History of Rocketry and Astronautics

Proceedings of the Forty-Sixth History Symposium of
the International Academy of Astronautics

Naples, Italy, 2012

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AAS History Series, Volume 43

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 32

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2015

ISSN 0730-3564

ISBN 978-0-87703-615-9 (Hard Cover)
ISBN 978-0-87703-616-6 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 4

Walter Thiel—Short Life of a Rocket Scientist (March 3, 1910–August 18, 1943)*

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Abstract

In 2012 we celebrated the 70th anniversary of the first successful rocket launch that reached a height of 84.5 km and had a speed of 4.824 km/h (five times sonic speed). This rocket flew 190 km to the target location. One of the masterminds of this launch was Walter Thiel, a German chemist and rocket engineer. Thiel was highly talented, during his education from primary school until diploma exams he always received a grade of A in his exams. He was called "the student with the 7 A grades." In 1934 Thiel became Dr.-Ing. (chem.), with the highest possible honor (summa cum laude), when he was only 24 years old. He started to work for the rocket development department at Humboldt University, Berlin. Walter Dornberger asked him to leave the university research department and become head of rocket propulsion development in his team in Kummersdorf, near Berlin. Thiel's groundbreaking ideas for the rocket engine would lead to a significant reduction in material, weight and work processes, as well as a shorten-

* Presented at the Forty-Sixth History Symposium of the International Academy of Astronautics, 1–5 October 2012, Naples, Italy. Paper IAC-12-E4.3B.01.

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ing in the length of the engine itself. Thiel and his team also defined the fuel itself and the best ratio of mixture between ethanol and liquid oxygen for the engine. In 1940 the propulsion team moved from Kummersdorf to Peenemünde after the launch sites were completed there. Thiel became deputy of Wernher von Braun at the R&D units. One of Thiel's team members was Konrad Dannenberg, who later became famous in the development of the Saturn program. On the night of 17 August 1943, Thiel and his family (wife and two children) were killed during a Royal Air Force bombing raid (Operation Hydra). The Moon crater "Thiel" on the far side of the Moon is named after Walter Thiel. The research results of Walter Thiel had a strong impact on the U.S. rocket program as well as the Russian rocket development program.

Biography

Early Years, 1910–1929

Walter Thiel was born on 3 March 1910, in Breslau. His talent was noticed very early, already in elementary school he was giving fellow students private tutoring. Later on he even stood in for his teachers during school lessons. In 1920, 100 pupils from Breslau were invited to do intelligence tests, 20 of them received a scholarship at high school. Thiel received one of these scholarships and he attended Bender Oberrealschule on Lehmdamm in Breslau. After spending only three months in grade five he was able to jump to grade six. He remained top of the grade every year until he graduated. In his final exams (Abitur) in 1929 he passed all of his exams with the highest possible marks.

As a small boy Thiel had always been fascinated by technology and science. During the 1920s Germany experienced rocket euphoria. Hermann Oberth was one of the pioneers, and he wrote the books *Die Rakete zu Planetenräumen* (published 1923) and *Wege zur Raumschiffahrt* (1929). He had a strong influence on the younger generation, including Thiel and von Braun. In addition, Oberth advised the film crew of Fritz Lang during the shooting of *Frau im Mond.*

In 1927, the Verein für Raumschifffahrt (VfR) was founded in Breslau. Hermann Oberth and Willy Ley were some of the first members. Willy Ley immigrated to the United States as early as 1935, and promoted the Moon exploration with von Braun after the war. Thiel was also a member of VfR.[1] It is not known if Thiel joined the club in Breslau at the age of 17. In 1929 the club moved to Berlin. It could well be that Thiel joined the club later in Berlin.

University Studies, 1929–1934

Thiel discovered his passion for chemistry during his time as an intern in his school teacher's lab. He then decided to study chemistry at the Technical University, Breslau in 1929. Starting with his third semester he could study "for free," and in 1932 he was accepted to the "Studienstiftung des Deutschen Volkes."[2]

Thiel studied inorganic chemistry with Prof. Ruff and organic chemistry with Prof. Straus. In the winter semester of 1933 he graduated in chemistry (Diplom-Hauptprüfung), and he achieved the highest possible marks in all seven exams. He wrote his diploma thesis at the Institute of Organic Chemistry with Prof. Straus.

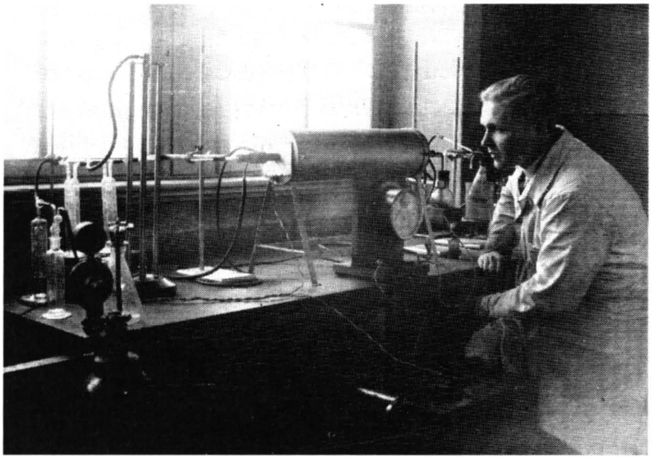

Figure 4–1: Organic Institute, Technical University Breslau, Christmas 1932. Credit: Archive family Thiel.

After that he started to work on his degree dissertation with the title "Über die Addition von Verbindungen mit stark polarer Kohlenstoff-Halogenbindung an ungesättigte Kohlen-Wasserstoffe," which was the continuation of his diploma thesis. From 15 April to 15 May 1934, he was the scheduled assistant at the Organic Chemical Institute of the Technical University, Breslau. He followed Prof. F. Straus to the First Chemical Institute of the University in Berlin, where he was an unscheduled assistant from 15 May to 31 August 1934.[3]

In Thiel's degree dissertation Prof. Straus is no longer his supervisor, but private lecturer Dr. Voss, until then a close colleague of Straus. Co-supervisor is Prof. Ruff. In his dissertation Thiel appreciates his "adored teacher Prof. F. Straus for the inspiration to this dissertation and his continuous and active interest in its execution."

Being non-Aryan, Prof. Straus was suspended from the TU Breslau in 1933,[4] but reinstated in his old position after a few months due to his past when he was a combat veteran. In 1934 he was ordered to go to the University of Berlin where he worked until 1936, when he was finally sacked because of further non-Aryan laws introduced by the state. He continued to work in private labs until he immigrated to the United States in 1939.[5]

Thiel's diploma thesis and dissertation where the basis for the publication "Anlagerung von Alkylhalogeniden an die Äthylenbindung—by F. Straus and W. Thiel."[6]

On 8 November 1934, Thiel defended his dissertation with "summa cum laude," he received the title Dr.-Ing. chem.

