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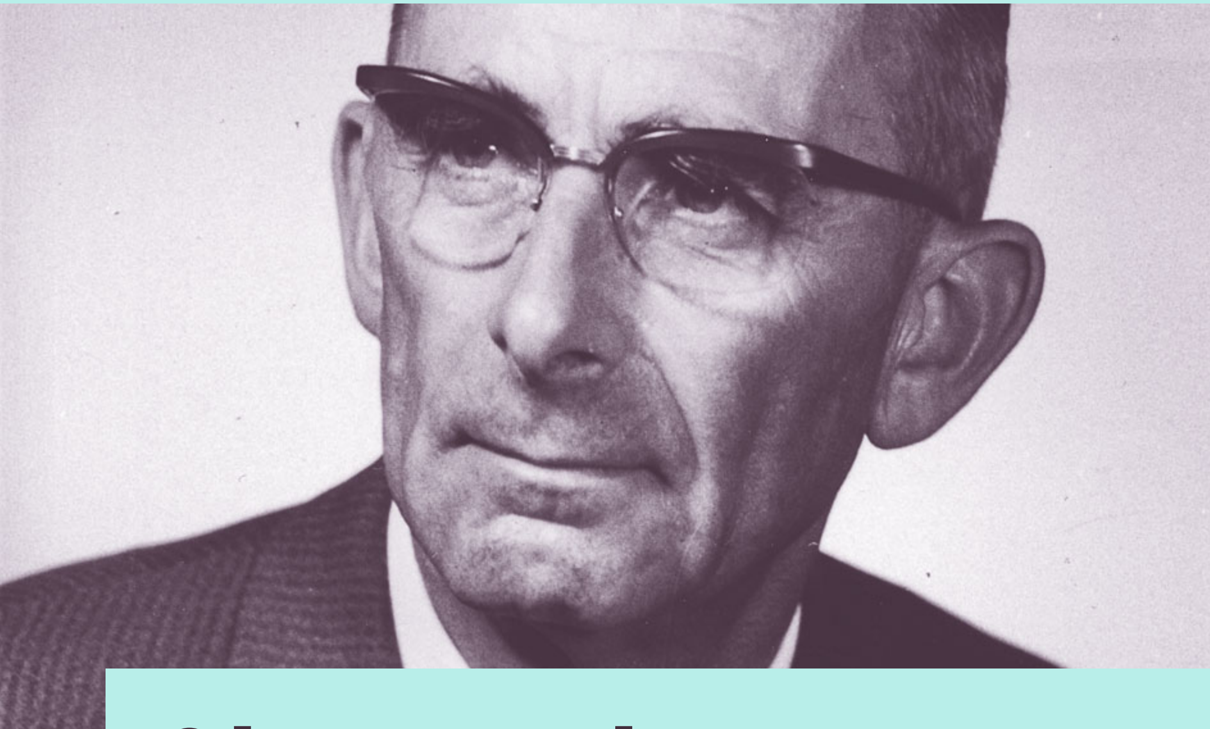

Obsessed by a Dream

The Physicist Rolf Widerøe – a Giant in the History of Accelerators

AASHILD SØRHEIM

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To Professor Tor Brustad
who handed me the baton
- and then cheered me on

Preface

I tell of a man of the world, tall and dark. Particular about his after-shave; trousers carefully pressed; gallant; cheerful in dance and fluent in speech. Knows where the martini glasses are stored, preferably in neat lines. Accurate German grammar. Less accurate English, but enthusiastically expressive. When he addresses a meeting his message is clear, whether it be about the storage of atomic waste or the treatment of cancer.

He is working in the garden, wearing a Mao suit that he bought in China. What will the neighbours think? As if he would bother about that. His wife might, but not him. He has brought some plants from overseas, carefully transported in test tubes in his hand baggage. Home now, he is planting the cuttings carefully in his overgrown garden, which despite all his loving care looks like a wilderness.

When he has a cold, he treats it by dipping a plug of cotton wool in red wine and putting it in his nostril. Doses himself with dietary supplements and just to be sure, thumps his chest seven or nine times. 'Alternative medicine' some ten years before it became fashionable, practised by a man who has several honorary doctorates in medicine and is among the company of the great physicists.

Even before he had completed his doctorate at the age of 25, electrical engineering companies were lining up to headhunt him. Philips, AEG, Siemens, Brown Boveri or ASEA—he has either worked there himself or has good friends who are senior figures in one company or another. Ever since his student days, he has been almost married to his job. But he reads a bedtime story and says the evening prayer with his children every evening. On Sundays he dons knee breeches, packs a thermos and a lunch pack and goes walking with his family, carrying a framed Bergans rucksack, Norwegian 1950's style. The proper gear, no nonsense, and speaking Norwegian. That is when we are Norwegian! Or he takes the car and the old, worn picnic basket with the plastic plates, the cutlery fastened inside the lid with leather straps and a methylated spirit stove to heat the sausages. When the nephews visit during the school holidays he generously takes them along too, even though *they* think he is a miser. The meal service doesn't exactly match their expectations of what a famous uncle overseas can offer, but he is a bit odd, exciting to be with, a perfect uncle.

Formative experience on the ski trails in the Nordmarka forest north of Oslo has grown into a love of the Alps. His three children, one after another, have to be taught the European style of downhill ski-ing. But first they have to climb *up*, preferably alongside the line of the ski-lift. Or he takes them to a chateau in France on a visit to the director of Martell, who apparently is one of his father's business contacts. Or at Easter to a big family gathering at a friend's cabin in the Norwegian mountains. Or to a summer gathering at the family's country house by the Oslo Fjord. High and low. Hut and country house. Never dull. Variety in abundance.

He became a father again at the age of 70. He registered over 200 patents, in various countries. He has medals and honours from all around. He has a research prize named after him. Plays tennis. Ice bathes in his own pool. Swims every morning. Lectures every week, at a prestigious technical school in Zurich. Is brought in as a consultant on major international projects. Manufactures equipment for treating cancer. That is to say, that's what he really does. Either he has deceived the Germans during the war, or *they* have deceived him. Or perhaps they have deceived each other, or us. Who knows? But he doesn't talk about that.

Rolf Widerøe is no ordinary man. Just by being himself, he has a presence, an aura. All who know him become excited when they speak of him: family members, colleagues, others. A mixture of the socially awkward, almost psychopathic, always-far-away-in-his-own-thoughts nerd and the sensitive, warm, playful person, reliable and responsible. Some say he is single-minded and thinks only about his research. But he is sociable, eccentric, excitable, naïve. We could always turn to him when we had a problem. He was close. He was distant. He saw us. He didn't see us.

It all hangs together, but doesn't fully make sense. Not all at once. Or maybe it does. He was so many. You name it. It depends on having eyes to see it. You need to have an eye for nuances, see things from several perspectives, and not try to see everything all at once.

I would like you to meet this person, and I am almost certain you have not heard of him before. But I am almost as certain that having met him, you will wonder why he isn't better known.

But first let me tell you a story of three people.

The Zarephath Widow's Cruse

Once upon a time there were three men from different countries who happened to meet one and the same person, each in his own time and place. None of them knew each other. The only things they had in common were that they had once studied physics and that they had met a man who made a strong impression on them. The first wrote a book about him. The second tried to restore his reputation. The third tried to understand him. The man they had met was Rolf Widerøe.

For the first of them, the story began with a gang of boys in Argentina hearing wild rumours about one of Hitler's miracle weapons. The story continued in Italy and Germany, and ended at Widerøe's home in Switzerland when Widerøe was 90 years old.

The second man's journey was much less exotic—from a reading room at Oslo University, via research laboratories at the Radium Hospital to the Norwegian National Archives in Oslo. With laborious steps, within a radius of just a few kilometres, a quiet drama was building up throughout the second half of the twentieth century, culminating in material form as a bronze statuette called 'The Widow in Zarephath'.

The third man, the youngest, is still in America, wondering about something he heard one May day behind the 400 year old walls of Rosendal Manor amid the fruit blossoms of Hardanger. It has little or nothing to do with what he himself is known for, but it is relevant to current ethical debate about how far a researcher can go in pursuit of his goal.

Each of these three will tell us about *his* Rolf Widerøe. They all have doctorates, but we are not talking science here. They point out, from their own perspectives, their views of a man entangled in rumours and mystery, famous abroad but cruelly and deliberately hidden and forgotten in his own land. Their narratives combine in the story of the German, the Norwegian and the Dane who find themselves 'In a hotel in North Italy', 'In a shielded bunker in the Radium Hospital' and 'In a grand seventeenth century house'.

The German

Pedro Waloschek needs to write a book about him.

In a hotel in North Italy where they are attending a conference, two colleagues are sitting in the bar one evening. They are both physicists, in their thirties and of Jewish origin. They both grew up in Austria. One is called Pedro and one called Bruno. They have had unsettled lives, but they both now live in Italy and they try to meet at conferences. There in the hotel by Lake Como, they spent a long evening as Bruno spoke about an amazing boss he had once had, who sorted out all sorts of things for him, even in his private life. Pedro told me later that his friend Bruno seemed a little eccentric, but the two of them had similar backgrounds and spoke the same dialect. Even their surnames were rather similar, Waloschek and Touschek, and they enjoyed talking together.

That August evening, Bruno spoke about his life during the war. Because his mother was a Jew, he was expelled from high school, where however by a little manipulation of the system he had managed to sit the exam. Then he was excluded from the university in his home town of Vienna. He tried to study in Rome and planned to continue in Manchester, but ended up instead in Berlin to study mathematics and physics, aged 19. There he worked secretly for the Luftwaffe, tasked with doing calculations on a project involving radiation, with none other than Rolf Widerøe as his boss. Pedro continues the story:

> My friend Bruno told me that he had been assistant to an unusually talented electrical engineer from Norway, from whom he had learned a lot. Not only that; this boss had visited him when he was in prison in Hamburg after he had been caught in the act of reading foreign magazines in a library and arrested by the Gestapo. The Norwegian had visited him, bringing cigarettes, schnapps and his physics notes.

At the conference in Varenna, Bruno told many stories about the Norwegian. He admitted that for a while he had thought Widerøe was following a false trail. He seemed obsessed by what he thought was a brilliant idea to build an accelerator that was more effective than any that had been built before. Widerøe hadn't given up on the idea. He was sure it was revolutionary—and he had been right.

Pedro came away with an impression of a remarkable Norwegian who was determined, thoughtful, clever and persevering. A man to be taken seriously.

Pedro had no idea at that time that he himself would meet Widerøe almost by accident 30 years later. However, the coincidences were wider than that, as in fact he had come across him indirectly several times long before. Unknown to him, there had been links as early as his schooldays. The first was when he went to school in Argentina, aged 14. During the war his father, a Jewish architect, had had the right to run his business in Vienna removed and the family had fled to Buenos Aires. One of Pedro's classmates was a German who told him for the first time about 'death rays'. Scientists in Hitler's Germany were apparently building the super-weapon that would make the Allies' planes fall like flies. His classmate had expanded the effect of the wonder-weapon and vigorously maintained that even New York could be bombed in this way. When Pedro came home, however, he learned that rumours of such a wonder-weapon arose from time to time and disappeared just as quickly.

People are still captivated by the dream of magic rays that can be used as a weapon in space and that lie in the interspace between science fiction and reality, between computer games where the enemy is exterminated by a laser pistol and Ronald Reagan's *Star Wars.* But what the boy had said was true. The Germans really did have a death ray project—and it appeared that Rolf Widerøe was involved in it.

When Pedro began his studies, he came across the fascination with rays again. He met a lecturer who was almost obsessed with betatrons and how they were made. So had this lecturer met the machine's inventor? No, far from it, but one of his professors had. The fascination had been contagious, though Pedro didn't understand—at that time—why the lecturer had to promote the science of betatrons to others. As a student in the 1950's, Pedro obviously had no idea who was behind this type of machine. He just wondered why they were required to learn about something so obscure as analysing 'the stability of electrons in a particular type of accelerator, known as a betatron'.

> I was interested in a lot of things, but not particularly in electrons blowing around and allowing themselves to be accelerated in such a gadget.

Forty years later, however, Pedro wrote a book about Rolf Widerøe, the man who had invented the betatron. By then, Pedro had long since completed his doctorate and was now the information manager of a nuclear research laboratory in Hamburg which the Norwegian had in his day been involved in planning. Pedro was about to retire, and from his background in the organisation he had long been aware that here was a story waiting to be written. He sought out Widerøe, who was then almost 90 and was living in Switzerland. The pair of them worked on the project for two years, and the book was published in Germany in 1993. It consists of Widerøe's own memoirs and records of the conversations between the two of them, read and approved by Widerøe himself. It is written mostly in the first person and is considered as Widerøe's authorised autobiography. It was later translated into several languages, but never into Norwegian.

Waloschek had for many years been a correspondent for the monthly journal *CERN Courier*, published by the world's biggest accelerator laboratory in Geneva. The editor of the journal wanted to commission a review of the book about the Norwegian who had been a consultant when the laboratory was set up. Nothing came of his request. The editor wanted a Scandinavian to do the job but found nobody to take it on, whether in Norway, Sweden or Denmark. So the biography of one of CERN's pioneers did not get a mention in the centre's own monthly journal. Pedro said that nobody up there in the North was interested in Rolf Widerøe.

But one person was interested: a retired professor in Oslo.

The Norwegian

Tor Brustad wants to restore his reputation.

In a shielded bunker in the Radium Hospital, a new machine was being installed in the 1950s. A machine to treat cancer, the newest and most advanced in the World, was being fine-tuned. An enormous black colossus of 2 by 2 by 2 metres, well mounted in a shielded bunker, a monster not in the least like today's hi-tech medical equipment but able to produce incredibly strong radiation, 31 million electron volts. A machine specially developed; such equipment is not bought 'off the shelf'. International research had concluded that high-energy radiation was about to revolutionise the treatment of cancer, and Norway's investment was leading the way. Only one such machine had been built before in Europe. A representative from the suppliers, the Swiss company Brown Boveri, is in Oslo to take care of the adjustments.

One day a newly appointed research assistant, Tor Brustad, comes into the bunker, curious about the marvel that they had been busy installing and testing for over a year. He sees a man upside-down in the machine with an adjustable spanner in one hand and a soldering iron in the other.

> I immediately noticed this man in a hospital laboratory coat which had once been white. I assumed that he was a service engineer. Tall and thin. He spoke constantly and enthusiastically; spoke Norwegian in fact. He really *was* Norwegian. He obviously knew what he was talking about, and enjoyed talking about it. I was young and eager to learn, and he answered all my questions thoroughly. This man knew the machine inside out. The factory in Baden had sent the head of their development department himself, a Dr. Rolf Widerøe, to sort out a fault that had cropped up. After a while I realised that this was the man who had built the whole machine.

Now, over sixty years later, that is what Prof. Brustad tells me about his first meeting with Rolf Widerøe. At that time, the Radium Hospital was in the process of setting up a treatment centre that combined medicine and technology. Obvious today, but revolutionary then. Brustad was one of the experts from the University of Oslo brought in to take part in the development. He later became head of the hospital's medical physics department and head of technology and research at the cancer research institute's biophysics department. He started and took part in a specialised medical-technical course at what was then the Norwegian Technical College in Trondheim. He continues:

> At Oslo University I had obviously learned about accelerators and also heard about the new type, called the betatron, which an American was said to be developing. Widerøe, on the other hand, was unknown to me. I had never heard of him during my training, even though I was specialising in nuclear physics.

He realised eventually that the Norwegian Rolf Widerøe from Brown Boveri had been the first person in the world to try to build such a machine. Indeed, it was he who had pioneered the idea of the betatron, which would create many new possibilities by propelling particles on a round course instead of along a straight line. The purpose of an accelerator is to accelerate charged particles to high energy. Widerøe's boyhood dream had been to find an ingenious way to do this. At an early stage, he had the idea that it should be possible to accelerate charged particles in a glass tube shaped like an enormous doughnut. The particles would go round the circuit faster and faster, increasing their energy with each turn.

Widerøe did not manage at first to put his idea into practice. An American, Donald Kerst, built on Widerøe's method and achieved this 13 years later. Now Widerøe had gone on to build a machine himself, with higher energy and greater therapeutic potential than the American model.

After going round the circuit a million times, the particles would achieve a very high speed. For this to happen, there needs to be no hindrance blocking their way; there would need to be a vacuum. A changing magnetic field would impart energy to the particles and a magnetic steering field would hold them in position round the course. When the particles had built up high enough energy, they would be brought out through two small openings in the 'doughnut'. The high energy particles could have numerous applications: in hospitals, to treat cancer; in industry, to show and test the internal structure of materials; and in research, to advance understanding of nuclear physics.

The Radium Hospital had now acquired such a state of the art apparatus. At that time radiotherapy had been shown to be effective in treating cancer. Deep-seated tumours were still a problem, however, because the necessary high doses of radiation would damage the healthy tissues they had to pass through on their way to the tumour. Physicists thought that the solution to this problem was to create X-rays with much higher energy than had been possible before. But that needed new technology. The answer came in the form of what were called accelerators, and the founding father of accelerator technology was Rolf Widerøe. He had built the world's first accelerator, a linear accelerator that had been the topic of his doctorate in 1927, and he went on to develop betatrons that were successful both medically and commercially. Later, he was honoured with numerous prizes and his work came to be included in advanced physics courses the world over. But when young Brustad met him in the Radium Hospital with the spanner and the soldering iron in his hands, not many of those present associated him with ground-breaking science. He was just Brown Boveri's betatron man. The focus of attention was on the epoch-making equipment rather than on the underlying research and how it had come to fruition. Far less on who had first had the idea.

Several decades later the former research assistant finally had time to look further into something he had been wondering about for so long. There was something about Rolf Widerøe, and Prof. Emeritus Tor Brustad wanted to get to the bottom of it. No-one wanted to know about him. Brustad knew that Widerøe had been imprisoned in 1945 and that there had been wild rumours about what he had been up to during the war. He was said to have been almost personally responsible for the bombing of London. But what had he really been doing, and for what had he been condemned? If indeed he had been condemned. What was rumour and what was reality? It appeared that nobody had wanted—or perhaps dared—to approach the subject. Sometimes it even seemed as if somebody didn't want the questions answered, as if the whole problem was too uncomfortable. Why was there an undertone of something 'dangerous' about Widerøe?

Brustad soon discovered that the physicists at Oslo University at that time had not considered Widerøe to be particularly talented. However, when Europe was trying to build its technological capacity up again after World War ll and establish a research environment on a level with the USA, the leading international physicists had unhesitatingly turned to Widerøe. A synchrocyclotron and a proton synchrotron in the shape of a huge doughnut were to be built outside Geneva, on the Swiss-French border. The collaborative endeavour initiated by the *Conseil Européen pour la Recherche Nucléaire* is generally known as 'CERN'. Today, 17,000 people from over 100 countries work there on projects directed towards an understanding of the universe. It is hoped that a giant accelerator will one day help us to understand what the universe is made of and why the fundamental particles behave as they do.

The fact that Widerøe was a consultant on this project from the start was largely ignored in Norway. At the same time, he had a directorship with Brown Boveri at their head office in Switzerland. The company, which today is part of the ABB Group, had apparently made great efforts to recruit him and had given him considerable freedom. He was regularly on the move around the USA, The Soviet Union, China and Australia to give lectures and install betatrons. The same year the treatment apparatus was starting to be installed in Oslo, he was also working in Brussels, Paris, Copenhagen, Milan, Geneva, Berlin and other cities in Germany. Why then was he so unknown among physicists in Norway? It was one thing for the general public not to have heard of him, but fellow physicists? It didn't seem to make sense.

Brustad was a realist and a scientist, He had to make sense of this mystery, strip away the rumours and insinuations, put the facts on the table. So with permission from the Widerøe family he went to the Norwegian National Archives and sought out the documents from the prosecutions in 1945–46. What did he find? Exactly what he had anticipated. Widerøe should not have been imprisoned. Documents that had been locked away for fifty years showed that there had been no grounds to arrest him, far less imprison him. He had not done important military work for Germany during the war. He had never been formally accused of that.

In May 1997 Brustad presented his sensational findings at The First Scandinavian Symposium on Radiation Oncology. In front of representatives from the Norwegian authorities and the international research community he claimed that the time was long ripe to give Widerøe his deserved place as the pioneer of accelerator technology. Widerøe was not a traitor. It was Norway that had betrayed him. The following year, Tor Brustad summarised his source material in an article in the scientific journal *Acta Oncologica*. He asked rhetorically why the inventor of the particle accelerator had been overlooked in his homeland, and criticised the academic community for having reduced Widerøe to 'a footnote in the history of physics in Norway'.

Yes, Widerøe had indeed worked in Germany during the war, from 1943 to 1945. Yes, he had done top-secret research. Yes, he had worked on a project under the control of the Luftwaffe, who had sent German officers to Oslo to recruit him. But his research had nothing to do with the steering system of Hitler's V2 bombs, as had been alleged. During the war years in Germany he had developed a machine for treating cancer, a betatron of 15 megaelectronvolts (MeV), the forerunner of the 31 MeV one he later installed in the Radium Hospital.

Yes, there was a big 'but'. Why on Earth had Widerøe worked in Germany in the pay of the Nazi authorities? Other people than Tor Brustad had wondered about that. The court documents Brustad found in the National Archive had something important to say about that, namely that Widerøe should not have been arrested. But the documents didn't say everything. They clarified the formal account, but said little about the human story. The thin, typewritten A4 sheet entitled 'Treason Case 3418' said nothing about Widerøe's motive, and nothing about which side the man was on.

People had formed their own conclusions, but now there was someone who was trying to think a little differently.

The Dane

Søren Bentzen tries to understand him.

In a grand seventeenth century house, Rosendal Manor by the Hardanger Fjord, the Dane, Søren Bentzen, is among the gathering of cancer and radiotherapy experts attending a conference in spring 1997 in connection with the centenary the previous year of Wilhelm Röntgen's discovery of what later came to be called 'Röntgen rays' or 'X rays'. One of the contributions makes a particular impression on Bentzen. It is not what you would expect in a room full of cancer researchers. It has no formal technical language and not a single Latin expression. It is about Rolf Widerøe, who had died the year before and to whom the speaker thought great injustice had been done, especially by his own people. The speaker—Tor Brustad from the Radium Hospital—delivered a strong personal appeal to give Widerøe the honour and respect he deserved for his scientific achievements and to do him justice by restoring his public reputation, now that the finds in the archives had cleared him of the accusations of having developed German weaponry.

'That's all very well,' thought Bentzen, 'but what about the ethical issues Widerøe must have faced?' Bentzen recognised in these the same issues as he himself had faced in his research. This was the aspect of Widerøe's story that gripped Bentzen. What is right and what is wrong when you choose whether to research a topic or to listen to conflicting advice round about you? Bentzen had studied both physics and medicine and was world-renowned in the field of medical ethics. He eventually became a professor at the University of Maryland School of Medicine, USA. He has held numerous appointments in medical physics and published many academic papers.

After the seminar in Hardanger, Widerøe's fate continued to fascinate Bentzen. The more he thought about this man, whom he didn't really know very much about, the more fascinated he became. He must have had an interesting life, with his important positions, many friends, healthy leisure pursuits and countless business visits to many parts of the world. Altogether this appeared quite normal, but Bentzen saw that Rolf Widerøe had faced a stark choice, whether or not to go to Germany in 1943. That must have been an almost existential problem for Widerøe in 1943, when his country was occupied by the Germans and people saw the situation as black and white. Are you for us or against us? Widerøe faced a fateful decision, and its consequences affected the whole of the rest of his long life.

Researchers are coming up against more and more moral and ethical questions. Should we carry out research on fertilised eggs? A pig's heart in a human being, is that going too far? What about cloning a sheep? A cow? A human? Bacteria that feed on oil, so that we can win more oil from the North Sea? Great! But what if they damage the marine environment? Should we permit a trial, or should we do more research first? Or stop the research? Should we allow good to be done even when it can lead to something bad? Is the best the enemy of the good? Such are the eternal dilemmas that a researcher faces. As an expert in ethics, Bentzen knew a lot about this.

Almost ten years later, in September 2006, Bentzen came across Widerøe's story again. This too was at a medical conference in Norway, and this time he was one of the speakers. This time too, what absorbed his attention most was not recent therapeutic advances. He was to be awarded the Widerøe Prize and had to give a speech of thanks. The prize takes the form of a bronze statuette named *Enken i Sarepta*, a reference to the story of the prophet Elijah and the Zarephath widow's cruse, and crafted by sculptor Nina Sundbye. The National Radium Hospital in Oslo was celebrating the opening of its new radiotherapy building with a two day conference called *The Rolf Widerøe Symposium—Advances in Radiation Oncology.* Clinicians and scientists from USA, Germany, Sweden, Ireland and Norway would be speaking. Among those present were officials from the Department of Health, the President of the European Radiotherapy Organisation and other important people who are included on such occasions. The wording of the invitation indicated that something had changed:

> To recognise the importance of research for the development of radiotherapy, the programme will include the award of the Widerøe Prize. This is awarded to a scientist who has made a major contribution to the development of cancer radiotherapy. It is awarded in memory of the Norwegian physicist Rolf Widerøe, who created the foundations for the development of modern radiotherapy and radiotherapy machines.

The invitation was signed by the head of the clinic and the head of research. The statement could not have been more clear. Widerøe had been officially and formally recognised, once and for all. The oncology establishment had quietly and calmly given Widerøe his place in the official history of radiotherapy. Tor Brustad's rehabilitation project was taking effect.

In his speech of thanks for the prize, Søren Bentzen tells the international gathering that 'There is a direct line from Widerøe's creative genius to the high-tech cancer therapy machines we see here today'. And so he continued his speech, talking not about technological details but about Widerøe's life history, which he had been interested in ever since the conference at Rosendal Manor.

Bentzen continued from where Prof. Brustad's documentation had left off. He tried to think himself into Widerøe's situation and imagine what had led him to his fateful decision to go to Germany during the war. He had come to this conclusion: 'Widerøe was *not* a victim of his political convictions', he said with the emphasis on '*not*'. He was quite simply a human being, a scientist who became a victim of his professional commitment. That is what fascinates me, and perhaps that is what we can learn today from his story'.

Bentzen may have been talking not just about Widerøe's choice and his day to day life. He may have been talking about all researchers who face the ethical problems that modern research has put into the order of the day and that can't be answered by looking them up in a book. He may also have been addressing politicians who have to deal with such impossible questions because they are required to take a position on them. Most of all, perhaps, he may have been talking to himself as a member of international research ethics committees expected to give advice on questions which people have barely been able to formulate fully and to which nobody has yet drafted answers.

It's about the conflict between pursuing one's research objective and at the same time considering what is right. Researchers have a lot of power. When should they use it and when should they *not* use it? Is it the researcher's responsibility to say 'Yes, that's fine' or 'Stop, I won't take part in this?' Or should others do this?

'The researchers have the responsibility. Most people are not qualified to understand the issues'.

'Of course not,' comes the reply, 'people have to use their common sense'.

'Really?'

The more voices join the clamour, the more difficult it becomes for public and politicians when they either cannot form an opinion or are divided in their views.

