The Great War as a Crucial Point in the History of Russian Science and Technology

Dmitry L. Saprykin (Moscow, Russia)

Abstract

The paper is devoted to one of the most important and, at the same time, relatively unexplored phases in the history of Russian science and technology. The Great War coincided with the beginning of a heyday in science, engineering education, and technology in Russia. It was precisely the time in which Russia's era of "Big Science" was emerging. Many Russian and Soviet technical projects and scientific schools were rooted in the time of the Great War. The "engineerization" of science and a "physical-technical" way of thinking had already begun before the war. But it was precisely the war which encouraged a large proportion of the Russian academic community to take part in industrial projects. Academics also played a significant role in developing concepts and implementing strategic plans during the Great War. This article also discusses how the organization of science and the academic community was transformed during, and after, the Great War. And it looks at the impact that war had on Russia's participation in the international scientific community.

Zusammenfassung

Der Artikel ist einer der wichtigsten und gleichzeitig unerforschten Phasen in der Geschichte der russischen Wissenschaft und Technik gewidmet. Der Erste Weltkrieg fiel zeitlich mit dem Beginn des Aufblühens der russischen Wissenschaft, der technischen Ausbildung und der Technologie in Russland zusammen. Ausgerechnet diese Periode war der Zeitpunkt, an dem die „große Wissenschaft“ aufkam. Viele der russischen und sowjetischen wissenschaftlichen Schulen und technologischen Projekte haben ihre Wurzeln in dieser Epoche. Der Entwicklungsprozess der „Technisierung der Wissenschaft“ sowie die Herausbildung der „physikalisch-technischen“ Herangehensweise hatten bereits vor dem Krieg begonnen. Es war aber ausgerechnet der Krieg, der einen großen Teil der akademischen Gemeinschaft zur aktiven Teilnahme an industriellen Projekten anspornte. Die Akademiker spielten ebenfalls eine große Rolle bei der Entwicklung von Ideen sowie der praktischen Umsetzung strategischen Planens während des Ersten Weltkriegs. In dem Artikel werden auch die Veränderungen in der Organisation der Wissenschaft und der akademischen Gemeinschaft während und nach dem Krieg untersucht. Außerdem wird der Einfluss des Krieges auf die Art und Weise der Beteiligung Russlands an der internationalen wissenschaftlichen Gemeinschaft beleuchtet.

Резюме́

Статья посвящена одной из наиболее важных и в то же время неизученных страниц в истории российской науки и техники. Первая мировая война совпала по времени с началом периода расцвета русской науки, инженерного образования и технологии в России. Именно этот период стал моментом зарождения российской “большой науки”. Многие из российских и советских научных школ и технологических проектов уходят корнями в эту эпоху. Процесс развития “инженеризации науки”, развития “физико-технического” подхода начался ещё до воины. Но именно война подтолкнула большую часть академического сообщества к активному участию в индустриальных проектах. Академики сыграли также большую роль в развитии идеи и практике стратегического планирования во время Первой мировой войны. В статье также рассматриваются трансформации организации науки и академического сообщества во время и после войны. Также рассматривается воздействие войны на характер участия России в международном научном сообществе.

1. Lost "Golden Age" of Russian Science

The development of Russian science and technology during the Great War (World War I) is one of the main "blank spots" on the historical map. Soviet and post-Soviet investigations, biased by Marxist ideology, have tried to emphasize the "wonderful" growth of science and industry after 1917. This explains why the pre-revolutionary roots of most Soviet achievements were hidden. Soviet successes were typically compared with notorious "1913 data", as if the period of the Great War was insignificant for their investigations. At the same time, Soviet scientists and engineers, especially persons from the old "privileged estates", tried to hide their pre-1917 backgrounds. Western "Sovietologists" have reiterated the key prejudices of their Soviet counterparts with regard to the pre-revolutionary history of science and engineering in Russia.

But, in fact, the crucial changes in Russian science, education and industry before, during and after the Great War are the key to understanding the scientific and technological development of Russia in the twentieth century.

In Russia, the beginning of the twentieth century was "the silver age" of art, literature, theology, philosophy, and music, but also a "golden age" in science, biology, engineering, and scientific education.