Research at Reichswehrministerium, 1934–1936

Prof. Ruff recommended Thiel to the Research Institute of the German army ordnance office of under-secretary Prof. Karl Erich Schumann at the University of Berlin. Thiel's previous findings had technological applicability and therefore he was able to continue his fundamental research in a leading position. Late 1934 or early 1935 Thiel became research instructor at Reichswehrministerium.[7]

Schumann, member of the National Socialist German Workers' Party (NSDAP)* since 1933, was head of the Second Physical Institute of the University of Berlin, and also head of the Central Office for Army Physics and Army Chemistry, which was transformed to the research department of the German Army ordnance office (WaF) in 1935.[8]

Schumann accompanied many diploma theses and dissertations,[9] including that of Wernher von Braun, who completed his dissertation in 1934. Kurt Wahmke, too, wrote his doctorate with Schumann. It was about liquid rocket propulsion.[10] Wahmke died on 16 July 1934, in Kummersdorf while testing a rocket propulsion engine.[11]

Thiel continued Wahmke's research and advised Hermann Walter (Walter-Werke, Kiel), who developed a hydrogen peroxide engine, and he also supported the postgraduate student Seifert.[12] Thiel and Seifert were working on the right choice and the right mixing ratio of rocket fuels.[13] Many more dissertations on the subjects of rockets and fuels were supervised in the lab of Schumann. Thiel and his colleague Heinz-Otto Glimm initiated the project "Exploration of combustion in liquid-fueled rockets." In 1935 they built the first concrete test stands at the Kummersdorf site. In addition, they developed measuring methods in order to analyze the rocket tests systematically.[14]

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* Nationalsozialistische Deutsche Arbeiterpartei.

The contacts between the testing ground in Kummersdorf and Schumann's Institute was close, the eastern part of the site in Kummersdorf served as an experimental base for Schumann's institutes, in the west a group of scientists around Major Walter Dornberger carried out their experiments.[15] Here Thiel got to know Dornberger and von Braun.

During these early years 1935–1936 an anecdote must have taken place during a trip when Thiel and von Braun visited Thiel's parents in Breslau's Adalbertstr. 7. Here, Thiel's mother was mending von Braun's socks.

In 1935 Thiel married Martha Strohwald, and their first child, daughter Sigrid, was born in March 1936. Godfather was Thiel's colleague Glimm, who stayed at WaF, became head of the ballistics department and later took on a teaching assignment at the Technical University Berlin.[16]

Kummersdorf, 1936–1940

In autumn 1936 Dornberger asked Thiel to move from fundamental research to Wa Prüf 11 at Kummersdorf's western testing ground. All topics regarding the engine were assigned to Thiel, and he had to further advance the propulsion, which he managed in a very short time.[17]

Before Thiel could start in Kummersdorf he had to do his military service. From 4 August to 2 October 1936, he was a radio operator in Magdeburg (with the unit 3./N.A.13).[18]

In his paper "Empirische und Theoretische Grundlagen zur Neuberechnung von Öfen und Versuchsdaten, Schießplatz Kummersdorf Vers. West," that he presented on 27 April 1937, Thiel introduces developments that lead to decisive changes, including a shortening of the oven and an optimization of the injection nozzle.[19]

Furthermore, Thiel continued to research different fuel mixtures for the rocket engines. He considered himself as a researcher and scientist, and he was looking for close cooperation with university institutes. Due to the confidentiality regulations of the Heereswaffenamt (HWA)* Thiel was not allowed to collaborate unrestrictedly with the universities. This only loosened up at the beginning of the war.[20]

Thiel was happy in Kummersdorf. He and his family were living in a newly built house in a five-room apartment with a garden, and he bought his first car, an Opel Olympia.[21]

* Weaponry office for the Wehrmacht (unified armed forces of Germany from 1935 to 1946).

Figure 4–2: Thiel's new car, an Opel Olympia. Credit: Archive family Thiel.

In 1937 the first scientists moved from Kummersdorf to Peenemünde. As the test stations were not ready yet, Thiel and his team stayed in Kummersdorf. This provided independence, Thiel was now working on his own, and very successfully.[22] In mid 1940 test stand I was completed, and he also moved to Usedom.

Peenemünde, 1940–1943

The Thiel family moved into an apartment at Hindenburgstr. 56 in Karlshagen, close to Peenemünde. Their neighbors were Klaus Riedel and his family, who lived in Hindenburgstr. 54.

Figure 4–3: The Thiel family with a friend (left) walking home from the beach, in summer 1942. Credit: Archive family Thiel.

Life in Usedom was pleasant if one didn't miss the big city too much. In the summer the beaches on the Baltic Sea provided holidays right on their doorstep. But the family didn't see much of the father. In the meantime Thiel had become director of the development unit, and also von Braun's deputy with regard to development topics.

In 1940 many new scientists were recruited in order to speed up the R&D of the A4. Chemist Gerhard Heller became a very important coworker of Thiel. They also established private contacts.[23] Other colleagues of Thiel at the development unit, who later followed von Braun to Fort Bliss (United States) as the first 118 Paperclip engineers[24] included: Hermann M. Bedürftig, Konrad Dannenberg, Werner Dobrick, Hans Fichtner, Werner Gengelbach, Hans J. Lindenmayr, Dr. William A. Mrazek, Kurt E. Patt, Gerhard H. Reisig, Walther J. Riedel (Riedel III), Ludwig Roth, and Helmut Zoike. Thiel had friendly relationships with the family of Bernhard Gerhardt, who later worked on the Russian space program. One of Thiel's secretaries, Ingeborg Kamke, later married Konrad Dannenberg.[25] Next to the demanding tasks in research and development, the exemption from military duty surely was reason enough for the scientists and engineers to move to Peenemünde.

How was Thiel as a boss? Thiel worked diligently, systematically and very motivated.[26] He demanded the same from his coworkers. He felt and worked like a scientist.[27] "He seemed older, more quiet and wiser...he was more of a serious type and always full of thoughts," said Dorette Schlidt, an office clerk of von Braun, about Thiel.[28]

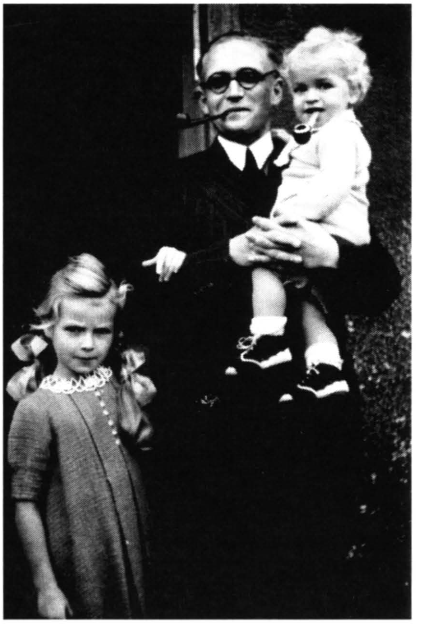

Figure 4–4: Thiel with his children, Sigrid and Siegfried (born September 1941), in front of his house in Karlshagen, Hindenburgstraße 56, summer 1942. Credit: Archive family Thiel.

