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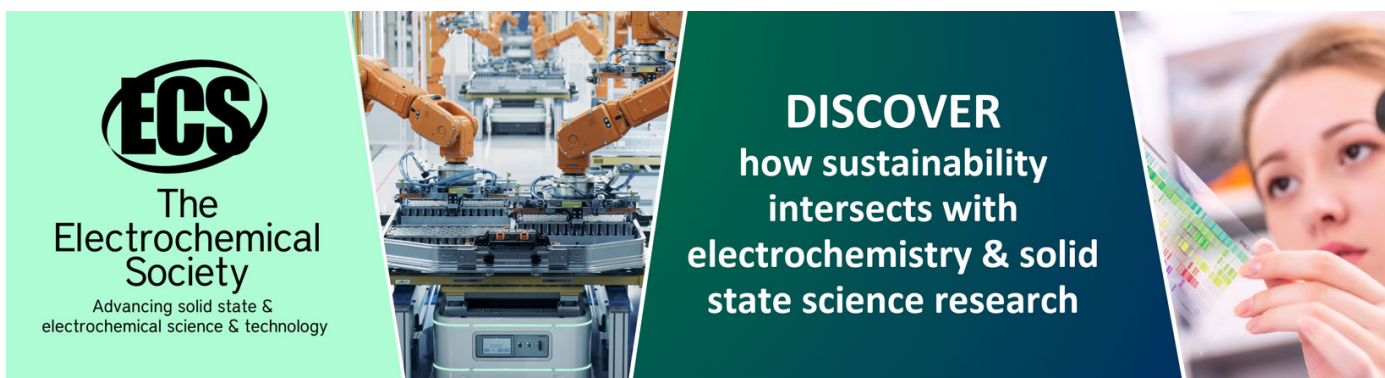
The History of Explorations of the Arctic Region: the Nuclear-Powered Icebreaker Lenin

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The History of Explorations of the Arctic Region: the Nuclear-Powered Icebreaker Lenin

A Prishchepa

Peter the Great St. Petersburg Polytechnic University, Saint Petersburg, Russia

a.prishchepa@list.ru

Abstract. The nuclear-powered icebreaker *Lenin* contributed greatly to the exploration of the arctic regions of the USSR. In the 1950s, the national economy of the USSR made a successful recovery. Jobs related to the development of northern and arctic territories were resumed. For the Soviet Union, expanding exploration of the country's arctic regions was a top priority. It was presented before research scientists and polar explorers by the country's highest leaders. Voyages in the Arctic were limited by a short period of navigation due to the thick layer of ice. The movement of vessels in the arctic regions was often impeded by ice, affecting navigation and communication with areas of the arctic and subarctic belts. During this time, powerful icebreakers would come to the aid of the ships. They helped pass communication along the Northern Sea Route from the west to the east of the Soviet Union. The 20th Congress of the CPSU (Communist Party of the Soviet Union) directed the public at working on creating nuclear installations for transportation purposes. The industrial expansion, which could be seen in the growth of the national economy in the arctic and northern territories of the USSR, required the creation of a powerful fleet of icebreakers for escorting caravans of ships and providing navigation along the Northern Sea Route. In this case, the stakes were placed on icebreaking vessels. These were ships which could independently remain in the arctic territories for quite a long time without refueling or ports of call. At the beginning of the design process of the nuclear-powered ship *Lenin*, the Soviet Union had previous experience in constructing icebreakers and nuclear installations. Thanks to the joint work of scientists, engineers, and technicians came a ship which confirmed the high specifications. It was successfully used in the most difficult conditions of navigation at arctic latitudes.

1. Introduction

The construction of a nuclear icebreaker was a milestone in the 250-year history of the Admiralty Shipyard, whose workers and engineers demonstrated an example of selfless and creative work. An icebreaker is not simply a steel giant equipped with good technology and able to navigate offline. Above anything, it is a mark and indicator of the scientific and technical achievements of scientists and engineers. It is well known that the nuclear-powered vessels were developed and designed by Soviet citizens with a high level of education and technical culture. The whole country was involved in its construction. More than 250 companies, 60 design studios, and 30 research institutes took part in the development, design, and construction of the vessel. Thanks to Soviet scientists and engineers, the *Lenin* served as the beginning to the peaceful use of atomic energy.

When writing this paper, general scientific methods of research were used: analysis, synthesis, historical and systemic methods, all of which made it possible to ensure the validity of the findings.



