History of Rocketry and Astronautics

Otfrid G. Liepack, Editor

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Front Cover Illustration:

The photo depicts Dr. Wernher von Braun (1912–1977) presenting Prof. Heinz-Hermann Koelle (1925–2011) with an Outstanding Performance Award on June 17, 1965 upon his retirement as the Director of the Future Projects Office at the NASA Marshall Space Flight Center. (NASA photo A253140U 065A 03, through the courtesy of the U.S. Space & Rocket Center, Huntsville, Alabama.) See page *x* of the Volume Editor's Preface for more biographical information on Prof. Koelle.

History of Rocketry and Astronautics

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Chapter 4

German Influence in the USSR*

Boris E. Chertok†

Abstract

In June 1945 this author was one of the organizers of the, first in the post-war history, Soviet–German institute, RABE [Raketenbau und Entwicklung or Rocket Production and Development]. The main task of its activity was to study the history of the German rocket technology developments and rebuild the technology of the long range ballistic missiles V-2. This work was supported by the Soviet military authorities and also by the Soviet government. In the Thuringia region of Germany a big institute, Nordhausen, was established, in which Soviet and German specialists jointly worked on the rocket technology problems.

In November 1947 a big group of German specialists was transferred to the Soviet Union. All the works in Germany were canceled. German specialists took part in the preparation and running of the flight test of rocket V-2 in October–November of 1947 on Kapustin Yar test range. Until the beginning of the 1950s a big group of German specialists worked in the daughter institute of the leading Soviet research institute on rocket technique, NII-88, under the management of Helmut Gröttrup, one of the former [Wernher] von Braun employees. They worked out the design of ballistic missiles of range up to 800 kilometers with a

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principally new guidance system. Germans also took part in the development of the technology of liquid rocket engine production.

In 1952–1953 German specialists returned to Germany and rocket technology in the USSR [Union of Soviet Socialist Republics] matured independently. The Soviet and German scientists' cooperation resumed in 1960s after manned spaceflights were started. The author was one of the leading participants in those joint works.

Introduction

During World War II there originated three basic new types of weapon technologies: atomic bombs, radars, and guided missiles. Guided missiles had been developed and were operational arms only in Germany.

At the beginning of the century individual scientists, such as [Konstantin] Tsiolkovsky, [Fridrikh] Tsander, [Yuri] Kondratyuk in the USSR; [Hermann] Oberth and [Eugen] Sänger in Germany; and [Robert] Goddard in the US [United States]; were developing rocket theory and designing projects with the aim of overcoming Earth's gravity to reach space and to realize interplanetary missions. However, the first long-range guided missile was launched in Germany.

Development of the V-2 long-range ballistic missile as a retaliation weapon (Vergeltung) received the highest priority in Germany. During the war, German scientists and engineers developed not only missiles, but the technology for their mass production and military application. Allied reconnaissance did not discover the core of this research and design activities and the actual scale of production almost until near the end of the war.

Soviet experts and the author of this presentation were first involved in the investigation of German rocket development and engineering in 1944. (A message from the prime minister of England, Winston Churchill, to Marshal [Josef] Stalin stimulated these activities.) On July 13, 1944, Churchill sent a personal and strictly confidential message to Stalin. This message reported that Germans had for a long time been testing missiles at the experimental facility in Debica, Poland. In 1944 Churchill and Stalin exchanged a total of six telegrams about the participation of England in searching for the remains of German equipment.

The Search for Missile Information in Germany

I was a member of the expert group, which was entrusted with a confidential mission to investigate all missiles and associated equipment found within the

Debica area before such was handed over to the Allies. When I arrived in Germany, I made sure that, in general, our redesign of the V-2 overall configuration and engine in 1944 had been done correctly. An engine was found in good condition in a missile that impacted without exploding. Its control system remained a mystery to us. We were amazed by the dimensions of the missile and its engine's theoretical thrust of approximately 20 tons. The maximum thrust of the Russian liquid-propellant engines was only up to 1,500 kilograms force.

On March 10, 1945, the second Belorussia front marched into the Peenemünde area. A group of Soviet experts led by General Andrey Sokolov was immediately detached there. Sokolov was one of the military experts for the Katyusha salvo rocket systems. During the war, the so-called Guard Mortar Units of the supreme commander-in-chief's headquarters were part of the Soviet armed forces. The commanders of these salvo solid rocket artillery units were the first among the Soviet armed forces to initiate investigation of large missile design, development, and engineering.