The achievements of Russian scientists had begun to receive international recognition before the war. This is reflected in the names of the candidates for the most prestigious scientific awards of the time (not only the Nobel Prize, but the Copley Medal of the Royal Society). Between 1905 and 1915, three of the eleven Copley Medal winners were Russians – Dmitri Ivanovich Mendeleev (1834–1907) in 1905, Ilya Illyich Mechnikov (1845–1916) in 1906, Ivan Petrovich Pavlov (1849–1936) in 1915. It was a creative period and a time in which many new scientific and engineering ideas were born in Russia.

The future promised to be even more successful. Russian universities and polytechnic institutes were full of talented students. The number of students attending Russian and German institutes of higher education (partly universities and polytechnics) before the Great War is shown in Table 1.[1] We see that Russia and Germany had the same number of students in the main scientific subjects of physics, mathematics, chemistry, economics, etc. However, Russia outnumbered Germany in engineering (see Tab. 1).

It was precisely this advantage in engineering and scientific education in the pre-war Russian Empire that formed the basis for the technical achievements of the Soviet Union in the twentieth century.

2. Russia as a Member of the International Scientific Community

Before the war, Russia had actively participated in international scientific cooperation. The Russians, along with the Germans, French, English, Americans, and Italians, were among the most active participants in pre-war scientific and technical conferences and associations. The largest pre-war 7th International Geological Congress and the 12th International Congress of Medicine were held in Russia in 1897. The 9th International Congress of Pure and Applied Chemistry was to have been held in St. Petersburg in 1915, but of course never took place.

1 Ringer 1979, Ivanov 1991, Mashkin 1997, Saprykin 2012.

Tab. 1 University-level student enrollments in science and technology in Russia and Germany (in thousands)

Germany		1900	1911	Russia		1898	1913–1914
Universities (faculties of arts and philosophy)	Science	4.7	7.8	Universities and women's university-type higher education institutions	Math and physics	3.6	9
	Agriculture and Economics	1.7	3.3		Math and physics	n.d.	2.9
Academies	Mining	0.8	0.4		Mining	0.4	1.5
	Forest and agricultural	1.2	1.3		Forestry and agricultural	1.3	6.2
	Veterinary	1.3	0.7		Veterinary	1.1	1.7
Technische Hochschulen (Technical universities)		10.4	11.2		Polytechnical and technological institutions	5.7	25.1

When attendees of international congresses of mathematicians are assessed according to nationality, it is revealed that, before the Great War, Russia was on par with Great Britain, the USA, Italy, and Austria-Hungary as a participant in international scientific congresses (see Tab. 2). In order to correctly evaluate this data, the host-country of each congress is excluded from the comparison. These are marked with an * in the table (*Icm Proceedings* 1893–2010).

Before the war, the intellectual and scientific relationships between Russian and German scientists were very close. But when war broke out, and even before that, such unfriendly acts as “The Proclamation of 93” with its crude blows to Russia and Russian culture had, of course, been creating alienation. This proclamation spoke of “wild Russians” and excluded Russia from civilization:

“Those who have allied themselves with Russians and Serbians, and present such a shameful scene to the world as that of inciting Mongolians and negroes against the white race, have no right whatever to call themselves upholders of civilization.”[2]

Some of the authors of this proclamation were corresponding members of the Russian Imperial Academy of Science: Hermann Emil Fischer (1852–1919), Wilhelm Wundt (1832–1920), Adolf von Baeyer (1835–1917), Wilhelm Ostwald (1853–1932), Carl Engler (1842–1925), Wilhelm Waldeyer (1836–1921), Lujo Brentano (1844–1931), Johannes Conrad (1839–1915), Eduard Meyer (1855–1930) (Basargina 2008). Others were honorary members of imperial universities and scientific and technical societies in Russia. Taking this into account, it is important to realize that the document was especially offensive to Russian scientists. The reaction of Russians was not as crude as could have been expected. But in any case, the war led to a consolidation of all groups of the Russian scientific community and its collaboration with the state.

The creative boom in Russian science at the time was marked by features of originality, and it was rooted in the European and Christian cultural traditions. In a certain sense, the

2 *Professors* ... 1919.