The hard, practical choice that Widerøe faced in 1943—whether to work in Germany or not—is beyond the experience of those of us who were born after World War ll. Nowadays we all think more globally, but at the same time more individually.

For today's 'Generation Me' who are raised across borders and want to make their own way in life, the problem is almost incomprehensible. There are so many wars. You can't stop living because of that. 'I have my own life to think about'. Many people also thought thus prior to 1940. But war affects a population, new norms arise, new things appear self-evident. War is war.

The fact that the world has changed doesn't exactly make it easier to put oneself into Widerøe's situation.

'Which glasses shall we use to look at it? Old or new?'

'Old, because that was when he lived'.

'But if those who think Widerøe was ahead of his time are right, what then?'

'Then you can use today's glasses', another voice says alluringly.

'Forget the glasses', calls another. 'Try to stand in his shoes'.

'Is that possible? To see things from somebody else's position?'

'Well, apparently not, but perhaps we should try'.

Bentzen had a lot to think about after the meeting at Rosendal Manor.

Not Finished Yet

So, German Pedro Waloschek published a biography of Widerøe in Germany. Norwegian Tor Brustad went to the National Archives in Oslo, found documentary evidence that Widerøe should not have been arrested, and published his findings both orally and in print. Then Dane Søren Bentzen was awarded a prize for building upon Rolf's pioneering work in radiation oncology. All three have continued to think about Widerøe.

Brustad was inspired by Widerøe. Bentzen was inspired by Brustad. From before, we know that Widerøe inspired Bruno Touschek, who inspired Pedro Waloschek, who also influenced Brustad. The main character, Widerøe, had also inspired Bentzen directly, as he had once inspired Lawrence and Kerst. He himself had been inspired by Einstein, Rutherford and a whole list of great scientists. To inspire and to be inspired—all according to talent and opportunity and the time one has been allocated on Earth. There is always enough for everybody to marvel over.

There is also more than enough for the three secondary characters in our story, the three men who each in his time had come across the remarkable main character. In a hotel in North Italy; in a bunker in the Radium Hospital; in a seventeenth century manor house. On different errands; in different places; at different times. Waloschek, Brustad and Bentzen. A German, a Norwegian and a Dane who couldn't forget him. The first succeeded in writing his book, the second cleared his reputation and the third thought he had found some sort of explanation for his choice during the war. But none of them was finished with him. They had not emptied the widow's cruse.

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For there was more to be discovered, that nobody knew about. There were archives yet to be explored, conversations that had not yet taken place. Was it right of Pedro Waloschek to get caught up in Hitler's radiation weapon? Didn't Tor Brustad try to understand Widerøe by portraying him as a humanist and a man trying to do good? Did Søren Bentzen make him undeservedly a passive sacrifice for his scientific ardour? And what about people who are still unheard, stones that are still unturned? Do we know everything about his role during the war?

This book could have been an anthology of accounts from people who had met him or had told about him—the German, the Norwegian, the Dane and all the others. It started out as that, a pious wish by the author to assemble and edit copious and widely varied material into some sort of a unified whole. To find the sum, and perhaps even the truth, in all that had been written and said. Bring it out and up into the light, so that the man could get the place he deserved. Not to make him either greater or less than he was.

But then it appeared that there was more material to draw on. So much that had *not* been said or written about this man who lived for almost a century. Born 1902. Died 1996. Known throughout the world, except in Norway.

Have you only heard of one Widerøe?

The one with the airline?

Yes, that's right. That's his brother, Viggo, a pioneer of flight.

But Rolf flew at least as high in his own sphere, physics. And he had a mysterious past, of which his brother was a part.

Oslo, Norway Aashild Sørheim

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Rolf Widerøe's life spanned most of the twentieth century, from 1902 to 1996. Many of the people who knew him and assisted with the research for this book had retired or died when the Norwegian original was published in 2015, and others have retired or died since. I have been able to thank them all personally as the work progressed, but I now express my thanks again both to the living and to the departed, without distinction.

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It all started with an invitation to Professor Holtkamp to speak at a symposium organized at the *Rheinisch-Westfälische Technische Hochschule* in Aachen in honour of Rolf Widerøe, who completed his PhD there in 1927. Professor Holtkamp appealed that 'it was time to make the book available to the accelerator community as a whole'. He declared that 'It is our heritage and the beginning of what we call today "Accelerator Science"'.

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Publishing this book as an open-access monograph ensures that students across the world, including those based in less favoured countries, will have the opportunity to learn about Rolf Widerøe's contributions to accelerator physics.

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Oslo, Norway Aashild Sørheim
2019

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A Comfortable Home

'Can you pass me the sauce please, Aunt Else,' asks Unn, one of the oldest grandchildren, a big seven year old girl. We are at Sunday lunch with Theodor and Carla Widerøe and their family at their house in the best district of Oslo in autumn 1943. They are all here, all who are in Norway or are not busy. So much has been happening. Little Arild, who is now five, is here for the first time. He was born the year after his uncle crashed his plane over the Oslo Fjord. Little-Rolf, two, is trying to sit nicely. He knows that he has to be on his best behaviour at his granny's and grandpa's house in Borgenveien.

It's good that the little ones are there, because this helps to preserve the rhythms of normal life. In a big family, there's always something. Nobody quite got over Arild's flying accident. Then came the war. Viggo was arrested quite early on and sent to a prison in Germany. Worse than that, Rolf the eldest son had taken up a position in Germany.

Viggo had been condemned to death, but the sentence had been commuted to ten years in prison. So far as they knew, he was still alive. They couldn't say much about that, but could only hope for the best. It was wartime, and people were being arrested. He had been betrayed by Finn Kaas, one of the worst. But what could they do? They didn't know very much, anyway, though they had managed to find out that he was now in *Fuhlsbüttel* Prison in Hamburg. Just think, it was now over two years since he had been arrested. They had managed to cope somehow, for the sake of the children if nothing else, and for the sake of their daughter-in-law, Solveig, with her two children aged four and six. For everyone's sake, really.

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The elderly couple missed all three of their ‘boys’ as they sat round the lunch table there in Borgenveien, but that was just one of the many things that had been turned upside-down. The war changed things for everybody. Two of their daughters, Edel and Else, were still in Norway, though Else’s husband had had to flee to Sweden. The youngest daughter, Grethe, lived in Stockholm.

There must be some reason why Rolf had taken a job in Germany, but it was an odd thing to do. Especially as he was so talented. And to think that he was in the same town as Viggo. Yes, it’s a strange world.

This particular discussion never really did take place among the extended Widerøe family; but it could have happened, with different details, when various combinations of grown-ups and grandchildren were there. Grandfather Theodor and Grandmother Carla were the gathering point. Their house in Borgenveien was the base and the focal point for a whole generation of the children of the family and their parents. Little-Rolf and Arild – for there were a Rolf and an Arild in that generation too – and Turi and Thor and Aasmund and the others can tell us a lot about that. They were always there for Christmas and birthdays, and on Sundays when they took part in family devotions before being allowed out to the garden to play. Life went on as normally as possible in what today we would call a comfortable home.

Describing the scene around the table, we didn’t include Rolf’s wife, Ragnhild. For some time, she was a less frequent guest at her in-laws. It was easier that way. We have built up our Sunday lunch scenario from what the generation of children saw and heard and have later told us about, recognising that they may not have fully understood at the time and that they may not remember everything from so long ago. Some of what they tell us is from what they themselves only heard about later, when they were adults. The lasting impression is of an extended family who were happy when they came together, either in ‘Borgenveien’ or on ‘Skjæløy.’

The country property on the island of Skjæløy in the Oslo Fjord was also important to the Widerøe family. Shortly before the war, Rolf’s father had sold his stamp collection and bought Skjæløy, a two and a half acre property between Hankø and Hvaler. ‘There is a time for everything,’ he reckoned. Now was the time above all to keep the family together. Here they held open house, with sunshine and bathing throughout one long summer. Everything was carefully recorded on Ragnhild’s camera and Rolf’s 16 mm. cine-camera. Rolf’s sister Else later inherited the property, with room for everybody in her house and her heart. Rolf and Ragnhild holidayed there with their own children more or less every summer, even though they lived in Switzerland, and they often had some of their children’s friends there too.

At the Same Time, Somewhere Else

That same year, there is another scene to be chronicled in the Widerøe saga. Here there are only two members, Rolf and Viggo. A German prison: Rolf in the business suit he wears at his work *for* the German authorities; Viggo thin, ill and in prison uniform because he had worked *against* the Germans. One employed by the Luftwaffe on a project developing weapons to shoot down allied planes; the other, an airman, imprisoned and condemned to death for having helped Norwegian resistance fighters to escape to England.

Their family back in Oslo round the Sunday lunch table missed them both, and didn't hear of the meeting until later.

If Theodor and Carla had been able to look into a crystal ball, they would have seen remarkable patterns of Europe's future in their family gathered round the table: a ballroom dancing teacher who married an architect from Yugoslavia; a professor of medicine; a jazz promoter and record producer who brought American stars to Europe; the Western world's first female commercial airline pilot; finance and business people; engineers, editors; more doctors; and several other occupations. In a family with six children, there were always many people round the table for family celebrations, even though there was always somebody or other missing for one reason or another. Nevertheless, Theodor and Carla would not have been entirely surprised by a vision of their family's colourful future. The Widerøes had always been pioneers following their own path.

A Family of Entrepreneurs

This was a time when the boys in the household got the best bits of meat and the girls got what was left. Carla was very ambitious for her children. Money would be spent on their education. The girls were to marry well and to be trained in sewing, languages and cooking, preferably in a finishing school in Switzerland or Germany – but they achieved more than that. Take Grethe, for example, who got her pilot's licence at the age of 17 as one of the first female pilots in Norway. Take Edel, with her skill as a telephone switchboard operator. Think of Else; when German soldiers knocked on her door to requisition her house she answered them politely in German, '*Kommen Sie bitte, herein*' ('Please come in'), but added that she felt obliged to warn them that they had tuberculosis in the house and there was danger of infection. The Germans, fearing infection more than anything else in the world, said 'No, thank you' and left the occupants undisturbed, all of them perfectly healthy. After the war, as a single mother, she and a friend started Norway's first locum bureau service, Contact Service AS.[1] The younger generations continued the business she had founded and developed it through the companies *Norsk Personal*, *Olsten Personal Norden*, *Adecco* and *Amesto* into what is today the 100 per cent family owned business *Spabogruppen*, a Scandinavian enterprise with about a thousand employees. Else outlived all her brothers and sisters, and was still driving a car well into her nineties[2].

Arild and Viggo were pioneers of flight. Viggo was the outdoors man who roamed through the mountains with dogs and a reindeer-skin sleeping bag dreaming of becoming the new Nansen or Amundsen, until the sport of flying became his passion. Taking over his father's wine import business would have been alright, but starting his own airline would be even better. Founding an airline would be difficult enough, but in those days he would first have to explain to people what a plane could be used for in everyday life. It wasn't so long since the Wright brothers had first flown and Lindberg had flown over the Atlantic.

The other brother, Arild, had piloted airmail flights in America. Then together they established the first airmail service in Norway, between Oslo and Haugesund, and flew often in North Norway. Then followed several adventurous years of taxi flying and demonstration flights, which led to the founding of Widerøe Airlines. Over eighty years later, it is one of the oldest airlines in the World still operating.

The venture into flight took off with the legendary demonstration on 14th October 1910 at Etterstadsletta in Kristiania, as Oslo was then known. This became a gathering point for the first Norwegian flying enthusiasts. The plane was transported to the town by train. Very few people had even seen a picture of a plane at that time; now they could see a real one. 'Everybody' was there. There is no exact number, but between 10,000 and 30,000 people saw the Swedish Baron von Cederström make the first flight in Norway. History was being made in a mixture of ceremony and madness.

Theodor was there with Viggo, who was then aged six, and eight year old Rolf; Arild was too young to come. For Viggo, this was a life-changing moment. He watched wide-eyed as the mechanic swung the propeller round to start the engine and the plane took off, flew a circuit over the city centre, swung out over the fjord and came back again to land 23 min later. Everybody stretched their necks up to watch and cheered loudly. The flying baron with the leather helmet was given a hero's reception and carried aloft in triumph. Viggo decided there and then that he would be a pilot. He started with model aeroplanes and aeronautical magazines from abroad, until he was old enough to join the Naval Air Division, where he trained as a flying officer. His dream was being realised, but it wasn't over yet.

The Eldest Son Would Study

And then there was Rolf, the eldest son, who was interested in science and who did his Ph.D. in Germany. Not many people could go abroad to study in 1920, but the Widerøe family was well-to-do and was both internationally and academically orientated. Theodor and his brothers had also had higher education, and several of them were university graduates. The family tree included doctors and theologians. Germany was the leading country in engineering at that time, and in most European countries the engineering textbooks were in German. If Germany was best that's where you went, even though it was a longer journey in those days than it is now. That's how it was in the Widerøe family.

Rolf stayed on in Germany after his course of study was complete. Many of his colleagues thought that he *was* German, but he didn't like that. Abroad, he was described variously as Swiss, German and Swedish, but he was really Norwegian. He was born in West Aker, which at that time lay just outside the city of Kristiania (now called Oslo). He grew up there in Vinderen and attended Halling School in Oscarsgate. He remained a Norwegian citizen throughout his 94 years. He eagerly kept his Norwegian identity, even though he lived most of his life in Switzerland.

Ham and Aquavit

Theodor, the father of the clan, was a businessman, the general agent in Scandinavia for the import of French wine and Martell cognac. He was also the wholesaler for Aalborg aquavit and Dutch vegetable oil for use in margarine production. The family of eight plus was governed firmly by Rolf's mother and lived in a villa that is owned today by Pål Waaktaar, a singer-songwriter and member of the pop group, *a-Ha.* There were mother, father, three sons and three daughters. The 'plus' was for many years the children's 'Granny,' Carla's German mother. Theodor's widowed mother, whose husband had been a priest, also lived with them for a while. And then there was Aunt Polly, an unmarried friend of mother's, who also stayed with them from time to time. The six children were born between 1902 and 1915, and all grew up here: Rolf, Viggo, Edel, Arild, Else and Grethe. With piano playing, entertainments and a large circle of friends, and not least, exploring the woods and hills around the city.

An old-fashioned home, perhaps, but more than that. The children's friends came out and in, sometimes the basement resembled a wine-cellar, Viggo and Arild's airline colleagues stayed overnight in the attic, the airline company held board meetings and in the midst of all this the mother of the house proudly cured hams. At the same time, it was strict. You didn't go into the study without permission. And sober. The three boys shared a room until they were grown up; likewise the three girls. Granny had the fine big room with the veranda. The maids needed a room too. Everybody in the family has their own memories, but these all have a shared theme; life in the Widerøe house at Vinderen was never boring.

> 'Carla was more strict and Theodor was kindness itself,' one of them says.
>
> 'For me, grandfather in Borgenveien was somebody you respected. And grandmother, she was one of the best people you can imagine, she was so kind,' says another.
>
> 'She was the strict Germanic type. He was gentle,' says a third, quoting grandfather's frequent response, 'Yes dear.'

So it seems that Rolf's parents in Vinderen in Oslo were both kind and strict.

Whichever member of the family you speak to, they all talk about the hiking trips in the hills and woods around Oslo. About skis and mushrooms and resting places. When I asked Rolf's sister, Else, to tell me about their childhood, this was the first thing she spoke about. She still lived at the edge of the forest and she said that her father was an exceptional outdoorsman of the old school. Rolf too, summer and winter, whenever he had an opportunity. 'They were almost born and brought up in the Nordmarka woods and hills,' she said. 'They were quite crazy about it.'[3]

She went on to tell me that when her brother was home in Norway he would take her sons, the same age as his own, on hiking tours when they would sleep out in the woods. Proud of her brother, she hastened to add that he was also musical and played the piano. Took to it easily. Played a lot of Grieg. She herself both sang and played; it was part of their upbringing. She was proud of Viggo too. He played the violin, and had once played in the concert hall.

When Rolf was interviewed at the age of 90 in connection with Pedro Waloschek's book, he too started by talking about Oslomarka and his father and the ski tours they had done together. Father and son understood each other, as Rolf put it, and their shared interest in the great outdoors was an important part of that. An entry in his diary shows that this wasn't just boasting. On Friday 2nd November 1917, when he was 15, he wrote:

> We have a day off school today. We've had a very exciting trip, Eilif, Frits, Pil, Angri, Viggo and I. We looked at the ski slope in Skaandalen and went up to Tryvandstaarnet. Then we took a very exciting route down through the woods, away from the beaten tracks. On our way we came across a beautiful little mountain lake where we had good fun.

Rolf wrote enthusiastically in his diary about such expeditions, just as he did about physics experiments. On Friday 5th October, for example:

> Kaare came to see me in the afternoon to talk about a trip tomorrow. I showed him the arc light, the telephone inductor, the induction apparatus, the telegraph, the scrap transformer and all my stuff. He was amazed and interested.

The following day he reports on the outing:

> Took the tram up to Holmenkolden with Kaare. Then had a three hour trip to Kolsaas. It was rather long, and my legs were tired. We had a fine view from Kolsaas. Then we went down to Stabæk and took the train home.

Spent 30 Øre on Steel Wire

That autumn he went into the first class at senior high school, known in those days as 'gymnas.' Not many teenagers commit so many formulae and notes about volts and watts to their diary. With pen and ink, he kept a log of his experiments alongside reports of broken light bulbs, poor marks, small loans and preparations for confirmation. On Sunday 7th October he wrote:

> Have been to church with Dad and Herbert. Kjeld Stub spoke well, but I was not greatly moved by him. I have turned the current limiter up from 2,000 watts to over 3,300 watts. I had to write an essay this afternoon. In the evening I came across a new phenomenon. The light went out without any problem with the fuses. The current limiter had gone wrong. I got the light working again, but the fault wasn't properly solved and repaired.

Sunday 11th November:

> K $I_1 = 0.1$ V. K $I_3 = 0.3$ V. I had to go to church again today. Frits and Eilif came with us. Kjeld Stub preached splendidly, and I was in full agreement with him. Have found out how to make N_2H_4 and HN_3.

When he spends 30 øre to buy fine steel wire for his experiments, it is recorded in his diary. Small and not so small everyday events are noted, such as the fact that the electric light experiment was successful after a little trial and error, just by putting a few pieces of soap into the water, or that:

> Things went as badly as they possibly could for me in French today.
>
> Have borrowed 1.25 kr from B. Næss and I've bought Chemi der Kohlenstoff [*The Chemistry of Carbon*] ll and lll. BF = + 1.25 (kr). K $I_1 = 0.2$ V. K $I_3 = 0.85$ V. It's still raining.

Problems with the fuses are a recurrent theme, for which he often blames his clumsy-fisted brothers. Big brother Rolf is trying to be responsible. His main concern is to maintain the power supply to Granny's room. But on Monday 8th October it happens again:

> This morning the current limiter went crazy again. We had no power at all until I was able to get it sorted. In the afternoon it went on bouncing up and down all the time. We had about 2,600 and everybody was complaining loudly. When I went up to have a look I found that several parts of the current limiter had melted in a nasty spark formation. The current limiter is now running between 3,000 and 4,000.

The language in the diary is direct and to the point. Not very elegant, stylistically rather chaotic. But if writing a diary at the age of 15 is about putting onto paper the contents of the day and your head and your heart, it gets full marks for content. And for fine writing. There is nothing to suggest that it has been locked away and kept secret. It is just an ordinary, lined notebook. He obviously confesses to his diary. The notebook is of the type he used all his life to make sketches and notes. His name and the from—and to—dates are on the front page, but there is no extra warning note such as 'NB! Strictly private.' His eldest son gave me the diary with a simple 'There you are,' together with other written material his father had left. So let us assume and hope that the writer would have thought it good that now, so many years later, we can share his confidences in between the formulae, such as when he was philosophical and in love on Thursday 18th October 1917:

> This morning K $I_1 = 1$ V Now at mid-day K I_1 is swinging between 1½ and 2 V. In the afternoon as I was walking back from the orthopaedic clinic I saw Elsie coming down Hegdehaugsveien. I greeted her and she responded and just her glance, her eyes, were enough to make me incurably in love with her. The human being, that is I, am a remarkably complicated person, when I am free from that sort of thing I think it over as if I was unassailable. 5 min later a single glance from Elsie is enough to drive me crazy. K I_1 is oscillating steadily between 1½ and 2 V. K.F = 3.20 kr BF = 0.60 kr.

King Oscar ll Comes to Visit

Rolf knew a lot about his family and spoke about his family background in several interviews. His paternal grandfather was a priest, who was born in Frosta in Trøndelag and died of stomach cancer 'in Kongsvinger as provost and parish priest in Vinger on 20th August 1891 at 10.30 in the evening, after being ill for 24 hours.' Such is the entry in the family history, copied from old official records.[4] Before he came to Kongsvinger he had been a priest in Trøndelag, where according to the local archives people said that 'Widerøe was a real man of the people' and that 'he knew more than just being able to recite the Lord's Prayer.' There was 'something strong and bold about him, like Peder Dass,' and 'The old people still remember him as the best priest the parish had ever had.'[5] He and Edel 'celebrated their silver wedding on 18th January 1883' and (in brackets) 'Great ceremony with presentations, speeches, and so on.'

King Oscar ll and Queen Sofie were frequent visitors to the Widerøe grandparents in the rectory at Kongsvinger, where there was a special room known as 'the king's room'. Of the Swedish union kings, Oscar ll was the one who spent most time in Norway, and Kongsvinger was a convenient stopping place on the route between Stockholm and Oslo. Also, the queen was in poor health and liked to spend time in Norway convalescing, preferably with the Widerøe family.

Grandmother was given a bracelet with green jewels by the king, engraved 'To Edel Widerøe from Oscar ll' and the date. It was inherited by Rolf's sister who was also called Edel and who as a child had spent a lot of time with her grandmother. Grandfather, the parish priest, had been long dead before Rolf and Edel and Else and the others were born, but they had close contact with their grandmother, Edel Johanne Solem. Her family roots were from the big farm of Solem in Klæbu, south of Trondheim. The farm had belonged to the family since the 17th century, and Edel's sister was married to General Fleischer, famous for his part in the Battle of Narvik during World War ll. Rolf's grandmother did well in bringing up her nine sons and one daughter. She was a widow for almost 37 years and eventually moved to live with her son Theodor in Oslo, where she died in summer 1928, having lived long enough to know that her grandson Rolf had got his doctorate. Her son Sofus had long since qualified as Doctor of Medicine and specialised in surgery. He served as an army doctor in Serbia, but he was in Arild's plane when it crashed and he didn't survive. Another of Edel's sons had become a priest like his father, and another was an accountant who later had Widerøe Airlines as one of his clients.

The Wealthy Family from Romsdal

Going back to the 16th century, the founder of the Widerøe family was Aage Hanssøn from Romsdal. He was married to Synnøve Oudensdatter from the Aspen family, who can be traced right back to the 14th century and who were originally from Brandenburg in what is now Germany. The family owned farms throughout the land. Looking at the family tree and its connections, we find high status names such as Gyldenløve and Rosenkrands and people who consulted with the archbishop and kept company with the aristocracy and Lady Inger of Østråt and Vincent Lunge's bailiff. We find knights and national politicians and others with fine historical titles, governors, regents, chancellors and squires. Back in the 15th century, the family tree included 'the biggest landowner who had lived in Norway up to that time,' with over 1,000 farms. There are also estates and goods acquired from the cathedral in Trondheim, houses referred to as 'The King's House' or 'The Manor;' indeed all the possessions appropriate to a venerable, wealthy dynasty. The founder of the family lived on Veøy, an island west of Molde which is mentioned by Snorre Sturlason; the place where Håkon Herdebrei was killed in the Battle of Sekken against Erling Skakke in 1162. Until the late 16th century Veøy was the biggest trading centre in the district, while Molde was just a little coastal settlement. The island was situated at a nodal point for boat traffic in Viking times. Veøy is also known as 'The Holy Island,' and may have been a cult centre and the site of a pagan temple in heathen times.[6]

The founding father's son, Ouden, was the first to use the name Widerøe. In the first hundreds of years the name was written in many different ways, such as Veeyir, Vidøy, Vedøy, Widø, Widøy. Various explanations have been offered, but one is that the name originates from the name of the island, as it was usual in those days to adopt the place name as the family name. Several succeeding generations on Veøy were trendsetters both in wealth and in power, but for one reason or another the place lost its influence, possibly in connection with the death of Archbishop Engelbrektsøn. The Widerøe clan then moved to Lyngvær, a fishing and trading centre, but this also became too small and they moved on to Molde. There they took part in developing the settlement into a town at the beginning of the 17th century. If we trace the tree upwards to Rolf's branch of the family in the 19th century, we find many senior public officials and businessmen.

Hiding Grandpa in the Oven

Rolf's mother, Carla Launer, had a no less colourful family history. Her parents were both German but had moved to Norway before she was born. Her father, Carl Gottlieb Launer, was born in 1819 in DüroBrockstadt, south of Breslau. The name Launer originates from the Huguenots who fled from France during the reign of Frederick the Great. Carl Launer's dream in life was to be a master brewer. So he travelled on foot all the way to Constantinople as a journeyman gathering knowledge and experience. At that time, this was the way to become trained as a qualified master brewer, and membership of the Guild of Brewers was much sought after. From Constantinople he travelled to Vienna, where he became involved in the Uprising of 1848. He took part on the side of the revolutionaries and became a captain. He was wounded. His then wife hid him in the bakery oven to avoid capture and cared for him until he recovered. But then she died and he resumed his travels, still with the dream of becoming a master brewer.

He ended up in Northeim, near Hanover. Here he married Johanne Dorthea Margrethe Cramer, who was fifteen years younger than him. The pair of them moved to Halden in Norway, where he was able to realise his dream and become a master tradesman, having been headhunted to teach Norwegians how to brew beer. Rolf's mother Carla was born in Halden in 1875, but the family later moved back to Germany, where Carl got a job as a master brewer in Hamburg. In later life they moved back to Halden where he died in 1902, the year his first grandson, Rolf, was born.

His widow, Johanne, lived her final years with her daughter and son-in-law in Oslo, in the house where Rolf and his siblings grew up. She died in 1925. Her daughter Carla, Rolf's mother, was a strong and ambitious lady who died in 1971 at the age of 91. 'I may have inherited something from my grandfather, possibly including the urge to travel,'[7] Rolf said when he spoke about his mother's side of the family.

