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Research Supplement to
Scientific Intelligence Report
CIA/SI 2-57

CONTRIBUTIONS OF GERMAN SCIENTISTS TO THE SOVIET ATOMIC ENERGY PROGRAM ELEKTROSTAL

CIA/SI 2-RS IV-57
15 July 1957

CENTRAL INTELLIGENCE AGENCY

OFFICE OF SCIENTIFIC INTELLIGENCE

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PREFACE

This is one of a series of six reports dealing with the activities of the German scientists who were imported into the Soviet Union in 1945 to do work related to the development and expansion of the Soviet atomic energy program. This supplemental report is concerned primarily with Soviet nuclear metallurgy at Factory 12, Elektrostal.

A summary report CIA/SI 2-57, Contributions of German Scientists to the Soviet Atomic Energy Program, January 1957, Secret, deals with the overall aspects of the German contributions. See also:

CIA/SI 2-RS I-57	Contributions of German Scientists to the Soviet Atomic Energy Program - SINOP, Secret
CIA/SI 2-RS II-57	Contributions of German Scientists to the Soviet Atomic Energy Program - SUHGUL, Secret
CIA/SI 2-RS III-57	Contributions of German Scientists to the Soviet Atomic Energy Program - AGUDZERI, Secret
CIA/SI 2-RS V-57	Contributions of German Scientists to the Soviet Atomic Energy Program - OBNINSKOYE, Secret

All information presented herein has been obtained from the testimonies of returned German and Austrian scientists and technicians.

Intelligence research ended 15 August 1956.

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CONTRIBUTIONS OF GERMAN SCIENTISTS TO THE SOVIET ATOMIC ENERGY PROGRAM

ELEKTROSTAL

PROBLEM

To determine the extent and the importance of early German scientific participation and assistance in the initial operations at the vital Soviet metallurgical complex for atomic energy at Factory 12, Elektrostal.

CONCLUSIONS

The major advances in Soviet nuclear metallurgy that were made by the German laboratory at Factory 12 during the 7 years from 1945 to 1952 are:

1. The production of uranium metal of sufficiently high purity for the first Soviet plutonium producing reactors by methods that could be adopted by the factory may have advanced the Soviet atomic energy program by about 6 months.

2. The fabrication of uranium and its alloys into ribbons, bars, and other special shapes laid the basis for the future development of reactors of many different types.

3. The development of special metallurgical methods in collaboration with Soviet laboratories and organizations working on plutonium, uranium-235, radium, nickel barrier for gaseous diffusion plants, and other special materials for an atomic energy program not only provided direct assistance to the Soviet program but also relieved Soviet scientists for the most critical phases of weapons engineering.

SUMMARY

By the end of World War II, the Soviet Union had placed top priority on the development of atomic weapons and had begun its program with a sense of urgency quite similar to that which pervaded the Manhattan Project in 1942 and 1943. The material most needed for this program was pure uranium metal in sufficient quantity for the operation of reactors producing plutonium. To initiate this program at an advanced stage, about a dozen German scientists familiar with the metallurgy of the element were "invited" to Moscow. A few weeks later, the German stockpile of rather impure uranium metal also was taken by the Soviet Union.

The German scientists continued their research at Factory 12 on the purification of uranium oxide and its reduction to metal. The Soviet administration proceeded to convert the bulk of the plant at Elektrostal into an industrial complex for processing uranium ore, reducing uranium oxide to metal, fabrication of reactor fuel elements, and for the manufacture and processing of critical materials for the program. Because of the urgency of the program, the conversion of the industrial plant and the construction of new buildings (for yet unknown metallurgical processes) proceeded simultaneously with the research work of the German scientists.

Apart from preparing pure uranium salts by fractional recrystallization and later by ether extraction, the most important contribution of the German scientists was the development of a satisfactory metallurgical method for producing pure uranium metal. The first attempts involving minor changes in the German technique of reducing uranium oxide with calcium proved unsatisfactory. Success was achieved only when the uranium oxide was replaced by uranium tetrafluoride. The reducing element was pure calcium, initially manufactured by the Bitterfeld Electro-Chemical Combine, East Germany, and later, by the Elektrostal Factory 12.