The scientists' hard and intense work on the A4 project was crowned with the first successful launch from test station VII on 3 October 1942. The rocket flew 190 km in the targeted direction and it reached a height of 85 km. The top-speed was 1,322 m/s.[29] The successful launch was celebrated accordingly at Hotel Schwab in Zinnowitz.[30] As the A4 was now showing military qualities, the NS leadership was demanding immediate implementation in war. Mass production replaced science, although the whole unit was still immature. There were many launch failures after 3 October 1942.[31]

In 1943 Thiel and many fellow scientists and researchers were very exhausted and unhappy in Peenemünde. Work overload, pressure to succeed and the changeover from a research unit to a production facility started to take its toll on the scientists. Thiel refused to declare the rocket engine ready for mass production. In a letter to von Braun, sent during a trip to a health farm, Thiel described the Aggregat 4: "where it is more of a complicated lab product than a mass item...."[32] And he should be right. The A4 was not ready and had no significance to the outcome of the war, even if it was used as a weapon of terror. The undertaken effort, financially and materially, was extraordinary compared to its military performance.[33]

Thiel formulated his protest by handing in his resignation orally on 17 August 1943. He planned to get his professorship at a university. Dornberger rejected his resignation.[34]

During the following night of 17 August 1943, the Royal Air Force launched a bombing raid on Peenemünde (Operation Hydra). The Thiel family died in a slit trench in front of their home in Karlshagen, it is very likely that a bomb hit the slit trench directly.[35]

Figure 4–5: Thiel's destroyed house in the residential area of Karlshagen, view from the garden. Credit: Archive family Thiel.

Thiel was always carrying his pending patents with him in a sealed brief-case. He will have had this briefcase with him during that bombing raid. The briefcase also contained his recognized professorship thesis. The briefcase was not found, it remains missing. It may have burned during the bombing raid. It is unknown at which university Thiel planned to receive his recognition for the "Venia legendi" (teaching qualification), he probably wanted to go back to Schumann at the University of Berlin.

Thiel and his family (wife Martha, daughter Sigrid and son Siegfried) were buried at the war cemetery in Karlshagen.

Figure 4–6: The original grave of the Thiel family at the war cemetery in Karlshagen. On the cross the names of his wife and children were spelled wrong. Credit: Archive family Thiel.

Years after Thiel's Death

On 29 October 1944, Thiel was awarded the Knight's Cross posthumously. The certificate and the cross seem to have gone lost during the wartime chaos. Wernher von Braun wrote a letter to the bereaved parents, in which he describes Thiel's qualities:

> I was present at a speech by Reichsminister Speer, who was praising your son's achievements at the awards ceremony. His statements showed great respect for Walter's achievements within this epochal technology and new weaponry, and even the Führer himself had the highest praise for his findings.... You can be assured that Walter's findings have earned him a monument, which will last forever. His work will have a great impact way beyond the current war events, and it should be seen as a basis of a completely new technology that most people today consider fantastic, and that cannot

> be considered realistic today. ... An old saying says that the real accomplishment of a person will only become visible after his death. The immensely important position Walter occupied has been vacant since August 18, 1943 and he will be difficult to replace. Every day I see how the new staff is closely and strictly continuing to work on Walter's initiated projects, though without being able to develop his elasticity or the amount of new ideas.[36]

Thiel's accomplishments were not forgotten. In 1970 a Moon crater was named after him. It is located on the dark side of the Moon and it is not visible from Earth. (Coordinates: 40° 42' N / 134° 30' W, mean diameter: 32.0 km).[37]

In addition, Thiel was one of the first pioneers to be inducted in the "Space Hall of Fame" in Alamogordo, New Mexico, in 1976.[38]

After Thiel's death the organizational structure war changed, Thiel's successor in the area of testing was Dr. Ing. Martin Schilling[39] whereas Walther Riedel (Riedel III) became head of development and construction.[40] Later both followed Wernher von Braun as Paperclip scientists to the United States.

Support by Wernher von Braun

After the war von Braun supported the Thiel family. Thiel's older brother Herbert wrote to von Braun and received care packages for the parents and his own family, included was the following letter:

> After reading your description about the state of your parents, I immediately initiated a collection for groceries here. Although I don't know the final amount yet, I am very happy to tell you that right now we have collected 60.00 $. And for that money you can buy a lot of groceries and send them to Germany.[41]

Party Membership

The achievements of the scientists in Kummersdorf and Peenemünde were impressive, especially those of Walter Thiel, but the period has to be viewed critically because research and development took place during the Nazi era. One should not forget that the rocket was a military development.

A photo provides proof that Thiel was a member of the NSDAP. The photo shows the party badge. The party membership card has been lost so that the entry date cannot be determined anymore. Thiel was not a member of the SS.[42]

Fuel Optimization

Oberth already suggested using liquid fuels for rockets in the 1920s in order to achieve a higher discharge speed than with solids.[43] In 1931 Paul Heylandt developed a 20-kg thrust engine for the HWA under Karl E. Becker, which was powered by liquid oxygen (LOX) and alcohol.[44] In 1932 Nebel, Riedel and von Braun were also working with liquid oxygen on the rocket airport in Berlin-Tegel, and combined it with gasoline.[45]

Apart from to the combination of LOX and ethanol and/or gasoline, Wahmke was alternatively testing hydrogen peroxide as an oxidizer at Schumann's institute.[46] In cooperation with the institute, Hellmuth Walter (Walter Werke, Kiel) was also doing research with a hydrogen-peroxide-alcohol engine.

Thiel was a chemist, and he was hired by Schumann's institute to do research on fuels. He accompanied the doctoral candidate Seifert, who was working on the process of combustion of the 20-kg engine built by Heylandt: "Bericht über Untersuchungen über die Eignung verschiedener Kraftstoffe als Brennstoff für das Rauchspurgerät II."[47] Here, the LOX/fuel, LOX/butane, LOX/benzene and LOX/varol combinations were analyzed. Thiel utilized the results of these tests later after he joined Dornberger in Kummersdorf West.[48]

Thiel realized very early that the fuel used in Kummersdorf West, a mixture of LOX and alcohol, was not ideal. The boiling point of oxygen is –183°C. It was difficult to keep this low temperature, the oxidizer evaporated easily and the tanks had to be well insulated. Another disadvantage was the icing of rocket components that came into contact with the liquid oxygen. Furthermore, the non-hypergolic fuel needed some kind of ignition. This, for example, came as a glow igniter with a platinum-iridium alloy in 1938.[49] Later, rubidium was used.[50]

A report from 1938 shows that next to the known fuel components, research was also done on an Aurol oven.[51] Aurol was a cover-up name for T-material (T-Stoff), also called H_2O_2 (see Table 4–1).[52]

The exploration of new fuels experienced a real boost by the employment of many new scientists in 1940, among them the chemist Gerhard Heller. Both Heller and Thiel wrote many reports on the enhanced combination of fuels respective patents.

For example, in 1941 they formulated the following:

> a) Contrary to common belief, liquid oxygen is not the most effective, instead it is tetra-nitro-methane, nitric acids and nitrogen tetroxide. The impact of its higher density is that great, that its lower outflow speed...is more than compensated... d) Among the listed fuel combinations are the combinations tetra-nitro-methane-hydrocarbon (diesel, gasoline, benzine) and nitric acid-hydrocarbon.[53]

Next to the A4 engine, Thiel and his crew were working on other projects: A8, A9 (A4b or glider), A10 and on the anti-aircraft missile "Wasserfall" (Waterfall) C2.