Jørgen Holmboe (nephew; Ragnhild's sister Anna Margarete's son) '*You can safely say that the Widerøes have been more than just an ordinary family in Norwegian society.*'

Arild Widerøe (eldest son) '*We were in no doubt that Dad was something special.*'

Thor Spandow (nephew; Rolf's sister Else's son) '*We were brought up to be frugal. I grew up in my grandparents' house at Vinderen, lived there with my mother from the age of three until I was twenty. Granny was strict, we weren't allowed to have friends home in the evening to dinner. But when Granny had gone to bed, Mother said "Come and eat" to everybody.*'

Thor Spandow (nephew; Rolf's sister Else's son) '*Life was strict at Vinderen, especially when Uncle Viggo came to visit. At dinner the rule was that children should be seen, not heard. There was steak every Sunday, herring or fish on Monday, and porridge or pancakes on Saturday. On Sundays in winter, the dining room was warmed up and we ate there. After dinner the grown-ups went into the smoking room and the children were not allowed there.*'

Aasmund Berner (nephew; Rolf's sister Grethe's son) '*They were out in the woods and hills a lot. Uncle Viggo, for example, the first thing he did when he came home after four years in prison and looked like a corpse, was that he gathered his friends together and they went out on an overnight trip. He preferred to sleep in a tent in the woods and watch the birds, instead of being at home with his family. His friends seemed to come first.*'

Rolf Widerøe jnr. (youngest son) '*I remember when some German soldiers passed through the back garden of our house in Røa. I remember it well, because we had a garden that led into a wood and below that there was a football pitch. And there they were, between the wood and our garden. And ever since I was a child I've always thought that there was something sinister about people wearing military uniforms.*'

Arild Widerøe (eldest son) '*I remember when we sowed potatoes in our big lawn. Two people walked ahead pulling the plough and one walked behind to steer it. It was a big event. All the neighbours stood watching and laughed and* *found it funny, even though it was – no it wasn't sad - but it was a serious situation, for potatoes were important at that time. And I remember my mother going down into the town to exchange things. That must have been on the black market. And I remember once when we were in town there was a fire alarm and we had to sit for two hours in the underground, on the Røatrikken that went up from The National Theatre. And we weren't allowed to parade with the Norwegian flag on 17th May. When peace came, I remember the German transports of people freed from the prison at Grini, coming down along Vækerøveien, and people stood watching and were happy.*'

Aasmund Berner (nephew; Rolf's sister Grethe's son) *The aircrews used to stay over in our flat in Stockholm, and they were often babysitters for us children. Uncle Viggo's wife lived in Voksenlia, and the planes sometimes flew low over her house and dipped their wings in salute. Sometimes they were chased by fighter planes. Once they came over Hamar and Saksumdal, and I know that one of the pilots – I think his name was Piltingsrud – was being chased by a fighter, so he dived down towards the ground and levelled up just in time but the German fighter didn't make it and crashed into the ground. And then he went on to Scotland. So he was able to give us news, because he had heard from somebody in Stockholm that Uncle Viggo was still alive in Germany.'*

Egil Reksten *(brother-in-law) and* ***Louise Reksten*** *(sister-in-law; Ragnhild's sister Louise)*:

Egil: Yes, there were several Widerøes. We knew Viggo too.
Louise: He was a very fine type too.
Egil: Yes, a good fellow.
Louise: Yes, a really good sort.

We can safely say that Rolf's family background was solid and exciting, on both sides of the family. At the time, however, the friends with whom he grew up were reckoned to be more important than the family. A friend whose father subscribed to *Science Illustrated*, for example, opened many possibilities. Rolf was rather alone in the family in his interest in natural science, but when visiting a friend who later became a professor of geography, he could read the magazine, *Naturens verden* ('The World of Nature').

Else, his sister, said that they were often scared he would blow the house up with his experiments. Her other brothers, she says, were only interested in planes. The boys shared a room, and as Rolf wouldn't tolerate anyone interfering with his circuits and causing complications, there was a certain amount of pushing and shoving. Rolf would push his equipment so far as possible under the bed, which obviously just excited his little brothers' curiosity. Else feared that her big brother thought she was a little stupid, and she still remembers with slight anxiety that he called her 'fathead' once when he had to help her with her maths. There is no doubt that he was especially talented, she said. She also understood clearly that he was stubborn and knew exactly what he wanted.

A high point in his boyhood career in physics was when he led a telegraph cable over to the neighbouring house at the age of 14 or 15, so that he could communicate with his friend using Morse code. The equipment in his room, a mixture of electrical and mechanical, was an important part of his teenage years as for many other boys at that time. But in Rolf's case, the fascination continued. Getting things to work and at the same time understanding the theory behind them became an obsession. The order of priority could vary. In adult life, his research was both a driving force which led to practical applications and a necessary response when things didn't work. How lucky he was to be a teenager just at that time in history, the decade when atoms were 'discovered.'

King Solomon's Mines

Rolf considered himself to be a fairly ordinary high school student. His school reports show that he did best in science subjects, but it is difficult to say how much that is related to a lack of interest in other subjects. Anyway, he did buy extra books on physics, chemistry and mathematics. His urge to learn led him to find stimulation and knowledge without the facilities available to us today through the Internet and social media. His maths teacher was an important role model, and Rolf joined the Norwegian Mathematical Association as a teenager because of him.

He got insight into higher mathematics through a series of booklets, *Sammlung Göschen*, issued by the German publisher G. J. Göschen. On one occasion he sent a question to a professor of physics at the university and got an encouraging letter back with a list of books that could give him the answer to what he was wondering about, concerning Planck's Quantum Theory and Einstein's Theory of Relativity and other topical themes. These might be thought to be too 'grown up' for him, but as he himself said, 'My physics teacher knew nothing about this, so I had to explain it to him,' and he did give a lecture on Einstein at school when he was 17.

His diary shows that books were a major item of expenditure. On Tuesday 9th October 1917 he wrote:

> Today I have bought *Qualitative Analysis* from B. Næss for 1.8 kr. I paid 60 øre from the book fund and he had borrowed 20 øre from me. The rest was

> paid for together with an ampere and volt meter I had bought from him. There was still 5 kr. and I got Dad to take that out of the bank for me. Have got 50 øre for some electrical goods. B.F = 28 øre K.F = 2.88 kroner.

But there are also entries such as: 'Got a book from Dad.' He was no ordinary scholar, but he wasn't a nerd either. 'Went to the cinema and saw "Civilisation." It was altogether magnificent,' reads the diary entry for Friday 26th October 1917. He got his dose of fiction and action stories, in fair measure. There was no *Harry Potter*, but they had Jonas Fjeld, the Norwegian answer to Indiana Jones the doctor, explorer and adventurer who fought with bandits and faced mortal dangers in distant latitudes. An over-confident hero full of the joys of life, created by Øvre Richter Frich to go out into the world with his inventor friend and achieve the most sensational coups; a major criminal who is saved at the last moment by fate taking a hand in events and facing him with challenges that enable him to find love and be reconciled with society. The first book in the popular thriller series came out when Rolf was nine, and he felt as if it had been written specially for him.

Then there was Sir Arthur Conan Doyle, the author of the Sherlock Holmes stories, with his book *The Lost World*, about a plateau in the Amazon forest still inhabited by dinosaurs. At least, that is the genial and eccentric Professor Challenger's hypothesis. His views are scorned by the scientific community, but he sticks to his hypothesis and a scientific expedition of four men goes out into the unknown to investigate. This is obviously a more daring, more dangerous and more fantastic journey back in time than anybody could imagine. Another favourite—even though it was not new—was Rider Haggard's adventure novel about King Solomon's diamond mines. According to the story, an enormous treasure lay hidden in King Solomon's mines deep in darkest Africa, well protected by an aged witch, Gagool. There was a curse over the place. Many had tried to reach it but none had come back alive.

As a young boy, Rolf devoured books such as these and all the serial stories he came across in pamphlets and magazines. In later life he enjoyed science fiction and futuristic novels.

Into the Atomic Age

He also read newspapers. That was how he learned about the achievement of Rutherford, the physicist who had managed to unveil the structure of the atom, thereby initiating the atomic age. The theory about electrons orbiting round the atomic nucleus, the understanding of the structure of the atom and the development of quantum mechanics were still in the early stages of development, but the splitting of the atom fascinated him and ignited his life-long interest. At the age of 79 when he was giving a lecture about his role in the development of sub-atomic physics, Rolf started by saying that when he was in his teens it was Rutherford's discovery that had sparked his lifelong interest.[8] As further historic discoveries were made, he heard and learned about them and became part of the development. Several years previously, in his only formal interview with the newspaper, *Aftenposten*, he had said that the main reason he had become interested in high-energy accelerators in his younger days had been because of the great possibilities he saw in them for atomic research. He described Rutherford as very far-sighted, but as a practical man he thought that not even Rutherford had fully anticipated the possibility of practical applications arising from the splitting of the atom:

> The developments have shown that he was mistaken. So far as the accelerators are concerned, I think that the treatment of cancer with high energy particles and radiation must be considered a very useful by-product.[9]

For a long time, people had believed that the atom was the smallest entity that existed. Then we understood that we could split the atomic nucleus into protons and neutrons, and these were thought to be the smallest building blocks. We now know that even they can be broken into component parts. Rutherford's point was that if one bombarded the atomic nucleus with radiation of high enough energy, one could learn even more about the structure and properties of the atom. This was the foundation of a new branch of physics, namely experimental nuclear physics. It was a question of finding a way to produce high-energy particles, and this was what came to be the major part of Rolf's work, creating accelerators that could create such high-energy radiation. That takes us into the realm of high-voltage electricity.

Electrical Engineering

After passing the university entrance examination in 1920, Rolf was in no doubt what he wanted to study. It had to be electrical engineering, and it had to be about high voltage and large power applications. If he was to make anything of his career he would need to become a graduate engineer, and his parents were quite clear that to achieve this, he would need to go abroad.

Norway had just established a technical college in Trondheim, but father reckoned that a college with 100 students would be less stimulating than the traditional institutions on the continent.

Rolf celebrated his 18th birthday that summer, and when the semester began that autumn his father followed him to Germany. He was to matriculate into *Die Technische Hochschule* in Karlsruhe in South-west Germany, near the French border. He soon found his feet. There is not a word of homesickness anywhere, even though he was leaving his friends, his five brothers and sisters, his mother and father and two grandmothers. The young student from Norway flourished. Life was really starting now. The environment was congenial, and even though he thought that 3,000 to 4,000 students were rather many, he considered that the relationship between students and teachers was friendly and informal. He remembered the names of his teachers for the rest of his life:

> I especially remember Professor Schleiermacher in theoretical electrical engineering; a lovely old man. We also had a good professor of mathematics, he was called Böhm. In physics we had Professor Wolfgang Gaede, he was one of the 'gods,' rather high above us students.[10]

He was still working with transformers, resistors and condensers, and now there were also lectures and lab work, group work and set projects, which all came together to consolidate in his mind the theories behind his childhood electrical endeavours. The guru of electrical engineering, Professor Richter, was one of the reasons Rolf had chosen the college in Karlsruhe. Rolf was fascinated by Professor Richter's very practical lectures. The syllabus included work experience, which in Rolf's case consisted of a month's practical work in a motor factory in Strasbourg. Here he had to build an electric motor, including making the windings; not an easy task. Climbing masts and mounting cables were also part of the course.

Enthused and energetic, Rolf also threw himself into projects outwith his technical syllabus. One of the first of these was when he wrote an article with the serious-sounding title *Analysis of Inflation* and submitted it to the academic journal of the Norwegian Economics Society in Oslo. This was at the time when the German mark was very low and it was said that one needed a wheelbarrow full of money to buy a loaf of bread. His father had provided him with money, and Rolf was following the exchange rate closely. In his usual methodical way, he started plotting the rate on a chart, with the rate on one axis and time on the other. He used the American dollar as the basis of comparison, and plotted a dollar curve that went from the floor to the ceiling on the big sheet of paper fastened to the wall of his room. At first the dollar rose in a more or less straight line, apart from a few swings. In January 1922 a dollar was worth 192 deutschmarks, but by December it had reached an incredible 4,200,000,000,000 marks and the exchange rate rose so steeply that he had to continue the chart onto an even bigger sheet of paper. Everybody was worried about the economy, not just students living on money from home. Rolf's article was accepted, and was published in the journal in 1924, on pages 189 to 206. Rolf had not formally studied economics, but he had an enormous appetite for life, with corresponding talent and enterprise.

Student Social Life

Much of the student social life in Karlsruhe took place in The Nordic Club. Most of the members were Norwegians and Swedes, with a few Finns, an Icelander and a Dane. Rolf described it thus:

> We partied a lot. There were regular national festivals to be celebrated, with cognac and lots of Swedish punch.

As aspiring engineers, their main preoccupation was to find solutions to everyday practical problems. This involved making inventions and having them patented. Their creativities followed many diverse routes. Rolf spoke about some of them, such as the chemistry student Erik Rotheim who invented the aerosol spray can during his time there and managed to have it patented but died before he could experience its success. There were others, too:

> I also remember Jack Nielsen, who had been Norwegian Tennis Champion. He became master brewer at Ringnes, and I bought his bicycle when he left for home. Grude from Stavanger was a great baritone singer. There was an architectural student called Bjørnson-Langen. His mother was a daughter of Bjørnstjerne Bjørnson. I remember he was quite entertaining. And then there was my good friend Kaare Backer.[11]

Backer became a structural engineer and founded the contracting firm Dipl. ing. Kaare Backer AS. They kept in contact throughout their lives, and Rolf took part in Kaare's diamond wedding celebrations when they were both about 90.

Rolf often came home during the holidays, or had visitors from home. Judging by all the mountain-tops in the family photograph albums, there were many ski and hill-walking trips. On all types of high days and holidays. With fellow-students and family members. The brothers together, all three of them or sometimes just with Viggo. Former schoolmates too, either visiting him abroad or getting together when he was home in Norway. Sometimes brothers and friends together, often with his own and his friends' parents, and uncles and aunts and old neighbours. Logged on the stiff, black pages of the photo albums: *Biong's Cabin Easter 1921; Garmisch-Partenkirchen and Nürnberg Pentecost 1921*; *Feldberg Christmas 1920–21*; *Schattwald Christmas 1922–23*; *Easter trip Odenwald 1926*; *trip with Viggo summer 1926*; *Feldberg on ski Christmas 1926–27*; *Wangen's Cabin in Eiker winter 1927–28—moonlight trip*; *Longvass Cabin 1928.*

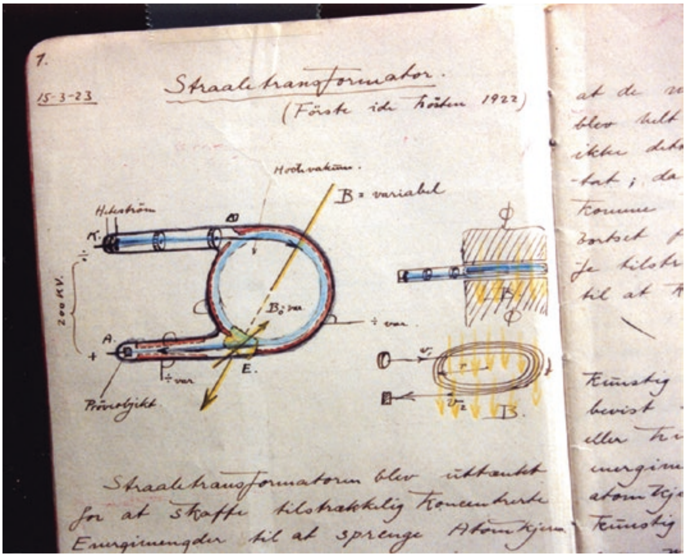
If they weren't on skis, there were towns and car tours: *Brussels summer 1924*; *Paris Pentecost 1924*; *Viggo visiting in Karlsruhe autumn 1922*; '*Kaaresbo*' *August 1925*; *Rukkedalen autumn 1923*; *Fougner's Cabin Kolsås 1921; tour in mother's and father's first car autumn 1921*; *long car tour summer 1922.* His childhood home in Vinderen not only had antique *Biedermeier* furniture and a smoking room. They were also among the first people to get a car, an American-made 'King.' Like most other cars at that time it was black. The family bought it about the time Rolf was beginning his studies. Father owned it, but never drove it. Viggo and Rolf were the chauffeurs, and it was mostly used for family tours or to take business contacts on an excursion. In a country that according to the national records office had 6,700 cars in 1920, an offer of a trip in a car was something to be valued.

An Idea on the Side …

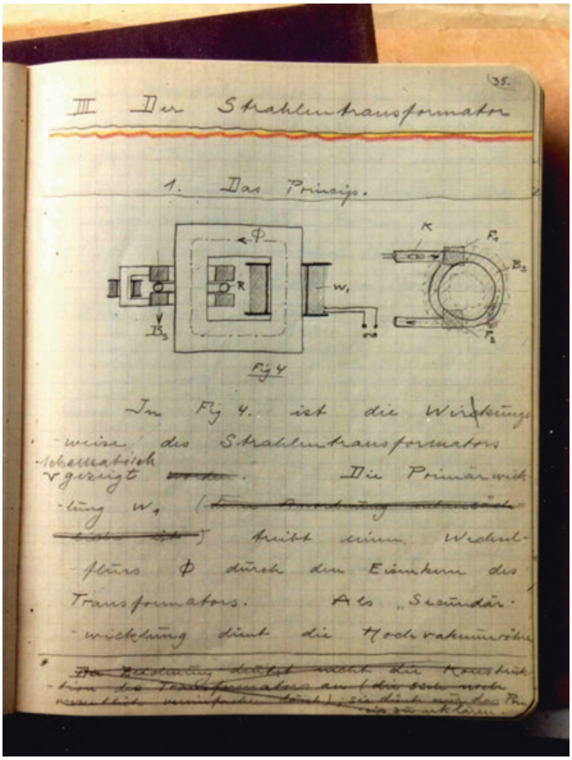
While pursuing his studies, Rolf was also incubating an idea. Behind this lay Rutherford's theories about how one could create high-energy beams. By the age of 20, Rolf was already wondering whether the same principle that was applied in an ordinary electrical transformer to change an electrical current from one voltage to another could also be used to accelerate electrons. He envisaged a transformer with the secondary winding removed and a glass tube in the shape of a slightly flattened doughnut put in its place. Could this be used to accelerate particles in the same way as could be done using very high voltages? Such high voltages would be dangerous, and there was no practical way of generating them. So the world needed his invention.

He had developed his idea thus far when he was in the fifth semester of his college course in autumn 1922, but there was much groundwork still to be done. One of the questions was whether electrons in a circular glass tube would behave in the same way as they would in a copper cable in a normal transformer. He thought it was possible to achieve this, but that as the electrons were not restricted within a copper cable he would need to use a magnetic field to keep them on track.

He was unable to solve this problem meantime, but he had written all his ideas down in a notebook with a blank, black cover bearing the title 'Technical Ideas.' On 5th March 1923 he wrote: 'The radiation transformer was conceived to create sufficiently concentrated energy to split the atomic nucleus. Four years ago I wanted to achieve this by …,' and there follows a technical explanation. Then he had realised that he might be able to do it a little differently, and he gave a little explanation of that.



As a twenty year old student in Karlsruhe, Rolf Widerøe drew this sketch of his idea for a betatron. His notebooks of the betatron are in ETH Library in Zurich. (*Photo* Pedro Waloschek)



A further sketch by Rolf Widerøe, which explains more precisely the operation of the betatron. (*Photo* Pedro Waloschek)

… Set Aside for Now

But he had to sit exams too. That was why he was there, to study for the degree that today would be called 'Master of Technology' or 'Master of Science.' The invention—or idea for an invention—that he was developing on the side had to be set aside for the time being. He continued to write down his ideas, sometimes in German and sometimes in Norwegian, alongside calculations and sketches in his notebooks. These little notebooks are a representation of his life and his thoughts, and he kept them for his whole life. Pictures of pages from his notebooks can now be found on the Internet, in textbooks and in physics lectures the world over whenever his theories are being explained.

For the time being, however, he was still a student. Before putting the idea aside, he was so bold as to submit his design to a patent office and apply for a patent. He never got a reply from them. Many years later when he was back in Karlsruhe he found that the whole area where the patent office had been was completely changed, and he never did discover what had happened to his first patent application.

Just now, he had to concentrate on his undergraduate dissertation. For this, he chose a very practical topic, typical for a high-voltage electrical engineer. Knowledge should be applied to something useful. There was a wave of electrification sweeping across Europe, including Norway. Power stations were being built and networks of high-tension cables were being strung up on masts across the land. So high-tension was to be his field. He would master areas such as electromagnetism and transformer technology. The teacher of high-tension technology had written a book on the subject, but Rolf thought that one of the calculations in the book was wrong and he corrected it in his own dissertation. First he worked it out mathematically, but then he asked for a deferment so that he could investigate it experimentally. He persuaded the college to provide equipment and a workshop, where he built a model of a high-tension mast on a scale of 1:100. He put the mast in a bath of electrolyte solution, so that he could measure the change of voltage in the fluid. His critique of the teacher's mathematical problem was accepted and his dissertation was given a grade of 5.9: the maximum was 6.

When his dissertation was complete and the exam was over, he returned home to Oslo in 1924, initially for his six months of practical experience. This consisted of maintenance and development work in the railway workshop. Then military service in summer 1925, which he summed up in two sentences:

> For 172 days I was in command of six men and a farmer with a horse and cart. It was a fantastic summer![12]

His next goal was a doctorate. His interest in electronics had grown during his studies, and to be an electrical engineer was not enough for him. The idea of getting electrons to go round in a circle still fascinated him, but if he were to realise his dream he would first need to know more about the theory. After a year at home he moved back to Germany. 'I believe in my ideas. Karlsruhe, here I come!'

In Karlsruhe he went to see his former lecturers. Said he would like to be taken on as a doctorate student. And for his doctorate thesis he would like to build a new type of accelerator, an induction accelerator or 'radiation transformer' as he called it at first. A machine the world had not seen the like of before, that could be used whenever there was a need for high energy. World-changing! 23 years old! We could say that this was a little more than normal youthful enthusiasm and ambition. Did he see any obstacles? Or just the goal? Starry-eyed? Or brilliant? Either way, it was worth a try.

'It Won't Work!'

His favourite professor, Schleiermacher, received him warmly and read carefully through the notes and calculations he had brought with him. 'Yes, this should work out. You've got the topic for your thesis here! Just get going!'[13] But the teacher of electrical engineering theory didn't make all the decisions and Rolf had to go to Gaede, the venerable professor of physics. Gaede was not so impressed. He could certainly accept Rolf as a doctorate student, but he was very doubtful about the idea of a radiation transformer. It wouldn't work. Rolf could get to choose a different topic. There was no way the college could accept that constructing and testing a transformer according to the ideas proposed could be accepted as a doctoral thesis. It was technologically quite unrealistic, even if he did manage to create the best vacuum in a glass tube that was possible at that time. There would be so many gas molecules still present that the electrons, instead of travelling several thousand kilometres in the round glass tube, would be absorbed too quickly, much faster than they could be accelerated. But as the professor said, he would be welcome to study further in his old college—on a different theme.

It must have been a personal victory for Rolf thirty years later when the college in Karlsruhe bought one of his betatrons to use in physics experiments. The old professors were not there any more, but nevertheless.

The newly qualified engineer had not allowed himself to be beaten. He knew how to solve the problem of disappearing electrons, and he did further calculations that he thought showed that Gaede was wrong. However, he didn't go back. He decided that Karlsruhe was no longer the right place for him. He was determined to build a radiation transformer. If he couldn't do it here, he would do it somewhere else, and what's more when he thought it over carefully he concluded that the technical facilities in Karlsruhe were not good enough for his plans. Basically, he had grown out of the whole milieu of Karlsruhe. Whatever the obstacles he faced, lack of self-confidence was not one of them. Difficulties are just challenges to be overcome, with back straight and head held high.

So he sat down and wrote a letter to another technical university, in the city of Aachen much further north in Germany, level with Bonn near the Belgian border. He knew that in *Die Rheinisch-Westfälische Technische Hochschule* in Aachen there was a professor called Walter Rogowski, and he addressed the letter to him. He came straight to the point and asked if he could go there to do his doctoral thesis. He had found Rogowski's name in the journal *Archiv für Elektrotechnik* where Rogowski and another researcher had described an attempt they had made. The journal was published by Springer, the world-renowned publishing house which already at that time was almost a hundred years old. The journal continues today under the name, *Electrical Engineering*.

The journal and its editor would weave in and out of Rolf's life for the next twenty years, and it is interesting to speculate whether he would have done the same if he had known what would happen later. But Rolf and the professor were on the same wavelength, and Rolf has given an enthusiastic account of their first meeting and how it came about:

> Rogowski wrote back immediately to say that was fine. Obviously I could work with him; no problem. He was due to be going to Switzerland on holiday between such and such dates and would be coming through Karlsruhe on the way back. "Meet me on the train, then we can travel together to Mannheim and you can tell me all about it." So I did as requested. The train journey took an hour. I don't think he really understood many of my explanations, but I mentioned several times that I planned to build a transformer of six million volts and that must have really caught his imagination. He was ambitious and wanted to be a little ahead of the competition. "It sounds good. Come to Aachen and we can sort out the details."[14]

The road was clear, and the evening before he left his old student flat in Karlsruhe he had a wild farewell party:

> We ended by hanging all the chairs up on the wall. I got onto the train in the middle of the night, or early in the morning. The cleaner was angry when she saw the state of my room, but my friends dealt with that.

In Professor Rogowski he had found someone brave enough to let him prove himself. Another benefit of being in Aachen, considering the specially manufactured glass tubes he would require, was that there was a good glass-blowing workshop there.

He started his work in May 1926. The college in Aachen was considered slightly unconventional, which suited him well. It was a stimulating environment. Here Rolf met, among others, the man who had been Rogowski's co-author of the article that had led him to apply to Aachen.[15] But above all he met Ernst Sommerfeld who was the son of the famous physicist Arnold Sommerfeld. Ernst specialised in patent registration and over the years he would come to handle most of Rolf's over 200 patent applications. The two of them became close friends and went hillwalking together, and Ernst visited Rolf in Norway several times.

Rolf enjoyed Rogowski's lectures on electrical engineering, and up to a point he enjoyed being taught by the professor of aerodynamics, though he obviously found it more entertaining to play tennis with his laboratory assistants than to listen to the professor himself.[16] The biggest department in the college was metallurgy, naturally enough, as it was situated in a mining and industrial area. There was nobody in his own department working in the same field as he was, and moreover he was the only Norwegian. So he had to manage the project mostly on his own, as there were few people around with relevant knowledge to help him.

It Still Won't Work!

He set to work quite quickly to build his accelerator, greatly helped by the fact that Rogowski had arranged for the work to be sponsored by the German Research Foundation.[17] Rolf obtained a large transformer, about a metre high, from which he removed the secondary winding. He had a rather cramped and unattractive workshop in the basement, just a few cubic metres where the machine itself took up most of the space. The news that someone had managed to split the atomic nucleus had caused him concern. In one of his student notebooks he had written that one needed 'at least 10 million volts and possibly more' to split heavy atomic nuclei. So he had come to the conclusion that the only way to accelerate particles to such high energy was to build a piece of equipment like a transformer:

> If there was a vacuum in the tube there would be hardly any electrical resistance and the electrons would very soon reach a very high speed as a result of the acceleration produced by really high tension. I was soon convinced that it would not take a long time for the electrons to approach the speed of light, and that classic formulae would then no longer apply[18].

There would need to be a vacuum in the tube, so that a magnetic field acting within the tube would generate current. If there were electrons in the tube, they would be affected by the magnetic force in the same way as the flow of electrons in a secondary winding. He realised that if the electrons travelled in a straight line for a short time they would hit the wall of the tube. So he would need somehow or other to compel them to travel in a circle. He knew enough about magnetic fields to realise that he would have to apply an additional magnetic field that would steer the electrons round a circular course.

