, and the Institute had a special relationship with Mikhail Karlovich. He was given optimal conditions for his work there and the scientist became interested in research, like in his youth. Moreover, his nephew, Mikhail Viktorovich Kirpichev, the future academician, taught at this institute. Most likely, his mother, Matilda Karlovna, the elder sister of Mikhail Karlovich Zeigler's elder sister, also lived with him. In Petrograd, M.K. Ziegler tried to complete the research he had been doing for many years. But his strength was running out.

Some of his activities were reflected in the journals of the sessions of the State Hermitage Council. They noted that M.K. Ziegler tried to continue his studies on damask steel. Whether he wanted to pass this knowledge to others, or was going to provide the cavalry (the main branch of the army of that time) with destructive weapons – we will not know. If he managed only to mass-produce the technology and obtain ordinary kitchen knives with beautiful original pattern on the surface and blades that do not require sharpening for decades, just this would be a great achievement in metallurgy.

On April 11, 1921, Mikhail Karlovich inspected the collection of damask blades in Hermitage and suggested that the Hermitage staff should start analyzing these edged weapons. On May 30, 1921, the Hermitage Council

adopted a Solomonic decision: "not to extradite, so as not to create precedents".[108] On July 4, 1921, the Scientific Secretary of the Hermitage, F.F. Hess, announced the decision at meeting of the Council and explained that the Petrograd Polytechnic Institute should apply to the Security Department, where the Hermitage had already taken appropriate steps.[109] Alas, apart from except talking, no real steps have been taken.

Thus, museum workers have deprived humanity of the opportunity to reveal the secrets of damask steel, which seems to be ordinary carbon steel with original properties, namely the blade not requiring sharpening for decades, even when used.

We know that Mikhail Karlovich mobilized his students and employees to complete the research on determining the strength of steel depending on the conditions of its crystallization. Under the guidance of Professor Ziegler, engineers Mikhail Porfiryevich Slavinsky, N.I. Berkoltsev, D.F. Karavaev, N.P. Kirillov, A.A. Moskalenko and S.A. Khodkovsky carried out comprehensive studies on the diffusion of impurities in steel.[110] This trend of research is promising even today, a hundred years later, since it allows for predicting the properties of steel not only during its crystallization, but also during usage in increased temperature and higher pressure. This work enabled to cast steel by the continuous casting method and use it in nuclear technology, in underwater work, in space exploration and under other extreme operating conditions.

Alas, Mikhail Karlovich did not have time to publish the results of the research. This was done by his students.[111] The authors Nikolay Vladimirovich Ageev and Mikhail Ivanovich Zamotorin bitterly wrote:

M.K. Ziegler, together with his students, set up studies of the influence of temperature on the development of diffusion and determination of the temperature of its beginning. These studies were carried out completely only for copper and phosphorus. The study of the effect of mechanical pressure on the diffusion of impurities in steel was planned by M[ikhail] K[arlovich], the samples were prepared, but he did not have enough time to carry out the experiments.[112]

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[108] Anonymous$_{17}$ 2009, p. 337.
[109] *Ibid.*, p. 338.
[110] Slavinsky 1926, p. 2
[111] *Ibid.*, pp. 3–4; Ageev 1928, p. 184.
[112] *Ibid.*, p. 188.

Because the extremely difficult trials undermined Mikhail Karlovich's health.[113] Another serious blow was the news about his brother-in-law, Yanuariy Alexandrovich Rykov, being deported from Crimea to the Narym Territory for 3 years, which he received in December 1924.

According to the historian of the Polytechnic Institute Boris Nikolaevich Menshutkin, Mikhail Karlovich Ziegler died on January 20, 1925.[114]

The name of Mikhail Karlovich was last mentioned in 1922, among professors of the Polytechnic Institute living on the site of the institute in apt. No. 11[115] (the proceedings "All Petersburg"). In the proceeding "All Petersburg" for 1923 and in the proceedings "All Leningrad" for subsequent years, the name of Professor Ziegler is not mentioned. The indirect confirmation that his death took place in 1922 was the rereleasing of the journal of the Russian Metallurgical Society in 1925. The editor-in-chief of this publication was Ziegler's colleague at the institute, Professor Mikhail Pavlov. In 1925, the magazine published several obituaries. But the death of Mikhail Ziegler was not mentioned there. And, if Ziegler passed away in 1922, then such attitude towards the memory of the outstanding scientist and university lecturer is quite understandable: obituaries are not published after three years since death. Note here, that at the time of Ziegler's death the technical journals on metallurgy were practically not published in the country.

We are left with the classic works of Mikhail Karlovich, which today form the foundation of knowledge on steel metallurgy.[116] In them, he reveals the secrets he discovered: about obtaining high-quality steel from wide variety of ores and using variety of melting units. Even in the last days of his life he worked, for he was in a hurry to finish the research he had begun.

6. Conclusions

This present publication analyzes the scientific, organizational and educational activities of the outstanding metallurgist Mikhail Ziegler.

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[113] Blokh 2018, p. 33.
[114] Menshutkin 2012, p. 358.
[115] Anonymous$_{16}$ 1922, p. 638.
[116] Ziegler 1901, pp. 25–31; 1908, 39 p.; 1912, 160 p.

We prove that his theoretical and practical work became the basis for continuous casting, one of the most important world inventions of the 20th century in the field of metallurgy. We show that Ziegler as a scientist and university lecturer developed fully during his work at the Warsaw Polytechnic Institute of Emperor Nicholas II.

The fundamental work performed by Mikhail Ziegler and his co-researchers, namely determining the strength of steels depending on the conditions of their crystallization and studying diffusion of impurities in steels, became the basis for huge amount of activity that enabled producing billion tons of steel in the world at the beginning of the 21st century. The work of Mikhail Ziegler about the effect of sulfur on the service properties in iron-carbon alloys, in particular steels, has long become classic one. It was him, who managed to prove, for the first time in the world, that sulfur and its compounds have extremely negative effect on all service properties of steels.

Innovative scientific research, initiated by Mikhail Ziegler, became the basis for the restoration of Russian metallurgy after the revolution of 1917 and the Civil War of 1918–1920.

The development of science at the beginning of the 20th century can be characterized as gradual transition from the activities of individual scientists to collective cooperation in its most effective form: the scientific school. The scientific team, headed by Mikhail Ziegler, had all the main features that characterize a scientific school. In particular, these were: important theoretical and practical results that received worldwide recognition; implementation of results in the industry on the global scale; the presence of scientific leader and system for training scientific and engineering personnel; the continuity of generations; the development of scientific school, which led to the creation of new educational and scientific centers.

Unfortunately, just few archival materials and works by Mikhail Karlovich Ziegler are published in the open press today, or are otherwise available for study. This gives reason to believe that these materials will be sources for future historians; and just future researchers will be able to highlight the last pages of the scientific achievements of the classic of metallurgy, Mikhail Ziegler.

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