Tab. 2 The number of participants in international congresses of mathematicians 1897–1936 (by nation)

Pre-war Congresses	Russian Empire		Germany	Austria and Hungary		UK	USA	France	Italy	Switzerland
Zurich	16		41	17		3	6	23	20	60*
Paris 1900	14		25	9		10	17	90*	23	7
Heidelberg 1904	30		173*	25		7	15	24	12	12
Rome 1908	19		120	51		22	16	63	190*	16
Cambridge 1912	30		53	36		221*	60	39	35	8
Post-war Congresses	Russia	Ukraine		Austria	Hungary					
Strasbourg 1920	1	–	0	0	0	9	11	80*	5	14
Toronto 1924	14 (10)	3 (2)	0	0	0	71 (13)	206* (15)	42 (18)	14 (3)	5 (1)
Bologna 1928	27	10	76	9	22	47	52	56	336*	29
Zurich 1932	10	–	118	10	12	37	66	69	64	144*
Oslo 1936	11		35	10	5	48	86	28	5	20

period of the Great War was the peak of pre-revolutionary developments in science and technology. It was also the height of Russian national, religious and cultural consciousness. At the same time, the Great War and the Revolution heralded an intellectual, spiritual, cultural and scientific severance from the West. But in spite of this, Russian intellectuals did not lose their intellectual ties with European culture during the war.

The Revolution changed the situation entirely. Partly funded by the German secret service, the Bolsheviks really were "wild Russians". For them, old cultural values were meaningless. To them, scientists and engineers were a very important and valuable group in practical terms, but they were the "class enemy" from a main ideological point of view. The Bolsheviks initially used "bourgeoisie specialists", but later repressed them. On the other hand, the Revolution marked the beginning of a long period of isolation for Russian science. The Revolution was instigated by westernized radicals strongly prejudiced against the traditional Russian cultural, religious and national heritage. But, paradoxically, it was precisely this radical westernization which detached Russia from the West. Only during the short period of the "New Economic Policy" ("NEP") between 1924 and 1929 – which for the Bolsheviks was, in some sense, a "step backward" to old Russia – was the participation of Soviet scientists in international cooperation partly restored. From 1917 until the end of the 1950s, the USSR was represented to the same degrees as the Russian Empire at only one international congress – the International Congress of Mathematicians in Bologna in 1928.

3. The “Engineerization” of Russian Science

A real understanding of the history of Russian science and engineering cannot be achieved if we remain within the limits of the ideologized picture drawn by Soviet and (mainly American) “Sovietologist” authors. One of these prejudices is to affirm the “backwardness” of pre-revolutionary engineering in Russia. As the American professor Loren Graham (*1933) wrote: “The Russians were excellent theoreticians but poor engineers.”[3] But the history of pre-revolutionary Russian science and technology, especially during the Great War, is quite the opposite: The Russians were, first and foremost, very good engineers, followed by being good theoreticians.

At the time, the “physical-technical” way of thinking (in line with that of Felix Klein [1849–1925], Karl Ferdinand Braun [1850–1918], August Föppl [1854–1924], Ludwig Prandtl [1875–1953] and Arnold Sommerfeld [1868–1951] in Germany) was prominent in the minds of Russian scientists. During the reign of Emperor Nicholas II (1868–1918), and especially during the Great War, there was a trend to “engineerize” the Department of Physics and Mathematics of the Imperial Academy of Sciences by converging science and engineering. The academy’s president, Grand Duke Konstantin Konstantinovich (1858–1915), though better known for his poetry, also had an education in engineering. Most of the full members elected after 1900 – Prince Boris Borisovich Golitsyn (1862–1916), Alexei Nikolaevich Krylov (1863–1945), Paul Walden (1863–1957), Mikhail Aleksandrovich Rykachev (1840–1919), Vladimir Nikolayevich Ipatieff (1867–1952), Nikolai Semenovich Kurnakov (1860–1941), and Evgraf Stepanovich Fedorov (1853–1919) – were not only famous scientists, but also competent engineers. A similar trend could be seen outside the academy, for example Dmitri Sergeyevich Rozhdestvensky (1876–1940), Abram Fedorovich Ioffe (1880–1960), Stepan Prokopovich Timoshenko (1878–1972), Pyotr Leonidovich Kapitza (1894–1984), Leonid Isaakovich Mandelstam (1879–1944), and Nikolai Mitrofanovich Krylov (1879–1955).