As early as 1941, Thiel had made suggestions for a 180-t engine for the A10. He considered the fuel components liquid oxygen and ethanol to be already outdated. The basis was a mixture of "Salbei" (sage) and gasoil (see Table 4–1).[54]

The C2 was supposed to have hypergolic (self-igniting) fuels. Thiel and Heller marked SV-material and visol (a combination of vinyl ether and aniline with a solvent iron compound) as fuels.[55] The research team on the "Wasserfall" rocket included a namesake of Thiel: it was Adolf Thiel, a later member of the paperclip team. They were not related. Adolf Thiel worked at the Technical University Darmstadt with Prof. Walther on the "Wasserfall" rocket.

For security reasons, the fuel components were given code names. The following list shows the used expressions and a selection of components:

Term	Description
Oxidizing Agent	
A-Stoff	Liquid Oxygen (LO_2 or LOX)
S-Stoff or Salbei (sage)	Mixture of: 96% nitric acid HNO_3 and 4% ferric chloride $FeCl_2$
SV-Stoff	Red fuming nitric acid; Mixture of: 90-97% nitric acid HNO_3 and 3-10% sulfuric acid H_2SO_4
T-Stoff or Aurol	Hydrogen peroxide H_2O_2
Combustible	
B-Stoff	Mixture of 75% ethanol and 25% water
Br-Stoff	Gasoline
C-Stoff	Mixture of: 50% hydrazine hydrate, 50% methanol with addition of 0,25% potassium-copper-cyanate as catalyst
M-Stoff	Mixture of: 75% methanol and 25% water
N-Stoff	Chlorine trifluoride (ClF_3), also called C3
R-Stoff	Tonka 250: hypergolic, 57% xylidine $(CH_2)_2C_6H_3NH_2$, 43% triethylamine $(C_2H_5)_3N$
Catalyst	
Z-Stoff	(= Rubid) Solution in water of:
Z-Stoff N	Sodium permanganate $NaMnO_4$ resp.
Z-Stoff C	Calcium permanganate $Ca(MnO_4)_2$ and potassium permanganate $KMnO_4$, Catalyst for T-Stoff

Bertolin or B-Stoff	The abbreviation B-material was used twice (see above). Hydrazine hydrate: solution of 92% hydrazine N_2H_4 and 8% water, Catalyst for T- and M-Stoff
Nebulizer	
F-Stoff	Titantetrachloride

Table 4–1: Used Code Names for the Different Components of Rocket Fuels. Stoff = material. Source: Lange, "Peenemünde," 64[56] and own listing by author[57]

Thiel's professor in inorganic chemistry at the Technical University of Breslau, Prof. Ruff, discovered monochloramine fluoride (ClF) in 1929 and synthesized additional and previously unknown fluorides, e.g. C3, chlorine trifluoride (ClF_3), which was also called N-material (N-Stoff). C3 is a very strong oxidizer. In the early days there were considerations if it could be an addition for rocket fuels. Ruff had good contacts to Schumann and he was willing to collaborate with the institute in Berlin. A special production site for N-materials was set up in the forests around Falkenhagen.[58]

In 1942 Thiel received a phone call from Schumann, who asked him to test N-materials in rocket fuels. Thiel ordered the Technical University Darmstadt to test the N-materials for the use with gasoil and nitric acid. The results showed that the outflow speed increased by only 2 percent, which meant they did not have an advantage to the two-component system.[59] Therefore, the N-materials were not considered by Peenemünde, in addition ClF_3 was highly dangerous, difficult to handle, and it posed a health risk to the workers.[60]

Next to the selection of fuels and oxidizing agents, their mixture ratio "m" was also an important research feature. Dipl. Ing. Dollkopf (Technical University Stuttgart) researched performance improvements of the A4 by applying different fuel mixture ratios. He discovered that there were no improvements between m = 0.8 and m = 1.[61] So Thiel fixed the mixture ratio at m = 0.8 on 2 February 1943.[62]

Nuclear propulsion seemed to become another interesting form of rocket propulsion. In August 1941 Thiel and von Braun requested an appointment with Schumann in order to receive monthly updates on the research development in this area.[63] One of Schumann's numerous positions included the presidency of the Uranverein (uranium club).[64] However, the uranium program could not guarantee short-term success due to dwindling resources, and so this program remained a project for the future.[65]

In March 1943, Thiel wrote to von Braun from the office in Friedrichshafen/Bodensee, and he once again explained the problems of the current liquid oxygen/alcohol fuels: "but I would never start again with liquid oxygen, if we had a new device today. The experience we are gaining now with sage and self-igniting materials with C2 are excellent."[66] During his absence (Thiel took a cure vacation) Heller had to research on the possibility of a hypergolic oxygen-spirit mixture, Püllenberg had to work on a catalytic destroyer.

At the end of the day Thiel had no other choice than succumb to the targets of the Wehrmacht and the demands of war. The A4 went into production with liquid oxygen and ethanol technology. All other fuels would not have been available in sufficient quantities during wartime, and they would have made alterations on the engine necessary.

Years later the research of Thiel and his team were continued in the United States and the Soviet Union, e.g., the Jupiter rocket used a high-molecular fuel—kerosene. The Saturn V—the rocket to the Moon—was powered by hydrogen and oxygen.[67]

Rocket Engine Development

What kind of concrete technical solutions did Walter Thiel provide for the demands of chemical and thermo-dynamic processes in the development of thrust chambers for rocket engines? Until he took over the propulsion development department in 1936, Walter Riedel ("Papa Riedel," Riedel I) and Wernher von Braun were testing different engine models. Wernher von Braun did his Ph.D. with Schumann and explained his experience in his dissertation.

Before Thiel was fully employed, he was already cooperating from Schumann's institute with the developers in Kummersdorf. Probably one of the first improvements of Walter Thiel took place in July 1936: the reduction of the concave part of the combustion chamber 2B9, which generated 300 kg of thrust, from globular to a leveled-out "ramp" with a total range of 60°. All previous combustion chambers had a plug in front of the narrowest cross-section.

Since taking over the development of the rocket engines, Walter Thiel's R&D department was working on a number of rockets with the same or similar exterior and interior design as the Aggregat 3 (e.g., to minimize size and optimize positioning the thrust chamber is always integrated into the fuel tank), and the thrust of the thrust chambers was 5, 10, 60 or 100 t respectively.

In 1937 the military for the first time specifically demanded a rocket that was able to carry a payload of 1 t for 200 km. Thiel complemented the last line of the drawing's table with a combustion chamber with 20 t thrust for one of the first predecessors of the rocket type Aggregat 4.

From the results of chemical tests by Doz. Dr. Fritz Schmidt at the Charlottenburg University of Berlin in 1932 that were pointing toward oxygen afterinjection, Thiel developed in 1937 a new, adjustable thrust chamber head for JATO engines (Type 4B9 for 1,000 kg thrust), which is now conical: 4B12 (Figure 4–7).