The batch process of producing uranium was carried out in a "bomb" in which about 40 kilograms of uranium metal was reported to settle as a regulus following a rather violent exothermic reaction between calcium and uranium tetrafluoride. Except for an increase in weight of charge, this was the method adopted by the Soviet production plant.

Although in the late spring of 1946 the mission of the German scientists was accomplished, they still retained much value for the Soviet atomic energy program. They provided consulting service and did research on special projects on the diverse operations at Factory 12. They completed particularly helpful tasks relating to uranium ore processing, ether extraction, fabrication of uranium metal into fuel rods or slugs, production of nickel barrier, separation of plutonium from irradiated slugs of uranium, production of radium, and many other activities at the plant.

Since an all-Russian metallurgical laboratory had finally been established at Elektrostal, there was less need for the German scientists after 1947. In the following years, the German group slowly began to disperse to other laboratories in the Soviet atomic energy empire. In 1950, Riehl went to the Sungul laboratory in the Urals to direct research in biophysics. Only a remnant of the original 12 scientists stayed at the Elektrostal Factory; and, in 1952, all of the remaining research workers were sent to Sukhumi, on the east shore of the Black Sea, for "forgetfulness" before their repatriation to Germany.

DISCUSSION

The Industrial Environment of the German Scientists at Elektrostal

The Significance of the Location of Factory 12.--The industrial and scientific activities of Factory 12 were of such a high priority and indirectly of such a great strategic importance on the international level that the plant was located near the town of Elektrostal (55°47'N-38°28'E) only about 53 kilometers east of Moscow. The plant with its 10,000 to 15,000 employees formed an industrial complex that could rely not only on Elektrostal but on the entire Moscow area for labor, materials, and special engineering and scientific skill. Furthermore, the particular location of this plant, in a somewhat isolated and partially wooded area just east of the town, favored its protection from espionage.

One noteworthy advantage of this location was the good railway connections. Although Factory 12 is correctly addressed on the Moscow-Kursk railway, it is actually located on a short railway line connecting Noginsk on the Moscow-Gorki main line on the north and Frazevo on the Trans-Siberian railway on the south. The length of this connecting line is about 15 kilometers from Noginsk to Frazevo. Noginsk, only some 8 kilometers from Elektrostal, is frequently the recipient of material whose ultimate destination is Factory 12, Elektrostal.

Factory 12 not only is somewhat east of the town of Elektrostal but also is east of the Noginsk-Frazevo railway line. Two spur tracks lead to the plant. The plant area ostensibly occupies a rectangle of several square miles. According to descriptions dated 1945 and earlier, it is almost a town in itself.

The Background of Factory 12 and Indications of Early Post-War Activity.--Even before 1945, the vicinity of Factory 12 was heavily guarded and "off limits" to all unauthorized persons. Factory 12 was then an ammunition loading plant primarily for artillery shells of medium to heavy calibre. At that time, the plant was reported to be in operation on a 24-hour basis. From some reports, it seems likely that the plant may have manufactured the explosives as well as loaded the ammunition. In May and June 1944, two series of explosions caused severe damage in the plant and broke windows in the town of Elektrostal about 1 1/2 kilometers away. The most severe explosion occurred during May and was felt even in Moscow, a distance of 53 kilomteres.

The nature of the work of Factory 12 during World War II was hazardous and often sufficiently injurious to health to require special privileges for the workers. As compared to the other large plants of about equal size at Elektrostal such as the Elektrostal steel plant and the Novokramatask Machine Building Plant, Factory 12 provided better pay, shorter hours, and superior rations.

Immediately following World War II, rather strangely, the plant is said to have kept its labor force intact, to have continued most of the same policies of liberal treatment of employees, and to have worked just as intensively. The plant was still run by General Nevstruev who had gained communist favor in the 1917 revolution and who supervised operation of the plant in the 1940-45 period. No one in the town appeared to know exactly what was in progress at the plant except that several explosions heard every day at the same time gave some credence to the mistaken belief that ammunition was still being manufactured.