This partly reflected the personal attitude of Emperor Nicholas II, who had stressed the necessity of accelerating the development of engineering education before the war. As a result, Russia had overtaken France and had begun to overtake Germany in the number of engineers and scientists working “in a professional capacity” before the war (see Tab. 3). Table 3 estimates the number of engineers with academic experience. It takes into account average life expectancies.[4]

After the Revolution, some elements of Russian engineering education were exported to the USA, Eastern Europe, and France. The most prominent example of such “export” is the work of Stepan Timoshenko – “the father of American mechanical engineering education” – in the USA. But we should also understand that Timoshenko actively utilized the educational experience of his prominent predecessors, such as Ivan Vsevolodovich Meshersky (1859–1935) and Viktor Lvovich Kirpichev (1845–1913). At American universities, he not only used Russian textbooks, but in general followed the “Russian way of an engineering education” (Timoshenko 1963).

3 Graham 1967, 1993a, b, 2013.

4 Data for France, Germany, and Sweden are taken from Ahlström 1982. I calculated the data for Russia myself using Ahlström’s method (Saprykin 2012).

Tab. 3 Engineers with scientific higher education experience working "in the profession"

	1850	1860	1870	1880	1890	1900	1910	1914	1916
France	6687	8972	12050	15994	21504	28829	38317	42850	
Germany	3343	6731	11856	24452	32166	41657	59738	65202	
Sweden	637	854	1121	1406	1612	2237	3145	3504	
Russia	5631	6466	7008	9662	13875	20776	33564	43138	47483

Typically prominent Russian scientists who were working successfully abroad in the 1920s and 1930s – such as Peter Kapitza in Cambridge, Vladimir Ipatieff in Germany and the USA, Dmitri Vladimirovich Skobeltzin (1892–1990) and Alexei Jevgenyevich Chichababin (1871–1945) in France – had worked at the crossroads of pure science and engineering. Peter Kapitza, for example, was a pioneer in using very complex engineering equipment to create extra-strong magnetic fields in experimental physics. In chemistry, Ipatieff used "the method of extremely high pressure", also based on sophisticated engineering equipment. In any case, before the Great War, Russia was a "great power" not only in "pure science", but also in engineering.

4. Science and Traditional Russia

In contrast to the Soviet and "Sovietologist" view of pre-revolutionary history, traditional cultural forces in Russia – the Empire, the Church and the aristocracy – favored science.

Like his "old friend" and cousin *Kaiser* Wilhelm II (1859–1941) in Germany, Emperor Nicholas II, was a personal supporter of a scientific and technological education. So, too, were other members of the Royal Family, such as the president of the Imperial Academy, Grand Duke Konstantin Konstantinovich, the president of the Imperial Russian Technical Society, Grand Duke Alexandr Michailovich (1866–1933), and his brother, the General Inspector of Artillery, Grand Duke Sergei Michailovich (1869–1918), all of whom were devoted to the development of Russian science and technology and personally did a great deal for it. The same is true for the members of other aristocratic and clerical families.

It is no coincidence that many Soviet academicians were the sons of aristocrats, priests and top czarist officials and officers. For example, the most prominent Soviet mathematician and nuclear physicist Nikolay Nikolayevich Bogolubov was the son of the famous priest and professor of theology of Kiev University, Father Nikolay Mihailovich Bogolubov (1872–1934). The leader of Soviet mechanics Ivan Ivanovich Artobolevskii (1905–1977) was the son of the priest and professor of theology of Petrovskaya Agrocultural Academy, Ioann Artobolevskii. The leader of the Leningrad (St. Petersburg) Mathematics School, Vladimir Ivanovich Smirnov (1887–1974) was the son of a priest and professor at the Lyceum of Emperor Alexandr I, Father Ioann Smirnov. It should also be noted that "the conflict of two cultures", so well described by Charles Percy Snow (1905–1980) in the case of England (Snow 1963), does not appear to have existed in pre-revolutionary Russia. "Engineerization" did not mean "dehumanization" in pre-revolutionary Russia. Poets, engineers, theologians, scientists, and mathematicians were close relatives, in a sense.