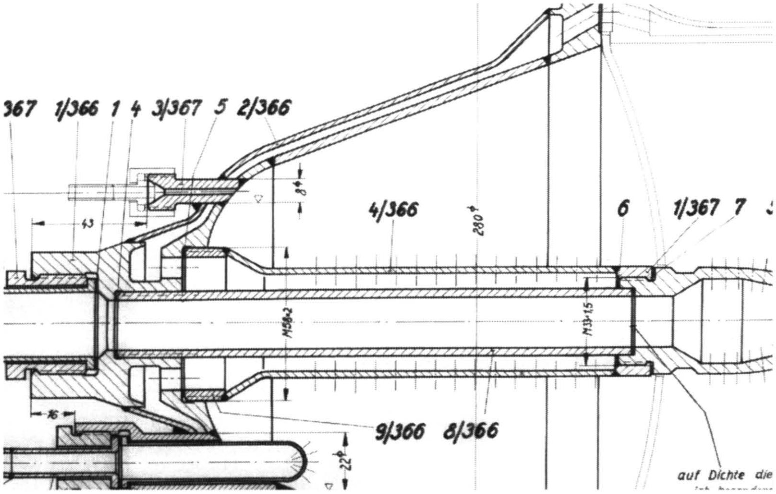

Figure 4–7: Type 4B12.

In addition, a "mixing grid" made of heat-resistant molybdenum was built into the connecting flange that created a "front chamber," and this term is only used in these drawings and documents. In this front chamber oxygen and fuel was mixed with a huge amount of fuel surplus. Three so-called oxygen studs (in Figure 4–7, lying at the bottom) brought the cold medium via so-called pre-injection through the head's narrow diameter. As the inflowing fuel gains volume inside the chamber, the wall "retreats" like a cone and so reduces excessive pressure build-up. Some more oxygen was injected through a central "rod" to the head and now in the actual combustion chamber behind the mixing grid, where it was acting as a so-called afterinjection. In between, around this "rod," lays a paling outer ring as a tubular fuel injector.

As a variant within a combustion chamber with a thrust of 1.5 t, this "front chamber combustion" should gain maximum operational reliability in the Aggregat 5 rockets as of 1938 (but without the mixing grid).

Thiel's findings in "Empirische und Theoretische Grundlagen zur Neuberechnung von Öfen und Versuchsdaten" from August 1937 summarize the until then known rules and principles. His previously stated findings ("to achieve complete combustion, one has to target the largest possible chamber"), somewhat contradict the then applied mixing style throughout the oven itself, although he does go hand in hand with findings of von Braun's dissertation: "An enlargement of the oven's diameter (which prolongs the droplets' stay in the combustion chamber) is therefore generally more rewarding than the extension of the oven's length." (Dissertation reprint, German edition, p. 28). Thiel continues: "While the droplets evaporation route requires a minimum length oven, a good mixture and complete combustion requires a possibly large diameter" (underlined by Thiel).

Finally, Thiel sets up an equation, which for the first time calculates the ratio between the combustion chamber volume (cm^3) and the narrowest diameter (cm^2). Subsequently, he takes these results as comparing figures. Today, we call this ratio "characteristic combustion chamber length" L* (pronounced L star) as a defining comparative value of different combustion chambers.

1 October 1937: A research report on ongoing developments shows that different injection systems were tested in different-sized kilns. A related construction drawing from 30 August 1937, reveals the following (Figure 4–8):

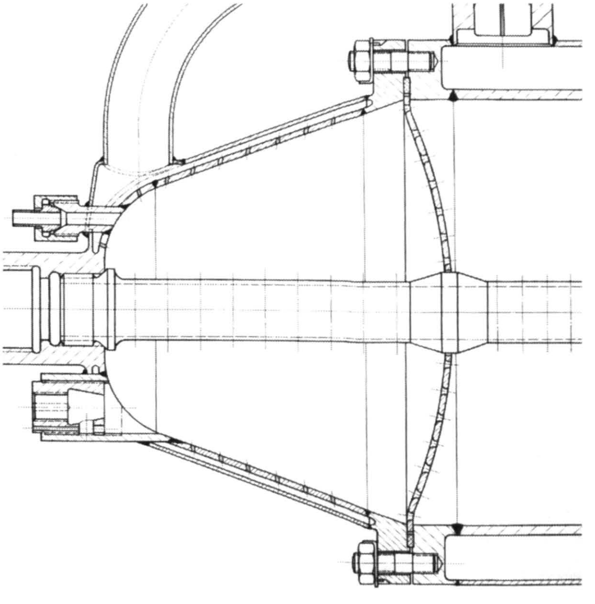

Figure 4–8: Combustion chamber head with drillhole injection.

The above mentioned cone head (Figure 4–7) has not changed its geometrical shape. The mixing grid is still there, and the axial oxygen injection now comes as a volume-related feeding pipe. The most important feature: the fuel has "lost" its central injection position, it has now "moved" to the outside. From there the fuel enters the "pot" through drills in the wall. This constructive change is a fundamental "milestone" of Thiel's chemo-dynamic idea that he utilized for subsequent solutions.

Early 1938: a conical head is fitted with several rows of fuel-injection nozzle insets made of brass that are now adjusted to the thin wall. Similar to the special nozzle, but reduced radically in length and weight, this gyroscopic nozzle went into operation. The following Figure 4–9 displays all previously tested injection nozzles for ethanol fuels.

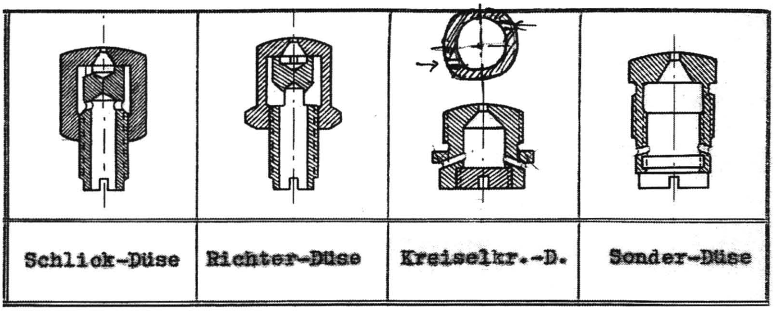

Figure 4–9: Tested injection nozzles.

3 April 1938: Both construction types appear in a patent specification with the title "Rakete" (Rocket).[68] According to the cover letter the patent applicants are Dr. Walter Dornberger in Berlin-Charlottenburg and Dr. Walter Thiel in Kummersdorf (without any reference to a military facility). The patent describes "centrifugal force nebulizers" that atomize the fuel and supposedly increase the combustion chamber's performance by 30 percent compared to "simple blast nozzles."

Mid July 1938: Thiel decides that the developed injection system from the preliminary illustration V 246 (so called "Einheitskopf") from the 1 t-chamber should be transferred to its smaller "sister." The 725-kg chamber is redeveloped (type 5B) for the sole rocket engine of the He 112 V4. With the standardized head and the subsequent optimized mixture Thiel's team was able to shorten the combustion chambers considerably, which was not only advantageous for the cooling problems. Subsequently, the larger chambers could be reduced to one fifth (!) of their previous combustion chamber volume, which provided significant improvements in all directions.

26 August 1938: Systematic tests of Thiel's research team on the testing range P 5 at Kummersdorf with a thrust chamber delivering 100 kg of thrust. The major result was an angle of 30° for the nozzle. This would lead to a significant reduction in material, weight and work processes, as well as a shortening in the length of the engine itself. The 25-t thrust chambers in Peenemünde, built according to the plans in Kummersdorf, would only have a length of 1.6 m, compared to 4.2 m of the 1936 model with 20-t chambers.