In Peenemünde our experts found neither valuable engineering documentation, nor rockets, nor engines, or equipment. All important ammunition, engineering documentation, and experts had been evacuated, initially to the Nordhausen area, and farther to the west, in February 1945, 15 days before the Soviet forces arrived.

On May 2, 1945, I put my signature on the wall of the smoky Reichstag. In the group of aviation experts we managed to save Adlerhof documentation, to get familiar with the equipment used for the German missiles at the Kreiselgerät, Askania, Siemensapparat, Lorenz, etc. plants. In one of the safes at Adlerhof I found and kept a confidential report, which had been prepared by engineer Kurt Magnus and approved by Professor Schuler, famous in the engineering world. Later in October 2002, I handed over that already declassified report to the honorary professor of the Munich and Stuttgart University, Kurt Magnus, in connection with his 90th birthday.

On May 2, 1945, the managers of Peenemünde led by Wernher von Braun and Walter Dornberger surrendered to the American forces. More than 500 leading experts of Peenemünde passed into the American occupation zone. In the Mittelwerk underground plant, near Nordhausen, the Americans captured and then sent overseas more than 100 ready-to-fire missiles, ground test and launch equipment.

On July 10, 1945, the American forces had already left Thuringia, and this land went into the Soviet occupation zone. On July 14, I, together with Alexey Isaev (future general designer and head of one of three Soviet liquid rocket engine development enterprises), arrived at Nordhausen and, supported by the mili-

tary authorities, started searching for any remaining German engineers, who used to work in Peenemünde and the Mittelwerk underground plant. We were sure that, after the secondary evacuation of the German missiles from Nordhausen, there were still many units and parts left. Assembling an entire missile was reasonable to attempt. In addition, an engine-firing test facility was found in Lehesten, near Saalfeld (Thuringia). For some reason, the engine-firing test facility had not been dismantled or destroyed by the Americans. There were several dozens of ready-to-fire propulsion units in rail cars.

We could hardly overcome the temptation to take all our findings and send them to the Soviet Union as soon as possible. However, after the situation had been evaluated and support from the local military authorities had been obtained, we made a decision, unusual for those times and incompatible with the directive from Moscow. We decided to establish the first Soviet–German institute for rocket technology in the occupied territory of Germany. Late in July 1945, the RABE institute was founded with its center in Bleicherode.

I became the leader of the institute. In parallel, I commissioned one of the German specialists who had remained in the area occupied by the Soviet forces, to be a director of the institute. The RABE institute undertook recruitment of German scientists and experts to work together with the Soviet experts on research, restoration, and redesign of the German rockets. First of all, in particular, the V-2 missile and its further modification was a matter of concern.

In two months almost all the staff vacancies in the institute were filled. Control systems and propulsion automatic equipment laboratories, as well as a ballistics group, were established. We succeeded in involving the electronics and control specialist, Helmut Gröttrup, the closest collaborator of von Braun, in the RABE institute. He wrote the first and detailed history, which described the A-4 rocket system development. By the end of the year, 5 professors, 24 doctors of science, 14 certified engineers, and 71 practical engineers were working in the institute. About 150 Soviet engineers were working in close contact with their German colleagues. Among the Soviet engineers, there were future leaders of the Soviet space science and industry: Sergei Korolev, Valentin Glushko, Nikolai Pilyugin, Mikhail Ryazanski, Viktor Kuznetsov, Leonid Voskresensky, Yevgeny Boguslavsky, and others.

The Berlin institute was founded in Berlin, in a similar way as the RABE institute, with Vladimir Barmin as its director. The major objective of the institute was to study and restore German developments of the Wasserfall rocket and other air-defense missile projects.

Our work was supported by the artillery headquarters in Moscow, the Guard Mortar Units authorities, the party, and the Ministry of Armament. A trib-

ute should be paid to General Lev Gaidukov, who was among the first to report to Stalin about the scope of work, carried out in the rocket development area in Germany, and to prove that joint work was worth continuing. Stalin personally gave all necessary instructions to expand the area of joint activities. After a thorough investigation of the problem, a historical decree of May 13, 1946, on rocket development engineering and industry in the USSR was distributed to the government departments and ministries.

