



European scientists swear allegiance to the US in 1952 at the US Army Signal Corps Engineering Laboratories in Fort Monmouth, New Jersey. Harold Zahl, the US-born director of research, is third from left. Hans Ziegler, a German researcher, is third from right in the front row. The image is from Amy Gerber-Stroh's 2012 documentary *My Grandfather Was a Nazi Scientist: Opa, Von Braun and Operation Paperclip*.

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PHYSICISTS AS REPARATIONS?

Johannes-Geert Hagmann

In addition to recruiting more well-known rocket scientists, the US government brought from Europe thousands of other scientists who helped to advance numerous research fields during the Cold War.

Before the end of World War II, the US and other powers, including the UK and France, became preoccupied with securing technical and scientific knowledge from Germany and its allies. In addition to large-scale field missions that aimed to secure technology and its documentation, the US initiated programs for the evacuation and relocation of specialist scientists, engineers, and technicians from Germany, Austria, and other countries. Despite the secrecy of those operations, the programs were public knowledge: As early as November 1945, the *New York Times* reported on the arrival of groups of specialists, many of whom would go on to support government research in ballistic missile development and the US space program.

Representations in popular media—for example, those of the aerospace engineer Wernher von Braun and the physicist Heinz Haber in Walt Disney's 1955 documentary *Man in Space*—contributed to foreign-born research-

ers' public profile as experts in rocket science and space research.

Those popular depictions, however, obscured in the public eye the larger scope of the immigration programs and their impact on US research beyond the ballistic

Later caricatures of scientists and engineers, such as the fictional Dr Strangelove in Stanley Kubrick's satirical 1964 film of the same name, were reminiscent of the sudden career transitions of real-life figures from working for

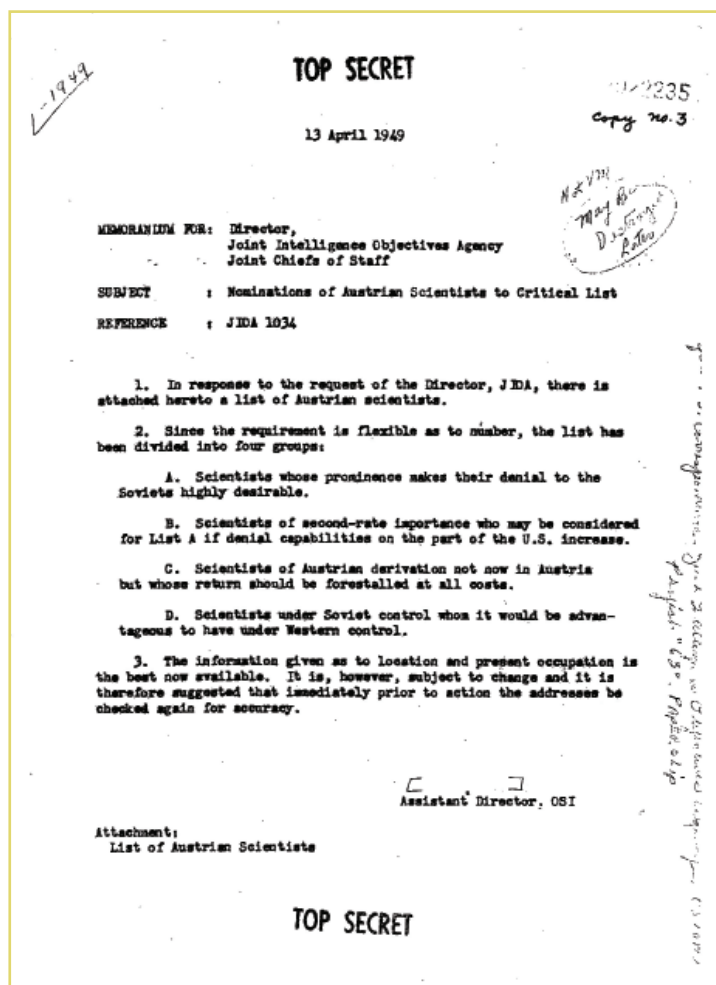


FIGURE 1. A TOP-SECRET MEMORANDUM from 1949 lists four categories of Austrian scientists whom the US government hoped to prevent the Soviet Union from employing. (From “Nominations of Austrian Scientists to Critical List,” memorandum, 13 April 1949, box 54, folder 2, Second Release of Subject Files Under the Nazi War Crimes and Japanese Imperial Government Disclosure Acts, record group 263, US National Archives and Records Administration.)

argue that an evaluation of those researchers’ contribution to a kind of intellectual war reparations should, in future research, be balanced by an account of the careers of researchers who participated in those programs but later returned to Germany.