In general, the social origins of the most prominent Soviet scientists active in the late period of Stalin's rule appear to be an enigma. The members of the Academy of Sciences of the Soviet Union in 1950–1960 almost seemed to be elected by a kind time machine. Stalin's academicians, almost without exception, were the offspring of the suppressed imperial elite: sons of czarist officials, top officers in the Imperial Army and Navy, priests, teachers and professors, high-salaried engineers and rich capitalists. Comparative data on the social origin of Soviet academicians in 1950–1960, and professors and students of technological institutes of the Russian Empire in 1914 are shown in Table 4.[5] As we can see from this data, the staff of the Academy of Sciences of the Soviet Union in 1950–1960 was more socially exclusive than the students and, to a certain extent, the professors in 1914.

Tab. 4 Comparison of the social origin of Stalin's professors and students from 5 Russian imperial institutes of technology between 1913 and 1914 and members of science and technology academies (in percentage, %)

Social origin (father's status)	Professors of 5 Russian Imperial Technology Institutes 1913–1914, %, (out of 100 persons)	Students of 5 Russian Imperial Technology Institutes 1913–1914, % (out of 9704 persons)	Full members of the Academy of Sciences in Physics, Math and Technology, 1950–1960, % (out of 106 persons)
Nobility, top officials and officers	49.6	24.6	36.8
Priesthood	4.8	2.4	7.6
Merchants/honorary citizens	14.4	14.1	9.4
Petty bourgeoisie (“Meshane”)	21.6	35.2	14.2
Liberal professions (teachers, engineers, artists and so on)	4	n.d.	17.9
Peasantry and Cossacks	4.8	22.4	1.8
Foreigners	0.8	1.3	–
Unknown	–	–	2.8

In order to understand the history of Russian science and engineering, we should not only study the development of institutes, but also informal traditions, including family and private teaching. In this case a very useful question is: What did this famous scientist (or his father or teacher) do during the Great War?

5. The Beginning of “Big Projects” in Russia during the Great War

It should also be noted that most large-scale Russian and Soviet “projects” in science and technology were rooted in pre-revolutionary times and, in part, during the Great War. Major wartime “big projects” headed by the academicians Ipatieff, Krylov, Rozhdestvens-

5 I collected the information on Soviet academicianss. The main source of data is the official database of the Russian Academy of Sciences (IS ARAN). The data on social origin of pre-revolutionary professors and students was collected by Ivanov 1991.

ky, Kurnakov, Golitsyn, and Vladimir Ivanovich Vernadsky (1863–1945) affected the course of scientific and industrial development and the emergence of "Big Science" in Russia.

The first example of such "big projects" was the program of Russian military shipbuilding launched before the war which had a strong scientific foundation. A prominent role in the program of Russian shipbuilding was played by the academician Alexei Nikolaevich Krylov, who was Chief Inspector of Shipbuilding of the Imperial Navy in 1908–1910. He was a world-famous mathematician and mechanics specialist, awarded the gold medal from the Royal Institution of Naval Architects for naval engineering, and author of a new "theory of ships". The program of building new Russian battleships, submarines and destroyers was, on the one hand, the result of thorough analysis of the experience gathered in the Russo-Japanese War of 1905 by the General Staff of the Imperial Navy. On the other hand, it was the embodiment of the mathematical and mechanical theories of the academician Krylov and his collaborators. Among the scientists working on the construction of new ships were Ivan Grigoryevich Bubnov (1872–1919) and Stepan Timoshenko (Krylov 1956, Timoshenko 1953).

The second example is the building of chemical plants during the Great War under the guidance of the Chemical Committee of the War Office, headed by academician Ipatieff. Ipatieff was also a prominent scientist and a teacher of generations of Russian, German and American chemists.

The harsh defeats and the retreat of the Russian Imperial Army in 1915 were owed to the fact that the army was badly supplied with explosives. The inability of the Russian war industry to produce additional explosive materials was, in turn, caused by the lack of production of benzene, sulfuric acid, nitric acid, and other chemical products by Russian industry. In 1915–1916, Russian chemical plants were partly modernized and partly rebuilt under the guidance of Ipatieff and his students. The huge new Russian chemical industry had begun to work and produce benzene, toluene, and different kinds of explosives and chemical weapons. At this time, the group led by Nikolay Dimitrievich Zelinsky (1861–1953) also invented an effective gas mask and mass production of it began. Millions of such gas masks were produced by Russian industry. Alexey Chichababin and his group at the Russian Physico-Chemical Society[6] played a similar role in the rise of the Russian pharmaceutical industry.