But then there was the additional complication that the electrons would be accelerating, moving faster and faster. So the magnetic field would need to be made stronger to hold them on course and adjusted according to the acceleration of the electrons. This was the idea underlying the 'radiation transformer' which later came to be known as the betatron.

He got help from the glassblowing workshop to make the glass tube as he wanted it, in the form and size of a flattened doughnut or a transparent lifebuoy. After he had inserted the tube into the machine, the next thing was to create the magnetic fields. The difficulty was locating all the components in the right relationship to each other. He calculated the strengths of the various magnets required to control the electrons in their course and developed a technique to measure the relationship between the main magnetic field and the steering field. This enabled him to adjust the fields. He developed a theory of how the magnetic fields must be placed in relationship to each other so that they would propel and steer the electrons round the circle. This was later called the Widerøe Condition or the Widerøe Equation.

Now he can begin to test the machine. We are still in the year 1926. Will the electrons go round the circuit as the theory says they should? They don't. They go round one and a half circuits and then stop. He tries adjusting the magnetic fields, but no matter what he does, he cannot get the accelerator to work. Finally he has to go to Professor Rogowski and admit defeat. The professor, who is results-orientated, is adamant that he can't be awarded a doctorate for an apparatus that doesn't work. The idea was good enough, but Rolf has not managed to apply it in practice. The circular radiation transformer—his youthful dream—doesn't work.

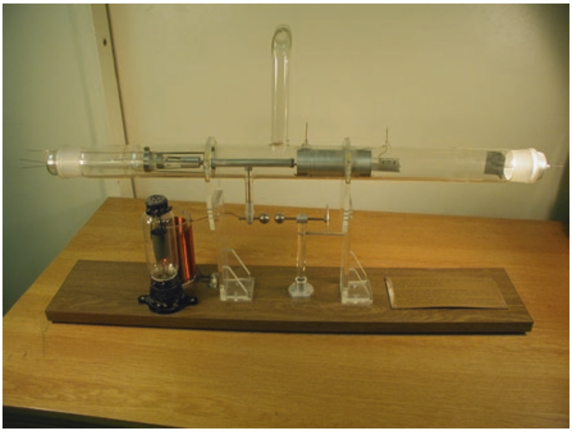
Needs Must

What now? Young Rolf was a far-sighted strategist who didn't give up. He was also a pragmatist. So he put the idea of a circular accelerator aside. The promising, rather determined doctorate student visited the library and looked out an article by the Swede Gustav Ising that he had come across before. Two years previously, Ising had suggested an alternative method of accelerating charged particles but had not built a machine himself. Perhaps his method deserves a closer look? It was based on what was called 'multiple acceleration,' consisting of repeated bursts of acceleration. A particle gets a push, moves to a new point, gets a further push and so on, the speed increasing with each stimulus. Rolf studied the principle and speculated further. How can I locate these stimuli in exactly the right place to achieve what I want? Then he tackled all the other questions, one by one.

Rolf concentrated on the straight line accelerator, and got it to work according to plan. He has made the world's first linear accelerator. The foundation has been laid for the twentieth century's amazing development and construction of accelerators. Used in cancer treatment, materials testing and further atomic research. Throughout his life, Rolf remained grateful to the Swede who had set him on the right track.[19]

Rolf completed his thesis and called it 'About a New Principle for Generating High Voltages.' In the original language: *Über ein neues Prinzip zur Herstellung hoher Spannungen*. In the first part he describes the working linear accelerator that he has built. He gives a detailed description of the principles he has applied, the underlying mathematics and how the machine works. In part two he writes about what he has not yet achieved but which is his predominant idea, the circular accelerator for which he has thought out the solution but for which he has not managed to construct a machine that works. He still thinks that the theory is valid. He is working on it step by step. I am setting myself a hard task, *Herr Professor*. He writes a detailed account of the theory and of his work trying to construct the machine. He also includes what later became known as the Widerøe Equation, the 2:1 relationship between the acceleration and the steering magnetic fields. But he has to conclude disappointedly that the circle-shaped method didn't work. Nevertheless, whether the track be round or straight, his thesis contributed something quite new to physics.

This time, on 28th November 1927, he was awarded his doctorate of engineering, the first of several doctorates. His work was published in the journal *Archiv für Elektrotechnik* the following year. However, his work did not receive the acclaim that might have been expected. It wasn't just that Professor Rogowski, who had had such faith in him at the start, was no longer seriously interested in what he had done. 'I don't think he even so much as looked at my linear accelerator.' More significantly, the timing was wrong. Experimental nuclear physics was not yet an established field of research, and the technology was not yet sufficiently developed to overcome the challenges he faced. He was before his time.



Exact replica of the first High-Frequency Linear-Accelerator successfully built and operated by Rolf Widerøe in Aachen, 1927. On display in a glass cabinet in the Norwegian Radium Hospital's vestibule. (*Photo* Knut Bjerkan)

Headhunted

In contrast, the industry did recognise his talents. In March 1928 he moved to Berlin and began work as an engineer with AEG. It had been rumoured that he was able, and he was offered jobs both in Norway and in Germany. He chose to go to AEG's transformer factory, where he would be working in industry rather than in research. AEG was involved in developing electricity supplies, building power stations, setting up high-tension cables and other things that Rolf understood. His job would be to build relays, switches that direct electrical current to selected cables rather like points on railway lines, and that cut off the current in the event of significant faults. These were distance relays, designed to protect the generating plant from damage by failures of current flow in high-tension cables. Such interruptions could be caused by many things, including trees falling on the line. The monitoring equipment would be used to show where the break was and how far it was from the monitoring site. The relays could also show the location of the break. AEG was the market leader in relays but there were problems with them, and Rolf immediately set about looking at the possibilities for redesigning them.

He liked the city, and he had come right into the middle of a stimulating scientific environment. In 1929 he took part in an international conference in Berlin with lectures by Einstein and other famous physicists who spoke about atomic power, the new big idea. After a while he moved over to a separate relay department that AEG was now setting up.[20] Practical man that he was, he enjoyed making things that were useful, but he was also fascinated by having to think out new solutions to problems. The result was 41 German and 2 American patents from barely four years at AEG.

Rolf made useful contacts and worked with top people. The head of the department had developed a new type of distance relay in collaboration with a colleague from the Siemens factory, who at that time was regarded in Germany as the authority on high voltage technology.[21] Rolf also got to know another physicist, Max Steenbeck, who worked with the expert at Siemens. Rolf and Max jointly registered a patent. Rolf would come across Max Steenbeck again later, but in much more dramatic circumstances. Rolf had a good relationship with his boss at AEG, and visited him again many years later. He also got on well with the boss's assistant[22]. He had suggested a new variant of how to design a relay, and Rolf was given the job of constructing it. The two of them were about the same age, and they subsequently maintained contact as friends.

After completing his doctorate, Rolf Widerøe worked for four years with AEG in Berlin. (*Photo* Archives AEG)

During his years in Berlin he also met Leo Szilard, the Jew who later wrote Einstein's famous letter to President Roosevelt warning that Nazi Germany might be researching how to make an atom bomb, the letter that is said to have initiated America's response in the form of the Manhattan Project. Little did Rolf realise then that he himself would be the subject of investigation in connection with the American atom bomb project. Szilard already had good contact with Einstein, with whom he had worked on a subject so mundane as refrigerators and had jointly registered a patent about refrigeration technology. An entertaining chap, as Rolf described him after a visit to a café together:

> I remember when we were sitting in a café in Berlin and he told me about his high voltage project. He wanted to build several transformers on top of each other, and the lowest one would control the topmost. Lots of airy ideas, typical Hungarian, and enjoyable company.[23]

Keeping an Eye on the Competition

While he was at AEG, Rolf was able to concentrate on technology and set administrative work aside. He also put to one side his ideas about accelerators, but he did keep an eye on what other people were doing. Things were happening elsewhere in the world. In America, Lawrence was having success with his cyclotrons. Rolf's friend Ernst Sommerfeld kept him updated through his father who was now a professor in the USA. In the Carnegie Institute in Washington, machines to generate high voltages were being developed, by – among others – the Norwegian trio of Breit, Tuve and Hafstad, known as 'The Three Musketeers'[24] and also another Norwegian, Odd Dahl, who was there for a while.

At Princeton University in New Jersey, the American Van de Graff was working on another type of accelerator. His machines were copied throughout the world and also manufactured industrially. Haukeland Hospital in Bergen acquired one of these. In Great Britain, Cockcroft and Walton had split an atomic nucleus with artificially accelerated particles for the first time, using a cascade generator. Lawrence was able to use his cyclotron soon after to confirm the results. Lawrence was awarded the Nobel Prize for Physics in 1939 and Cockcroft in 1951.[25]

Rolf was trying to keep up with his field of interest, but now he really wanted to come home to Oslo. Life in Germany was starting to become less comfortable. First there was the depression at the start of the 1930s.

Workloads increased dramatically, and pay was halved both for himself and for his colleagues. As head of the department now he had to dismiss people, and he didn't like telling people he had trusted and worked with that they were no longer wanted. He felt awkward about sacking people when he was younger than them and also a foreigner. What disturbed him most, however, was the imminent change in the political regime. 'Hitler was threatening to take over power, and I left Germany just in time before that happened,' he said. He was convinced that '*Alles zum Teufel gehen würde*' ('Everything would go to Hell') with Hitler in power.[26]

He came home to Oslo at Christmas 1932. By the end of January, Hitler had taken over as Chancellor, suspended the constitution and replaced it with an emergency decree. The German people were denied freedom of speech and civil rights. Scientists could no longer do research freely and independently and public officials had to declare if there were Jews in the family. The Norwegian writer, resistance fighter and concentration camp prisoner Kristian Ottosen summed up the new situation thus:

> According to paragraph one of the emergency decree personal freedom, the right of free expression, press freedom and right of assembly were legally restricted. The law permitted those in power to censure letters, post, telegraph and telephone communications. It was now legally permitted to ransack house and home and to arrest people who one suspected either had or intended to trade in contravention of one of the paragraphs of the decree of 28th February. Using the authority of this decree, Hitler had all his political opponents – many of the opposition in the *Reichstag* – arrested. The same fate befell leading members of the German civil service, leading academics and religious leaders. They were all branded as a threat to the German nation.'[27]

Aeronautics and Airshows

Rolf's brother Viggo and a friend had visited Berlin the previous October, to attend the international aeronautical trade fair. Germany was a world leader in flying technology, and they revelled in the exhibitions of aerodynamic details, polished metal and new records. It was five years since Lindbergh had flown over the Atlantic, and twenty-eight years since the Wright brothers' first flight. Propellers still provided propulsion, but the industry would soon be jetting into a new age when humans would master the air as they had mastered the land and the sea. Viggo returned home inspired by visions. Later, when he sat in a German prison writing about the experience on toilet paper or whatever paper he could get hold of, he described these happy days in enthusiastic terms:

> The exhibition was a temple for us. Seeing what had been achieved strengthened our belief in the future of flight. It gave us confidence. As we walked between the rows of seaplanes, sports planes and commercial aircraft, big ideas began to take shape. Our country would become a major power in the air, as our ancestors had made it a major power on the sea. As our flag was carried over the seas of the world, so would it be carried through the air to distant lands.
>
> We saw high heaven above our dreamland of flight. We imagined a wide, sun-soaked plain – Ekeberg was where we had in mind. – We placed everything together there: hangars; workshops; factories. Commercial planes and training planes were lined up in rows. We also put gliders there on the green grass, and others were soaring through the blue skies. Flights came and went. The Oslo Valley lay below in the summer mist, with the fjord glittering in the sun beyond.
>
> We had also developed a base on the island of Sjursøya, where big flying boats touched down from their travels before ploughing across the waters of the fjord and winging into the air again.
>
> Oh, those happy days at Kaiserdam, when our mood was still confident and our dreams uninhibited.[28]

Yes, they would create an airline. Norwegians would be told about the wonders of flight and the possibilities of air travel. Model aeroplanes, gliders, flying as a sport, air taxi services, postal flights, scheduled airline flights, not to mention marketing and lobbying—they would need to master and accomplish all these things. Just look out, here we come. Like an echo of big brother.

Over Christmas, Viggo and Arild and three other young men who were mad on flight met in a flat in Schultzgate in Oslo.[29] They put their ideas, courage, adventurous spirit and aeroplanes into a magic pot. The strategy that emerged was to give talks and arrange airshows throughout the country, combining the public relations exercise with taking on contracts for passenger flights that would generate income. They would need to find starting capital and acquire more planes, but that would come.

The first flying demonstration was scheduled to take place at Sundvollen beside Steinsfjord in Ringerike on 12th March 1933 at 1 p.m.[30] Viggo has left us a detailed description of the dramatic start of the event:

> When we opened the curtains on Sunday morning at Norderhov vicarage, it was snowing heavily. The mood at the breakfast table was tense, as if a fiasco was looming. The fact that the planes were at Bogstadvannet near Oslo didn't make the mood any lighter. How would they manage to come across Nordmarka in this weather?

The pilots who were due to come from Oslo were just as concerned:

> (…) As the pilots approached the starting point for the demonstration, they became less and less confident that flying would be at all possible. The only break in the white snowfield was the vehicle for towing the glider. It stood stuck in half a metre of new snow. Optimistically, everybody set about tramping a surface on the runway, digging out the vehicle and advising people not to go home. There would be a flying event, they said, 'Flying is going ahead as planned.'
>
> The sound of the planes was heard at five to one. (…) They had found their way up Sørkedalen and jumped from lake to lake across Nordmarka without coming to Ringerike, where the weather stood like a wall over everything. Eventually they had found a line of power cables which they followed down to Steinsfjord.
>
> The demonstration did take place, with spins from 350 metres, rolls, flying upside-down, stall-turns, formation flying, gliding and balloon competitions where the pilots vied to burst the most balloons with the propeller. The spectators were excited, and despite the challenging weather the very first airshow was a success.[31]

The next show took place the following Sunday at Akersvika near Hamar. School classes came midweek to hear about planes and flying, followed by a taster flight and finally writing about the experience. The local press also took part. There was publicity for the flight project in town after town throughout the winter, and as Viggo later remembered as he sat in his cell during the war and thought back, there was brilliant sunshine and high spirits every single time after the first unfortunate snowy weather at Sundvollen.

The World's Best Relays

To dream, develop an idea, plan, invest, overcome difficulties—these traits all lay in the family genes. Rolf was also interested in flying, but he had more than enough to do with his own ideas that he had brought back from

Germany. His electrical relays should be improved even more, according to plans he had developed during his time at AEG. The distance relays they produced were the best currently available, but they were not especially accurate and not really sensitive, even though Rolf had further developed them during his time there. His new design was both faster and more accurate, more reliable and easy to use. He was well informed about the state of development of electrical power in Norway before he came home and he knew that the many small power stations that were now being connected together in a combined distribution grid needed such distance relays. They would need to be simple and robust, as many electricity companies used unskilled workers and complicated precision technology was impractical. The task was clear; to create the world's best relays for use in the Norwegian power stations.

Several months before he came home he had sent an article to the Electrical Engineering Journal in Oslo. Over almost 15 pages, he described the new situation the power industry was in and the great possibilities that the grid connection could offer. For many people, these were novel and exciting ideas. This is the power engineer speaking out, but also the PR man—just like his brothers who were trying to convince everybody of the great benefits of flight. He described how the industry had developed and he addressed both the consumers and the providers:

> In the early days of electricity transmission it was a relatively simple matter to protect the lines and the machines against short-circuits and overloads. The power stations were mostly linked directly to their major users and there were no connections between different power stations and different users. Indeed, the very idea of a shared power distribution network with x power stations feeding energy in and y users taking energy out was unfamiliar at that time. The lines were protected on a simple cut-out principle; when the current in a cable rose above a chosen maximum level, the lead was disconnected and the user was left without power. This is the same principle as is still used in domestic installations.[32]

But now the electricity supply systems were being connected together over larger areas into a shared network. This had advantages for all parties:

> This sharing of the network is a benefit for the users. They can now be provided with power through more supply lines, so that they will not have a power-cut if one of the lines fails. It is also of great benefit for the various power stations. First, they act mutually as back-ups for each other and second,

when the flow of water is irregular they can use the network to even out production and maintain regular power supply.

But there were disadvantages too. The combined generator output can become very high. When the grid is receiving energy from all the power stations there can be a heavy load on the switching mechanisms in the event of a short-circuit. This problem had long since been solved, Rolf wrote. But then there was another problem about levelling out the current flow, namely that a fault in one line would affect the whole network. If there was a short-circuit at one place, all the supply cables would cut out and all the users would suffer a power-cut. The effect of this was that the more the grid was extended, the more frequent became the failures of supply. Therefore, he wrote, two requirements must be specified for all relay systems: first, the short-circuited cable must be able to be disconnected independently of the others, so that only it and the nearest switches were cut out; and second, the interruption of power supply must be as short as possible.

Then he described the different types of relay one by one. This was popular science and technical description combined, explained simply and modestly. He enjoyed his role as an interpreter of scientific technology to the general public and he had inherited a sense of how to present the good news. He maintained this straightforward style of presentation for his whole life and especially when he was lecturing and had an audience he presented his topic with enthusiasm.

Onwards and Upwards

Back in Norway, he had selected N. Jacobsen's Electrical Works in Oslo as the place he would like to work. Jacobsen had made crystal sets and was well known for 'the people's receiver,' the radio the firm produced for NRK, the Norwegian Broadcasting Corporation which was established the same year. Rolf contacted the director and convinced him that his relays were the right ones for the Norwegian situation and that Jacobsen should manufacture them. He negotiated a salary of 500 kroner per month, which he thought was good, and started on 1st April 1933, two weeks after his brothers' airshow at Sundvollen.

He soon got production started. The relay turned out to be cheap to build, and the result was good. He developed a gadget that was more accurate than previous models but had no over-sensitive fine mechanical parts. It also reacted quickly, within 1/25th of a second. This was important, as otherwise the generators in the power stations would fall out of synchronisation and the whole system of interconnected power stations could fail.

The new relay was ready by the autumn and Rolf went on a combined holiday and sales tour in his Ford A to England, Spain, Italy and Germany. He often slept in the car. In England he visited a colleague, Torvald Torgersen, who joined him on the trip. Then the tour took a dramatic turn. Torvald fell ill with typhus and Rolf caught paratyphus, but they came home safely and Torvald later bought himself a summer cabin just beside the Widerøe's family property on the Oslo Fjord. Whether or not it was the result of salmonella bacteria, Rolf decided that a career as a travelling salesman was not for him.

In March he carried out the first tests on a power line in Vestfold. He then wrote another article for the Electrical Engineering Journal, in which he once again described the need for new and better relays—and uninhibitedly advertised his own and Jacobsen's newly developed design:

> We found, however, that not all existing relays were suitable for Norwegian situations. The relays were too delicately built, they needed a lot of attention and above all they were very expensive. (…) The situation has however now entered a completely new phase as N. Jacobsen's Elektriske Verksted A/S is bringing to the market a new, Norwegian distance relay, designed and manufactured in the first instance to satisfy the needs that were expressed at the relay conference in 1932. The relay is based on a completely new, Norwegian invention (Norwegian patent registration no. 52417 R. Widerøe), and N. Jacobsens Elektriske Verksted A/S has become the first manufacturer of relays here in Norway.[33]

The Brothers Take Off

While Rolf had been travelling round Europe to promote the sale of relays, Viggo and Arild were continuing their PR stunts to promote enthusiasm for flying. When 6,000 people were bathing at Ingierstrand on Sundays, they held a flying demonstration there. When whole families had gathered at Bogstad Lake in winter to go skating, they were there with balloons and talks. Their urge for adventure didn't stop there, and they decided to fly to Africa. They read all they could find, collected maps and sought out information about landing stops on the way. This was a long journey that needed thorough planning. But the money didn't stretch to it, and a film script they had prepared also had to be set aside. Another rather high-flown plan was to fly round the world in a Lockheed plane, but they managed to control their ideas to concentrate instead on acquiring aircraft that could be used for utilitarian purposes in Norway.

They got hold of what was available: several surplus planes from the navy and a glider from the Aeronautical Club. Also, one of their colleagues already had his own plane, a Gipsy Moth that was useful right up until it was wrecked in the mountains one Easter. If they were to invest professionally and commercially, they still needed a proper aeroplane. In December, Viggo travelled to the USA and bought a five-seater Waco seaplane. The problem was how to get it home to Norway. The costs of packing, various loading and unloading and then transport by ship to Norway were too great. The solution was to start by flying it to New York. Such a trip was verging on hazardous, but he could cope with that and it made a good story afterwards:

> The weather was dreadful, with the cloud base at 100 metres, mist, rain and icing. It was an exciting trip among the skyscrapers looming up in the mist and over bridges and parks. Fortunately I had a local guide on board, who counted off the streets and nodded approvingly every time a familiar skyscraper soared up. By the time we landed we had almost an inch of ice on the leading edges of the wings and the rudder, and the engine had started vibrating significantly because of ice on the propeller.[34]

Safely arrived, the seaplane was loaded onto a barge and towed to the *SS Europa*, which took it across the Atlantic to Bremen, ready to be flown home from there. This was a rather exciting flight too. He obtained permission to take off directly from the quay, and flew through thick snowfall, following the railway line towards Hamburg, where the complications really began. The customs had re-stowed some of the spare parts, which had altered the adjustment of the compass:

> I flew by my instruments for four hours, in and above the layer of cloud, without seeing any sign of the clear weather that had been forecast. I had only half an hour's supply of petrol left, and I had to take the chance of going under the cloud level to orientate myself. I came out of the cloud at 50 metres, above a railway line which I followed. I was very surprised to spot a German flag and then to read a German name on a railway station as I passed. According to my instruments I should have been somewhere near Gothenburg. After an emergency landing, it turned out that I was near Stolp on the boundary with Poland.

When the aircraft was in place in Norway, they could start the airline company. Things now happened quickly. Viggo is 29, Arild 24. Why hesitate? On 13th January 1934 they held their founding general meeting. All three of the brothers were there – Rolf, Viggo and Arild – plus their father and two of his friends. Theodor had proxy votes on behalf of his wife Carla and Uncle Sofus. Viggo was exercising another three proxy votes. Theodor, who had been sponsoring the project for a long time, followed the protocol. Widerøe Airlines was founded. Today, over 80 years later, it is one of the oldest airlines in the world still operating.

Now that they were formally in business, Viggo was appointed Managing Director. He said modestly that that was because he was the only one who had a telephone, and that that was why the company was named after him. In reality, everyone knew where the power lay and the choice was hardly difficult. More planes were acquired in the course of the year.[35] The flying demonstrations continued. There were air-ambulance missions and other work. The planes had their admirers, and so did the hostesses. On an air-taxi trip to Ustaoset Hotel at Easter 1934 one of them was the hotel manager's daughter, Solveig Schrøder, who married Viggo the following year.

Dance of Love

Making the world's best electrical relay was not the only dream in Rolf's head when he came home from Germany. He also wanted to find himself a wife, and he set about this in his characteristically methodical way. He enrolled in Miss Fearnley's Dance School, ostensibly to learn the newest dances. He could dance, but this was the new age of quickstep and slow foxtrot and tango. Luck was on his side. At the dance school he met Ragnhild Christiansen, who lived at Ullern, not far from his own childhood home. They were married on 14th November 1934.[36]

Ragnhild also came from a big family, with four sisters and one brother. Ragnhild was the eldest. Her father, Alexander Christiansen, became a Nazi during the war. This was not much spoken about, but it was mentioned sufficiently for Rolf and Ragnhild's youngest son, Rolf jnr. who was born in 1941, to sense that there was something unusual about this grandfather. He was a prosperous businessman until something went wrong, and he later tried energetically to defend himself. His Nazi affiliations became a problem for the family, but in the 1930's the preoccupations of the Widerøes in Borgenveien and the Christiansens in Ullernveien were with marriages and baptisms.

The Fishermen Set Their Clocks by Us

The Widerøe family's airline was well established by the time the war started. Acquiring the green Waco had been a decisive step. The colour had not been of their choice, but had been how the plane was delivered from the factory. Viggo had dreamt of a 'silver bird' with red lettering, but he had neither time nor money to wait for the right colour and he just had to take what he could get. On 15th June 1934 the company was awarded the concession for the Oslo-Kristiansand-Stavanger-Haugesund route. Three days later, at 07.50, the Waco left its berth at the seaplane harbour at Ingierstrand with Viggo at the controls and took off for Kristiansand fully laden with passengers, goods and post. The new age of air traffic in Norway had begun.

The routine was not always glamorous:

> These were long days for the aircrew. The trip to Haugesund usually took five hours and ten minutes. We got back to Ingierstrand at 19.30, but by then we had also been down to Vannsjø near Moss to deliver international mail to the train. Then the mechanics worked on the planes all night so that everything would be ready for next morning. Our flights ran on time with 100 per cent regularity and the fishermen used to set their clocks by us.'[37]

The original green colour became part of the company's identity. Short-runway airfields were also developed and people in Western and Northern Norway became familiar with the Twin Otter, Dash 7 and Dash 8. It has been said that Widerøe's small aircraft united coastal Norway. The districts valued them and thought of them as their own.

Viggo's trademark was the capacity to think in the longer term. One of his successors in the airline characterised the founder as the type who never gave up.[38] The same could well be said of his brother Rolf. They both had lofty dreams, but both of them combined this visionary thinking with hard work. One of them was busy transporting people and post, up and down, North and South in all sorts of weather, struggling to maintain 100 per cent regularity and have money in the bank. For the other, it was a series of formulae, investigations, up-turns, down-turns, sales promotion and fine technical detail. Year in, year out. With success in sight far ahead in the distance.

Grasp the Opportunities

Viggo was both an adventurer and a responsible businessman, spurred onwards by encouraging moments as his venture progressed. It was a matter of grasping the opportunities as they presented, for example in the form of a commission in the polar seas when whale trader and consul Lars Christiansen invited him to join an Antarctic expedition in 1936. Viggo recalls:

> He wanted to send an expedition to Antarctica to chart the unknown coastal region between 80° East and 10° West. Aerial photographs of the coast would be put together to make maps of the previously unknown territory. (…) I was given a free hand in the selection of personnel and choice of equipment. Only one condition was imposed on me – that everything should be first class.[39]

They were in the Antarctic for two months, living on a whaling ship and flying over the ice whenever the weather allowed. During this time, they photographed about 2,000 kilometres of coastline. On one occasion they almost came to grief. His aviator daughter, Turi Widerøe, has described the incident clearly and soberly:

> Because of a misunderstanding, the mechanic had not put in enough petrol. They flew 450 km. east across the land and then started taking photographs. They had been flying for about four hours when the pilot realised that there was hardly any petrol left in the tanks. They switched off the camera and set course directly back towards the whaling ship, where the people on board had been warned to be prepared for an emergency landing. (…) The sea-ice conditions had deteriorated while they were in the air. (…) The landing space was no bigger than two boat-lengths when they arrived. The pilot managed to bring the plane down and they were hoisted on board immediately. By the time they had taken their flying clothes off the ship was surrounded by ice on all sides.[40]

The newly-weds, Rolf and Ragnhild, in the meantime followed much less exotic itineraries, but they managed to make their own excitements. The pair of them travelled round Norway in their free time selling relays to Norwegian power-stations and in the course of a year Rolf installed thirty of his distance relays. In the summer of 1935 Ragnhild worked alongside him at Jacobsen's Electrical Works. According to a true story which Rolf himself has recounted to several people, they were working there late one evening when Rolf was intensely absorbed in his calculations. Ragnhild was sitting in the neighbouring room. Rolf opened the door, looked in and said 'You can go home now, Miss Christiansen.' He had momentarily forgotten that they were married, eight months after the wedding. He said that Ragnhild never forgot this incident.