The origins of Project Paperclip

The 20th century was shaped by World Wars I and II. Tens of millions of people became victims of murder and war, and many others had to emigrate from their home countries to escape persecution. But that phase of motion and migration did not stop at the end of World War II.

In a variation of a famous quote by the military theorist Carl von Clausewitz, the historian Roy MacLeod commented not only that war is a continuation of policy by other means, but that “warfare has become the continuation of science by other means.”² Before and during World War II, many countries, including the US, prioritized scientific and technological research for military applications. To that end, the US Office of Scientific Research and Development (OSRD) was founded in 1941 to coordinate research relevant to the war.

In addition to guiding research on microwaves, radar, advanced medical therapy, and the first atomic bomb, the OSRD advised the US government on key policy questions. OSRD director Vannevar Bush laid out his vision for postwar research policy in a July 1945 report titled *Science: The Endless Frontier* that eventually led to the creation of NSF. Concerned with the support and formation of scientific talent, Bush not only described various measures to foster domestic education but also foresaw “the official reception of foreign scientists of standing in this country.”³

Even before the end of the war, Allied military intelligence units started to assess and document the scientific and technological state of the art of research in enemy territories. Between 1944 and 1947, they created more than 3000 reports describing research in academic institutions and companies and identifying key personnel. Advancing onto German soil in the spring of 1945, the US Army interviewed an increasing number of specialists in captivity about their work during the war.

Later in July 1945, the US started an initially secret recruitment program for selected German scientists, engineers, and technicians with the asserted aim of curtailing the war in the Pacific. After the war, the program received the name “Paperclip,” a reference to the clips holding the personnel dossiers of candidates. The program and its successors were organized by the Joint Intelligence Objectives Agency (JIOA) of the Joint Chiefs of Staff.⁴

“Exploitation” and “denial”

Among the first cohort brought to the US were scientists and

rocket and space programs, despite extensive historical research and books on the subject.¹ Although the transplanted specialists included a sizable cohort of physicists, their stories are mostly unknown to the physics community. Looking in the archives of *PHYSICS TODAY*, for example, yields few articles related to the post–World War II immigration programs and their history.

Why is there an apparent gap in the collective scientific memory? One hypothesis is ignorance: Physicists mistakenly associate the historical episode with “rocket scientists,” many of whom were engineers, rather than with the history of their own discipline. A second possibility, admittedly more difficult to prove, is avoidance: Dealing with the events requires acknowledging the subordination of research to political aims and opportunism in the management of the scientific workforce.

This article moves the focus from rockets to other areas of physics and engineering. Physics-oriented research done by recruited scientists fits into a broader spectrum of military and industrial research in the US during the Cold War. Recruitment programs serving the aims of exploitation and denial of scientific talent for national interest lasted at least through the early 1960s. Beyond the space program, the recruited specialists made vital contributions to semiconductors, atomic and molecular physics, metrology, and many other research areas. Historians have discussed the impact on post–World War II reconstruction in Germany from the brain drain created by the US’s and other countries’ recruitment programs. I

engineers who had been working in aeronautical and rocket research. The US government had two main motivations for rapidly relocating specialists who had contributed to wartime research in Nazi Germany. First, it aimed to catch up in certain areas of scientific and technological research considered to be less developed in the US at the time—a motivation often referred to by the shorthand “exploitation.”

But a second goal became dominant as tensions increased with the Soviet Union. Similar to the US, France, and the UK, the Soviet Union had started its own recruitment efforts, called Operation Osoaviakhim, to exploit German research by deporting specialists to work in its defense programs. By evacuating personnel to the regions of Germany and Austria under US control—the American occupation zones—or by offering employment in the US, the US government aimed to foil access to key researchers by the Soviet Union and other countries, a strategy referred to by the shorthand “denial.”

The US compiled target lists of individuals under consideration for employment. Figure 1 shows an example from 1949 of such a list for a subcategorization of Austrian specialists. List C comprises Austrian citizens whose return to Austria “should be forestalled at all costs,” given that Vienna lay in the center of the Soviet zone. It named, among others, Lise Meitner, Erwin Schrödinger, and Wolfgang Pauli. The JIOA was not alone in compiling those types of lists: Other countries’ intelligence services likewise systematically assessed the status and the scientific capacity of researchers in the occupied zones.