The third example is the launch of the Russian aircraft industry, especially the construction of heavy planes. During the Great War, a distinguished aircraft industry was built up in Russia. The aviation department of the Society of the Russian-Baltic Plant, headed by Igor Ivanovich Sikorsky (1889–1972), produced the biggest and the most sophisticated heavy airplane of the war – the "Ilya Murometz". The success of the Russians in producing heavy multi-motor aircraft was no accident. The achievement of pre-war Russian aeronautical science and mechanical engineering were embodied in the plane. Some of the calculations of the strength of materials for Russian aircraft were carried out by Professor Timoshenko. Later, in the USA, Timoshenko's lectures on the mechanics of aircraft became an important event in the history of American mechanical education.[7]

As for Russian (or Soviet) schools of physics and mathematics, it should be mentioned that almost all of them were derived from a few seminars which took place just before and during the Great War. For Russian mathematics, this role was played in part by the seminars

6 Ipatiev 1945, 1946, Kojevnikov 2002, Dmitryev 2005, Mikhajlov 2007.

7 Mikheev and Katyshev 2004, Sikorsky 1939, Timoshenko 1963.

of Professor Dmitri Fedorovich Egorov (1869–1931) and Professor Nicolai Nikolaevich Lusin (1883–1950) at Moscow University. For physics, the most important events were two seminars by Professor Rozhdestvensky and Professor Ioffe in St. Petersburg. The main Soviet institutes for scientific research were also based on pre-revolutionary structures. Thus, the State Optical Institute was founded in 1918 on the basis of laboratories in the Physics Institute of Petrograd University, and others in the Imperial Porcelain and Glass Factory. The Faculty of Physics and Mechanics was founded at the Petrograd Polytechnic Institute in 1916 as a development of the seminars of Professor Ioffe and Professor Timoshenko. In late Soviet times, this paved the way for the Leningrad Institute of Physics and Technology. Soviet chemical institutes – GONTI, the Institute of Applied Chemistry and the High Pressure Institute – were founded on the basis of chemical laboratories at Michailovskaya Artillery Academy and the Scientific-Technical Laboratory of the War Office. The Physics Institute of the Academy of Sciences (FIAN) was developed on the basis of the physics laboratory at the Imperial Academy of Sciences and the Physics Institute at the Imperial Moscow University, and so on.

The main line of thinking in Russian physics at the time was the so-called “physical-technical” way of thinking, which presumed there was a correlation between pure scientific and engineering efforts. The first engineering tasks for such “physical-technical” investigations were from the fields of optics and radio technology.[8]

Along with a lack of chemicals, another problem that the Russian army and navy faced was a shortage in optical glass. The production of different optical and opto-mechanical devices began in Russia before the war. For example, military optical instruments were produced in the optical workshop at the large Obuchov artillery plant. But before the war, all Russian optical factories used German optical glass as their primary product. During the war, Russian production of optical glass successfully began at the Imperial Porcelain and Glass Factory. The technical head of the project was the engineer Nikolay Nikolaevich Kachalov (1883–1961). He was a member of an old Russian family that was very closely linked to the Royal Family. Scientific research was carried out by a group of very young scientists from the Institute of Physics at the Imperial Petrograd University and from the Petrograd Polytechnic Institute. They were mainly assistants and students of Rozhdestvensky and Ioffe. Among them were many future academicians and professors – Sergei Alexeevich Lebedev (1902–1974), Ivan Vasilevich Obereimov (1894–1981) and others. Future Nobel prize-winner Nikolay Nikolayevich Semenov (1896–1986) and the future director of the FIAN, Dmitry Skobeltzin, also attended Rozhdestvenskii’s and Ioffe’s seminars at the Institute of Physics in 1915–1917. The head of the group was Rozhdestvenskii himself. He was not only director of the biggest institute of physics in Europe, but also the president of the Russian Physico-Technical Society from 1916 onwards. His work on optical glass was richly financed directly from the budget of the Royal Family under unequivocal orders of the Emperor. Work was successful – production of Russian optical glass began in 1916, but it was halted in 1917 and finally set up again by Kachalov and Rozhdestvenskii in 1926.[9]