End of 1938: By the end of 1938 it was common knowledge that the atomization of the liquid oxygen was not the primary problem. The liquid easily evaporated in the chamber due to the existing differences in temperature. An oxygen vaporizer developed for aircraft thrust chambers was implemented additionally in the 25-t chamber development as of 1939.

The following Figure 4–10 shows a section of a standardized 4B head with a thrust of 1,000 kg and four rows of gyroscopic nozzles with a central LOX nebulizer that also acts as a back-pressure valve.

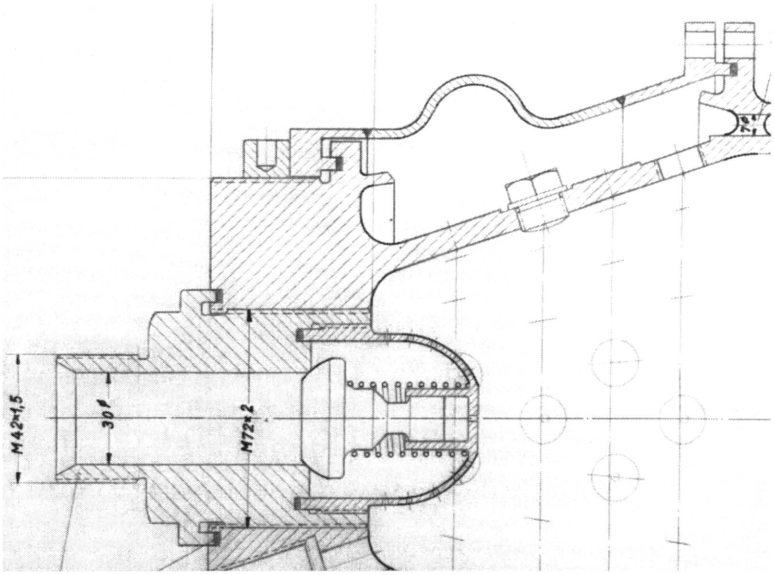

Figure 4–10: "Einheitskopf," Type 4B.

Beginning of 1939: First technical drawings of a large thrust chamber with the name 6B/10 appear on the drawing board in Kummersdorf (type 6B with 10 atü [air pressure over ambient] = 11 bar pressure). There are examples with 19 separate standardized heads from the rocket engine development for planes, adjusted to larger mass flow rates of approx. 1,300 kg thrust on a collective spherical "lid."

These heads from now on are called the nebulizing system. Today's widely used term "pre-chamber" is actually wrong, because the above mentioned mixing grid is no longer present, and so there is no closed "chamber" as such. Only the basic shape is reminiscent of the "chamber."

The philosophy regarding the setup of an optimized vaporisation system meant clear-cut testing with different results. For the optimized positioning of the rocket it is very beneficial to place the thrust chambers next to each other instead of in a line. Different setups of the vaporization system were tested. Here are the versions: on a more or less cylindrical, heavy-caliber upper section Thiel places many nebulizing systems; eight pieces with a thrust of 3,000 kg each are mounted radially and horizontally around the head; another version has the nebulizers placed tilted and upwards, thus streamlining the fuselage; as a "ring combustion chamber" the "pot" is imaginarily cut up and formed as a ring; the preferred version projects the nebulizing system as a single 25-t conical head.

End of April 1939: The very first fire tests with large amounts of thrust fail in Peenemünde on testing range P I. Due to cooling problems in the 19-pot head, especially in the middle section, both 25-tonners explode. Because cooling also occurred through the fuselage's feeding area, there was not enough cooling in the center section.

26–27 May 1939: First successful fire test of a 25-t engine at the Peenemünde P I testing range (roughly 90 seconds). It was an eight-star engine called 6B7K/10 atü (Figure 4–11).

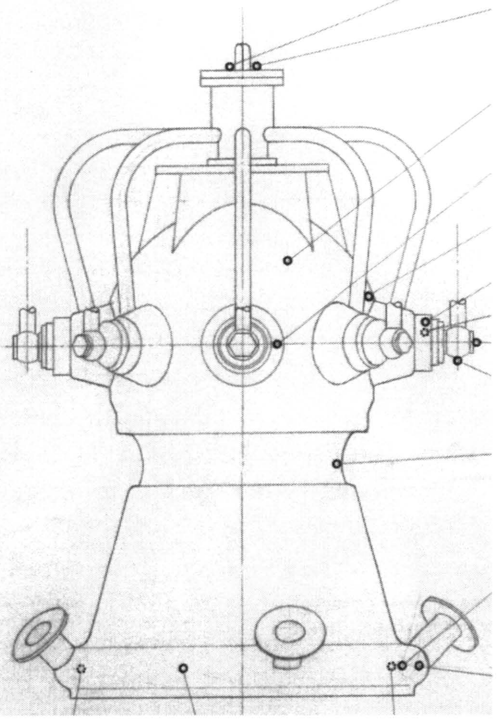

Figure 4–11: The eight-star oven.

As the outflow speed only reached a maximum of 1,200 m/s, Thiel tried to place the nebulizing systems linearly according to the outflow.

2 October 1939: Thiel sends reports on practical tests on small thrust chambers from Kummersdorf. The use of ethanol as a "film cooling jacket" inside the chamber will facilitate the construction of the 25-t engine, e.g., the thick walls of the aluminium alloy are no longer necessary.

29 November 1939: A centrally located valve in the head reduces the number of atomizing systems to 18. In addition this model is designed as a tri-valve construction that provides two "head rooms": coming from the ring area near the nozzle's mouth, the ethanol cools the head, flows into the head's center towards the valve and from there into the upper chamber to the different atomizing systems.

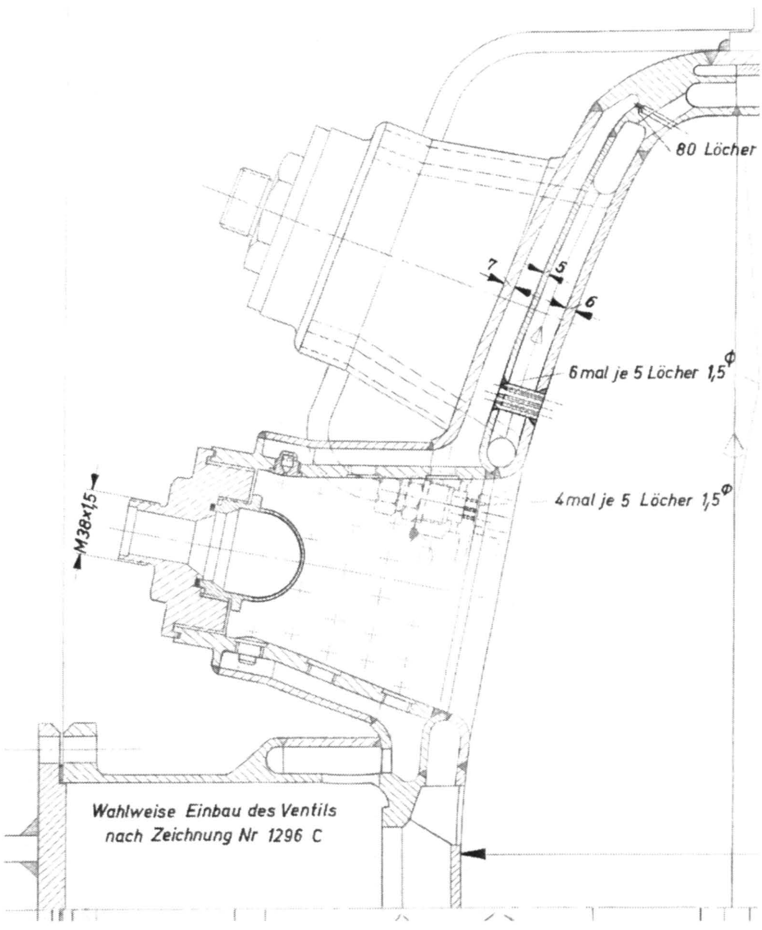

Figure 4–12: Combustion chamber head with two "head rooms."