Officials in Germany, including physicists, watched the departures of colleagues with concern. In 1947 a German physics conference took place in Heidenheim, where the US Army had relocated 400 scientists and their families from Jena, which was in the Soviet zone. In an opinion article entitled “Physiker als Reparationen” (“Physicists as reparations”), Werner Kliefoth, a nuclear physicist and then mayor of Heidenheim, noted that dismantled factories could be rebuilt, but lost scientific talent could not be replaced.⁵

Alien specialists for national defense

Between May 1945 and December 1952, 642 so-called alien specialists entered the US as part of Paperclip and related programs.⁴ Not all were German or Austrian; the lists included smaller numbers of other nationals as well. Many of the selected scientists, engineers, and technicians were directly approached and invited to the US. But not all the courted individuals wanted or intended to emigrate. Some declined invitations, referencing the need to reconstruct research in Germany.

The small selection of experts from Jena who were offered employment and eventually migrated to the US included several former employees of Carl Zeiss, the German optics company. Among them were Georg Joos, the former head of research and a physicist; Gerhard Schwesinger, an expert on airplane cameras; Werner Weihe, an electronics researcher; Karl Leistner, a photography and photochemistry specialist; Olek-



FIGURE 2. HANS ZIEGLER (left), Harold Zahl (right), and their colleagues pose with a weather satellite in 1959. (Image by Andreas Feininger/The LIFE Picture Collection/Shutterstock.com.)

sandr “Alexander” Smakula, inventor of antireflective coatings; and Eduard Gerber, an expert on piezoelectric crystals.

Joos and Schwesinger returned to Germany after a few years, while Smakula, Gerber, Leistner, and Weihe stayed in the US. The Ukraine-born Smakula, who initially appeared on a UK list and whom the US traded with British intelligence for another crystal specialist, became a professor at MIT⁶ in 1951. Weihe worked for the military at the Night Vision Laboratory in Fort Belvoir, Virginia. Gerber and Leistner worked for several years at the US Army Signal Corps Engineering Laboratories in Fort Monmouth, New Jersey. Beyond the aviation and rocket specialists, the group of specialists at Fort Monmouth was among the largest fraction of Paperclip participants in a single location. Between 1947 and 1962, when the JIOA was disbanded, historians estimate the number at at least 50 specialists.

The article’s opening photograph shows the first cohort with the Signal Corps during the ceremony that conferred permanent residence status on Paperclip personnel. The event took place under a picture gallery of atomic bomb tests as if to symbolically underline the sincerity of the commitment. Harold Zahl, the director of research at the Engineering Laboratories, later wrote,

I have in my office a photo of the first 16 which came over, hands up, swearing allegiance to the United States, as they moved into Schedule-A. Of these 16, now twenty years later, 11 still remain at the Monmouth laboratory, all in very high positions, and one in the very highest. It was a wonderful experience to see the old “Melting Pot” in action.⁷

The recruitment of European scientists came at just the right time for military research institutions. Many US physicists

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April 10, 1962

K. LEHOVEC

3,029,366

MULTIPLE SEMICONDUCTOR ASSEMBLY

Filed April 22, 1959

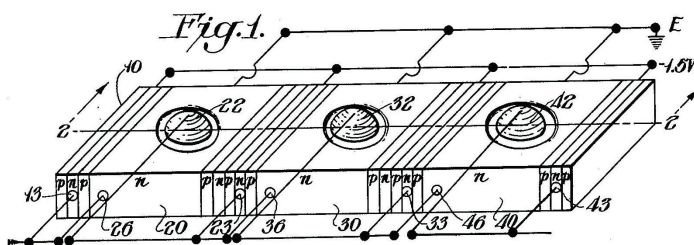


FIGURE 3. THE P-N JUNCTION ISOLATION, whose original patent design is shown here, was invented by Kurt Lehovec, a Czech physicist recruited to work after World War II at the US Army Signal Corps in Fort Monmouth, New Jersey. (K. Lehovec, "Multiple semiconductor assembly," US Patent 3,029,366, 10 April 1962.)

employed by government laboratories during the war had quit national service to start careers in academia or industry. At the same time, the number of graduates from US universities and colleges was insufficient to fill the demands of research facili-

ties. Project Paperclip helped partially alleviate that deficit. The many specialists recruited for Fort Monmouth thus shaped and expanded research operations for the Signal Corps.