The methodology used in this work was based on general scientific methods (logical and historical). Likewise, a preliminary study of the study was conducted on individual facts, and the atmosphere of the events was reproduced.

The first nuclear-powered icebreaker in the world was laid out on the slipway of the Admiralty Shipyard on 24 August 1956. It was first launched on 5 December 1957 [1]. After successful testing, the government commission signed an act on 3 December 1959 on the acceptance and operational readiness of the *Lenin*, which left on its first arctic voyage in 1961 [2].

2. Technical specifications of the icebreaker

The first arctic voyage of the nuclear-powered icebreaker *Lenin* took place on 19 August 1960 and lasted a total of 3 months and 10 days. During this time, it traveled 10,000 miles, providing escort for 92 vessels.

In September 1961, the nuclear-powered vessel made a second trip. On 14 October, after successfully passing through the ice in the Chukchi Sea, the vessel was successful in bringing the necessary cargo and crew to an ice floe north of Wrangel Island for the new drifting ice station NP-10. A little while later during the polar night, the first drifting unmanned radio meteorological stations were established at the edge of the perennial pack ice.

In June 1962, the icebreaker, with the help of the icebreaker *Leningrad*, opened a passage in the Yenisei Gulf in a short time. This allowed logging carriers further on to enter the port at Igarka by 27 June. Over the course of its operation, the *Lenin* was used annually in breaking ice passages in the Yenisei Gulf and broke channels through the ice in the Vilkitsky Strait, which allowed navigation time to be increased by several weeks.

Main features of the nuclear-powered icebreaker *Lenin*: length - 134 m, width - 27.6 m, height - 16 m, draft - 10.5 m, displacement - 16,800 t, capacity of power installation (which included three water reactors, steam generators, steam turbines, electric generators, and propeller electric motors) 44,000 hp, speed - 19.6 knots, crew - 210 persons.

During its trial period, measures taken for radiation protection and safety of the personnel, along with the protection of water areas, ports, and the surrounding environment from radioactive contamination were completely justified.

The hull was entirely welded from especially durable and high-quality steel without the use of rivets. The icebreaker employed a powerful towing winch with a pulling force of 40 tons for towing vessels through ice [1]. For the first time, electric cranes and winches were used in lifting operations onboard the vessel.

It should be noted that the nuclear-powered vessel was equipped with the latest and most advanced technology and modern equipment. When designing and constructing the mechanical installation, special attention was paid to the reliability of the junctions and machinery used. The mechanical installation was divided into two independent sections. The machinery and electric motors were fed from two independently located power stations. Five turbogenerators were also added to these. For safety reasons, the reactors had at least two independent energy sources.

3. Combining theory and practice

Scientists and designers tried as much as they could to consider all features of working in the especially difficult arctic conditions and in conditions of the polar night. Because of this, an electric radio navigator was installed on the icebreaker with a comfortable control panel and powerful means of communication, which supported radio communications with the most remote points and vessels [1]. Powerful searchlights maximally adapted for working under polar night conditions were also provided. From the outside, the icebreaker was a flush deck vessel with two masts and an elongated superstructure. The outer part of the ship was accommodated with boat decks with motorboats and life boats. The icebreaker also featured a landing strip and hangar for helicopters used in ice exploration.

It should be pointed out that a specific number of large icebreaking vessels were built on the Admiralty Shipyard before the start of the Eastern Front of WWII. The first vessel *Semyon Dezhnev*,

and after it *Levanevksy*, were successfully used at arctic latitudes for retrieving caravans of vessels which had passed the winter there [3]. After the end of WWII, the shipyard built a number of self-propelled icebreaking ferries and one icebreaker. Thus, it can be concluded that a close connection had formed between the design studios and factories and between the scientists, designers, and engineers in the area of developing and building icebreaking vessels.

At the very beginning of the journey, admiralities were aware that the new vessel should be fundamentally different from previous icebreakers manufactured at the factory, despite the fact that it was a nuclear-powered ship. It was necessary to not only develop and use new technology but also to determine new work methods which would be available for training factory employees in a short period of time. Various issues arose, but the most important of them concerned the power installation, which showed high power with great “vitality” in conditions of rocking, vibrations, and shock loads, with a reliable automatic control system [3]. Designers and the leading creators of the project did not keep information from the builders, engineers, and workers about the difficulties which could occur during construction. A number of foreseen and expected problems were solved with the help of scientists and engineers before construction had even begun. However, most of the problems were impossible to predict and were therefore only solved as a matter of course with help from mechanics, craftsmen, technicians, and workers.