Headhunted Two

Rolf was a valuable asset to Jacobsen's Electrical Works, but his talents were taking him further. The electricity distribution authority invited six companies to put forward proposals for a distribution grid using the new relays. The six firms were Siemens, AEG, Brown Boveri, Compagnie des Compteurs, Westinghouse and Rolf's company, little Jacobsens. Rolf's company won the contract, convincingly. His comments were laconic: 'My relays were quicker, more accurate, more robust and also cheaper than all the competitors.'

In securing the sales deal for Jacobsens, Rolf had also sold himself. The American company Westinghouse wanted to get hold of the man who almost single-handedly had won in competition with European giants. The director of the Norwegian daughter-company, National Industri Westinghouse, came to see him one day around New Year 1937. The firm had a transformer factory in Drammen and an office in Oslo.

Rolf was given the impression that he would take over the manager's job. He accepted the offer and started with National Industri in April. However, the position was a disappointment and he only stayed there for three years. Most of the work consisted of repairing equipment that the company had had manufactured elsewhere. Servicing and maintenance, in other words, plus time spent on sales. This didn't suit him at all; he was unhappy and didn't conceal his feelings. *Es war für mich keine glückliche Zeit*, ('It was not a happy time for me'), as he said clearly in a German interview many years later. At Jacobsens he had published eight academic papers, at National Industri not a single one. He still gave a few lectures, including a lecture about relays at a Nordic engineering conference in Copenhagen. He became frustrated:

> Typical! I was as if in cold storage at National Industri, as if dead. I obviously gave a few lectures about high-tension leads, but there were no real challenges.[41]

But things are never so bad that there is not some good to be found. At home, he now had a one year old daughter and he had more time to be at home with her and take lots of photos. Their first son was born that year, and family life was recorded in photo captions. 'Arild in the pram in the garden,' 'Arild crawling' and 'Arild learning to walk.' There are also mother's pictures of the proud father on the lawn with their son and father's pictures of the proud mother jumping for joy with Arild on her shoulders. Pictures of Unn's tricycle and of skis and the toboggan. Another son soon followed. Birthday parties with neighbouring children, children in the sand-pit, children on fishing trips, children in the boat. Children, brothers and sisters, aunts, uncles and grandparents bathing at the family's country home. Rolf went on ski trips with his sisters, went skating on Bogstad Lake near his brother's aviation workshop and celebrated Easter with his wife's brothers and sisters in the hills at Ringebu.

On 1st August 1937 a tragedy struck the family. The first one. They could speak about this one. At the age of 29, Arild died. Arild, who was so happy and whose future looked so bright. Arild, who was so meticulous and careful about safety when he was flying. Arild, of whom his brother Viggo wrote: 'In he air, he was the most careful of us all.'[42]

The plane was new, but there was an undetected metal flaw in the wing. I wonder if older brother Rolf may later have asked himself whether if he had continued what he started and built the amazing accelerator that only existed in his head, the flaw in the wing might have been detected. He only found out later that accelerators could be used among other things to test materials and find weaknesses in metal by penetrating it like an X-ray. Such are the ironies of fate and the strange thoughts that come together when someone dies. I hope he didn't think like that; it wouldn't have helped. None of the five who died would have been saved by Rolf berating himself and being wise after the event. Even if such a machine had existed, neither the aeroplane factory nor the Widerøe workshop at Bogstad would have had one.

A question that I *know* he asked himself in his older days and surely also wondered if others were asking themselves, was why he had not continued working on the accelerator when he completed his doctorate. A few great physicists, especially in the USA and England, were researching intensively. But life is lived forwards, not backwards. When he finished his thesis in 1927, he didn't know that somebody would get a Nobel Prize for developing his idea into practical application. At that time, it was a question of finding a job and then starting a family. There wasn't time for experimentation.

While he was working on his thesis he didn't have much contact with other institutions working in the same field. Neither Rutherford's laboratory in Cambridge, nor the Radium Laboratory at Berkeley. He just didn't know of others working on the same topic. He heard and read about this subsequently and understood that he had been in on one of the great ideas of the time, but at that time the only use he could envisage for particle accelerators was to split atoms, and he reckoned that lay a long time in the future. Twenty or thirty years later he said it even more strongly, even though it didn't sound wholly convincing:

> In fact, at that time I was not particularly interested in the possibility of using high energy electrons to produce stronger X-rays, or rays that could penetrate deeper. So I wasn't thinking about X-rays, either for material testing or in medicine. At the time, I considered my work in Aachen as completed and turned my mind to other projects.[43]

The USA Takes up the Thread

The first practical application of Rolf's doctoral thesis was when the American Ernest O. Lawrence invented the cyclotron. Lawrence had Norwegian parents and his real name was Larsen. He grew up in a Norwegian settlement in North Dakota and attended the Norwegian St. Olav's College in Minnesota. The cyclotron was a follow-up of Rolf's ideas, a round particle accelerator that prepared the way for new gigantic atom-smashers. Lawrence was always careful to acknowledge Rolf. He knew where the theory came from, and he never discarded his hand-written notes from when he had come across Widerøe's method of accelerating electrically charged atoms.

Lawrence told Rolf himself about the time when he had been attending a conference at Berkeley soon after he had started there. He had become bored and had left the conference hall to go to the library instead. There he had more or less randomly picked up the journal *Archiv für Elektrotechnik* with the article about Rolf's doctoral thesis. He didn't know much German, but he understood the drawings and the equations. Rolf thought it was good that Lawrence had not understood the text, for then 'he would have got to know about my stabilisation problems' and not persisted. In this way, Lawrence understood the main principle and was able to bring accelerator research the next step forward. It gave him the idea of building the world's first cyclotron.

In American universities, rumours circulated that as soon as Lawrence had seen the article he knew that he would manage to solve the problem even better than Rolf had done. He was said to have run back to the laboratory, bumped into a colleague's wife on the way and shouted out aloud, 'I'm going to be famous! I'm going to be famous!'

Rolf met him many years later and described him kindly as temperamental, headstrong and enthusiastic, and added as yet another positive that he was ready for adventure. Together with his assistants in California, Lawrence had begun by building a linear accelerator but had proceeded a little differently from Rolf and managed to generate significantly higher energy with much lower input. 'Fantastic,' commented Rolf. Eventually Lawrence started to develop a spiral path instead and so invent the cyclotron. Rolf immediately saw that this was the same idea as one of his assistants at the college in Aachen had been considering while Rolf was studying there.[44] He had asked Rolf if they could create a circular path, and Rolf had replied in terms of which he was later ashamed:

> I replied that one could indeed but that it would be difficult to stabilise the circular paths, just as I later wrote in my thesis. Thus died a proposition for the cyclotron, and it was I who more or less dropped the idea.

In one of the lectures he gave in Norway, a very personal presentation at Geilo in 1983, he repeated this self-criticism:

> Professor Flegler had really invented the cyclotron, but my doubt and premature judgement of the idea as a result of my experiments with the ray transformer killed his idea. So: Beware premature judgements!'

Lawrence built his second cyclotron, a little bigger than the first, 10 inches in diameter. With this he could accelerate protons up to one million electron volts and confirm what had earlier been observed by Cockcroft and Walton in England. The third cyclotron was even bigger, with a diameter of 27 inches. This could accelerate heavy hydrogen nuclei, a component of heavy water, up to five million electron volts. The age of atomic physics had begun.

Rolf still didn't throw himself too quickly into accelerator research, mostly because he was pre-occupied with other things. These were the years when he was building up a career in the Norwegian electrical power industry. He did however follow developments from the sidelines and develop his own ideas. He didn't always agree with those he admired, including

Lawrence. One point of disagreement was the size of magnet being used, and even non-scientists can get some insight into this by reading about his thoughts:

> I came to the conclusion that this was not the best way to achieve higher energy. The spiral paths in these accelerators require a magnetic field covering a large area, which can best be created using an iron yoke. Not a big problem so long as the energies are not too high. But on the other hand, if you want to reach higher energies you will soon reach a new limit imposed by the weight and cost of the magnet itself. My ray transformer met the same problem. The magnet needed to accelerate to higher energies would have been altogether too big.[45]

He also thought about a method for solving this problem, even though it would be many years before he could prove it:

> I hoped nevertheless to be able to hold the particles in a relatively narrow ring-shaped tube, like the situation in the ray transformer, and still be able to accelerate them. (…) and so my thoughts went in that direction. But this remained a dream. I never followed this up seriously until later when for purely personal reasons I found time for it, and that was not until 1945.

Big Science

The Berkeley laboratory was the source of other important inventions in the 1930's in addition to the cyclotron. Many people contributed to these, not least Louis Alvarez, another of Lawrence's assistants who battled with the same problems as Rolf. Subsequently, the fundamental structures in accelerators have been considered as being of two types: Widerøe's and Alvarez'. The work done at the Radiation Laboratory, 'Rad Lab,' at Berkeley and at certain other nuclear physics centres was the start of what came to be called 'Big Science.' This term refers both to the magnitude of the topics, and to the size of the research teams required to tackle them. What was especially new was the size of teams. When it comes to big questions such as what the Earth consists of or what are the very smallest particles, one person working in a laboratory is no longer enough. The term 'Big Science' arose during the inter-war years because of the need for heavy technical equipment, big budgets and large teams of scientists working together. The research also had a practical value that was not of equal interest to everybody, and Rolf had his own clear understanding of the motivating power behind the American contribution:

> For Lawrence, the motivation was to build accelerators, especially cyclotrons. It was as if he was obsessed by this, and all his efforts were directed towards it. But for his younger colleagues, assistants and students, splitting atoms and nuclear physics were sufficient motivation to build bigger and bigger machines. I think that this was also the case with Rogowski when he supported my ideas for a six million volts ray transformer. He was a highly educated, extremely intellectual man with a very lively imagination. We never spoke about these possible applications, and I didn't mention them in my thesis.
>
> It was probably too early to mention such things at that time and it would not have been considered serious physics. It would probably have been thought of as science fiction. In my thesis I wrote cautiously: 'It is possible that high-energy ionised radiation might have significance for physics.' Really a bit of an understatement, for ever since 1919 the splitting of the atom had been the main motive behind my interest in high-voltage technology.[46]

The approach of the Second World War added urgency to the research. The Berkeley Laboratory started a rapid programme to build cyclotrons, summarised thus in their own archives:

> In September 1939, as the Nazis started World War II, Lawrence announced plans for a 100 MeV cyclotron. A tight bond developed between the two events. Fear that German scientists might contrive a bomb on the principle of nuclear fission introduced by Lise Meitner and Otto Frisch in January 1939 provoked a crash program to build one here, and the magnet for Lawrence's new accelerator, completed as a wartime priority, helped to develop the machinery for making the first nuclear explosives. The mobilization of the Laboratory brought irreversible changes in its size, scope, and corporate life. It became the embodiment of big science. Its pre-war development had provided a base on which the temporary expansion demanded by the war could not only take place, but take hold.[47]

A Sponsorship Campaign

Norwegian physicists were also interested in the big discoveries that were being made in the first part of the twentieth century. Already at the beginning of the century there was a society that arranged lectures on Kristian

Birkeland's northern lights experiments and where Professor Ellen Gleditsch, who had trained with Madame Curie, spoke about Rutherford and radioactivity. It would still be several years until 1938 when the Physics Society at Oslo University was founded and started publishing the journal *Fra Fysikkens Verden* ('From the World of Physics'). Rolf was not one of the group of physicists around Oslo University in the 1930s, but he knew Olav Netteland well. Netteland worked at the Physics Institute and was on the journal's management committee, which also functioned as an editorial committee. When the sponsors withdrew at the last minute and the publishing initiative seemed destined for failure, Rolf came to the rescue with his industrial contacts. He persuaded his employer, National Industri, to donate 5,000 kroner to the society and also collected several hundred kroner towards the publication of the very first issue in summer 1939.[48] The editor was Egil Hylleraas, a high-ranking professor and head of the theoretical physics department at Oslo University.

Rolf would meet Hylleraas many years later in a rather different context, but if anybody had been able to predict these later events at the time, they would have seemed not just unlikely, but totally absurd. Rolf wrote for the journal in the early years and subscribed to it throughout his life. He reckoned that some good had come from his job at National Industri, as it had contributed to the financial rescue operation for the journal.

When Rolf was interviewed at the age of 81 by a group of young Norwegian physicists, they asked him if he had thought about staying on in Germany after completing his studies and his job at AEG. Would that not have given better career prospects than going into the Norwegian power industry? His answer was a clear 'No!' Hitler's rise to power did not suit him at all. He had had enough of everything German and wanted to go home, and he had never regretted that. He had been able to spread his wings at Jacobsen's, though admittedly not at National Industri, and there had been other benefits. He was in his best years, he was well educated and he had his family, his own house and even a car.

The fact that he was not finished with Hitler when he moved from Berlin to Oslo in 1932 was one of the ironies of fate.

Headhunted Three

In his job at National Industri, Rolf had contact in Oslo with NEBB, Norwegian Electric and Brown Bovery, a daughter company of the Swiss firm Brown Boveri & Co. In spring 1940 he was offered a position in

NEBB, as head of the department that supplied equipment to the power industry. Rolf assumed that this had come about through contact between his boss at National Industry and the director at NEBB. He took up his post in June.

A job in the developing power industry was very appropriate for a man who in his time had written a student essay on 'Voltage distribution through isolator chains in high tension lines.' The high voltage engineer could now show his talents. He earned a reputation for being a good problem-solver, the man to call when things were difficult, a man who saw technical problems as challenges to be overcome. Rolf was effective, got good feed-back reports and generally thrived. He did things his own way, with the result that he could be considered positively to have integrity or, rather more negatively, as being arrogant.

At a conference in Copenhagen he commented rather cheekily on Niels Bohr's opening address that 'I must have heard it, but I can't remember it at all,' and added that 'Bohr's lectures were always a little difficult to understand.' After the conference there was a guided tour of the institute, in which he did not take part. 'As I was in Copenhagen with my wife, I reckoned that I had other things to do. We were probably sightseeing somewhere or other.' You could say he was a little superior and rather laid back in his relationships with the great and famous.[49]

The science of electricity is closely related to the science of atomic power. Rolf was fascinated by this on several levels. It lacked research. It lacked dissemination of the research that had been done. The journal needed articles. So Rolf stepped forward again. He wrote an article for the second issue in 1940, 'Will atomic energy be technically useful?' In the article, he also refers to an article that the editor, Hylleraas, had written. The answer was a resounding 'Yes.' Atomic energy would be useful. Until recently the situation had been that scientists knew a lot about atomic energy, could make calculations and also release 'very small, technically quite insignificant amounts of energy. But the possibility of practical application of atomic energy seemed so distant that nobody considered this possibility and many thought the problem was totally insoluble.' He supported those who thought that they were now facing a breakthrough. In January 1939 German researchers had made 'a discovery that totally changed the situation:'

> On the basis of this and other investigations we can now consider it highly probable that atomic energy can be utilised practically. There are still many conditions to be met and a series of processes to be investigated more

> thoroughly before we can give a definitive answer to the question. But if atomic energy technology is successful the world will undoubtedly enter a new era so different from the present that we can hardly imagine the changes to come.[50]

Doctor of Engineering

Rolf's articles in the Journal of Electrical Engineering were written by 'Dr. Ing. R. Widerøe,' whereas his publication in the journal of the physics society at Oslo University gave his name simply as 'R. Widerøe,' without further degree or title. It is difficult to know how much significance to attach to this. His degree was not from Oslo University, to which most of the members of the society belonged, and academics do have a tendency to value their own institution above others and to undervalue expertise from elsewhere. This may be part of the reason why the industrialist Rolf Widerøe with his patented inventions never gained the same status in Norway as academic researchers who published on scientific matters. Any concern about him not being an academic was unfounded, for in his article on use of atomic power he starts by referring to Einstein's Theory of Relativity:

> The discovery of radium and the study of radioactivity clearly showed that there are large energy sources concealed within the atom. The research carried out by Einstein and others cast new light on this energy, and in 1905 Einstein proposed the Theory of Special Relativity, of which possibly the most important result is the following: "Every mass corresponds to a fixed amount of energy and conversely, every form of energy corresponds to a fixed mass:
> $e = mc^2$.

He continued enthusiastically, and you don't have to understand the details to understand his enthusiasm and his support for those who now saw atomic power as the solution to the world's energy problem:

> Thus we understand that the massive energy concentrated in atomic nuclei represents an Eldorado, an immeasurable and inexhaustible source of energy which, if it can be utilised, could satisfy humanity's hunger for energy for all time.

The article was written in 1939. But then something happened on the research front just as the journal was due to go to press. The Frenchman

Jean Frédéric Joliot and his co-workers claimed that they had managed to prove that uranium could be split using a chain reaction. This news had to be included, and as the article was ready it had to be added as a post-script. Jean Frédéric was often at this time referred to as Joliot-Curie, as he was married to Madame Curie's daughter Irene, herself a chemist. When the couple wrote articles together they signed them with the double sur-name, even though he never officially took the name Curie. They had been awarded the Nobel Prize in 1935 and in his acceptance speech Joliot had, probably for the first time in history, referred to the possibility that chain reactions between atomic nuclei could be a future source of energy. Now they claimed to have shown how such chain reactions could happen, and that was good news for Rolf as an advocate for atomic energy.

In the article Rolf had sketched out grand scenarios where power stations could be fuelled more simply and more effectively with uranium instead of coal. He asked rhetorically: 'Will these amazing possibilities come to reality?' He referred to uncertain results and to research that remained to be done but he ended optimistically, for even if Niels Bohr's hypothesis had not yet been proven, Rolf thought there were grounds to 'assume that the question of the practical utilisation of atomic energy will be solved quite soon.' Then came the news of Joliot's successful attempt which he attached in the post-script dated February 1940.

Things now happened rapidly. By October 1940 a further post-script was required. In this Rolf summarised the latest findings, which confirmed what Bohr had said and what Joliot had discovered. He liked this. At the same time, one had to remember all the considerations that had to be taken into account. And—co-founder of an airline as he was—he remembered the significance of the weight of the fuel. 'So it is almost unnecessary to point out the revolutionary significance for air travel of a fuel that is practically weightless.'

His article showed that the road from particle accelerators in laboratories to relays in the power industry – and back again – was not all that long. It left no doubt that the author believed that atomic energy could one day become a practicality.[51]

I Was Right!

Even though his everyday job was with relays in the Norwegian power industry, Rolf kept himself informed about the research that was going on in the wider world. For example at the University of Illinois, where Kerst, an American, managed to make the world's first betatron in 1941. What's more, it worked well. Was Rolf disappointed to hear this? Irritated? Angry? Sad? No. Should he feel frustrated and reproach himself? Not at all. Is it really true? Did he get it to work? No, you don't say! What a triumph! Donald Kerst has done it! The USA has really picked up speed on accelerator technology since Lawrence. So I was right after all! My theory was correct. Now it's in print, not just anywhere, but in *Physical Review*, no. 60, pages 47–53, in 1941.

This was 14 years after Rolf's pioneering work. The technology had now caught up. The system was stable. The electrons flowed round and round and round. On course as directed. They achieved an energy level that could only be achieved by an otherwise impossibly high voltage, 2.3 million electron-volts, or 2.3 MeV in technical terminology. All this in a tube of only 7.5 cm radius. When everything had been done properly and all the parts put together correctly. But the principle, the idea, the invention; Rolf had thought this out as a 20 year old student in Karlsruhe and written it in his little notebook. It tallied, and had now been fully confirmed in practice.

In the USA, General Electric immediately snapped up both Kerst and the betatron. GE had made the doughnut-shaped glass tube to Kerst's specifications, and Kerst was already pressing ahead with new research for the company when the article was accepted for publication. There was no time to be lost. Nuclear science was on the rise. With optimal management, the electrons in the little apparatus achieved a radiation level equivalent to about one gram of radium. With the price per gram of radium equivalent to about 2.5 million dollars in today's values, it is hardly surprising that Kerst's machine excited attention. Its possible use in medicine was seen immediately.

The way the news about Kerst's betatron reached Rolf is a story in itself. It happened at a meeting of the Physics Society at the University of Oslo in October 1941. It was a rather unlikely sequence of events that would not have happened if the German censorship and postal restrictions had been fully efficient. The war had stopped access to new technical and scientific literature in the libraries. All postal connections between Norway and the Allies had been cut off, and when the USA entered the war postage from there was cut off too. Nevertheless, a remarkable breach of these restrictions occurred when a copy of the current issue of *Physical Review* came in the ordinary post to Roald Tangen at the Norwegian Technical College in Trondheim in autumn 1941, a few days before he was due to deliver a lecture on particle accelerators in Oslo. During his lecture he reported the news of the American who had managed to build a betatron that worked. He had also studied the list of references, and he informed the meeting that it was the work of a Dr. Widerøe that had laid the groundwork for the invention.

Tangen has also told the story himself and explained that his reaction when he read the article was that he 'didn't know any Rolf Widerøe, but that judging from the name this must be a Norwegian.' So a key person in experimental physics at the Norwegian Technical College in Trondheim didn't know about Rolf's contribution until he learned about it from an American. But Rolf himself was in the room, and after the lecture he introduced himself. Thus they met for the first time: Tangen, who worked with Van de Graaff generators and later became a professor both in Trondheim and in Oslo; and Rolf, who made an international career with his betatrons. He has also told of the second time they met at the same place, many years later when Rolf was delivering the lecture. The interesting thing about this account is what Tangen *doesn't* mention:

> It would be 42 years before we met again. In the same auditorium where I had spoken about Kerst's betatron, 80-plus year old Widerøe was talking about his academic career, at the invitation of the University of Oslo. In my vote of thanks, I referred to what had happened in the same place in 1941.[52]

Tangen skipped over the fact that he had had dealings with Rolf in the meantime and had almost held his fate in his hands. He could hardly have done otherwise as he stood at the lectern with Rolf in the room.

Hot on the Trail

When Rolf got hold of the journal and was able to read it for himself, he saw with his own eyes that what the Americans had written could be understood as a natural continuation of his own ideas, and also of the ideas of the later Nobel Prize winner, Ernest Walton, which were developed independently and almost at the same time. The news from America stimulated Rolf to action. This was the field he should work in. The calculations should be done again. That Kerst had found this solution was one of the most useful things that could happen. Mountains are there to be climbed. Stumbling is an opportunity to learn to get up again. While still working at NEBB he also worked for several months on a new scientific paper. He then sent a long manuscript to the same German journal that had published his doctoral thesis and also subsequent articles. This time he wrote about how it would be possible to make betatrons with higher energy than he had written about in his thesis and even higher than in Kerst's betatron. He submitted the article on 15th September 1942 and it was published the following spring. These dates were not important at the time but they would prove to be important later.

He didn't stop there. He wrote a further article a few months later about how the energy could be raised a further notch. He wrote about how to construct a betatron that would produce radiation with energy of not two million like Kerst's, but two hundred million electron-volts. A little more high-flown than the first article, certainly. Submitted to the same journal in Berlin. For one reason or another it was not published. Perhaps it didn't arrive. Perhaps it was stopped by a German censor. In wartime, everything is possible.

Rolf was in mid-life now. He had just passed forty. Father of small children. Full-time employee at NEBB, articles to write, meetings to go to, documents to read in the evening. Trying to keep himself updated about the physicists in Bergen who were eagerly trying to establish a nuclear laboratory and who also, oddly enough, came to hear about Kerst's betatron in an unusual way, but only towards the end of the war. Odd Dahl, who had once worked at the Carnegie Institute in Washington, wrote about this in his autobiography, in the chapter entitled *As an 'atom spy' in the USA*:

> I had received a film roll from the USA via London . One winter night in 1945 I noticed somebody walking up the dead end street to our house in the suburbs of Bergen. It turned out to be the leader of the home front in Bergen. He gave me the film roll with the information that it had been handed over to him from London. Not much more was said.
>
> It was my old friends and colleagues Tuve and Hafstad who had initiated this. They were engaged in electronic research of great importance for the conduct of the war, but the film was not about that. It described in text and diagrams the details of a new type of electron accelerator that had been built by Dr. Donald Kerst, who was unknown to me. The accelerator was known as a betatron, and Kerst and a colleague had built a functioning installation in 1940. This would undoubtedly play an important part in future atomic research, so Tuve and Hafstad had quite rightly thought that it would be of interest to me.[53]

Dahl eventually realised that Rolf had been in the picture, and even though Dahl had good contacts in the USA he credited Rolf in his memoirs. By that time the pair of them had both met and worked together. He had developed great respect for Rolf, and he gives honour where honour is due:

Kerst did indeed build the first betatron, but twelve years before he got it to work the Norwegian Rolf Widerøe had formulated the principles for such a machine.

Following the Trail

These were dramatic times. Research groups were competing to be ahead. In Norway certainly, but mainly between different researchers in the USA and between the USA and other western countries. Competing in atom-splitting, accelerator technology, use of atomic power, new machines. In Europe the Second World War was coming to a climax with the Battle of Stalingrad which was a catastrophe for the German war machine. Hitler was becoming more and more desperate and was looking for something to convince the world—and his own people—that Germany would win the war.

There was now widespread speculation among the allies that the Germans were designing an atom bomb. Most people thought this was just propaganda. The German public didn't know what to believe. Anything might happen. The research became part of the war effort. The Americans started their Manhattan Project to get ahead of the Germans. In Germany, Hitler shuffled the senior people in political control of research programmes. New talent was brought from the inner circles into the atom project, with instructions from Göring to get a move on. See to it that better weapons are produced, and fast. Wonder-weapons. The Luftwaffe racked up its own research, used its contacts, hunted through the scientific and technical community for able people. Anything that could be considered important for the war effort was prioritised.

1942–1943 was a hard wartime winter in Oslo. But Rolf seemed to be holding things together. A Nazi father-in-law, a brother captured by the Germans. A full-time job plus his own research in which he became more and more absorbed. Adversity had never stopped him. He was on the trail now. He had rediscovered the research interest he had worked on in Karlsruhe. Theodor and Carla's eldest son was really beginning to make his mark.

Surely not … ?

Then the Widerøes' world seemed to collapse. For the elderly parents in their house at Vinderen, domestic calm was shattered. Rolf had taken a job in Germany! On a German research project, in Hamburg of all places! The city where Viggo was in prison. Rolf would commute by air, in a German plane. Norway was still at war with the Germans. Could things be any worse in August 1943?