Solar cells and satellite electronics

The individual highlighted by Zahl in the "very highest" position was not recruited out of the blue, as were most Paperclip recruits. Konrad Johann "Hans" Ziegler started his career developing proximity fuses for the German army and eventually moved to applying solar cells to US satellites. His path took him from immigrant to US citizen and chief scientist and from volunteer recruit to active recruiter for the Paperclip program.

Ziegler studied electrical engineering at the Technical University of Munich. After earning his degree, he briefly worked for the company Siemens & Halske before eventually joining Rosenthal Isolatoren in Selb, the porcelain capital of the Upper Franconia region in Bavaria. He initially worked in the field of high-power isolators, but during World War II, his department supplied the German army and air force with fuse systems for bombs, shells, and mines.

Most specialists moved to the US because of relocation re-

Immigrant specialists in private research institutions

The US government was not alone in the search for scientific talent from Europe. Industrial research institutes similarly recruited from Germany. One notable example is Herbert Kroemer, a physicist whose talent was recognized by Edward Herold from Radio Corporation of America (RCA)¹⁷ in 1953. Although the Joint Intelligence Objectives Agency (JIOA) had no direct involvement in the recruitment, the agency helped expedite Kroemer's visa. The scientist had an exceptional career in the US, and in 2000 he was awarded the Nobel Prize in Physics, alongside Zhores Alferov, for the development of semiconductor heterostructures; they shared the prize with Jack Kilby for his contribution to the development of integrated circuits.

The JIOA sought placements in industry for those researchers who were considered for government work but failed to receive a contract. Editha Karl-Kroupa, a part of the small group of women in the Project Paperclip cohort, exemplified some of the difficulties faced by numerous immigrant scientists. Seen in the photo, Karl-Kroupa was an inorganic microchemist who specialized in radioactive elements. Her research on radium, in particular, gained international recognition before the outbreak of World War II. She and her husband arrived in the

US in June 1953, and they initially resided in the Hotel Alamac at 71st Street and Broadway in New York City, seen in the postcard. Because of the hotel's location in the German-speaking area of Yorkville, the JIOA chose it as a transition center for scientists, engineers, and technicians who had yet to obtain a government contract and visa and thus remained under military custody.

Most government research institutes expressed a lack of interest in Karl-Kroupa's profile or expected delays in obtaining necessary security clearance for her work, so the JIOA agents searched for an industry placement. They wrote to more than 20 large corporations, including Shell, Standard Oil, General Motors, and Ford Motor Company.¹⁸ After more than six months of waiting and interviewing, Karl-Kroupa started to work for Monsanto Chemical Company as an analytical chemist in January 1954.

Women specialists like Karl-Kroupa were a minority in the recruitment program: Among the 1704 names in the Foreign Scientist Case Files kept at the US National Archives and Records Administration (see the

discussion on page 48), only 24 (1.4%) are women. The group also included Gisela Elsholtz (Eckhardt), a physicist and coinventor of the Raman laser. (Photo of Editha Karl-Kroupa courtesy of the Smithsonian Institution Archives, accession 90-105, Science Service Records, image no. SIA2008-4975; postcard courtesy of Seymour B. Durst Old York Library Collection, Avery Architectural & Fine Arts Library, Columbia University.)





FIGURE 4. POLYGRAPHS, such as this one from the 1960s, became part of the vetting process for potential recruits during the Cold War. (Image by dpa picture alliance/Alamy Stock Photo.)

quests from the Office of Military Government for Germany (US), which was a military-established temporary government in the American zone of Germany after World War II. Ziegler, on the other hand, actively pursued opportunities to immigrate from Germany to the US. In March 1947 he received his first contract with the Signal Corps and entered the US before a so-called denazification court (*Spruchkammer*) reached a verdict in his trial, which was eventually terminated because of Ziegler's absence.⁸ In order for applicants to obtain employment in military research facilities, US authorities investigated their criminal records and political biographies, including possible membership in Nazi organizations—although membership in the Nazi Party and other groups did not render candidates ineligible. Applicants had to name contacts for interviews about their past and present political views and professional and personal conduct.

Similar to many other Paperclip researchers, Ziegler came to the US without a valid visa and remained under military custody. While he was under custody, a Signal Corps officer submitted regular reports tracking his performance and behavior in and outside of work, and investigators checked his private correspondence. In May 1949, after his successful probation, the Signal Corps sent Ziegler and an escorting officer on a business trip to Niagara Falls, where they crossed over to Canada to regularize his residence permit on reentry into the US.⁹ He obtained permanent residency in 1952, alongside other members of the Paperclip group, as a step toward naturalization as a US citizen, which came in 1954.