Technological Potential of Elektrostal.--Of all industrial areas in Russia in 1945, Elektrostal probably offered the best metallurgical facilities because the town had not suffered from enemy action during World War II, was close to Moscow, and had well developed metallurgical industries.

The first stainless steel in Russia was manufactured at Elektrostal during the early 1920's. To provide for the demands of its electric alloy steel furnaces, the town was connected with the electrical system of Moscow. Elektrostal became one of three locations in the Soviet Union noted for the manufacture of stainless steel. Besides steel production, the availability of power brought related industry with facilities for casting, forging, rolling, heat treating, and machining. These operations with stainless alloy steels require more than ordinary metallurgical skill and are successful with uranium only after considerable advanced development and adaptation.

The fact that a new method for the manufacture of stainless steel was discovered at Elektrostal is further evidence of a high technological level of the people working there. It will be recalled that I. I. Kornilov, an outstanding expert on stainless steel is reported to have gone to Elektrostal for consulting purposes. The objects of these visits may have been due to the difficulties with stainless steel encountered at the Elektrostal metallurgical plant or with about equal probability the greater difficulties connected with the manufacture of uranium metal at Factory 12.

Historical and Organizational Factors Relating to the German Group

The Background of the German Group.--The urgency with which the Soviet AE program was prosecuted in 1945, 1946, and 1947 is essentially the same as the program that had been completed in the U. S. in 1943, 1944, and 1945. In both programs, industrial plants were built while laboratories were still at work perfecting the technology that would be necessary to carry out these programs.

With the defeat of Germany in 1945, the Soviet leaders lost no time in enlisting the support of two groups of German scientists who had been working on uranium technology within the areas occupied by the Soviet armies. The more important of these two groups was under the supervision of Dr. Nicholaus Riehl who was director of research at the Auergesellschaft (Auer) chemical plant at Oranienburg, Germany. Under Riehl's supervision, uranium metal was produced in sufficient quantities required for German reactor experiments. In fact, the operation was highly successful in over-fulfilling the initial order of 6,000 pounds of uranium placed in 1942 by the German government. By 1945, 10,000 pounds was said to have been produced. The uranium was powdered and then sintered in cubes, plates, and other shapes. Thorium, radium, and associated radioactive metals were also produced by the Auer group.

The first assistant and deputy to Dr. Riehl and the one most concerned with the reduction of uranium metal at Auer was Dr. Guenther Wirths. Also assisting in this work were Dr. Heinrich Ortmann, a chemist; Dr. Karl Heinrich Riewe, a nuclear physicist specializing in spectroscopy and high frequency apparatus; Dr. Herbert Thieme, an expert on radiological phenomena and health physics; Werner Kirst, a chemical engineer and expert on genetic and physiological effects of radiation; Heinrich Tobien, a chemist and foreman in charge of purification of uranium at Auer; and Klinge, foreman in charge of the uranium foundry at Zechlin.

The second group was under Dr. Nikolai Vladimir Timofeef-Ressovsky, director for the Genetics Department at the Kaiser Wilhelm Institute for Brain Research, Berlin. There were three significant members of this group who collaborated in the research at Auer. Dr. Hans Joachim Born and Karl Guenther Zimmer were biophysicists who specialized in effects of radioactivity on living organisms, absorption of various types of radiation, and identification of fission products. Dr. Alexander Catsch, the third and youngest of the group, was a medical doctor interested in changes in the organs of the body caused by radiation. The research of the second group, under Dr. Timofeef-Ressovsky, supplemented, from the standpoint of health physics the work of the first group under Riehl.