Other similar tasks included the manufacture of Russian radio devices and partial-vacuum tubes. Three main centers of Russian radio-engineering research were: (*1*) the laboratory at the Petrograd plant of the Russian Society of Wireless Telegraphs, headed by Nikolay Dmit-

8 Saprykin 2013, Timoshenko 1963, Pechenkin 2014.

9 Rozhdestvenskii and Grebenshikov 1993, Kojevnikov 2002, Polikarpov 2011, Saprykin 2013.

rievich Papalexy (1880–1947), (*2*) the radio laboratory at the sequestered Siemens-Galske plant, headed by Leonid Isaakovich Mandelshtam (1879–1944), (*3*) the radio laboratory at the Tver special radio station, used for Allied communication and for monitoring of the enemy's messages. The head of this station was Michail Dmitrievich Bonch-Bruevich (1870–1956). The production of Russian vacuum tubes began at the Tver lab; Oleg Vladimirovich Losev (1903–1942), the inventor of the LED (light-emitting diode) and other semiconductor electronic devices, began his pioneering work here.[10]

Thus, physicists and engineers began collaborating in the field of optics and radio-physics, which was to define preferences for a long time.

6. Self-Organization, Planning, and the Scientific Community

Returning to the beginning of the story, we should not forget the consolidation of the Russian scientific community and the State in 1914–1916. As a result of the Great War the State was faced with immense problems concerning the supply of armaments, fuel, and provisions, and the organization of transportation on a national level. Blockades and a breakdown in international communications, coupled with limited resources, necessitated the nation-wide planning and control of the economy and industry.

The idea of strategic planning, usually associated with Soviet industrialization, was rooted in the time of the Great War. The Soviet conception was the result of lop-sided growth in sophisticated imperial practices and technical and economic theories. A large contribution to the development of the theory and practice of centralized state regulation of markets, industry and science was made by the full members of the Imperial Academy of Science, Ipatieff, Krylov, and Vernadsky. Experiencing the Great War and imperial centralized organizations had a dramatic effect on notable Russian economists (Nikolay Dmitrievich Kondratiev [1892–1938], Wassily W. Leontief [1905–1999], Alexander Vassilevich Chayanov [1888–1937], Stanislav Gustavovich Strumilin [1877–1974], Gleb Maximilianovich Krzhizhanovsky [1872–1959]). Even the term "five-year plan" was first invented in the Russian Ministry of Transportation in 1916.[11]

The Emperor appointed four "Special Councils" for national regulation and planning. These were the special councils for defense, fuel, transportation, and provisions (Zagorsky 1928). All four special councils closely cooperated with scientific organizations – the Imperial Academy of Sciences, the Imperial Russian Technical Society, and the Russian Physico-Technical Society (see Fig. 1). In order to improve coordination, a special unit under the control of the War Office was founded – the Central Committee for War-Technical Aid of United Scientific and Technical Organizations.[12]

In contrast to the late Soviet practice of "scientific planning", self-organization and consolidation of the Russian scientific community peaked between 1915 and 1917. The Revolution under the flags of democracy and freedom gradually destroyed all forms of real self-organization of scientists and engineers.

10 Alexeev 2009, Pechenkin 2014, Graham 2013.

11 See, for example, the Special Journal of Russian Imperial Council of Ministries no.10055 from May 31, 1916. Russian State History Archive (RGIA) F.1276. Op.12, D.760).