After initial research on power generators and transformers, Ziegler focused on electronics for the space program (see figure 2) starting in mid 1950s. At the Engineering Laboratories, scientists, engineers, and technicians worked in more than 75 technical fields, including microwave and radar systems, battery technology, satellite electronics, photography, and time standards. Research on satellite components intensified after the 1957 launch of *Sputnik 1*, which led the comedian Bob Hope to joke about the success of the Soviet Union: "It just proves one thing, . . . their German rocket scientists were better than our German rocket scientists."¹⁰

Despite the growth of the laboratory, scientific personnel were in short supply, which led the Signal Corps to recruit in

Europe. In November 1952, as part of that recruitment, Ziegler joined an army delegation traveling to Vienna and to Heidelberg, Salzburg, and Berlin with the objective of hiring 60 young experts. More trips followed in later years, and Ziegler advised the project on its strategy for recruiting. For example, a major attraction for candidates was a salary considerably higher than the available income in West Germany at the time. (The US, UK, and France merged their occupation zones in 1947–48 and granted them limited independence as West Germany in May 1949. In October of that same year, the Soviet Union established a client state, East Germany, in its occupation zone.)

Ziegler's scientific and administrative success earned him successive promotions at the Signal Corps. By the end of his career in the early 1970s, he was director of a research laboratory with oversight of 400 staff members and an annual budget of \$30 million.¹¹

Semiconductors and integrated circuits

Although Ziegler's and the Czech physicist Kurt Lehovec's work in the US started in a similar way at the Signal Corps, Lehovec's career took a path into industry and academia, which other Paperclip personnel would follow. Lehovec attended school in Troppau, Czechoslovakia, before entering the German University in Prague in 1936, where he later became a scientific collaborator of the semiconductor physicist Bernhard Gudden. From 1942 to 1945, Lehovec's research on selenium rectifiers was associated with the *Süddeutsche Apparate Fabrik* in Nuremberg and Nazi Germany's Ministry of Aviation. He joined the Signal Corps as an expert on semiconductor physics in June 1947, shortly before transistors were invented.¹²

Although highly successful in his work and prolific in his publishing while at the Signal Corps, Lehovec asked for a release from government work to join industry, where salaries were significantly higher. In summer 1952, he was hired by the Sprague Electric Company, and he continued to work in the private sector for 20 years before eventually taking a professorship at the University of Southern California in 1972. Although some Paperclip recruits would likewise first work for the government before joining industry, others started directly in the private sector (see the box on page 46).

Lehovec's broad areas of scientific activity included battery technology, solar cells, and LEDs. Most notable, however, was his 1959 patent of the p–n junction isolation, shown in figure 3, which is considered one of the key papers in the development of integrated circuits.

Time standards and metrology

Project Paperclip, later known as Project 63, in 1956 received another new title directly communicating its ambition: the Defense Scientist Immigration Program (DEFSIP). In the 1940s the political screening focused on researchers' ties to Nazi

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Germany, but by the 1950s, authorities instead began investigating communist beliefs or connections. In 1954 Senator Joseph McCarthy (R-WI), whose name became synonymous with the Cold War and a climate of denunciation, took aim at the Signal Corps in Fort Monmouth. The electrical engineer Julius Rosenberg—who was convicted of spying on behalf of the Soviet Union and was executed alongside his wife, Ethel—had worked for the Signal Corps during World War II. McCarthy used his case as a pretense to claim the existence of a larger spy ring at Fort Monmouth.¹³

As a consequence, recruitment efforts from 1955 on included additional screening with polygraphs, such as the one shown in figure 4. The devices recorded body activities, including respiration, pulse, and skin conductance, in theory to establish whether interviewees were telling the truth. The US applied the debatable procedure in Germany at several US stations, but it is unknown how many researchers were identified as a risk because of polygraph tests. In 1965 a Department of Defense official testified before a subcommittee of the US House of Representatives' Committee on Government Operations that DEFSIP was not a recruitment program, and that the program's security experience had "proved favorable,"¹⁴ an intentionally vague claim. In a different case of espionage, in 1967 the US sentenced former JIOA director William Henry Whalen to prison for handing over military secrets to the Soviet Union.