The Gestapo were ravaging the country. 1100 Norwegian officials were arrested in their houses. 1200 Oslo students were captured, and half of them sent to Germany. 500 politicians were interned in the prison at Grini. Viggo had also been there, as one of the first—prisoner number 352—before he was sent to Germany. It was good that they didn't yet know that prisoner number 8197 had been transferred on 29th July from Grini to the concentration camp at Nazweiler. After the war he would become Rolf's brother-in-law when he married Ragnhild's sister. And as Rolf's son Arild later said, 'If Uncle Arild had not died in the plane crash he would certainly have worked with the resistance and been caught by the Germans. I'm sure of it.'

Rolf's wife stayed on in the house in Røa in the Oslo suburbs, with three young children aged seven, five and two. Coping on her own with daily life, birthdays, ration cards, blackout curtains, neighbours, gossip and rumours. Not made easier by her father being a Nazi. Fortunately she was tough and knew her own mind.

The comfortable parental home is creaking at the joints. The ground is giving way, the world collapsing. Then everything is calm again. A father aged 75 and a mother aged almost 70 slowly manage to hold the family together. Christmas must be celebrated, Sunday lunches prepared and grandchildren cared for. One son has died, another is in a German prison. And now this business. Surely not… ? Rolf… ?

***

Then comes the news that Rolf has visited Viggo in prison. One of them working *for* the German authorities, the other arrested *by* the German authorities. Two brothers at the same place but each in his own world. The scene is so absurd that it will take years to see it in perspective and comprehend what has happened.

Notes

1. Else Widerøe and Elisabet Juel started Contact Service AS.
2. Else Widerøe died in August 2012, almost 99 years old, after this chapter was written.
3. Interview during preparation of the book.
4. *Slektshistorie over* ('Family history of') *Kane – Aspen – Widerøe*, written by Ivar Andreas Widerøe and published in Trondheim in 1981.

5. Ole Studevold Hansen: *Opptegnelser fra Tydalen, annex til Selbu.* Kjell Haarstad, Per O. Rød: *Selbu I fortid og nutid.*
6. Wikipedia: *Aftenposten 15 June 1997.*
7. Thanks to two young Norwegians, physicist and scientific historian Finn Aaserud and physicist Jan Sigurd Vaagen, who had heard about his contribution, an interview was arranged with Rolf Widerøe, then aged 81, during his annual summer holiday in Norway. The interview took place in Oslo on 12th July 1983 at what is now the Nordic Institute for Studies of Research, Innovation and Education, and lasted almost a whole day. Two other physicists took part in the interview along with Aaserud and Vaagen, and the whole interview was recorded.
8. *Some Memories and Dreams from the Childhood of Particle Accelerators*, lecture dated 3rd December 1982. The meeting was at Geilo on 12th January 1983.
9. *Aftenposten*, 17th July 1971.
10. The interview with the physicists in 1983.
11. Pedro Waloschek: *Als die Teilchen laufen lernten. Leben und Werk des Großvaters der modernen Teilchenbeschleuniger – Rolf Wideröe. Redigiert und zusammengestellt von Pedro Waloschek.* In English translation: *The Infancy of Particle Accelerators. Life and Work of Rolf Widerøe. Compiled and edited by Pedro Waloschek*, Vieweg, 1993: Later referred to as 'The biography'.
12. The biography.
13. The biography.
14. The interview with the physicists in 1983.
15. Dr. Eugen Flegler.
16. Professor Karman.
17. *Notgemeinschaft der deutschenWissenschaft.* The organisation was then only four or five years old. It is now called the *Deutsche Forschungs-Gemeinschaft* or *DFG* ('German Research Foundation').
18. The biography.
19. 'In 1924, Gustav Ising had suggested a principle of multiple acceleration, or repeated acceleration, of charged particles in a straight line. Widerøe brought Ising's idea into reality by establishing the principle of multiple acceleration using alternating current. Then he constructed the world's first linear accelerator, based on this principle, and showed that it worked in practice: He accelerated Ca and Na ions to 50 keV in two successive steps, each of 25 keV, in a high frequency voltage field. The principle of alternating current based multiple acceleration – first achieved by Widerøe – was the basis for the amazing development of both linear and circular accelerators that has continued throughout the twentieth century. A copy of Widerøe's accelerator now stands in the 'minimuseum' in the reception area of The Norwegian Radium Hospital.' (Tor Brustad in discussion during the preparation of the book).
20. The Dr. Paul Meyer Laboratory.

21. J. Biermann in AEG and Reinhold Rüdenberg in Siemens.
22. Otto Meyer.
23. The biography.
24. Gregory Breit, Merle Tuve and Lawrence Hafstad.
25. Kaiser, H. F. (U.S. Naval Research Lab., Washington, D.C.): *European Electron Induction Accelerators,* in *J. of Applied Phys. 18, 1–17* (1947).
26. Per F. Dahl: *Rolf Widerøe: Progenitor of Particle Accelerators,* Superconducting Super Collider Laboratory, Dallas, Texas, March 1992.
27. The biography.
28. *Nordmenn I fangenskap* ('Norwegians in Prison') *1940–1945.* An alphabetical register with an introduction by Kristian Ottosen.
29. Helge Skappel and Viggo Widerøe: *Pionertid* ('Pioneering Time'), Oslo 1945.
30. The three were Halvor Bjørneby, Helge Skappel and Leiv Brun.
31. He wrote Sunday 13th March, but the 13th was a Monday. So the date must be 12th March, as the display took place on a Sunday.
32. Turi Widerøe presented an excerpt of his father's description in a series of articles in the airline's magazine, *Perspektiv*, in connection with the company's 75 year jubilee in 2009. This text is from the February 2007 issue.
33. No. 8, 15th March 1933: *Relébeskyttelse i kraftfordelingsnett* ('Relay Protection in the Power Distribution Network').
34. No. 14, 15th May 1934: *De første kotslutningsforsøk med norske distansereléer* ('The first use of Norwegian distance relays to detect short-circuits').
35. Helge Skappel and Viggo Widerøe: *Pionertid* ('Pioneering Time'), Oslo 1945.
36. Erik Engnæs, Ditlef Smith, Helge Skappel and Leiv Brun were also members of the company. The latter two, together with Halvor Bjørneby and the brothers Viggo and Arild were the day-to-day driving force.
37. One source says that he met her at *Svæs danseskole* in autumn 1933, another that they met at Miss Fearnley's Dance School in February 1934.
38. That is how Viggo described it in the airline's 50-year jubilee book the year before he died.
39. Per Arne Watle in: P.A. Watle: *Oppdrift i motvind* ('Soaring Against the Wind'), Abstract, 2004.
40. Helge Skappel and Viggo Widerøe: *Pionertid* ('Pioneering Time'), Oslo 1945.
41. Turi Widerøe: *Is, fly og skip. Oppdagelse og kartlegning med fly i Øst-Antarktis 1929–1939.* ('Ice, Planes and Ships. Exploration and Map-making by plane in East Antarctica 1929–1939). Masters degree dissertation in history, History Department, Humanities and Social Studies Faculty, Tromsø University, 2006.
42. The biography.

43. Helge Skappel and Viggo Widerøe: *Pionertid* (‘Pioneering Time’), Oslo 1945.
44. The biography.
45. Eugen Flegler, one of the assistants of Rolf’s supervisor, Rogowsky.
46. The biography.
47. The biography.
48. *Lawrence and his Laboratory. A Historian’s View of the Lawrence Years.* Published in 1981, in honour of Berkeley Laboratory’s 50th anniversary. Chapter 3: ‘Deflecting Physics for War.’ Nuel Pharr Davis: *Lawrence and Oppenheimer*, 1968.
49. He says 5,000 kroner in the biography that was written in 1993, but he doesn’t specify whether the payment was 5,000 kroner in 1938 or the equivalent of 5,000 kroner at 1993 values.
50. The quotations are from the biography.
51. Otto Hahn and Fritz Strassman.
52. He wrote several articles on this topic, including ‘*Thoughts on the Energy Situation*, Atomenergie (ATK) Bd 31 (1978) Lfg. 2.
53. The biography.
54. *Trollmann og rundbrenner* (‘Wizard and Maverick’), Gyldendal 1981.

2

The World Awaits

19th August 1946. A family of mother, father and three children—two boys and one girl—pack their car and leave Oslo. They are going to a new life, in a new land. First by boat to Antwerp, then on through Holland and Luxembourg. The war is over. The world awaits. Father has been offered a management position at Brown Boveri's head office in Switzerland. Mother sees this as the way ahead. She is the oil in the machine, the hub in the wheel, the person everybody turns to, the one who runs the household. Her husband has always travelled a lot, but now the whole family is on the move. The appointment is for three years. The children are to go to the Steiner School there, and the house in Røa in Oslo is being leased out to his sister and her husband.

'He' is Rolf. 'She' is Ragnhild. 'The children' are Unn, Arild and little Rolf, born towards the end of the war. They are moving into a little flat in Zurich. Their new life is beginning. It's exciting for them all.

Rolf had gone to Switzerland before Easter to negotiate his appointment. He had flown there, even though they could scarcely afford it at that time. Indeed, he had had to sell about thirty of his patent rights that year. The firm he worked for in Oslo, NEBB, a daughter company of the Swiss company Brown Boveri, had bought them from him. During his visit he had met one of the Boveri brothers, Walter Boveri, and his first assignment was to build a big betatron for the hospital in Zurich. Neither of them believed that such a powerful betatron could be built in Norway. The technical equipment was not good enough, there were no glassblowers capable of making the tube, and technology to make the tube airtight was unavailable.

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_2

Rolf had taken quite detailed construction plans with him on his preliminary visit, and preparatory work started while he was there. This was obviously a prestigious project that was given high priority. Brown Boveri wanted to show the world what they could do, and they had got hold of exactly the person they wanted. The Americans were in the lead in technology after the war, and many of the best European researchers had gone to the USA to improve their prospects. Europe was left with a brain-drain problem. The company wanted him to start as soon as possible. As he himself said years later in an interview, the company thought that the betatron was as good a way as any to compete.[1]

In October-November he was back in Oslo to sort out various formalities. Then it was just a matter of pressing on with the job. It was up to him now. But to develop an idea into reality involves many days devoted to an endless list of small details, and this affected the whole family. He hardly travelled at all during the first three or four years. Everything depended on building the betatron. If he succeeded, it would be the first of this special type of radiotherapy machine in Europe. He had to succeed. His professional reputation depended on it.

Sound, Stench and Knitted Mitts

By spring, the betatron was beginning to take shape. It was being built in an inspection tunnel under a big assembly hall where generators were tested. The tunnel also served as a conduit for air conditioning and heating equipment, with all the associated smells and sounds. Such working conditions would not be acceptable today. The noise bothered him most. When machinery was running in the hall above, the people in the tunnel below couldn't hear each other speak. From time to time the generators were coated with various types of insulation material, and it became difficult to breathe because of the fumes seeping into the tunnel[2].

Fifty or sixty years later, Rolf himself found it difficult to believe that he had really got the Zurich betatron to work at last. He had made a smaller one during the war, but it was sent to England and disappeared. He had dreamt of this new one for so long. Toiled over it; there was no lack of effort. Needed it; for his reputation, for his livelihood.

Radiation hazard had been a problem. More than just a problem, a real danger, even though he himself was not so scared of it. They didn't have much protection against the radiation, and once a week he and the staff had to drive 30 km to the hospital to have their white blood cells counted. If the level was lower than 3,000 per cubic millimetre they would need to 'have a little holiday,' as he described it. Then when they increased the power of the machine even further the radiation level also became too high for the workers on the floor above. But nothing is without some good, for this led to them getting their own radiation laboratory that was not only safer but also better equipped. They were glad to see the light of day, and in his lectures he used to point out that 'developing a betatron was 95 per cent sweat and 5 per cent inspiration, though he did add that 'Sometimes you really need that inspiration.'

Nor was their flat anything to boast about. It was small and gloomy, and as autumn progressed into winter they soon realised that it was also cold. The children found some things familiar and some rather different from what they were accustomed to, but with enough novelty to whet their interest, such as downhill skiing in the Alps using cross-country skis. Using the ski-hoist was out of the question, and the wind blew right through their home-knitted woollen mitts.

The Secret Room in the Attic

Their time in Norway had had dramatic moments too, with a war on and much happening that they hadn't understood. Father had only been home in the holidays, plus a few days now and again. Now that they had moved to Switzerland he was home all the time. The children later came to realise that mother had not had an easy time in Norway. Her husband was constantly on the move without her being able to say very much about it. Plus three small children, everything rationed, rumours of Nazi affiliations—and uncertainty, uncertainty.

Arild, the eldest, remembers best and has thought about it since. When asked how his mother had fared in Norway during the war, he replied:

> It was certainly difficult for my mother, for I know that we had lots of home front newspapers stored in a secret attic in our house in 8 Melumveien. I know exactly where. And that was risky.
>
> *Were they for onward distribution?*
>
> Yes, they were passed on further.
>
> *So bundles of newspapers came to your house?*
>
> Yes.
>
> *Who distributed them then?*
>
> That I don 't know.

> *Someone came and fetched them?*
>
> Yes, someone certainly came to fetch them. I reckon my mother had connections with the home front, otherwise that wouldn't have happened. I'm sure of it. It's not just something I have suddenly discovered.
>
> *What was the paper called?*
>
> I don't know. I just know that the house had a type of annexe on the first floor, a dormer, where father had a sort of office, which was the guest room and in there we had two secret spaces that you didn't see right away.[3]

That was a lot for a little boy to think about. Some of life's questions remain unanswered even as an adult.

BBC Becomes ABB

The business Rolf worked for after the war was not just any company. BBC was not something to do with British broadcasting, but stood for Brown Boveri and Co. Charles Brown and Walter Boveri had founded it as early as 1891 and had started building their first generator factory in Switzerland that year. The firm played an important role in the electrification of the European rail network, which started with BBC taking responsibility for a 20 km stretch in Switzerland at their own risk. The next big development was steam turbines. Shortly before the First World War the company delivered what was till then the biggest steam turbine in the world, at 40,000 horsepower. The company soon outgrew the home market and started establishing daughter companies throughout the world. Shortly before celebrating its centenary, BBC had almost 100,000 employees and an annual turnover equivalent to about 7 billion US dollars in today's values. Rolf came on the scene about half-way through the company's first century with responsibility for the development of betatrons, which remained one of their major specialties for several decades. They were in competition with Siemens, another global firm with a rich tradition.

If you drive into Baden today you will see the company's buildings grouped almost like a little town within the municipality. *Brown Boveri Strasse* runs as it did then past the original brick building that now faces a modern reception area in glass and steel across the road. The name on the reception building is no longer BBC, but ABB in red, illuminated letters with the logo's characteristic square pattern of thin white lines binding them together.

In 1988 Brown Boveri merged with the Swedish company ASEA to become ABB, ASEA Brown Boveri Ltd. Percy Barnevik from ASEA continued as chairman of the combined company, turnover soared and for a while the firm made repeated appearances in jubilant headlines in the Norwegian press. ASEA had secured a majority shareholding in the Norwegian telecommunications and industrial concern *Elektrisk Bureau A/S*, which was among the leaders in the Norwegian electronic and telecommunications industry and until then had supplied telephone apparatus to most Norwegian households. These were significant times in Norwegian and European industrial history.

Norsk Elektrisk and Brown Boveri A/S, better known as NEBB, had been a daughter company of Brown Boveri ever since 1908. Among other things, they had built locomotives for the Norwegian Railways in their factories near Oslo. The company had its origins in 1874, as Frognerkilens Fabrikk and changed name in 1894 to Norsk Elektrisk A/S. Collaboration with BBC had started in 1905 and in 1908 the two companies had merged to become NEBB.

Skabo Railway Carriage Factory joined the group in 1948. Then in 1973 the Skabo Railway Carriage Factory was closed down and the assets transferred to Strømmens Værksted, which was bought up by NEBB six years later in 1979. Nine years after that, in 1988, NEBB became part of ABB when the parent company merged with ASEA.

NEBB had a proud history by the time the Swiss company came into the picture. The Solberg family had owned the famous Frognerkilens Fabrikk for several generations, and they continued to lead the business long after the firm was taken over by NEBB. When Rolf was employed in their factory at Skøyen in 1940 the manager was Sven Adolf Solberg, one of the third generation of the family. He and Rolf were about the same age, and they became good friends for the rest of their lives. Sven Adolf had the same name as his grandfather who founded the company. He had qualified as an engineer at the same technical college in Zurich where Rolf later taught for many years. Immediately on qualifying he had taken up employment in the mother company in Baden until four years later when his apprenticeship was complete and he came home to join the family business in Oslo, where he became managing director in 1926.

A New Ford and a Free Hand

Now, in 1946, it was Rolf's turn to take up a position at BBC's head office, where he was given a free hand. The company wanted to establish its reputation in atomic physics and particle physics in competition with Siemens and the rest of the world, and the management supported him in all his enterprises. He was clearly the leading expert on betatrons in the whole of Europe. Rolf himself thought that the wide authority he was given was largely thanks to Professor Scherrer, whom he had met during his visit in the spring and who was an ardent advocate of betatrons and a good friend of Walter Boveri. Scherrer was a great scientist who later had a research institute named after him, and he was a good friend and helper to Rolf.

Although the betatron was primarily designed for medical use, the management at BBC saw it as a means of getting into atomic physics, which was now the big thing in science. At a time when the atom bomb dropped on Japan had affected the whole world and stimulated the industry, the idea of a 31 million electron volt accelerator had a certain psychological effect even on people who knew nothing at all about physics. The exact figure of 31 million electron volts was chosen because that strength could pass through 10 cm of human tissue, which Rolf at that time thought would be sufficient. He developed a good working relationship with Dr. Hans Rudolf Schinz at the University of Zurich, who was also an enthusiastic supporter of the new treatment machine. In addition to his university appointment, Schinz was also head of the radiotherapy department in the town hospital. So Rolf had all the supporters he needed: in the company management, because the senior director knew a professor who was positive about it; at the university, because they saw the scientific potential; and at the hospital, because they needed the machine and were willing to pay for it.

That didn't mean that the task of building it was easy, however. There were major technical problems at the start, and it was difficult to get the machine to work as it should. Rolf tried to build it similarly to how he had built his smaller machine several years before, and he studied the American Kerst's latest machine. Six months later, in January 1948, he found the solution. The project gathered speed. In 1949, after three years in Switzerland, he renewed his contract. Didn't return home as he and Ragnhild had expected. Stayed on in Switzerland. That was where the opportunities were. And the children's schoolmates, and their own friends, and the tennis court. Moreover, he had to see the betatron fully installed and in use in the hospital that had ordered it.

The machine had now come to a stage of construction when it could be moved to the hospital. The business of mounting and calibrating it began in a special room there, paradoxically at the same time as Rolf and family moved house in the opposite direction, out of the town. The family of five moved into a house nearer the factory, in the town of Ennetbaden. There was still a lot of work to be done, particularly on radiation shielding, and various modifications were made to protect people from stray radiation. These mainly involved the use of sheets of lead to protect against X-rays, but machines such as this also produce neutrons. Protection against these was more complicated, because of the need to distinguish between fast and slow neutrons, each of which had to be dealt with differently.

Testing continued. It was a race against time as the customer began to get impatient. When Dr. Schinz came to inspect the work one day and saw Rolf lying under the machine, he said jokingly but not without some sting, 'There lies my worst enemy,' and poked him with his walking stick. But Rolf reached his goal at last. Europe's very first high-energy radiotherapy betatron was ready. There was great enthusiasm, and the first patients were treated in April 1951. Rolf and Dr. Schinz continued to work together and wrote several articles on high-energy radiation.

The investment paid off. Rolf's son Arild says that Rolf got a pay rise when the betatron was ready. They had now been in Switzerland for five years. Arild was then 13 years old, and he remembers it well. His father sold the old Chevrolet and bought a brand-new Ford.

Arild *(eldest son)*
When Norway was occupied by the Germans, the Norwegian defence forces had already requisitioned private cars, because they didn't have enough vehicles of their own. At that time my father had an American Ford, a '36 or '37 vintage, that he had to let go. But, man that he was, my father went straight into town and bought a new car. A Chevrolet, that wasn't registered. It just sat in the garage. Without wheels. Under a tarpaulin. Nobody knew about it. At least, the defence forces didn't know that there was a car there. It just stood there until the war was over. So my father was one of the first people to drive a car in Oslo after the war.

Arild *(eldest son)*
In 1951 we drove to Norway in the old Chevrolet, left the car behind in Norway and took the train back to Switzerland. We stood almost the whole way. We did have seats, but we youngsters, we stood, for there were masses of Germans invalided by the war who needed to sit. My brother, little-Rolf, he always stood in the car too, stood from Switzerland to Norway. There was really no room to sit on the back seat, because we had so much baggage there, so he stood over the universal joint, and so he saw better too.

Rolf jnr *(youngest son)*
The car that we drove when we moved to Switzerland, we had it until 1951. Then Dad bought a car here, a new Ford. And the Chevrolet was sold to an in-law, Egil Reksten. That was when the first betatron had been sold, and he was given some money. He had sold his patents to Brown Boveri and he had

an agreement with them that if it was a success and they managed to sell the machine, he would get a commission. And the first thing he bought with that money was the car.

***Rolf jnr** (youngest son)*
I think I remember us being on the boat. But maybe I remember it because I've seen photos.
Did you know why you were moving?
'Because my father had got a job in Baden.'

***Arild** (eldest son)*
My mother told me later that it was she who had decided that we would live in Zurich, even though my father was working here in Baden. She thought that there would be nothing to do in Baden. She wanted to go to Zurich which was a proper town, not just an ordinary little village. But she regretted it later, for when we moved to Baden she made good friends there and joined the tennis club and all her social life was based in Baden.

***Rolf jnr** (youngest son)*
The Steiner School was on the other side of Zurich, near the University Hospital. We could get the tram there but in the summer I saved, I think it was five centimes, every time I used my scooter.

***Arild** (eldest son)*
He was good with us children too. I remember we were allowed to be there when the first betatron was installed at the hospital. There had been a lot of night work, for they were behind schedule, and Sunday work too. And then we were allowed to come too – at any rate I was – and we were in the hospital and looked around and there were many strange things to see there. But I have thought since that perhaps it was not just to be kind to us, it may also have been to stir up a little excitement. He wanted to show that he had done it at last. The invention back in 1927 when he did his doctoral thesis, that was just pure theory. But here is my life's work! Which now works at last. And it can help people who are ill, by curing cancer, or at least by trying to cure cancer, without causing so much scarring around the tumour.

Bergen V. Oslo

Meanwhile, another race was taking place in Norway, where two of the nation's leading hospitals were vying for prestige. The hospital at Haukeland in Bergen was trying to get ahead of the Radium Hospital in Oslo. Both institutions wanted to be up-to-date in providing high-energy radiotherapy for their cancer patients. But how to obtain such a machine? There is no competition more fierce than a struggle between Oslo and Bergen, and both cities armed themselves with international expertise about the various types of high-voltage equipment then being tested in America and in Europe.

During the war, Haukeland Hospital in Bergen had decided that they would build a Van de Graaff generator. Local man Odd Dahl, who would later come to know Rolf, was to be responsible for making it. Odd was a colourful and self-taught practical man, an engineer and an aviator. He had been a pilot on the Maud Expedition with Roald Amundsen, worked as an assistant at the Carnegie Institute in the USA and earned a reputation for constructing various types of instruments. He was now employed at the Christian Michelsen Institute. Dahl played a leading role in the technical development of nuclear physics in Norway and later took part in the planning and construction of the first Norwegian atomic reactor at Kjeller.

Early in 1938 the Bergen district of the Norwegian Red Cross had set up a Committee Against Cancer, to take up the fight against the disease that was then causing more deaths per year than tuberculosis, as Dahl wrote in his book:

> They launched an appeal for money to buy radium for cancer treatment at Haukeland, but the price of radium was so ridiculously high that it became clear that nothing less than a million kroner banknote would suffice. That was when the idea of a high-voltage generator was proposed.[4]

Many universities throughout the world were now setting up atomic research groups as a natural consequence of accelerators having been developed. Dahl considered that a high-energy installation would increase Bergen's status as a scientific centre and would support the campaign to establish a university there. Surely Oslo shouldn't be the only Norwegian city to have a university? The Technical College in Trondheim was also working on high-energy radiation and had already built the country's first accelerator, a Van de Graaff generator that Haukeland Hospital thought was too small.

The generator project in Bergen was regarded sceptically both by the medical profession and by others who didn't hesitate to express their doubts, as Dahl recalled:

> The plans were hotly debated in the press, where the majority opinion was that it would be throwing money away on something that would never give results. "Do these people in Bergen think they can achieve something nobody else has done?' seemed to be the feeling in the capital.[5]

He and his colleagues went to Philips in Holland, but came back disappointed. The Van de Graaff generator was too expensive. If there were to be any apparatus, they would need to build it themselves. Dahl had been involved with such machines at the Carnegie Institute, and he asked his Norwegian-American colleagues Tuve and Hafstad to look at the plans. These were well enough advanced for building to begin, and in 1941 the Van de Graaff machine in Bergen was ready for use.

However, developments were proceeding elsewhere in the world, and by the end of the war Haukeland Hospital needed even more equipment. Again the problem was money, though this problem was solved in an unexpected manner. They won the equipment, but lost the race with Oslo. The man who pulled the strings was the chairman of the board of the Radium Hospital, and this is how it came about that Bergen's competitor became their rescuer:

> The Radium Hospital in Oslo, who had expressed strong opposition to the high-voltage plans at Haukeland before the war, had seen that the apparatus had fully proved its worth. "So we must have one too," they thought, and I readily accepted their invitation to build them a machine like the one at Haukeland. This work was well under way by the time the management at the Radium Hospital learned that Rolf Widerøe had been appointed at Brown Boveri and Co. in Switzerland to develop betatrons for commercial sale to hospitals. They decided that was the type of machine they wanted. I said I was willing to build one for them, but they preferred to buy one from Switzerland so that they could be sure it would work. The situation was resolved by Schibsted, the editor of *Aftenposten*, who was also chairman of the board of the Radium Hospital. He arranged for the high-voltage machine that they had ordered from me and on which I had started work to be fully paid for and presented to Bergen.[6]

Moscow also took note of Bergen's interest in atomic physics. World War 2 was followed by the Cold War, when anything to do with atomic power was hot news. The foreign commentator of the *Red Star* wrote what seems to us a rather distorted account of the situation:

> Norwegian scientists have for some time been taking part in the work on nuclear fission that is being done in the United States. This work is now also taking place in Norway. In Bergen there is a specialised institute where the Norwegians are researching nuclear fission under the direction of American colleagues.[7]

The Radium Hospital Changes Direction

Oslo also needed to renew its radiotherapy equipment. They too contacted Philips in Holland to enquire about a Van de Graaff machine. They came to the same conclusion as Bergen; it was too expensive. Then a new and even better possibility arose; a Brown Boveri betatron. The first and so far the only one of these in Europe had been built in Switzerland. Professor Tor Brustad, who has had a long career at the Radium Hospital, tells the story:

> 'Much of it happened by coincidence. It started in 1949 when the Radium Hospital appointed a physicist from Oslo University, Olav Netteland. Brown Boveri had delivered their first betatron to the hospital in Zurich that year, and Rolf Widerøe knew Netteland from when they had both taken part in rescuing the newly started physics journal before the war.
>
> Many years later, Netteland told me that in 1950 he had received a letter from Rolf Widerøe in Switzerland, saying that he had succeeded in building the first betatron for use in radiotherapy and that it had been delivered to the hospital in Zurich. Brown Boveri was going to build another machine and if the Radium Hospital was interested they would need to act fast as several hospitals around the world had already been in contact with the company. Netteland was so interested in this that he informed the director of the hospital, Reidar Eker. The director was a businessman and he decided to send both Netteland and a senior doctor to look at the machine and find out whether it was suitable for the Norwegian situation. They came back very enthusiastic, went to the director and told him not only that he must order a machine but also that he must do it immediately.[8]

Brustad told me that he spoke about this with Rolf many years later and that Rolf said that the order from the Radium Hospital was the strangest order that Brown Boveri had ever received. It simply read: 'We are ordering a betatron.' Full stop, followed by the date and the director's signature. No specifications, no indication of the energy level required. No mention of radiation intensity, voltage, radiation shielding and so on; none of the details normally included in an order.