12 Russian State Military History Archive (RGVIA) F.369, F.950, F.13251.

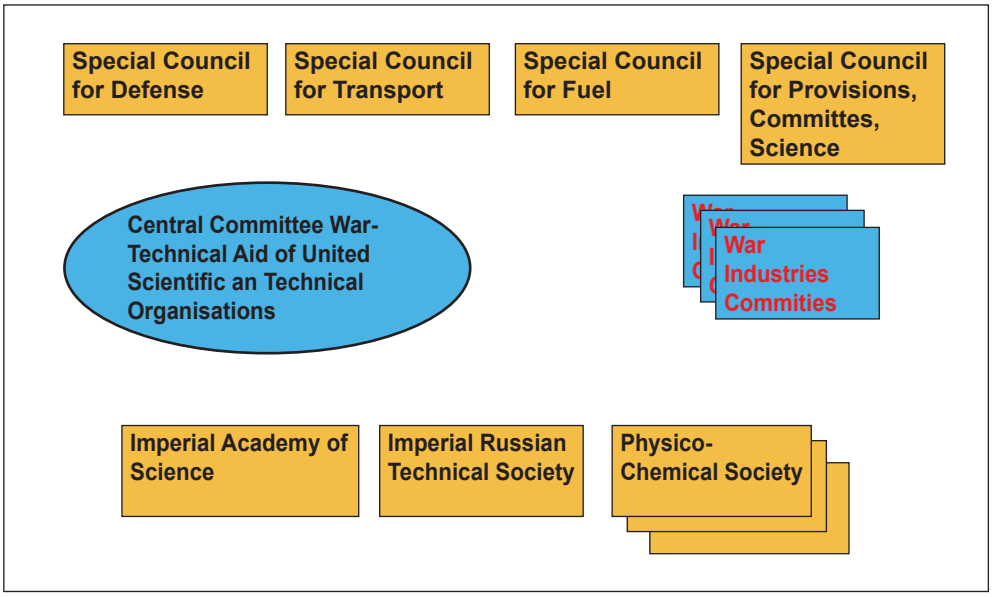

Fig. 1 Structures of central planning, control and scientific organizations during the Great War 1915–1917 in Russia and state – society collaboration in science and technology.

Before the Great War, the Imperial Academy of Science was an important, but not the only element, of a system of organized scientific and technological research. Along with the academy, there were also prominent scientific laboratories at universities, polytechnics, and state ministries. In Russia there were first-rate European scientific and technological societies (for example, the Imperial Russian Technical Society and the Physical-Chemical Society). After the Great War, Revolution and a civil war led to a large transformation in the organization of science and technology. In 1926–1933, most members of the old “privileged” body of engineers and professors were repressed, and almost all its societies and institutes were disbanded (*Process “Prompartii”* 1931, Schattenberg 2002). The Academy of Science was not only revived, but was also enlarged at this time. As a result, after 1934 the Academy of Science had the overall monopoly on science in the Soviet Union (Graham 1967).

7. Instead of a Conclusion

The Great War coincided with a time of flourishing science and education in Russia. It was the start of “Big Science” and major technical achievements in Russia. But it was also the beginning of a tragedy for many Russian scientists and engineers. The French Revolution had led to the execution of the greatest scientist of the time (Antoine Laurent de Lavoisier [1743–1794]), to the demolition of the old academies and scientific societies and to a “governmentalization” of science, education and engineering, concentrated in one state-controlled institute (*Institut de France*). Similarly, the Russian Revolution led to the repression of leading scientists and engineers (the “Industrial Party” and other trials in 1929–1931 – more

than 3000 specialists). The old form of self-organization was destroyed, and all activities were concentrated in two main state institutions – the Academy of Science of the Soviet Union and the NTO VSNKh.[13]

Stalin's academicians, scientists and top engineers – almost all closely connected with the "old" culture and old elite – rethought the experience of the Great War. Almost all of them had passed through repression and, of late, had not only been rehabilitated, but also received enormous resources for the realization of their technical ideas in the Soviet war industry, the aircraft and rocket industry, and for nuclear, radio electronics and laser projects. Almost all of them personally experienced the moral and spiritual tragedy of the time.

Their lives could be described by a profound thought expressed by Igor Sikorsky in the USA in 1947:

"Mankind is now passing through a crisis of unprecedented depth and magnitude. The destructive wars and revolutions which have shaken the world during the last three decades are only the other manifestations of the disturbance. The main cause can be traced to a deep inner dislocation in the moral and spiritual sphere of existence."[14]

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13 NTO VSNKh – Department of Science and Technology of Superior Soviet of the People's Economy (Научно-технический отдел Высшего Совета Народного Хозяйства). VSNKh was the superior state institution for management of the economy of the Soviet Russia in 1917–1932.

14 Sikorsky 1947.

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Dmitry L. Saprykin
The Russian Academy of Sciences
S. I. Vavilov Institute for the History of Science and Technology
Baltiyskaiya ul. 14
125315 Moscow
Russia
Phone: +7 916 601 11 52
Fax: +7 (495) 988 22 80
E-Mail: dsaprykin@yandex.ru
www.ihst.ru