The decree of May 13, 1946, signed by Stalin, empowered setting up of a special committee. Georgy Malenkov, the second person in the party after Stalin, was appointed to be a chairman of the committee. The Minister of Armament, Dmitry Ustinov, was appointed as a deputy entrusted with the major responsibility for rocket technology development. The decree determined the further infrastructure of rocket science and industry. The top-priority task was to master R-1 missile production and operation, a duplicate of German missile V-2 (A-4) and Wasserfall, while being manufactured completely from domestic materials and by domestic engineering documentation.

Restoration of engineering documentation and specimens of the V-2 long-range guided missile and the Wasserfall, Rheintochter, and Schmetterling antiaircraft missiles was recognized as the first priority task to pursue in Germany. Refurbishment of laboratories and test facilities, including all equipment and instrumentation, and training of Soviet engineers were considered first priority. The recalling of specialists investigating the German technology from Germany to the USSR was prohibited.

The decree stipulated an increased payment for the German specialists. All Soviet and German specialists employed for work on rocket industry in Germany were given 1,000 free-of-charge rations of standard No. 11 (flight rations); 3,000 free-of-charge rations of standard No. 2 (officers); 100 cars; and 100 trucks including fuel and drivers.

The Ministry of Finance was requested to allot 70 million marks to finance the activities in Germany. In addition, 2 million U.S. dollars had been allotted to purchase equipment and instrumentation in the USA and England.

In pursuance of the decree, a new institute, Nordhausen, was set up on the basis of the RABE institute. General Gaidukov was appointed to lead the Nordhausen institute and Sergei Korolev, the future academician, a developer of applied cosmonautics, and a rocket and spacecraft chief designer, was appointed a chief engineer. I was kept on as the head of the RABE institute to develop the V-2 control system.

Germans in the Soviet Union

Late in October 1946, the leading German specialists of the Nordhausen Institute were dispatched to the Soviet Union together with their families. About 20 percent of the total German staff of the Nordhausen Institute was sent to the USSR. Groups of specialists from the Berlin Institute and the Design Office of Dessau also were sent to the Soviet Union. German specialists, who stayed in Germany, were dismantling and evacuating the laboratory and bench equipment and engineering documentation. Ten completely assembled A-4 missiles and 10 sets of subassemblies and parts, to be further assembled in the Soviet Union, were shipped from Kleinbodungen (Werk-3). Two special railroad trains were also dispatched, each delivering equipment for testing, processing, and launching missiles from any site without having to build specific launch facilities.

Key personnel of the German staff were assigned to the NII-88, a leading rocket development institute, located in Kaliningrad (Podlipky), now Korolev, Moscow region. The special affiliate No. 1 of the NII-88 was set up and located on Gorodomlya Island of the Lake Seliger, close to Ostashkov. Professor Waldemar Wolf, the former head of the ballistics department at the Krupp Company, was first appointed to be a director of the affiliate from the German side. The German staff included prominent scientists whose activities were known in Germany, although they had not been working in Peenemünde. Among them were those listed in Table 1 and others.

Heinz Zeise	expert for thermal dynamics
Franz Lange	expert for radars
Werner Albring	expert for aerodynamics
Kurt Magnus	theory of mechanics and gyroscope engineering
Hans Hoch	theory of automatic control
Karl Umpfenbach	expert for engines
Kurt Blasig	expert for servo units from Askania company

Table 1—Leading German Specialists in the USSR.

The primary objective of the German experts was to assist testing, including flight tests of the V-2 missiles brought from Germany, as well as to organize laboratory research and production facilities on the island. In August 1947, the German specialists were reorganized into the Department G led by Helmut Gröttrup. Helmut Gröttrup was also appointed a chief designer for new long-range ballistic missiles.

By mid-1947 a total of more than 400 specialists were working on the island Gorodomlya. Of these, 177 were German specialists, including 5 professors,

24 doctors of science, 17 certified engineers, and 71 practical engineers. In October 1947, German specialists, together with their Soviet colleagues, departed by a special train to the launch site in Kapustin Yar to participate in the launches of the V-2 missiles assembled in Germany. Some specialists were directly included in the launch teams. Corporal Fritz Febach accompanied me in the Panzerwagen (carriage) during the launches of the first rockets in 1947.