> When Rolf Widerøe told me this, he laughed and said "So we built a 31 MeV betatron for them." It was delivered on time in 1952, a machine exactly like the one supplied to the hospital in Zurich. In the meantime the Radium Hospital had built a special bunker to house the wonder-machine. The test period after installation lasted until the end of the year, before it was applied to routine treatment schedules from the start of the new year. So the Radium Hospital had acquired Europe's second betatron to provide radiotherapy for cancer patients. The fact that we took part so early in the development of radiotherapy – you could call it a revolution – put the Radium Hospital right in front. Accelerator-generated radiation was clearly the big new advance.

Brustad, who told me this, was a newly appointed research worker when the Widerøe machine was purchased. He later became a professor and was head simultaneously of the cancer research institute's biophysics department and the hospital's department of medical physics and technology.

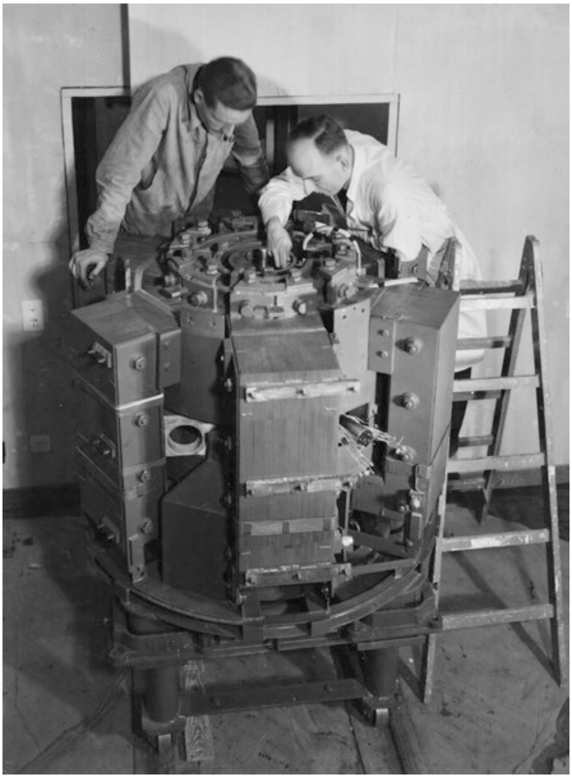
In Rolf's Own Words

Rolf himself has also told the story behind the Radium Hospital's order and what was going on in Bergen, and the story becomes no less dramatic when it emerges that Siemens had also been involved.

At first, the people in Bergen had tried to get hold of a Philips machine, which they found they couldn't afford. They had only managed to collect 150,000 kroner. 'We must remember that a Van de Graaff machine like this could generate radiation equivalent to the output of one gram of radium. And at that time a gram of radium cost about a million kroner,' Rolf explained in an interview. But Philips had advised that they could build a machine themselves, especially as Odd Dahl could take charge of the technical process of manufacture. He had already built and operated high-voltage machines in the USA. The Van de Graaff machine for Haukeland Hospital was completed in 1941 and was able to generate 1.7 million volts. Then Dahl went on to lead the work on a new machine of the same type, which went up to 2 million volts. Eventually the Radium Hospital in Oslo asked if they could have a machine like that, and work was started. But then things began to happen:

> When betatrons became topical in 1948 the senior doctor at the Radium Hospital, Dr. Bull-Engelstad, ordered one from Siemens in Erlangen. It was to have an energy level of 6 MeV and to be delivered in 1949. (…) The parts for the Van de Graaff machine that was already under construction were given to the University in Bergen as a gift. That was the situation when Olav Netteland started working at the Radium Hospital in September 1949. That autumn, Netteland went to Erlangen to look at the betatron. Siemens had already started developing a betatron of 12 or possibly up to 18 MeV.
>
> By that time Brown Boveri in Baden were well advanced with the 31 MeV machine they were building for the hospital in Zurich. Siemens presented their 6 MeV machine at a radiology conference in 1950 in London. It was discovered later that the equipment exhibited had been non-operational and that the machine had never had a drift tube. Olav Netteland then got in touch with me, and in September 1951 he and a doctor, Dr. Steen, came

to Switzerland to look at our 31 MeV betatron that was already up and running at the regional hospital. I went to Erlangen later that autumn, when all Siemens could show me was their 6 MeV betatron. They were still a long way short of completing their 12 MeV machine. I had no difficulty arranging for the Siemens order to be cancelled, and Professor Eker immediately ordered "a betatron" from Brown Boveri. We delivered a 31 MeV machine in summer 1952, and it was in use six months later.[9]

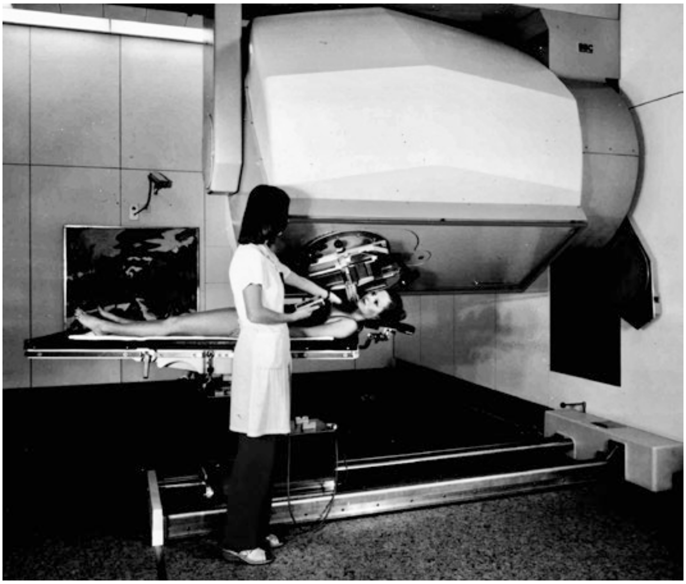


The work on the first medical betatron, a 31 MeV machine, took four or five years up to 1950. Rolf Widerøe participated actively all the time. (*Photo* ABB Archives)

The first medical betatron was a machine for the hospital in Zurich. On the left: D. Gamper. (*Photo* ABB Archives)

Rolf Widerøe at the control panel of the betatron that was developed for the Norwegian Radium Hospital, his second 31 MeV betatron, which was delivered in 1952. (*Photo* NTB scanpix)

The acceleration tube from the Norwegian Radium Hospital's first betatron, on display in a glass cabinet in the hospital vestibule. (*Photo* Knut Bjerkan)



The Inselspital University Hospital in Berne in 1952 got their first medical betatron, number three in the series of 31 MeV machines. (*Photo* ABB Archives)

Throughout the next few years Rolf was in contact with the Radium Hospital several times to ensure that the glass tubes were as they should be. It was during one of these visits that the research worker Tor Brustad got to know him. The tubes that were available at that time lasted only about 500 h, or perhaps sometimes as much as 1,000 h. That was not nearly enough. They experimented with different types of tube but Rolf was not satisfied, even though Netteland thought that there had been an improvement after the first year. The problem was not resolved until autumn 1957 when Rolf himself went to Philips in Eindhoven, who recommended their own patented method. From then on, the tubes were always supplied by Philips. The life of the tubes rose to over 20,000 h, and sometimes as high as 40,000 h. Subsequently, tubes were developed that could last 25 years or more.

Another part of the history of the Radium Hospital's famous first betatron is that the experts were concerned about the radiation hazard the operators were exposed to. The betatron came to be referred to as 'the sterilising machine.' Rolf forthrightly rejected their fears.

French Chateaux and Norwegian Summers

The first two or three years in Switzerland were quite hard for the family. Rolf was very taken up with his work, and holidays like those of former days were infrequent. Norway was a long way distant, and Ragnhild took the children on her own for summer holidays in Norway. The war had ended only a few years before, and travel was still difficult and exciting, as Arild recalls. He was aged ten at that time and travelled on the back seat.

> We drove through Germany, which was quite problematic at that time. It was impossible to buy petrol, and so we had depots in various places and always carried 40 litres in two spare cans. Our route went through Basel and on to Heidelberg. An old student friend of father's lived there, a director of Brown Boveri in Mannheim. We stayed overnight with him, as there were no hotels. Or rather, they were all full of Americans or English. It depended which zone you were in. Heidelberg was in the American zone, and we got petrol there. Then on to the next depot, where we filled the petrol tank again. That lasted us as far as Northeim, where we were able to fill up again at the Norwegian military base. That was enough to take us to Hamburg. He had another friend there who was called Seifert, and we stayed there overnight too. And then we were soon in Denmark. But the journey took a long time in those days, as the motorways were narrower and people didn't drive so fast. Many bridges had been destroyed, blown up by the Germans themselves to block the American

> and English advance. Almost every second bridge had been damaged, and there were numerous diversions. It took five or six days to get to Norway. My mother usually drove at first when father didn't have time to come with us. So then my mother arranged either for one of her sisters to come, or sometimes it was an uncle who came down to visit us and drove us back up, or the other way round and someone drove us down again.

Starting from Switzerland, other continental countries were quite near. In the short spring and autumn holidays the family went by car to, among other places, the neighbouring country of France, where Rolf's father had business connections. The children were very impressed by their visits to the wine chateaux, as they have later recalled. This was a time of new experiences for young and old. Hard work for father, yes, but full of excitement for them all. Throughout the year, despite work and everything else, Sunday was kept as a free day for the family, and that meant going out on a trip. Both Rolf and Ragnhild took many photographs, as is evident from their albums: eating sausages; quiet lakes amid the forest; mountaintops and ski trips.

After an intensive induction period in the first few years, Rolf began travelling abroad for Brown Boveri. His travels really took off in 1952, when he was away every month to some place or another and usually to several. This continued for the rest of his career at Brown Boveri, with visits to more and more new countries. Altogether, he visited about fifty different countries where he delivered lectures, attended conferences or discussed betatrons one way or another.

He enjoyed travelling, but he also liked having people coming to visit. 'You must come down to visit us' was a repeated refrain when he was talking with the family in Norway. And they did, young and old, alone and together. 1950 was the start of a social era which lasted more or less for the next half century. Welcome! Bring your friends! We have room for all! They came: siblings; brothers-in-law; sisters-in-law; nieces and nephews. They all thought it fun to travel abroad and visit Rolf. Didn't he do it really well? He had a lovely house, and was always so welcoming. But they did realise that he worked hard. One of the nephews on his wife's side, Jørgen Holmboe, uses the word 'inclusive' when he recalls these days:

> They kept really close ties with Norway. We were in regular contact and visited them many times, and they always came to Norway in summer, to visit the family and stay at the holiday home on Skjæløy. It was like part of our family tradition in summer. I'm not a Widerøe, but it's as if I was married into the

family, as Ragnhild was my mother's sister. That's not really a close family tie, but I do know several of the Widerøe family, such as Rolf's brother Viggo and sister Else for example. My extended links with the family show that when Rolf and Ragnhild, were home they were very inclusive. I have also visited old Mrs. Widerøe at the house on Skjæløy. Why would I have done that? I'm only a rather distant relative. They have nurtured these wide family ties. Their home was a staging post for everybody who travelled abroad. There was always somebody visiting them in Switzerland. I would say that we had closer contact with them than one often has with families living in Norway.

They also kept their house in Røa in Oslo for a long time, plus a vacant site next to it that they also owned. At first they rented the house out to other members of the family, until their daughter moved to Norway and lived there for several years with her family. At home, they always spoke Norwegian. They had never quite "moved away." They were always Norwegians in Switzerland, even though their friends and social circle were obviously Swiss. They brought these Swiss friends to Norway, their own friends and the children's friends. They came every summer with their Swiss friends to show them this beautiful country. They maintained really strong links with Norway and regular travel to Norway at every possible opportunity. They were and remained Norwegian émigrés, not Swiss.

Plus-Fours and Dreams

Another nephew, Aasmund Berner, Rolf's sister Grethe's son, also recalls a hospitable uncle of the old school whom he had visited in Switzerland on his honeymoon:

> I grew up in his house in Røa. My parents rented it until they took over my mother's childhood home in Vinderen, where Rolf had also grown up, in Borgenveien 30. When we married, my wife and I drove down through Europe by car and visited him in Zurich. And then we saw how typical he was – so really Norwegian, with old leather boots and plus-fours and a wind jacket and a rucksack with a proper frame as they were at that time, and really striding out.

Rolf and Ragnhild had been at their wedding in Oslo, where Uncle Rolf had made a speech. He started by introducing himself courteously and correctly as the eldest family member present, and went on to wish the bridal couple success. He conveyed greetings from his mother, who was the bridegroom's grandmother and unfortunately not well enough to be present. Greetings also from his three children Unn, Arild and Rolf. Then he continued on a more personal note to say that he had not met the bride before, 'but I have met you often before, Aasmund, and your father has kept me well informed about your life and your activities.' He then went on to say that in the morning he had been chopping wood, and had philosophised about the old problem of spirit and matter:

> Now you may well think that chopping wood doesn't have much to do with spirit, but that is surely a mistake, for the mind is freed and thoughts go their own way. Nowadays bodily, material considerations occupy the driving seat. Other values are recognised but they are given lesser status. There are many who believe like me that this is a mistake, and that everything here in the world moves like a wave and the perception will undoubtedly change – possibly as soon as the next generation. Over-emphasis on material things is surely an important cause of many of the difficulties we have to contend with today, and on the other hand an over-emphasis on spiritual things can also lead us astray.
>
> The task therefore is to find a healthy balance, and this applies as much to ones own life as to the higher entity – marriage. I should imagine, Aasmund, that in the course of your studies you will already have noticed what a decisive role spirituality plays for a doctor. A true doctor understands that he is working at the boundary between the two realms and that when life is at stake the patient's own spiritual reserves need to be identified and brought into play.
>
> A marriage is also a journey that regularly crosses the border region between the spiritual world of feelings and imagination and the material world represented by physical chemistry, bronchial carcinomas, broken bones, tax returns and parking fines. So my advice to you is this: Find a healthy and natural balance between the two realms, remember that the boundary lines are not the same for two people and that they change constantly. Don't forget that dreams and the spiritual world are at least as important as, indeed today perhaps more important than all the little details in the material world. Try to understand each other and show patience.

Dancing Feet

Rolf enjoyed company. The family was important. Friends were important. He and Ragnhild were friendly with ten or twelve other couples whom they met regularly. Often at their own home, especially after they built their own house in Nussbaumen in 1956. Here they had their own 'fireside sitting room without a fireplace but with parquet flooring,' as they described it, and it was in frequent use. They also went to dance classes together, because they enjoyed dancing, wanted to learn more and were thoroughly sociable. Modern ballroom dancing was becoming very popular throughout Europe, with both North American and Latin-American influences. Charleston and swing obviously, but samba and rumba and cha-cha-cha were also part of continental European social life at that time.

Peter Hug *(a neighbour's son in Switzerland)*
I can remember Rolf Widerøe dancing at the side of their swimming pool once when they had company. And then I got to go to Norway with them on summer holiday because I was a friend of their youngest son.

Egil Reksten *(brother-in-law, married to Ragnhild's sister Louise)*
They had lots of parties down there. A wide social circle, and I don't know how often, but they were constantly visiting each other. We in the Norwegian family were there only a few days when we were passing through.

Arild *(eldest son)*
I've been told that your parents were very sociable.
Yes, now that I think about it, so they were. They really were. They had frequent parties, especially after they got the bigger house. In Ennetbaden we lived in a flat. But then in 1955 they bought an empty plot and built a house in Nussbaumen – a little further north, nearer the German border, but not far from Baden, about four kilometres. They had a basement living room there. It wasn't very big, but it was big enough for a table with over twenty guests, so they had a lot of parties there. And they also went to dance classes. Father was not the type of scientist to be totally tied up in his research, though he did work very hard.

Rolf jnr *(youngest son)*
They went to dance classes together, for a long time, with friends. They must have got to know many of their friends at these classes. There were certainly 20–25 they socialised with. I remember once when they were going to a class in Waldshut, and it was the middle of winter, and their car was out of action, and I had a 2CV van that they borrowed. But it had no left-hand door, and they drove over to Waldshut in the open CV to go dancing.

Martin Hug *(a neighbour's son in Switzerland)*
Rolf Widerøe was interested in music, especially classical music. Having a stereo apparatus was something to be admired at that time, and I was very impressed when he told me that he had made marks on the floor to show him where to put his chair so that he sat in exactly the right position to make the most of the stereo sound.

Arild *(eldest son)*
He wasn't just working all the time. He was a good family man too. Sundays were sacred for him. We would always go out for a trip in the woods then,

taking a pack lunch with us. He always took an old, brown case with plastic plates and so on, and a methylated spirit stove for warming sausages. And my mother always brought a potato salad. We drove out to somewhere in the woods, went for a long walk and came back to the car for lunch. We often had family and friends visiting, and then we usually drove towards Lucerne or to Bürgenstock – always with the case. Or sometimes we went up into the Alps, to the Klausen Pass or the Susten Pass and such places that impressed Norwegians at that time.'

Rolf jnr *(youngest son)*
Yes, he was not an extreme athlete or anything like that, but he was fit and he did help me to build a ski-jump when I was a boy and he jumped it himself when he was over fifty.

Rolf jnr *(youngest son)*
I started playing the piano when I was ten or eleven years old, when he was about fifty. I tried very hard to learn, but he just sat down beside me and played a duet with me. He could still do that. I knew that they had had a grand piano in his parents' house, but I didn't know that he could play and that he could read music.'

Musicality and dancing feet ran in the family. The daughter, Unn, became a ballroom dancing teacher after first trying engineering like her father. She married an architect. The eldest son, Arild, became a jazz promoter and music producer. An artistic profession, far removed from the physics laboratories. Rolf, the scientist and technologist, received new stimuli in the liberal arts through his children, and his own curiosity and drive were often reflected in the choices the younger generation made. The youngest member of the family eventually gave up engineering to become a business consultant and broker. The eldest son said that his enduring dream had been to become a pilot like his role-model, Uncle Viggo. His father and his uncle watched him take off in other directions. Independence was also part of the Widerøe family tradition. Instead, it was Viggo's own daughter, Turi Widerøe, who spread her wings to become the first female pilot in a western commercial airline.

Rolf's sons still keep close contact with their relatives in the old country and maintain the tradition of summer holidays in Norway. All the nephews and nieces were invited when Rolf celebrated his 70th birthday and Arild is still in touch with his childhood friends from Oslo.

I'm very glad that my parents kept in such close contact with Norway, and particularly that we went to Norway every summer. There was no question of

> doing anything else. I had – and I still have – a best friend who became a priest. We were best friends from early childhood, and we have managed to hold onto that, thanks to the fact that I was allowed to stay with them when we visited Norway. We continued to meet regularly when we grew up.

Rolf's sons settled just a few kilometres from their parents' house in Switzerland. The daughter, Unn, died in a car accident at the age of 36. Rolf junior's youngest son, Stian, inherited the vacant plot next to his grandparents' house in Røa and returned to the family's roots in Oslo.

The Asklepitron

In the late 1950s, a time when the children were still at home, Rolf was working on a greatly improved version of the betatron, that would move round the patient so that the radiation was always directed to the right location. This machine was completed in 1959. It was named the 'Asklepitron', after Asclepius, the Greek God of Medicine, often portrayed as a man with a beard, a hat and sandals who wandered around in ancient Greece accompanied by his pupils and who according to mythology could restore the dead to life. Temples to Asclepius were built both in Greece and throughout the Roman Empire. Sick people flocked to these, and there are many stories of healing and miracles.

The first client to buy this modernised version of the betatron was a private hospital in Milan. The Radium Hospital in Oslo bought an Asklepitron in 1963, the third betatron they had bought from Brown Boveri.

Rolf also developed an accelerator that could direct streams of electrons from different sources in a chosen direction to the part of the body that needed to be irradiated. This was built with a special magnetic lens that could be adjusted to direct the electron flow. The engineer had used his experience with relays in power supply grids to build a machine to direct the radiation even more accurately and further reduce the risk of damage to healthy tissue. The accelerator was a success medically and a prestige product for Brown Boveri commercially. Many hospitals that bought betatrons came to prefer those that had this type of lens.

As Rolf was striving to develop and improve his own design of betatron, competition was happening elsewhere. Mainly but not exclusively among Americans; Siemens in Germany were a big challenge to Rolf, as his son Arild explains:

> My father always knew exactly, or more or less exactly, how far the Americans had come. He also always knew what Siemens were up to. They were Brown Boveri's main competitor here in Europe. But the Siemens machines were never anything like as good as the betatron. So it's difficult to say whether it was a real contest, I really don't think so.

More impartial sources support Arild's view, and the sales figures also confirm that the Swiss betatrons were in a class of their own.

None Better?

Betatrons are classified according to how high a radiation level they can generate. Anybody wanting to acquire a radiotherapy machine would need to take many factors into consideration. In the early 1950s, the best choice for a client wanting a relatively compact machine with high energy and good precision was a machine like the one Rolf had made for the hospital in Zurich. However, the technology was developing fast and what was a powerful machine one decade could be considered a weak one the next. Price was obviously important, alongside effectiveness, dosage, radiation hazard and all the other variables that led to medicine, physics and technology coming together and gradually merging into one subject, as at the Norwegian Technical College in Trondheim in 1970.

In America, Kerst had written a comprehensive history of the various developments that had led to modern betatrons, in an article in *Nature* in 1946, the year Rolf had moved to Switzerland.[10] He summarised both earlier published material and other work he had heard about. From this, Rolf concluded that many physicists had been working in recent years with the same aim of making a betatron that worked, but without knowing about each other. Kerst himself had been the first to achieve this, in 1940, using the theory that Rolf had initiated in his doctoral thesis in 1927. Kerst did give credit to Rolf for this. It appeared that the basic idea of building a betatron had arisen independently in different places at the same time. Industry was quick off the mark when new technology arose and saw the market potential of the betatron both for medical use and for materials testing. Even during the war, far-sighted development projects were set in motion both in Europe and in the USA with a view to sales when freedom came.

Big American companies such as General Electric, Westinghouse and Allis-Chalmers were all in the race. Kerst had been working with General

Electric when he built his first betatron, but prior to that Joseph Slepian at Westinghouse had secured the patent on an important preliminary step towards building a betatron. Allis-Chalmers were also promoting their 20 MeV betatrons commercially. In Europe, Konrad Gund at the Siemens factory in Erlangen was developing small betatrons.[11] These were later developed further into 18 MeV machines. Philips in the Netherlands was the company that both Haukeland Hospital and the Radium Hospital had approached with a view to obtaining a Van de Graaff generator, but they were also major competitors in building betatrons and their interest in this area was already apparent at the end of the war.

In Switzerland, Rolf was developing and manufacturing more and more advanced machines at Brown Boveri. In the 1960s they were able to increase the energy level to 35 MeV, and in 1970 they had reached 45 MeV. Such a level was decisive in being able to use the machine for materials testing. At one time there was talk of making betatrons right up to 200 MeV and possibly even more. Machines between 31 and 45 MeV were a big commercial success for Brown Boveri. Rolf knew from experience that there were many good reasons not to try to reach higher energies. A machine of 31 MeV already gave problems with fast neutrons, and these problems increased in machines with even higher energy. At the same time, the market for betatrons was beginning to become saturated and demand declined throughout the 1970s. By that time, Brown Boveri were working to produce a type of smaller linear accelerator that was simpler and therefore cheaper than a betatron and in many respects just as suitable.

Similar progress was being made in the USA. Donald Kerst had succeeded in producing his second betatron, rated at 20 MeV, in 1942. Then General Electric set about building a 100 MeV betatron, which they achieved in 1945. In the meantime, Kerst had returned to the University of Illinois where he started by building a prototype machine of 80 MeV before going on to build a gigantic, 300 MeV betatron. This was the biggest machine of this type that had ever been built, and it was considered to be the final step in the development of betatrons.

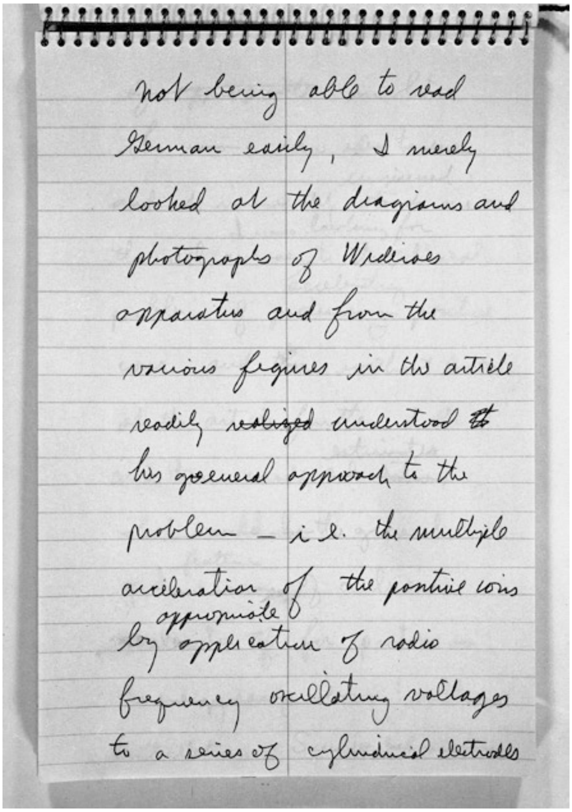
A newer machine was not always better, however. Different models had different functions and areas of use. In an article in 1962, Rolf compared three types of hospital betatrons and explained the differences between them. These were the machines from Siemens in Germany, Allis-Chalmers in the USA and Brown Boveri in Switzerland. He also described various linear accelerators that were then being produced, with many promising capacities for treating cancer.[12]

After the Betatron Came the Synchrotron

In the meantime, another type of accelerator had come on the scene. It was not necessarily better, but it met a different need which it fulfilled better than the betatron. The synchrotron was more successful than the betatron both in size and in price. Betatrons turned out to be most suitable for applications needing less than 50 MeV. For uses requiring lower energies, linear accelerators remained the preferred machines, especially in clinical use.[13]

So can we perhaps say that after the betatron came the synchrotron? Yes and no. Rolf played a part in both, or even prior to both. In this context we might well ask which came first, the chicken or the egg. Rolf himself considered and subsequent history has confirmed that the highlight of his career was the invention and perfection of the betatron. He reckoned that his next most important contribution was the synchrotron.[14] At the same time that he and others were developing and refining the betatron, he was also one of those working on a new method of achieving high energy—the synchrotron. In fact, he had been working on this issue from the very start. He was concerned to improve the stability of the path for the charged particles. His work on this led to a patent granted in January 1946 that included many of the formulae and the most important ideas needed for the construction of a synchrotron.