The two German groups enjoyed official and social relationships. The leaders of both groups had important similarities in background and in scientific attainment. Dr. Riehl, whose mother was Russian and father, German, was born in St. Petersberg, was educated in that city until 17 years old, and in later years, after leaving Russia, had become a well-known German physicist. Dr. Timofeef-Ressovsky, a White Russian who had left Russia during the Bolshevik revolution, was world-famous for his researches on genetics at the Kaiser Wilhelm Institute for Brain Research in Berlin.

<u>Riehl's Acceptance of Soviet Proposals</u>.-- With the gloomy prospects of science in a defeated Germany, and especially of that science that he knew best, Riehl was favorably inclined to accept Russian offers of a contract to produce uranium in a new laboratory in the Soviet Union. The offers came from Generals Zavenyagen and Khariton* who had appeared at Auer in May 1945 scarcely two weeks after its capture by Russian troops. In

*Probably Khariton of the Institute of Chemical Physics.

... 1945, Riehl flew to Moscow to establish the laboratory and by late fall of the same year, the principal members of the Riehl group had joined him. By early 1946, the three members of the associated group from the Kaiser Wilhelm Institute for Brain Research were also in Moscow. Since Dr. Timofeef-Ressovsky apparently was imprisoned for several years for not heeding Soviet requests in the 1930's to return to his native land, Dr. Riehl was the guiding force of the now combined groups.*

The Choice of Factory 12 at Elektrostal for the Riehl Group and Some Details of Administration.-- The Riehl group was not immediately established at Elektrostal. In June 1945 when Riehl flew to Moscow, he was accompained by Ortmann, Riewe, Thieme, Sommerfeld, Wirths, and their families. Tobien travelled with the above group by air; and Kirst, with wife, came by train with the baggage of the rest of the group. For about two weeks, the group settled at Loss, a recreation center near the Leningrad Chaussee in northeast Moscow.

In July, at a high level meeting with Beria, attended by German scientists Riehl, Hertz, Vollmer, von Ardenne, Doepel, and the Russians Colonel Professor Alexandrov, Prof. Kurchatov, and Zavenyagen, it was decided that Riehl should continue the same work on the production of uranium metal that he and his group had been doing in Germany. Immediately following this conference, a search for a suitable site for a laboratory began. Both Riehl and Wirths visited various likely locations. Wirths accompanied by Colonel Shevchenko of NII 9** and three other Russians even went to Krasnoyarsk where they visited a small platinum works about 15 miles down the Yenesii from the city.

In August 1945, spurred perhaps by the dropping of the atomic bomb at Hiroshima, the Soviet administration decided on immediate action and selected Factory 12 Elektrostal for the production of uranium metal. The ideal characteristics of this location may well have been immediately realized by the newly-created First Chief Directorate attached to the Council of Ministers. The head of this new organization was General Vannikov who only recently had been Peoples' Commissar for Armaments. In his former position, he doubtless had had much information on the plant.

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*In addition to the principal members listed here there were Schmidts who worked as an electrician for Dr. Zimmer; Walter Sommerfeld, who was a chemist under Dr. Thieme; Dr. Eugene Baroni, an Austrian physicist previously interested in heavy water, and Herr Walter Przybilla, Riehl's brother-in-law who acted as administrative assistant. Dr. Baroni may be considered as a possible replacement for Dr. Riewe who left the group in February 1947 to go to the Pose Laboratory at Obninskoye about 110 kilometers southwest of Moscow.

**Where nearly all of the German laboratory equipment for melting uranium had been sent.

Although Factory 12 was under the administration of the FCD of the Council of Ministers beginning in August 1945 and although Riehl stated that his group was directly subordinated to the FCD of the Council of Ministers, there was a strong MVD influence in the guidance of the Riehl group. The 9th Directorate of the MVD with Zavenyagen as its head under Beria was established in 1945 primarily to control the Soviet AE effort which it gradually began to take over. In 1946, Zavenyagen also became deputy to General Vannikov of the First Chief Directorate of the Council of Ministers.

Apparently the MVD maintained a most rigid security control of the plant. Each section of the works was effectively sealed off and admittance was gained only by means of special passes having photographs. Several days of waiting in a guest house outside the plant grounds were sometimes necessary and can be explained possibly by the time required for the final MVD clearances and for the preparation of special credentials.