The first launches were unsuccessful because of control system errors. To find out the causes for the control system errors, doctors Magnus and Hoch had carried out an investigation in the railway cars, which had been equipped as laboratories, and found the cause and gave recommendations on how to recover from those big errors (deviation). The missiles then started to fly better than those from Peenemünde. By a special order, Magnus, Hoch, and specialists assisting them were given a three-month cost-of-living bonus and a 20-liter canister of alcohol. The occasion was grandly celebrated at the launch site in Kapustin Yar.

The primary task of the Department G was to develop new projects of advanced long-range missiles. On September 24, 1947, a project for a 600-kilometer range missile, indexed G-1 (R-10 in classified documentation), was presented to the NII-88 Scientific and Engineering Board. According to the project, the missile launch weight was 19 tons, its engine thrust—27 tons, specific thrust—257 seconds. The upper stage separation, the load-carrying alcohol tank, and the engine turbine driven by gas extraction from the combustion chamber were a radical departure from the past designs. Onboard control system was greatly simplified by transferring control functions to the ground radio stations. As compared to the V-2, the missile dry mass was 1.8 less with the range increased by a factor of two.

During the preliminary design review, Gröttrup reported the comparative efficiency estimation for long-range ballistic missiles, made by Professor Wolf, and with the consultation of our artillery academy experts. To completely destroy a center of a city with a conventional diameter of 3 kilometers at a range of 300 kilometers, 67,500 missiles of the V-2 type would be required. And only 385 rockets of the G-1 type would be needed to achieve the same destruction at a range of 600 kilometers. In today's nuclear situation, the estimations made in 1947 seem ridiculous to us and show how unfeasible were Hitler's plans to destroy London by means of the V-2 retaliation weapon.

The project, as a whole, was approved by the Scientific and Engineering Board. However Gröttrup's proposals to expand the experimental and design activities were not supported immediately. The two main motivations were—the first was public knowledge—above all we had to master the V-2 (A-4) missile, and be able to produce and launch it at least as well as the Germans, and the sec-

ond confidential—Korolev, the Chief Designer, had already initiated work on the R-2 missile project assuming the same range of 600 kilometers, as G-1.

To manufacture two different missiles with a range of 600 kilometers was simply beyond the capacity of our industry. The military's arguments were convincing—we did not need missiles with such parameters for conduction of war in Europe. The military gave their support to the development of industry and research in the rocket technology area with the hope that a missile capable of flying overseas would be completed sooner or later. As for the present, the V-2 duplicate was to be used for the development of the rocket infrastructure in our state.

In December 1948, the German staff, led by Gröttrup, presented another design review of the modified missile G-1 (R-10). The range was increased from 600 to 800 kilometers with the maximum targeting errors of ±2 kilometers for azimuth and ±3 kilometers for range. The structure elements of the most proprietary design had been thoroughly verified. A single, common, load-carrying tank divided into two volumes by an intermediate bottom was used for both components. The exhaust turbine gas was used to pressurize the fuel (alcohol) tank. According to Gröttrup, "the theoretical calculations have been done in much more detail, as opposed to those made in Peenemünde, but a far better way would be to carry out bench experiments rather than excessively detailed theoretical analysis." Further work on the project was useless without experiments. Though the formal decision of the Scientific and Engineering Board was encouraging, the experiments, production, bench tests were not started!

In the time frame of 1948–1949, the development of a concept for the G-2 (R-12) missile with 2,500-kilometer range and a warhead of 1-ton mass was headed by Gröttrup and was underway on the island. The propulsion unit for this missile was proposed to be a design of three engines derived from the R-2 missile, thus achieving a thrust of over 100 tons. This project was the first time that gas-jet servo units were not used for control. It was proposed to implement control through changing the thrust of engines located around the periphery of the aft part canted at an angle of 120 degrees.

In addition to the G-1 and G-2 projects, the advanced design of the G-4 ballistic missile and the G-5 cruise missile with a range of up to 3,000 kilometers and payload of 3 tons was under way. The achievements reached in the development of these projects were greater than that of ranking below the Peenemünde's A9/10 and Sänger's intercontinental bomber.