The shortly afterwards implemented drills for film cooling finally stabilize the engine thermally.

21 March 1940: Start of combustion tests on the 18-pot 13 atü engine on the Peenemünde P I testing range. The very first tests generate high outflow speeds of 1,700 m/s.

17 December 1940: After only 48 tests with seven different thrust chambers the advance development is completed. The outflow speed is now 1,950 m/s. After that the vaporization system was further optimized.

15 September 1941: The final report of the "25.4-t 18-pot engine" is released by Thiel. The outflow velocity is 2,600 m/s at 16 bar internal pressure. The engine's head, made of aluminium alloy, is screwed onto the steel jet for the time being (technical name: "Korbkopfofen 39" for A4, model A).

19 June 1942: The thrust chamber made entirely of steel is ready for serial production (A4, series B). The currently developed vaporizing system will not be altered until the end of the war, and it will later even serve as a prototype for the thrust chamber RD-100 of the R-1 of the Soviet Union.

18 August 1943: Walter Thiel is killed during an allied bombing raid on the north of Usedom, but this has no influence whatsoever on the development of the thrust chamber of Aggregat 4.

(Further sources are in a detailed publication from Dr. Przybilski; not published yet.)

About the Authors

Karen Thiel is the grandniece of Walter Thiel. She is working on a biography about her great-uncle. She is still researching in several archives and museums, e.g., Militärarchiv Freiburg; Deutsches Museum München; archive at the University of Alabama, Huntsville; (Dannenberg estate); and Marshall Space Flight Center, Huntsville, Alabama. She is also looking for private photos, stories and anecdotes. Karen Thiel studied biology (major subjects: biochemistry, molecular biology and organic chemistry) and economics (major subjects: marketing and business strategy). She is working as a marketing consultant for the healthcare industry in Germany.

Olaf Przybilski (born 1960) studied machine engineering for five years at the "Hochschule für Verkehrswesen Friedrich List" (HfV). He received his Ph.D. in 1990 (Dr.-Ing.) and then worked as a "specialist for the prorector for research and scientific talent" at HfV until its closure in 1992. In 2012 he is working as an associate professor at the institute for space technology with the professorship for space systems at the Technical University, Dresden. His works on "newly designed rocket systems" generated a research assignment from the DLR. This assignment will enable the development and testing of combustion chambers for fuel rockets at the Technical University Dresden for the first time since the 1940s. His historic interest goes back to the development of fuel rocket engines of the Heereswaffenamt of the German Reich. These analyses enabled him to gain expertise on German combustion technology that will be published in the near future.

Endnotes

[1] Gerhard H. R. Reisig, *Raketenforschung in Deutschland: Wie die Menschen das All Eroberten* (Berlin: Wissenschaft u. Technik Verl., 1999), p. 31.

[2] A funding scheme for talents, established in 1925, closed in 1936, re-established in 1948.

[3] Walter Thiel, *Über die Addition von Verbindungen mit stark polarer Kohlenstoff-Halogen-bindung an ungesättigte Kohlen-Wasserstoffe* (Würzburg: Dissertationsdruckerei und Verl. Konrad Triltsch, 1935) p. 49 (Danksagung an Prof. F. Straus) and p. 51 (C.V.).

[4] Heinrich Kahlert, *Wirtschaft, Technik u. Wissenschaft der Deutschen Chemie von 1914 bis 1945* (Grevenbroich: Bernadus-Verl. Langwaden, 2001) p. 549.

[5] Heinrich Hauptmann, "Fritz Straus 1877–1942," *Chemische Berichte*, 83, Jahrg. Nr. 2 (April 1950) pp. I-XVIII.

[6] F. Straus and W. Thiel, "Anlagerung von Alkylhalogeniden an die Äthylenbindung," *Annalen der Chemie*, 525, Band, 1936; pp. 151–182.

[7] Walter Thiel, *Über die Addition von Verbindungen mit stark polarer Kohlenstoff-Halogen-bindung an ungesättigte Kohlen-Wasserstoffe* (Würzburg: Dissertationsdruckerei und Verl. Konrad Triltsch, 1935); persönliche Widmung an seinen Bruder Herbert vom 2. Mai 1935; archive fam. Thiel.

[8] Günter Nagel, "Sprengstoff- und Fusionsforschung an der Berliner Universität: Erich Schumann und das II. Physikalische Institut," in *Für und Wider "Hitlers Bombe"* Rainer Karlsch und Heiko Petermann, editors (Münster: Waxmann-Verl., 2007), pp. 235 and 249. Schumann's superior was General Becker (1879–1940), who first was the head of the department of testing at Heereswaffenamt (HWA), before he took over the whole of HWA.

[9] Werner Luck, "Erich Schumann und die Studentenkompanie des Heereswaffenamtes – Ein Zeitzeugenbericht," *Dresdner Beiträge zur Geschichte der Technikwissenschaften*, 27 (2001), pp. 27–45.

[10] BArch Freiburg, Nachlass Schumann, N 822/10, 1961–1970.

[11] Obituary to the relatives of Kurt Wahmkes, 16 July 1935, archive Dr.-Ing. O. Przybilski.

[12] Michael J. Neufeld, *Die Rakete und das Reich: Wernher von Braun, Peenemünde und der Beginn des Raketenzeitalters* (Berlin: Henschel, 1999), 2. Aufl., p. 95.

[13] Walter Dornberger, *Peenemünde. die Geschichte der V-Waffen* (Frankfurt/M, Berlin: Ullstein, 1995), 6. ed., pp. 62f.

[14] E. Haeuseler, "Zur Geschichte der Raketenforschung," *Weltraumfahrt, Zeitschrift für Astronautik und Raketenentwicklung*, Heft 4 (1956); pp. 105f.

[15] Günter Nagel, "Sprengstoff- und Fusionsforschung an der Berliner Universität: Erich Schumann und das II. Physikalische Institut," in *Für und Wider "Hitlers Bombe"* Rainer Karlsch und Heiko Petermann, editors (Münster: Waxmann-Verl., 2007).

[16] Werner Luck, "Erich Schumann und die Studentenkompanie des Heereswaffenamtes – Ein Zeitzeugenbericht," *Dresdner Beiträge zur Geschichte der Technikwissenschaften*, 27 (2001), p. 36.

[17] Walter Dornberger, *Peenemünde. die Geschichte der V-Waffen* (Frankfurt/M, Berlin: Ullstein, 1995), 6. ed., pp. 62f.

[18] Writing on the back of a photo that shows Thiel as a radio operator, archive fam. Thiel.

[19] German Documents Archive, Deutsches Museum München, GD 634.190.8, FE 573, 21. April 1937.