Probable Administration of Factory 12 and Soviet Concern for the Riehl Group. -- The probable status of the Riehl Group in the organization of Factory 12 can be deduced from the fact that when a protest to General Zavenyagen was written, it was given to Riehl who transmitted the letter to the director of Factory 12, who in turn gave the letter to General Zavenyagen, an immediate subordinate of both Beria and Vannikov. A new director who came to Factory 12 in the spring of 1946 (reported to be Kallistrov by repatriated German scientists) took vigorous action on complaints of insufficient cleanliness in the pilot plant and in the laboratory and had the rooms provided with bathroom tile. The chain of command for passing communications and the concern of the director of Factory 12 in the work of the German group appears to indicate joint supervision of this group by both FCD and MVD.

Apparently the aim of the Soviet authorities was to use the Riehl group as a high level scientific staff as well compartmentalized as possible from the production organization and the new Soviet laboratory at Factory 12. Some of the Germans mentioned that within sight of the building where they worked there was a new Soviet laboratory with completely unknown functions. It is reasonable to assume that a primary goal of the Soviet authorities was to become scientifically self-sufficient as soon as possible. Dr. Riehl, as the administrator of the German laboratory was close to Zavenyagen and gave him reports of progress every two weeks in the early stages of the program. It was felt by the German group that these reports were used by the Soviet authorities either to compare their work with that of an independent Soviet laboratory or to serve as the basis for other experimentation.

Dr. Riewe was charged with equipping the Riehl Laboratory. The type of equipment ordered by Riewe was the usual type suitable for almost any physical research laboratory, consisting of such items as voltmeters, bridges, Geiger-Müller counters, and amplifiers. In addition, Riewe was said to have placed orders in the United States for more complicated equipment worth almost $200,000. Few efforts were spared to assure good performance from the Riehl group.

The Major Technical Contributions of Riehl's Laboratory at Factory 12

Uranium of High Purity.-- During the closing months of 1945 and early 1946, the German group produced metallic uranium by the same methods they had used at the Auergesellschaft, using captured German materials. The process involved the precipitation of uranium oxalate, its conversion to uranium nitrate, and the purifications of this salt by fractional recrystallization. The necessarily high purity requirements for the metal determined the number of recrystallizations. With the relatively impure uranium of German origin numerous recrystallizations may have been necessary to attain the required high degree of purity.

When sufficiently pure uranium nitrate had been produced, the material was dissolved in distilled water and ammonium uranate precipitated out by the addition of concentrated ammonium hydroxide. After the ammonium uranate had been precipitated out, it was dried and ignited in order to thermally decompose the salt into ammonia gas and a residue of pure uranium oxide.. U_3O_8.

The U_3O_8 was reduced to metallic uranium by the DEGUSSA process, using metallic calcium as a reducing agent. Metallic calcium, about 20 percent in excess of the theoretical quantity, and mixed with the U_3O_8. An appreciable amount of calcium chloride was added as a flux; and the mixture was then placed in a calcium oxide lined sheet iron crucible of 100 to 150 liter capacity, covered with an inert atmosphere of dry argon gas, and heated to 700°C. A violent exothermic reactor then raised the temperature to about 1100°C. After the reaction had been completed, the regulus was broken from the crucible, ground to a powder, and the soluble components dissolved in water and neutralized with HCl. The uranium metal was separated mechanically from the unreduced U_3O_8 and other foreign materials.

The uranium metal powder was thoroughly dried with alcohol and then melted in a high vacuum furnace. The furnace operated at a pressure of 10^{-5} mm mercury. After the uranium had been melted, it was cast in graphite ingot molds. The entire melting process was carried out under the high vacuum. There have been some reports which indicated that the uranium was cast directly into fuel slugs. If this was done at all, it must have been at the very early stages when proper working equipment was not available or when the uranium was so impure as to preclude fabrication by approved methods of plastic information. It is generally axiomatic that the purer the metal, the softer and more ductile it is for any type of working.