In 1949, tests of the second series of the R-1 missiles were successfully completed. In 1950, the third series of missiles were tested jointly with the armed forces. Relying on the testing results, the R-1 missiles, including all ground support equipment, were added to our arsenal. During the verification tests in 1951,

all launches were 100 percent successful, i.e., hit a rectangle of 16×8 kilometers. With complete control by the automatic control system, the largest deviation did not exceed 5.5 kilometers. Although German experts did not participate in those tests, it would be impossible to underestimate the historical role of the A-4 and R-1 missiles. An entirely new area of technology had been ushered in. A large engineering system integrating many science disciplines and different technologies had been created.

The design activities of German engineers resulted in the development of new measuring instruments and equipment. Doctors Hoch and Magnus designed a summing gyroscope that found its way into the mainstream of automatic pilots of antiaircraft missiles. Under the guidance of Professor Werner Albring, a six-component aerodynamic balance of unique design had been developed. Also the first simulators had been developed for integrated development tests of control systems.

In August 1950, Dr. Hoch was moved to the KB-1 design office, a new institution for air defense systems development. His ideas for new control concepts for antiaircraft missiles have been materialized, and he was responsible for rapid development of the unique system, which entered service in 1955.

The R-11 missile was developed in 1953 without the participation of German engineers, as opposed to the development of the V-2 and R-1 missiles. Missile R-11 became operational in 1955. It was developed into a very effective mobile version with a mobile launching pad. This concept was accepted for an R-11M with a nuclear warhead. The first submarine missiles were based on the R-11 design. Missile R-11FM was launched from a submarine for the first time on September 16, 1955. However, the graphite gas-jet servo units derived from the V-2 were used for those projects (Table 2).

Main Characteristics	**R-1**	**R-11**
Maximum range, kilometers	270	270
Probable deviation from target, kilometers: Range Lateral	 ±8 ±4	 ±1.5 ±0.75
Rocket initial (launch) weight, kilograms	13,430	5,330
Propellant	oxygen, ethyl alcohol	nitrogen acid, kerosene
Warhead mass, kilograms	1,075	690
PU ground thrust, kilograms/feet (kgf)	27,200	8,300
Specific thrust of engine, kgf. f/kg	206	219

Table 2—Comparative Performance Data.

The Germans Return Home

In view of Korolev's work on the R-2 missile of a 600-kilometer range and the R-3 concept for missiles of more than 3,000-kilometer range, the work of German engineers was not compatible with governmental plans. In 1950 a governmental resolution was enacted to return German specialists to Germany. All were given large amounts of traveling expenses; special trains were built up. The military authorities in Germany were ordered to meet those arriving from the Soviet Union and provide them with accommodations and jobs.

The last train departed to the GDR [German Democratic Republic] in November 1953. Gröttrup, as the captain of a sinking ship is supposed to do, was the last to leave. I managed to bid my fond farewell to him, and we both hoped to meet again, once the cold war was over. However the GDR authorities and our special services had not been vigilant enough and Gröttrup's family was taken by the American special services at the railway station immediately upon their arrival. Their future fate turned out to be tragic.

Conclusion

While staying in the Soviet Union, no research and design work associated with development of artificial satellites was performed by German specialists. The first artificial Earth satellite and further space projects were brought about by means of the rocket R-7 designed by the Chief Designer S. Korolev. The German "birthmarks" disappeared from the rocket structure, its propulsion unit, and control system. It was all a Soviet engineering achievement. However chief designers, who formed the chief designer's board, initially had started their joint activities in Germany and became a unified team while developing the first rocket system, R-1. In those years, the groundwork was laid in the Soviet Union for rapid development of nuclear-missile technology and cosmonautics for the next decades.

On October 4, 1957, the first artificial satellite in the world was launched. Modern cosmonautics is 46 years now. During these years thousands of space vehicles have been put into near Earth and interplanetary orbits. Starting from Yuri Gagarin's spaceflight, 430 people of Earth have been in space. Cosmonautics accelerates progress of the science and technology, economy and culture, and stimulates social problem's solution.

But in spite of the greatest achievements of the cosmonautics, none of the scientists—creators of the rocket and space technology—was awarded Nobel

Prize honor. I hope at the 50th anniversary of the space era, Academy of Astronautics shall ask Nobel Prize committee to correct this historical injustice.

Figure 1: Press conference with Professor Boris E. Chertok (second from left) on 3 October 2003, in Bremen. From left to right—Jürgen Drescher, DLR [German Aerospace Center]; Boris Chertok; Jesco von Puttkammer, NASA; and Fredrick I. Ordway III. Credit: Otfrid Liepack.

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