Gernot Winkler, an Austrian astrophysicist, was one specialist in the first wave of DEFSIP recruits who underwent the new procedures. In March 1956 Winkler—who had a cousin behind the Iron Curtain and had been investigated while he was a US prisoner of war—passed the two-hour examination in Munich without any incident. At the time of his recruitment, Winkler was working at a distillery, but he had a background in the theory of microwave propagation, particularly in the ionosphere.¹⁵

Although how they first connected is unclear, the Signal Corps developed an interest in Winkler for its Camp Evans Signal Laboratory, where he could help calculate wave propagation in different meteorological conditions and atmospheric effects. With the Signal Corps, Winkler became involved in frequency control and research on atomic clocks—in particular, the commercially produced Atomichron. During the first year at Fort Monmouth, he consulted for the US Naval Observatory, where in 1966 he would become director of time services, a leadership position in metrology that he would hold for 30 years.

Uncertain numbers

Although these research biographies highlight contributions from recruited scientists, what is known about the immigration programs more broadly is limited. Historians and researchers still lack access to basic information, such as exactly when the DEFSIP program was discontinued and how many scientists were recruited. The historian Michael Neufeld estimated that the US brought over about 900 specialists from Germany and Austria and about 6000–7000 total from around the world.¹⁶ The Foreign Scientist Case Files at the US National Archives and Records Administration contain approximately 1700 records in 186 archival boxes. Those records, however, include files for people who did not enter the US through Project Paper-

clip and subsequent programs or, in fact, never left Europe.

Although the evacuation and recruitment of specialists from postwar Germany and Austria contributed to immigration, when considering the concept of "intellectual plunder," historians often do not recognize the factors contributing to voluntary migration. Those include the scientific, economic, and social opportunities that the US offered to their prospective employees. Previous studies on war reparations have included intellectual reparations in the form of technology transfer and the migration of personnel.

But the damage done to research in Europe after World War II because of the relocation of personnel must be considered alongside the subsequent return of physicists from the US to West Germany. That nuanced understanding requires the systematic evaluation of archival holdings, which is an extensive project given the large number of case files. Further research on the topic will improve our understanding of the transnational development of science and engineering, and of physics more specifically, after World War II.

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REFERENCES

1. See, for example, C. G. Lasby, *Project Paperclip: German Scientists and the Cold War*, Atheneum (1971); J. Gimbel, *Science, Technology, and Reparations: Exploitation and Plunder in Postwar Germany*, Stanford U. Press (1990); D. M. O'Reagan, *Taking Nazi Technology: Allied Exploitation of German Science After the Second World War*, Johns Hopkins U. Press (2019).
2. R. MacLeod, *War Hist.* 9, 246 (2002).
3. V. Bush, *Science: The Endless Frontier—A Report to the President*, US Government Printing Office (July 1945), chap. 3.
4. C. G. Lasby, in ref. 1.
5. W. Kliefoth, *Phys. Blätter* 3, 369 (1947). Translation from German by the author.
6. "Alexander Smakula," box 159, Foreign Scientist Case Files 1945–1958, record group 330, National Archives at College Park, MD.
7. H. Zahl, *Electrons Away, or Tales of a Government Scientist*, Vantage Press (1968), p. 109.
8. P. Engelbrecht, *Geheimwaffen für die Nazis: Kriegsforschung in Oberfranken* (Secret weapons for the Nazis: War research in Upper Franconia), Späthling (2018), p. 85.
9. "Hans K. Ziegler," box 186, Foreign Scientist Case Files, in ref. 6.
10. B. E. Crim, *Our Germans: Project Paperclip and the National Security State*, Johns Hopkins U. Press (2018), p. 3.
11. H. K. Ziegler, *Thirty Years of Electronics Research and Development in the USA: Methods, Results, Lessons Learned*, talk presented at Siemens Bildungszentrum, Berlin (10 March 1976), US Army Communications-Electronics History Office.
12. "Kurt Lehovec," box 101, Foreign Scientist Case Files, in ref. 6.
13. R. R. Raines, *Army History*, Spring 1998, p. 8.
14. W. T. Skallerup Jr, *Use of Polygraphs as "Lie Detectors" by the Federal Government*, testimony before the US House Committee on Government Operations, Foreign Operations and Government Information Subcommittee, 89th Congress, 19 August 1965, p. 611.
15. "Gernot Winkler," box 182, Foreign Scientist Case Files, in ref. 6.
16. M. J. Neufeld, *Hist. Technol.* 28, 49 (2012).
17. "Herbert Kroemer," box 94, Foreign Scientist Case Files, in ref. 6.
18. "Edith Karl-Kroupa," box 83, Foreign Scientist Case Files, in ref. 6.