Uranium of Extremely High Purity.-- By winter 1946, Riehl's laboratory was engaged in a critical struggle to find a method to produce metallic uranium of sufficient purity.

Much early effort had been expended on the powder metallurgy of uranium having a purity of only 99.15 percent. This was doubtlessly material produced by calcium reduction of confiscated German uranium oxide of relatively poor grade. There is a good indication that numerous other elements, even sodium, were actively considered and very possibly used for reduction of uranium oxide in the initial experiments. It was finally realized that a single change in the process was far from sufficient and that numerous changes would be needed.

To produce uranium having not only the requisite mechanical properties but also the low cross-section needed for reactor application, it was necessary to determine the most objectional impurities and to take very special precautions to eliminate them. The most objectional proved to be boron, nitrogen, iron, and the rare earths, especially gadolinium. Boron and the rare earths were found to be fundamental contaminants of the German uranium stock. The nitrogen was introduced by the calcium which had been obtained from Bitterfeld while the iron had been largely introduced by the steel processing equipment containing the uranium charge. In addition to this, various other impurities were introduced by the calcium chloride flux used to form a low melting mixture with the highly refractory calcium oxide resulting from the initial reduction of the U_3O_8 by metallic calcium.

To produce uranium of requisite purity, especially from the standpoint of low cross-section, changes were necessary in the following steps in manufacture: (1) The numerous fractional recrystallizations were replaced by ether extraction process; (2) Reduction of the U_3O_8 was replaced by the reduction of UF_4, retaining the calcium for the reduction metal; (3) The calcium, first used as an electrolytic product, was replaced by multiple distilled calcium; (4) The steel of the processing equipment was altered and special alloy steels utilized to reduce the likelihood of contamination of the material by flaking off of foreign oxides; and (5) Calcium chloride of better than pharmaceutical purity was substituted for the normal salt being used.

A most interesting further development along the above line was the necessity of resorting to induction melting, using induction furnaces purchased in the United States.* The graphite crucibles initially used in the process were also of American origin, and the vacuum pumps bore

*Reports of Riewe, Wirths, and Riehl agree on the use of American equipment.

the name of a well-known American firm. This use of American equipment was only temporary until the Soviet industry could be geared to produce the necessary equipment. It is possible that some of this equipment was produced within the confines of Factory 12 itself, but this is not definitely known.

None of the changes and alterations mentioned in the above paragraphs were easily made. Even the extremely accurate chemical analyses necessary (parts per million or parts per billion) were known to tax the ingenuity and scientific resources of the Soviet Union. The most delicate of these analyses were conducted at the Inistitute of Geochemistry under the direction of A. P. Vinogradov. The analytical section of Factory 12 was also under the direction of A. P. Vinogradov. After Factory 12 had completed its analysis of uranium, the uranium was sent to another laboratory in Moscow for a final check presumably by neutron counting. In every instance, the best available talent of the Soviet Union was used to attack each problem.

Some Critical Processes at Factory 12

Ether Extraction.-- Perhaps one of the most important changes in uranium processing was the substitution of ether extraction for the laborious and time consuming fractional recrystallization. During early 1946, there was continued difficulty with impurities in the uranium produced by German practices. When copies of the Smyth report became available in 1946, it was immediately decided to copy the ether extraction process revealed for the first time to be feasible on an industrial scale. While Wirths, Thieme, and Born were developing the details of the process from March to July 1946, a plant was being built and was ready for operation in July. The German contribution consisted of measurements of distribution coefficients, solution temperatures, solution times, and optimum volumes for efficient operation.