[20] Michael J. Neufeld, *Die Rakete und das Reich: Wernher von Braun, Peenemünde und der Beginn des Raketenzeitalters* (Berlin: Henschel, 1999), 2. Aufl., pp. 95 a. 103.

[21] Letter of mother Elsa Thiel to her son Herbert, Thiel's brother, from 14 April 1958, and photo album from Herbert Thiel, archive fam. Thiel.

[22] BArch Freiburg, Nachlass Schröder, N 773/13, p. 9, 1961–1970.

[23] Letter of mother Elsa Thiel to her son Herbert from 19 June 1953, archive fam. Thiel.

[24] Under the code name "Paperclip," Wernher von Braun and many German rocket scientists were brought to the Unites States in 1945 and 1946, where they would resume their military research work. The files of these scientists had paperclips which gave this operation its name.

[25] Fragments of the autobiography of Konrad Dannenberg, Dannenberg Archive, University of Alabama Huntsville, Alabama, U.S.A., 2002–2003; p. 109.

[26] Walter Dornberger, *Peenemünde. die Geschichte der V-Waffen* (Frankfurt/M, Berlin: Ullstein, 1995), 6. ed., p. 63.

[27] Michael J. Neufeld, *Die Rakete und das Reich: Wernher von Braun, Peenemünde und der Beginn des Raketenzeitalters* (Berlin: Henschel, 1999), 2. Aufl., p. 95.

[28] Letter of Dorette Schlidt (Huntsville, Alabama, U.S.A.) from 17 November 2009 to the author.

[29] BArch Freiburg, RH8-v-1228, GD.600.5.190, Fe 1250, 08.10.1942; S. 2.

[30] Volkhard Bode and Gerhard Kaiser, *Raketenspuren: Peenemünde 1936–2004* (Berlin: Links Christoph Verlag, 2004), p. 33.

[31] Michael J. Neufeld, *Die Rakete und das Reich: Wernher von Braun, Peenemünde und der Beginn des Raketenzeitalters* (Berlin: Henschel, 1999), 2. Aufl., p. 210.

[32] BArch Freiburg, RH8-v-1960, GD.638.0.9, FE 692F (1), 16.03.1943.

[33] Willy Ley, *Rockets, Missiles, and Men in Space* (New York: The Viking Press, 1968), p. 217; and Gerhard H. R. Reisig, *Raketenforschung in Deutschland: Wie die Menschen das All Eroberten* (Berlin: Wissenschaft u. Technik Verl., 1999), p. 609 (please note the mistake in the book: it should say Walter Thiel instead of Werner Thiel).

[34] Walter Dornberger, *Peenemünde. die Geschichte der V-Waffen* (Frankfurt/M, Berlin: Ullstein, 1995), 6. ed., pp. 168f; and letters of mother Thiel to her son Herbert, brother of Walter Thiel, from 19 June 1953 and 14 April 1958, archive fam. Thiel.

[35] Walter Dornberger, *Peenemünde. die Geschichte der V-Waffen* (Frankfurt/M, Berlin: Ullstein, 1995), 6. ed., p. 185.

[36] Letter from Wernher von Braun to Walter Thiel's parents from 13 January 1945, archive fam. Thiel.

[37] http://www.astrolink.de/p012/p01204/p01204091360.htm (Koordinaten); status as of July 2012.

[38] http://www.nmspacemuseum.org/halloffame/detail.php (Walter Thiel in der "Space Hall of Fame"); status as of July 2012.

[39] Michael J. Neufeld, *Die Rakete und das Reich: Wernher von Braun, Peenemünde und der Beginn des Raketenzeitalters* (Berlin: Henschel, 1999), 2. Aufl., p. 105.

[40] BArch Freiburg, Bestand RH8 II (Findbuch), S. XII und XIII.

[41] Letter from Wernher von Braun to Walter Thiel, archive fam. Thiel.

[42] BArch Berlin, Deutsches Reich: Nationalsozialismus (1933–1945), status as of 2011.

[43] Hermann Oberth, *Wege zur Raumschiffahrt*, Reprint d. Ausg. München, Berlin, Oldenbourg, 1929 (Düsseldorf: VDI-Verlag, 1986), p. 5.

[44] Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), p. 229.

[45] Bernd Ruland, *Wernher von Braun: Mein Leben für die Raumfahrt* (Offenburg: Burda-Verlag, 1969), p. 72.

[46] Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), p. 230.

[47] German Documents Archive, Deutsches Museum München, GD 624.6170.3, FE 403, 22.02.1943 (Excerpt from Seifert's Ph.D. thesis).

[48] German Documents Archive, Deutsches Museum München, GD 634.190.8, FE 573, 1937, p. 3.

[49] BArch, Freiburg, RH8-v-1204, GD 600.5.188, 26.08.1938, p. 4.

[50] BArch Freiburg, RH8-v-1960, 16.03.1943.

[51] BArch Freiburg, RH8-v-1204, GD 600.5.188, 26.08.1938.

[52] Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), p. 258.

[53] German Documents Archive, Deutsches Museum München, GD 624.621.8, 23.10.41 a. GD 624.611.28, 14.10.41.

[54] German Documents Archive, Deutsches Museum München, Box 244, HVP-108/46, 18.12.1941.

[55] Deutsches Museum München, ZLDI-Sondersammlung, Arch 110/5, 16.08.1943, Riedel III signs (the document) instead of Thiel on 19 October 1943.

[56] Thomas H. Lange, *Peenemünde: Analyse einer Technologieentwicklung im Dritten Reich* (Düsseldorf: VDI-Verlag, 2006), p. 64.

[57] German Documents Archive, Deutsches Museum München, GD 634.60.2, Arch 110/6, 24.06.1943 bzgl. N-Stoff und Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), pp. 295f, 258 bzgl. Auro.

[58] Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), p. 295.

[59] Deutsches Museum München, ZLDI-Sondersammlung, Arch 20/16g, 22.06.1943.

[60] BArch Freiburg, RH8-v-1216, GD.600.8.2, FE 728/D, 19.09.1942.

[61] Deutsches Museum München, ZLDI-Sondersammlung, Arch 33/7, 29.01.1941.

[62] BArch Freiburg, RH8-v-1954, 02.02.1943.

[63] BArch Freiburg, RH8-v-1260, GD 600.8.6, FE 733, 31.08.1941.

[64] Werner Luck, "Erich Schumann und die Studentenkompanie des Heereswaffenamtes – Ein Zeitzeugenbericht," *Dresdner Beiträge zur Geschichte der Technikwissenschaften*, 27 (2001), p. 36.

[65] Günter Nagel, *Wissenschaft für den Krieg: Die geheimen Arbeiten der Abteilung Forschung des Heereswaffenamtes*, R. vom Bruch and L. F. Beck, editors (Stuttgart: Franz Steiner Verlag, 2012), p. 189.

[66] BArch Freiburg, RH8-v-1960, 16.03.43.

[67] Gerhard H. R. Reisig, *Raketenforschung in Deutschland: Wie die Menschen das All Eroberten* (Berlin: Wissenschaft u. Technik Verl., 1999), pp. 767, 774.

[68] German Documents Archive, Deutsches Museum München, GD 624.194.3, FE 200, 03.04.1938.