The creation of the icebreaker was worked on by a large team of scientists. Academician and physicist Anatoly Aleksandrov headed the scientific leadership of the team. Major specialists and scientists worked under his leadership, among whom were head designer Vasily Neganov, leading designers Boris Gnesin, A. Vasilevsky, designers A.P. Kalinin, R.Y. Freman, and others [2].

The dimensions of the nuclear-powered icebreaker were chosen taking into consideration the ship’s operation in the arctic latitudes of the USSR. The length of the icebreaker reached 134 m, its width 27.6 m, power 44,000 hp, displacement 16,000 t, and ship speed 18 knots in clear water and 2 knots in ice over 2 meters in thickness. It should be mentioned that the large icebreaker *Glacier* already existed in the USA at the time, distinguished by its large size and high performance; however, the *Lenin* surpassed it twofold in all its specifications [3].

Before slipway work got underway, the first issues arose in relation to work on the hull. At the time, a production and technical commission headed by engineer V. Gurevich was formed. As a result of consultative events which were held, members of the commission made the decision to break down the hull into sections and were engaged in carrying out the phased work. After preliminary preparations had been made, those involved in the construction of the icebreaker created a production asset in order to continue construction and assembly. The asset was made up of ship collectors P. Pimenov, V. Solin, welder V. Bystrov, craftsman K. Polyakov, Y. Kremer, and others who concentrated on selecting working technology when assembling the hull. The team of builders of the arctic “giant” was led by the experienced engineer V. Chervyakov, along with prominent technologists from the factory V. Malenkovy, N. Klenovy, and others.

It is noted that invaluable help in the assembly work was given by scientists such as academician Y.A. Shimansky, professor N.E. Putov, A.A. Kurdyumov, and candidates of sciences G.I. Kopyrin and Y.G. Derevyanko.

4. Construction and assembly work and the innovation of Soviet citizens

On the slipway in July 1956, while carrying out construction and assembly work in the USSR, markers used a photo-optical method of marking for the first time. As a result of breaking the hull down into parts, the teams of N. Orlov and G. Kashinov were able to reduce the amount of layout work by 40% [3]. Working as a team, engineers B.I. Smirnov, S.G. Shneyder, hull workshop master A.K. Golubtsov, and gas cutter A. Makarov designed an original gas flux cutter, which was actively used in assembly work. The development and practical application of the new method and stainless steel cutting allowed a significant part of the ship’s details to be produced quickly and accurately over a short period of time with lowest labor costs. Thanks to the initiative by engineer of Admiralty

Shipyard, N.V. Martynov, thick sheets for the ice belt were processed in the hull workshop of the factory on factory presses which were not prepared for this work.

It is a well-known case when all members of the team unanimously decided at a party meeting on the need for gaining new skills and knowledge in such professional fields as gas cutting and electric tack welding. At the same time as this decision, it was also decided to create three experienced staff sections for honing skills in assembling and welding sections. While working on the outer plating of the ship, senior technologist B. Fedorov along with his colleagues made a labor-saving proposal about work on processing and bending sheets directly on the existing machines using a single template. This method made it possible to save around 200,000 rubles [3]. Workers of the central laboratory of the Admiralty Shipyard made a significant contribution to the construction of the nuclear-powered vessel. Factory engineer G.M. Bodalyan, along with employees of the central factory laboratory, carried out research and successfully incorporated their findings into protecting the ship's hull against electro-corrosion [4]. Thereby, employees from the corrosion laboratory independently developed and used a method of chemical cleaning for removing the inner surface of the dosimeter tank from rust [4].

The team from the Admiralty Shipyard achieved high performance with new technology being introduced over a short period of time in hull processing, electroplating, assemblage, and other departments. The factory department of the scientific and technology community of the shipbuilding industry solved the issues. Workers of the assembly floor carried out their work impeccably and turned in all boring devices for the nuclear-powered vessel ahead of schedule. M. Medvedev was given a difficult part of the work, to which he responded, "I can handle it alone. I won't let you down!" [3]. He had to prepare on his own machine tools, cutters, and accessory tools, since the other workers of the workshop were busy fulfilling other urgent orders. As soon as the work was completed, the following message was heard in the factory: "Comrades! Stand at attention for machinist-borer M. Medvedev, who completed on his own the responsible order for the builders of the icebreaker *Lenin* three days before the deadline"[3]. It is worth mentioning the work activity of machinist I. Anashkin, who worked in the workshop for around 20 years and had years of experience. The factory workers were able to develop the rudder on the boring machine in a short time.