Reduction of Uranium Fluoride by Calcium. -- Although the use of the ether extraction process reduced rare earths in the uranium nitrate to the required micro percentage, there was still difficulty arising from too high residual percentage of boron. There was also difficulty in obtaining a good separation of regulus from slag in calcium reduction of uranium oxide. It was accordingly decided to change the process from reduction of uranium oxide to reduction of uranium tetrafluoride. Calcium of high purity was still retained as the critical reactant. The uranium tetrafluoride was produced by exposing uranium dioxide to the action of acqueous hydrogen fluoride. The reaction of uranium tetrafluoride with excess calcium in a bomb was carried out in a manner quite similar to the earlier uranium oxide-calcium process.

The Batch Process.--The so-called bomb in the process finally adopted consisted of a sheet steel container lined with rammed calcium fluoride as a refractory. The inside diameter was probably about 15 inches and the depth 20 to 25 inches. After the steel crucible was filled and the ignition mixture put in place, the steel cylinder was put inside a heavy cast iron container with a lid. The lid was closed and the entire assembly placed inside a steel-lined reduction chamber with a heavy iron door. Then the container was evacuated and an argon atmosphere introduced. The reaction initiated by the igniter generally was complete after 2 to 5 minutes, and after about an hour, the still highly heater container was removed to another section for further cooling.

The Processing of Uranium Metal.--A regulus of uranium usually settled to the bottom of the crucible with a clear-cut separation between metal and slug. The regulus was remelted under high uranium induction furnace conditions for out-gassing and final purification. Vacuum casting in graphite took place in the same vacuum unit as the melting. There were six to eight of these melting units in operation at the plant.

Although some accounts state that slugs were cast directly in the vacuum unit, it is believed much more likely that the cast ingot was given a preliminary forging and then rolled to desired shapes as is claimed by probably one reliable source. Cylindrical uranium shapes were sent to another part of the plant for canning.* The production of uranium ribbon, wire, and other shapes was achieved at the German pilot plant in mid-1946 and probably these techniques were adopted immediately by the nearby Soviet production plant.

Relative Importance of the German Research

Although the German group gave occasional assistance to many of the activities at the Elektrostal complex that included not only ore dressing, uranium extraction, and processing facilities but also radium, calcium, and barrier production, canning operations, plutonium purification, temporary U-235 facilities, and probably others, it is believed that the major contributions were ether extraction and calcium reduction of uranium tetrafluoride. These two contributions made during their first year at Elektrostal may have advanced the entire Soviet program by as much as 6 months. German work on the processing of uranium ore may have been of some assistance to the Soviet ore dressing experts, but there is no special technology in this process that could not have been devised quite readily by Giredmet or by several other Soviet organizations.

The degree in which the German scientists were eminently successful may be gauged by the magnitude of the prizes awarded to them by the Soviet Union. Riehl was created a Hero of Soviet Labor with very substantial monetary compensations. Thieme and Wirths shared the Order of the Red Banner of Soviet Labor and 100,000 rubles with Kraskov, Golmanov, and Kylov, leading Soviet engineers at Factory 12.

*The uranium cylinders for the Soviet reactor were "canned" in aluminum sheaths to protect them from corrosion by the cooling medium of the pile.

The Dissolution and Repatriation of the Riehl Group

Following their essential contributions to the Soviet atomic energy program in 1946 and 1947, the Riehl group, although still contributing on important peripheral projects, slowly began to decline in numbers and importance. In December 1947, Zimmer, Born, and Catsch went to Sungul to work under Timofeef-Ressovsky in the field of biophysics and effects of radiation on living organisms in which they had most experience and could make the most contributions. Also in December 1947, Riewe left Elektrostal and began his work at Obninskoye.

Riehl, Wirths, Theime, and the less important members of the Riehl group for the most part stayed at Elektrostal until about 1950. In 1950, Riehl went to Sungul to take the place of Timofeef-Ressovsky who had been head of Biophysics research at the Sungul Institute. Both Wirths and Sommerfeld were sent to Obninskoye during August 1950. Theime stayed at Factory 12 until about 1952 when he went to Sukhumi before repatriation. It appears that with few exceptions, the members of the Riehl group were gathered together once more at the Institute at Sukhumi for 2 or 3 years as a means of "forgetfulness" or "quarantine" before their return to Germany in March 1955.

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