Various tasks were solved with the help of workers from the All-Union Research Institute of Autogen. K. Mladzievksy and specialists from the factory, K. Zhiltsov and M. Matsov, successfully conducted tests on the automated welding of stainless steel metal, involving the best welders of the factory, V. Daleev and F. Kazyuk. The experience proved a success. Five welders using welding machines took the place of twenty welders. It should be noted that the process was not as smooth during assembly work. Once arriving to work early, Timofey Andreev received information from ship collector Ivan Kiselev about the lack of electric-tack-welding specialists. After a meeting, the decision was made to create an assembly team which would include all the necessary specialists and permission to combine jobs. As a result, Andreev's team was able to advance and achieved high production performance.

It is worth mentioning as well the contribution of Soviet factories in the construction and operation of the nuclear-powered vessel. The Kharkov Electric Mechanical Factory not only produced power generators for the primary and auxiliary turbines, but together with the head of the electric-mechanical services of the icebreaker, S.A. Chernyak, they also made a number of significant changes to the design features of the ventilation for the primary generators [2]. The factory in Odessa carried out work on the production of cooling units; the city of Nikolaev shipped anchors and their chains; the city of Dnepropetrovsk provided stainless pipes, while the Kramatorsk Metallurgical Plant supplied rolled sections; the Moscow factory "Dinamo" made electric motors; and the M.I. Kalinin Factory released a few varieties of powerful pumps [2]. The Moscow factories created practically all the medical equipment for the vessel. However, the most significant contribution to the use of products and machines for the *Lenin* was made by the Leningrad factories. The S.M. Kirov "Elektrosila" Factory produced propeller electric motors, which were first created in the USSR. The Baltiysky Factory produced heat exchange equipment and boilers, while the Kirovsky Factory produced steam turbines. By the same token, the Kirovs were able to contribute a number of optimizing and innovative ideas for

reducing the weight and turbine dimensions. The group was headed by M. Kozakov. Meanwhile, at the Leningrad Shipbuilding Institute (LSI), a pool was built specially for the *Lenin* for developing various model types for launching the vessel into the water with the involvement of students currently in their practical learning [5]. Students of LSI helped with the preparation work before the ship was commissioned, specifically, they participated in the cleaning, washing, and painting of the ballast tanks for the nuclear-powered vessel.

The trial operation of the icebreaker turned out to be of invaluable help to Arctic explorers.

The *Lenin* mainly worked in the geographically challenging arctic latitudes of the country. At these latitudes, the section of the Northern Sea Route caused conditions to be difficult. The region was clogged with ice, and caravans of ships could not move without the help of the nuclear-powered vessel. In 1960, thanks to the high maneuverability of the ship, it was able to lead 38 river ships out of such rivers as the Lena and the Khatanga [6]. The *Lenin* was often involved in research expeditions. Automatic radio meteorological stations for monitoring the ice drift and weather were first set up from the ship on the edge of pack ice in the East Siberian Sea and the Laptev Sea. Also for the first time, polar explorers and gear for the drifting stations landed from the icebreaker in the East Arctic [6].

During construction and assembly, 12 work teams were able to meet the goals set at the start of the work. It is noted that when fulfilling the construction and assembly work, the labor was not always highly qualified and using the latest technological advances. At the beginning of the mooring testing, Komsomol teams of the Admiralty Shipyard came in time to the aid of builders of the icebreaker. In order to lay the electric cable, it was necessary to dig trenches as matter of course. After a meeting, the Komsomols decided to independently work on digging and backfilling trenches for cables on their own time [3].

The vessel was applicable not only for crossing over ice, but it was also convenient for the crew. Living quarters for the ship's crew and personnel were located on the upper deck of the nuclear-powered vessel. Single and double cabins were excellently equipped, furnished, and supplied with all the necessities. 60 furniture sets, a large number of wardrobes, sofas, tables, and nightstands, were specially made for the icebreaker. In total, more than 1,500 different pieces of furniture were manufactured for the nuclear-powered vessel; the Leningrad factory “Krasny Oktyabr” even made a grand piano.

Each cabin contained washbasins, showers, bathrooms, centralized water supply with hot water and air conditioning. A comfortable mess hall, music room, movie theater, club, and even private library were also provided. The medical unit was fitted with the most advanced and modern equipment able to handle full operations on the ship. Much attention when designing the ship's rooms was given to the architectural and artistic decorations and finishes of the rooms.

The Soviet industry passed the exam on the material security of the vessel with flying colors. Any vessel is first of all an engineering creative and constructive feat which should carry out only what is required of it, thereby paying no attention to its interior decor. A ship is also a synthesis of advanced achievements of the most diverse achievements of industry sectors. A nuclear-powered icebreaker should first and foremost carry out the duties assigned to it, and only then can it be comfortable and convenient for the crew. However, the icebreaker *Lenin* differed at times from other icebreakers of its kind. Thanks to the serious government control, perseverance, and courage of the Soviet population, and to the steel-makers, distributors, chemists, mechanical engineers, and other specialists, national interests were respected and embodied in the nuclear-powered vessel.

5. Conclusion

To conclude, we would like to draw attention to the fact that the creation of the *Lenin* was clear proof of the outstanding achievements of Soviet science and technology in nuclear energy. The whole world was shown that the noble pursuit of Soviet scientists to direct nuclear power for peaceful use by mankind was successfully realized [7]. It is worth mentioning that the *Lenin* was not simply an icebreaker, but was a ship with a big name and advanced technical equipment, and it was also the symbol of the country's communist party. For this reason, in 1959 it was decided that there should be

a party organizer on the nuclear-powered vessel. The choice fell on the assistant professor of electrical engineering and secretary of the party bureau of the Leningrad Shipbuilding Institute, Georgy Vasilevich Shlenov [5]. At the same time, the construction of the nuclear-powered ship *Lenin* was a huge contribution to the noble fight for peace in the whole world. Nikita Sergeevich Khrushchev said it best in his time, “Our Soviet nuclear-powered ship *Lenin* will not only break the ice of oceans and seas, it will also break the ice of the Cold War.” In conclusion, Khrushchev added, “The icebreaker will lay the way for the minds and hearts of the people, urging them to leave the competition of the arms race between nations to a competition of using nuclear energy for the good of humanity and the world...” [8]. In his report at the 4th Session of the Supreme Soviet of the Soviet Union, 5th Convocation on January 14, 1960, Khrushchev said, “Last year, the first nuclear-powered icebreaker in the world, the *Lenin*, was commissioned, creating opportunities for our ships to sail freely in the Arctic year round” [9]. Khrushchev’s words confirmed the status of the USSR in the Arctic. After all, the Soviet Union was a clear example of a circumpolar nation with its climatic features [10].

The Admiralty Shipyard received the Order of Lenin in May 1960 for successfully carrying out the task of the Soviet government in the design and construction of the first nuclear-powered icebreaker in the world and for its merits in the development of domestic civil shipbuilding. We also point out that 446 workers, engineers, and technicians of the factory received orders and medals of the Soviet Union. The head builder of the icebreaker, V.I. Chervyakov, was awarded the Lenin Prize; the head designer of the vessel, V.I. Neganov, and fitter P.M. Artsibasov were honored with the Order of Hero of Socialist Labor.

The *Lenin* made its final voyage to the arctic regions in 1989. Ice conditions were difficult and global warming was long from being thought about at that time [11]. The icebreaker worked the whole summer leading ships through the Vilkitsky Strait and the Laptev Sea together with the icebreakers *Moskva*, *Taymyr* and the nuclear-powered vessel *Sibir*. For this navigation, they covered 20,955 miles, of which 20,369 were in ice. Together with other icebreakers, the nuclear-powered ship escorted 185 vessels and served eight polar stations.

The advantages of using the *Lenin* in the arctic regions of the Soviet Union were obvious. The ice permeability of the ship was provided for by the presence of a reliably working nuclear three-sectioned steam-generating installation. The nuclear reactors installed could be used by the icebreakers without replenishing nuclear and other types of fuel for more than a year [12]. The designers, scientists, and engineers received invaluable experience in working and operating a nuclear energy installation. They were also able to obtain data which could be used in the future when designing and introducing diesel engines. Thanks to the workers, several labor-saving proposals were introduced, which were successfully used in the future. It is gratifying that the workers of the Admiralty Shipyard not only built a quality nuclear-powered icebreaker, but they were also able to reduce economic costs at the same time. The economic experience and advantage for the country were undeniable [13].

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