Particles can go round in a ring for as long as one is able to direct them. There is a third category of accelerator, with which Rolf was also involved. The cyclotron was invented by Lawrence, after he had been inspired by Rolf's sketches. So the cyclotron was really the first working particle accelerator with a non-straight path. At the risk of slight over-simplification, we could say that the betatron that Kerst invented in 1940—also inspired by Rolf's ideas—was a type of cyclotron.


not being able to read
German easily, I merely
looked at the diagrams and
photographs of Wideröes
apparatus and from the
various figures in the article
readily ~~realized~~ understood ~~th~~
his general approach to the
problem – i.e. the multiple
acceleration of the positive ions
by appropriate application of radio
frequency oscillating voltages
to a series of cylindrical electrodes

Ernest O Lawrence was always careful to acknowledge Rolf Widerøe. He knew where the theory came from, and he never discarded his hand-written notes from when he had come across Widerøe's method of accelerating electrically charged atoms. Lawrence's note reads: '… not being able to read German easily, I merely looked at the diagrams and photographs of Widerøe's apparatus and from the various figures in the article readily understood his general approach to the problem—i.e. the multiple acceleration of positive ions …'. (*Courtesy* Brookhaven National Laboratory)

If we were to set up timelines of the developments, they would read as follows:

The idea of the betatron (Widerøe)
A working cyclotron (Lawrence)
A working betatron (Kerst)
The idea of the synchrotron (Widerøe/Oliphant/Veksler)
A working synchrotron (McMillan).

The similarity of the names 'cyclotron' and 'synchrotron' can be confusing, especially as these two types of machine are not the most technically alike. There are three main types of circle-shaped accelerator: betatrons, synchrotrons and cyclotrons. Betatrons and synchrotrons are close relatives, in that they both accelerate particles on a circular course. Magnetic and electrical fields are put in place around this circular path to accelerate the particles and to hold them on course. The cyclotron is a low, round 'cake shape' in which particles are accelerated in a spiral path from the centre outwards by an electric field and held on course by a system of magnets. This is a simpler type of machine, with limitations on how high an energy level it can achieve. So it is logical that this was the type of machine that anybody first managed to get to work.

Something in the Air

There were rumours from the USA that Rolf had gone to Tandberg's Patent Office in Oslo in the winter of 1945–46 with his ideas for a synchrotron. He had been working intensively on these ideas over the previous few months. Things had been difficult for him in his private life that autumn, and it was good for him to be absorbed in his work. The text of the patent application was complicated and it included formulae that he said fifty years later he himself no longer understood.[15] But everybody who had understood it at that time realised that it was important for the development of the synchrotron. Many also understood that the basic idea was a ring-shaped vacuum tube surrounded by a magnetic field that increased in strength in relation to the energy of the particles and held them on course. There were hundreds of other details that only few people were able to understand and that made this apparatus different from other accelerators. We could say that the patent defined a synchrotron, or even that it converted a betatron into a synchrotron. Rolf was especially proud of this patent.

He later heard that other people had had the same idea, and he became fascinated by the thought that an idea could, so to speak, float in the air in different places at one time. McMillan in the USA had discovered the principle and presented it in an article in the September issue of *Physical Review* in 1945. It was a short article, only two pages, but it immediately became world famous. However, Veksler in Moscow had discovered the principle at the same time and already written a long article about it. As if that were not enough, it appeared that Oliphant, an Australian, and his colleagues in England had made the same discovery, or at least part of it, also without knowing about the others. Rolf claimed that he had lodged the patent application at New Year without any sure knowledge of what the others were doing:

> I saw McMillan's article a few months later. Communication and exchange of information among the scientific community was poor during the war.[16]

Several years before, while he was studying in Germany, he had also proposed and patented what he called the lens method. This was a way to co-ordinate or improve the focussing of the particle beams. He had thought about the problem for a while and had come to the conclusion that the new method was simpler to apply, and also better. The first person to develop this idea further was Nicholas Christofilos, a Greek who registered a patent on it in March 1950.[17] According to Rolf, however, that was not known about until February 1956. The Greek had been working at Westinghouse when Rolf was with Norsk Elektrisk Brown Boveri (NEBB) in Oslo, and they had met once at a conference in Russia. The lens method was the precursor of the better known 'strong focussing' that was introduced later.

Courageous Italians

A new and proud chapter was now beginning in Rolf's scientific career. In the 1950s he built a synchrotron for Turin University, that he considered his most important machine since the betatron. As if nomenclature was not already confused enough, he thought that the most suitable description of this machine would be 'beta-synchrotron,' indicating that it was a further development of the betatron. From 1953 onwards he had travelled to Italy several times to discuss the construction of synchrotrons. Two researchers were planning no less than a gigantic 1,000 MeV electron-synchrotron.[18] It was later built in a laboratory outside Rome where one of Rolf's former assistants, Bruno Touschek, was working.[19] Rolf took a different direction, however. He contracted with the researchers in Turin to build a smaller accelerator intended for experiments in nuclear physics. This was a prestigious project, supported by the FIAT factory and the Italian Research Council, and Rolf had found like-minded collaborators:

> It was clear to me that a betatron was not the best instrument for this task. If instead I used the synchrotron principle, I could achieve better results with much smaller machines of about 100 MeV. But a synchrotron requires an injector, a pre-accelerator to give the particles a starting energy. In this project, the researchers in Turin were willing to follow rather untried methods to produce a compact, reliable and economical machine that could also be used in future in other research institutes. So we worked on a rather original concept, though we owed much to the work that had been done by F.K. Goward and D.E. Barnes in England. (…)
>
> The machine would work as a betatron until the electrons reached 2 MeV. It would then work as a synchrotron to continue increasing the particle energy. For me, this was the long-awaited opportunity to use my ideas and my knowledge of synchrotrons to build a machine myself. Obviously, this new project was based on our earlier positive experiences building betatrons at Brown Boveri.[20]

This takes us to the mid 1950s. Rolf had described the basic principle in his Norwegian patent in January 1946, and in the first phase of operation, when the machine functioned as a betatron, he was applying ideas he had patented in 1948. The machine was required to accelerate electrons in both directions, as some of his earlier betatrons had also done. Several of the physicists at Turin University were actively engaged on the project right from when the machine was ordered until it was ready and installed.[21] They came across many difficulties, however, and by 1956 it was clear that they would need more time than they had originally thought. So Brown Boveri temporarily installed a 31 MeV betatron, which continued in use in Turin until the new beta-synchrotron was delivered. This took a further three years, but Rolf was very proud of the final result, a 105 MeV machine exactly as they had intended. He and a professor who had been closely involved in the project wrote an enthusiastic report along with a colleague from Brown Boveri who had also taken part.[22]

All three of them had worked on the concept, the development and the construction of the machine. Rolf praised the major contribution that the Italian researchers had made to the success of the project. The most important thing had been to demonstrate that it worked in practice, and that it was also easy and inexpensive to build. Since then even simpler and more compact linear accelerators have been developed to work at this level of energy, and these have supplanted both betatrons and small synchrotrons.[23]

Maybe the Answer Is in the Wastepaper Basket

The youngest member of the team working on the Turin synchrotron was a Norwegian engineer, Karsten Drangeid, who was only 29 when he started in Rolf's department.

> You couldn't wish for a better boss,' he says. 'I really didn't notice that he was the boss; he was a member of the group.
>
> *Some people say that he was not a team-player?*
>
> Yes, but he had so many ideas that he became the leader of the team. For me, he was an ideal boss. Encouraging, stimulating, fun to work with. And lively. He took part in what I was doing. I've never had the same contact with other bosses.
>
> *Was he impulsive?*
>
> No.
>
> *But involved?*
>
> Yes, personally interested.
>
> *In the job or in you?*
>
> Both.
>
> *What made him so special?*
>
> A good example is when we were working on the machine for Turin University. We had a fragile, ring-shaped synchrotron tube that I worked on the drawing for. It was expensive, certainly more than 5,000 kroner, and it usually hang on a hook on the wall beside his desk. One day after working on the designs I put the tube back on the hook, when the hook broke and the tube fell down and was smashed. I looked at him. He sat and wrote something. Then, without a word, he handed me a requisition for a new tube. It wasn't a matter of finding a scapegoat, but of finding a solution to the problem that had arisen. It didn't matter who was to blame.
>
> Another example is his optimism. We faced many problems when we were working on the synchrotron. I showed him some design drawings I had done, which must have been wrong. We looked at them together and then he said, 'Perhaps this is exactly what we need to get it to work!' I never heard him say that something was impossible. Or, one day I had forgotten something when I went home and I went back to the office. There he was, rummaging in my wastepaper basket. He looked up and said, "You write interesting things and then throw them away?" He wasn't out to steal my ideas, he just wanted to help to solve the problem.

'The Turin machine was complicated, and he taught me to persist with it,' Drangeid said. He and Rolf never spoke Norwegian at work, but they spoke it when they were alone together. After just two years, Karsten Drangeid was offered a position where he would take part in the building up of IBM's research laboratory in Switzerland, where he later became a director. This caused consternation in Brown Boveri, who would have preferred to keep him, and in his reference Rolf particularly mentioned that he had played an important part in bringing the Turin synchrotron into being.

> I admired Widerøe enormously. We exchanged Christmas cards every year after I left, and my wife and I visited him when he and his family moved into their new house in Nussbaumen.

Arild *(eldest son)*
One autumn holiday I think it was, we went by car to France. What I remember best is that we stayed with a wine merchant. Old Widerøe, Theodor, had a wine agency. Among other things, he had the agency for Martell cognac over the whole of Scandinavia. We were guests there for a couple of days, I think it was autumn 1949. Later, in spring 1950, we went by car to Spain. The whole family. Sometimes with a tent. Father was an outdoor man. He had been on masses of camping trips and ski trips in what we call 'the old days,' in the 1920s. Both with Viggo and with his younger brother Arild. We have loads of photos of that.

Rolf jnr *(youngest son)*
We were on holiday at the place where Martell make their cognac. We were invited to dinner in a chateau with a beautiful, huge park, all symmetrical like the one at Versailles. And we ate outside in lovely weather, I remember. With white tablecloths. It was very formal and very good.

Rolf jnr *(youngest son)*
He could switch off from his surroundings completely, and then he was unaware of almost everything going on round about him. He drove past me once when I was on my bike and I sprinted behind and threw my bag onto the baggage rack at the back. He didn't notice anything and took it all the way home. Or maybe he was just pretending that he hadn't noticed.

Arild *(eldest son)*
My mother's sister Lydia was married to Iens Ludvik Høst who was sales manager at Aschehoug publishing house, and they always sent books as Christmas and birthday presents. Good books. So that was basically how I learned to read and write Norwegian. My first year at school was in the Steiner school in Oslo, where we just made models and so on, there was no writing to begin with. So I didn't learn to write Norwegian until after we moved to Switzerland.

Norbert Lang *(former head archivist at BBC/ABB Switzerland)*
Rolf's dog, a schäfer called 'Rex,' obeyed orders in three languages: Norwegian, German and English.

Martin Hug *(a neighbour's son in Switzerland)*
Rolf Widerøe was an important person in the town where I grew up.

Arild *(eldest son)*
Father often took part in conferences. He was regularly invited to lecture and was a very popular speaker. The lectures were always in English. He wrote them in Norwegian and translated them into English. When I read them now, I see that there were some mistakes in the English. But that didn't really matter, because what he said was so interesting that people listened. And it wasn't just all about technical stuff. There was a lot of nature study in it too.

Aasmund Berner *(nephew, Rolf's sister Grethe's son)*
They were naturally cautious about money and thought it shouldn't be used on unnecessary luxuries.
The old school?
Yes, the old school. You should take the hard way and cope yourself. He didn't live in luxury at all. My cousins said that when they went for a Sunday outing they took very simple food with them, perhaps not as good as their friends had.
There were other things that mattered more to them?
Yes, even though they certainly had the means for it, the children didn't get any extras.

Thor Spandow *(nephew, Rolf's sister Else's son)*
Rolf was good with numbers. Viggo and Else were good with people.

Radiotherapy Machines Worldwide

Commercial work at Brown Boveri's head office was running full ahead, alongside the research and development work. New and better betatrons were being installed in hospitals throughout the world. One of Rolf's engineer colleagues, Christian Gerber, was responsible in the 1960s and 70s for adjusting and calibrating the machines when they were installed on site. He recalls[24]:

> I enjoyed my time working with Widerøe. I was young when I started there and was excited to travel around the world. This seemed to me a fascinating type of accelerator, quite different from what I had known before. Previously, I had worked with Van de Graaff accelerators. Widerøe was amazing, but he did demand a lot.

Gerber was responsible for dose metering. This is a vital part of radiotherapy and consists of adjusting the machine to deliver to the patient the precise dose of radiation that the doctor has prescribed to achieve the desired effect. All betatrons that were sold to the USA went through his hands. In the 1960s, betatrons were installed at many places, including: Montefiore Hospital in New York (1961); University of Maryland Hospital in Baltimore (1964); Galveston in Texas (1965); Mercy Hospital in Chicago (1967) and Henry Ford Hospital in Detroit (1968). These were all Asklepitron 35 models.

The first hospital he was sent to was in Helsinki. In consultation with Rolf he created his own tactical approach, based to some extent on intuition and on their good understanding of each other:

> When I went to Finland I was newly qualified and newly married, and this was my first job for Widerøe. He told me "You can finish off this machine and deliver it." Yes, right. I decided to involve the hospital personnel from the start; they were my salvation. I thought to myself, "When I deliver the betatron I need to know what I am giving them and they need to know what they are getting." And it worked. The Finns were interested in learning something new and moreover, if something later turned out to be not entirely to specification, as often happened, they understood why, and I think that was what Rolf Widerøe liked, because if the purchaser didn't accept and sign there was no payment.

Helsinki University Hospital bought betatrons both in 1962 and in 1963. When they came back the second time, Rolf said:

> You can do the job in six months.' I said "A year" and explained why. It took a year and everyone was satisfied.

They did struggle with one problem but finally solved it, thanks not least to one of the Finnish physicists who has since become a friend of his, Gerber recounts as he enthuses over his years working under Widerøe:

> He gave me confidence and opportunities. I enjoyed travelling – it didn't really matter where – and meeting other cultures. The social aspect was important to me, and my time in Helsinki was particularly good. We were working together on a commercial contract, but we got on well together. People were very enthusiastic about the new hospital, and we brought together a good team. The physicists and the physicians were all good at their respective jobs and by the time I left they knew the machine as well as I did. That was my secret. I had colleagues at Brown Boveri who wouldn't let anybody from a hospital come near a machine until it was ready, with the result that they got a surprise when the installation was complete but didn't know how the machine had been set up. I continued doing it my way throughout the world. This was possible because of Widerøe's reputation but also because of his leadership style.

In a way, he was the same enthusiastic type as myself. Keep going. You can do it. It wasn't always so easy, but the machines were amazing. I'm sorry to say it, but Widerøe wasn't really a businessman. He was an ideas man, a scientific genius. I remember the senior medical radio-oncology experts I met saying that they bought betatrons because of him – Schumacher in Berlin, Schinz in Zurich, Zuppinger in Bern.[25] All the leading people in cancer treatment. I could name many more. They all knew Widerøe. There was no effective competition. There was still a competitor in the States building betatrons, Allis-Chalmers. And Siemens in Germany. But we were the best. It began to change in the 1970s when people went over to smaller, cheaper machines, but these were also sophisticated, reliable machines.

Did he have a tough leadership style?

Yes, not a bad style but a firm style. He knew what he wanted. When he promised the customers something, he assumed that his promise would be carried out. He didn't ask if you could do it; he just assumed that you would. He gave advice rather than orders. He always said "It can be done!" and he really believed that it could be done. Often that was not the case, at least not without a lot of extra modifications. When that happened I didn't argue with him, but just showed him that it wasn't possible, and he respected that. Often there were things that had hardly ever been tried. When he promised things like that it was a bit of a job afterwards to sort the problem out and find solutions. Such was my life at that time, but it was a good life for me and my family. I was at Brown Boveri for fourteen years and I worked with Widerøe most of that time, including when he retired and continued working. At the end, to be honest, he was slightly forced out of his position as head of department, but not by me.

Why? Who pushed him out?

The person who took over from him, Dr. Max Sempert. Widerøe's mind wasn't on business considerations. He was still highly in demand as a lecturer at conferences throughout the world, because there was nobody better to talk enthusiastically about accelerators. Brown Boveri had to sell machines, and to do that they needed Widerøe. Leading a research and development department just by good salesmanship would be a mistake. Also, he wasn't always fully up to date with the very latest developments, and that can be risky for a company. I told him that. The others were too scared.

Not a Teacher

But what was he like as a person?

Everybody knew Widerøe, but hardly anybody knew him well. At the time of his ninetieth birthday there was a celebration at the technical college in

Zurich where he had taught, a colloquium in his honour with contributions by prominent scientists. I went along just as a member of the audience, but he rushed up to me and said "You must sit beside me!" "No, I'm not invited, I can't do that." "Oh yes you are," he replied, and simply took me to sit beside him in the midst of all these great names. Of course I felt greatly honoured by this, but we weren't close personally even though my wife and I had been invited to his house several times. He didn't let anybody get close to him. I don't know that he had any really close friends, except one. Remember, some of his colleagues were often competitors. That's how it often is in the world of science. People are obsessed about who gets research grants and who doesn't. If you cite me, I'll cite you.

Was he a teacher?

No, no, he was too domineering. Not a teacher. Nor am I for that matter, I'm not patient enough. But he was a personality. I don't think anybody really understands what an amazing man he was. He was a very special person. For example, he would come into the laboratory, stretch out his arm and say "Oh, I've got such a pain here in my elbow. Give me a little radiation." Then he went over to the machine and had his elbow irradiated. He believed in that, and he knew what he was doing. These were different times, obviously. Today you could never go into a radiation room without the necessary procedures.

Gerber recalls that when he was in the USA, Siemens tried to recruit him, but he declined:

I took the job here because it was interesting. It continued to be interesting, not least because of Widerøe. Long after he had retired, he often came to see what I was up to. I can see him yet, walking over the bridge towards the institution where I was working. Yes, he really was "somebody" in radiotherapy circles. He knew all the "big shots" in the world. There was nobody like him. Wherever he went – China, the States – the door was always open to him.

The Last Emperor

Did you go to China with him?

Yes, first to Hong Kong. We installed a betatron at the Queen Elizabeth Hospital there in 1963. A few years later we did the same in Beijing. Widerøe had been there beforehand to negotiate the sale. Then he came to me and asked, "Would you like to go there?" This was during the Cultural Revolution. He sent a team to construct it, and then we both went there. I had a group of twenty people: six or seven physicists, medical personnel, communist party representatives, the security service – 'everybody' was there. So I did exactly as I had done in Finland and elsewhere. I said, "We'll do this together." We built up a fantastic team. I was there for a couple of months. It was a very interesting stay, and I even managed to learn a little Chinese.

The head of the cancer clinic had studied in England. He was a good bloke, and we have kept in touch since. I wasn't working on my own. Everybody in the group was on the job, some of them quite remarkable people, good people, and we helped each other. When I was leaving, there was one of them whom I knew to be the highest communist official there. I felt I had to say to him, "You are a good communist." – meaning that he was an honourable and honest man. I didn't agree with their politics, but I could talk with them.

Was it unusual for these people to have such contact?

Yes, to be able to speak openly. We worked on the betatron that Widerøe had sold to them, we told them about life here in Switzerland and they showed me their homes and possessions. This was very unusual at that time.

How was it possible to run such a collaborative project during the Cultural Revolution?

I've been asked that many times, how they could do that in the middle of a revolution. I actually asked about that myself, asked one of the official representatives, and he replied to me in English, "One of the big guys got sick." Isn't that typical? It's the same everywhere. Things become possible when the boss is ill. The last Emperor of China was also a patient in the hospital, and I spoke with him once. He died while I was there.

The glass tube in the betatron in Hong Kong was a particular success for Brown Boveri, Gerber recalls. It lasted for over forty years. He knows this because the Chinese head physicist visited him almost every year and kept him updated. In fact, the team stayed in contact for a long time:

You would hardly believe it. Even though they were staunch communists, I stayed in touch with them for a long time afterwards. When I went to China almost twenty years later with my family, they provided a fine car with a driver and guide for us. When I asked "Why are you doing this?" they replied that "We were not always so friendly to you the first time."

Then Gerber says that he saw Chinese colleagues being beaten up, and that he himself was once arrested.

Walking in the street during the Cultural Revolution, I saw professors from the universities in Beijing being beaten on the back with sticks. I saw it for

> myself. I was right in the middle of it and nobody harmed me, except that I had to go to prison once. They accused me of something or another, and one morning when I came to the hospital there were placards everywhere and slogans painted on the walls, "Down with Gerber." My people at the hospital had tears in their eyes. They couldn't believe it. One revolutionary group was struggling with another revolutionary group, and I was caught in the middle. But the hospital needed me to finish the job, and I was released after three days.

Celebrities

Taking delivery of a betatron anywhere in the world was a big occasion both for the medics and for the local community, with press and TV invited to the ceremony. There are heaps of hospital magazines and newsletters from these times with reports of amazement at the wonder-machine and pictures of eminent doctors, politicians and donors who have made the purchase possible. Masses of articles about the revolutionary new treatment that could kill cancer cells in a tumour without damaging the surrounding tissue.

In Guildford in England, for example, Princess Alexandra of Kent had set up her own organisation, The Betatron Cancer Appeal Trust, to support the installation of a betatron in St. Luke's Hospital. Christian Gerber had been responsible for calibrating the machine and he was invited to the opening ceremony where the princess was present. Gerber says that the project was sponsored by Bugatti, who was a friend of the director, and the installation was very prestigious. A big feature on the front page of the local newspaper on 5th May 1967 showed the princess taking part in the opening ceremony together with the bishop and the local mayor, and of course, close-up pictures of the betatron, an Asklepitron 35. A machine of the same type was installed in Bristol three years later. This type of betatron, with a rotating lens, was a high status product for Brown Boveri. In the 1960s Rolf had four such projects in France, two in Belgium, one in Italy, two in Austria, two in Switzerland, four in Sweden, three in Denmark, two in Germany and two in Canada, plus a new machine for the Radium Hospital in Oslo which had already had its first betatron for over ten years.

By the 1970s Brown Boveri had developed the Asklepitron 45 as its leading machine in this field. This too had a rotating lens. It delivered slightly higher energy radiation and was no less popular. According to Rolf's meticulously hand-written list, twenty-three of these were sold. These included replacements for hospitals that already had the older model, plus new sales to countries such as Greece, Spain and what was then Czechoslovakia. Sales to America were now so big that an office was set up and Gerber was stationed there permanently. Shortly before, he had been in Japan to deliver a betatron to Toshiba in Yokohama for materials testing. Brown Boveri made two machines of this type, able to 'see' through 60 cm of steel while the metal was still molten. The other one went to Germany.

> *So you could detect holes before the material had set?*
>
> Yes, very interesting. Obviously it was difficult. The problem was to make fine adjustments on cameras and instruments that were handling red-hot molten metal at 600–800°C.

Despite all the praise, Brown Boveri never made really big profits from the betatron project on its own, Gerber says. It was a question of status and huge prestige. The betatron was very important for their reputation.

100 Betatrons and 200 Patents

In 1986 the betatron's time was over. By then 22 countries had received altogether 93 custom-built machines from Rolf and Brown Boveri: Austria 4; Belgium 4; Canada 3; China 2; Czechoslovakia1; Denmark 5; Finland 4; France 10; Germany 8; Great Britain 4; Greece 1; Hong Kong 1, Israel 2; Italy 6; Japan 1; Norway 3; Soviet Union 1; Spain 2; Sweden 4; Switzerland 12; USA 14; Yugoslavia 1.

Rolf considered that it was difficult to give a precise figure for the number of betatrons built by various companies throughout the world. There were at least 200, and he and Brown Boveri had been responsible for about half of them. Betatrons in the power range of 30–45 MeV were useful in many areas. Most of them were installed in hospitals, some in atomic research institutions and some in industry for materials testing.[26]

Rolf had been head of Brown Boveri's Electrical Accelerator (EA) department since 1954. In 1973 the department's name was changed to Electrical Components for Betatrons (EKB). At the end of his time in Brown Boveri, commercial changes were happening both within and around the company. Important contributions to the development of betatrons were made by Stanford Linear Accelerator Centre, often in collaboration with Varian Medical Systems, the company that took over Rolf's department in Brown Boveri when he retired. Today, Varian Medical is among the world leaders in radiotherapy equipment. Then in 1988 Brown Boveri merged with the Swedish firm ASEA to become ABB.

In the course of his career, Rolf registered over two hundred patents, mostly in Germany but also in Switzerland, USA and Norway.[27] Fifty-three of these were registered on behalf of Brown Boveri. He obviously didn't do all the work himself but was dependent on good assistants and colleagues. Karsten Drangeid was one of these. Another he particularly named was Dr. Nabholz who had helped him with the machine for Turin. He also gave glowing praise to the firm's 'scintillating mechanic,' Gräf, 'who knew exactly how to carry out the delicate work of building the cathodes,' and he added that 'It was mainly thanks to him that our machines lasted so long, as he had taken on the task of making the glass tubes.' Others Rolf considered himself indebted to were his second-in-command Dr. Arnold von Arx, plus Gamper in materials testing, the design engineer von Dechend and the workshop foreman, Jonitz. Among the engineers responsible for mounting and installing the betatrons on site, in addition to Christian Gerber he also mentioned Alfons Fischer and the Norwegian Knut Vikene. He also commended his successor, Dr. Max Sempert, but as there was a degree of competition between them this may have been mostly out of courtesy.

Arild *(eldest son)*
Was there any pressure on you to study engineering and technical subjects?

Not really on Father's part. But there was a pressure to gain university entrance qualifications so that we could study. Myself, I never sat the entrance exams. Me, I was maybe a little difficult at that time and wouldn't always listen to Father. I didn't want to be an engineer, because I felt I was always being plagued by people round about on the streets here in Baden – and Baden was a small town – asking me. My father was already well known then. Lots of people asked me, "But what will you do then?" and "Won't you do something in the same line as your father?" In retrospect I think that bothered me subconsciously, so it might have been a reaction.

Arild *(eldest son)*
What about your sister, didn't she have plans to become an engineer.

Yes, she wanted to go into he same line as my father. She was quite sure of it at the time. So after high school she began to study machine engineering. But that didn't last long, possibly one and a half semesters, and then she fell off a wall in the garden and got concussion. I've always said that that happened very timely for her. She could drop out and say, "No, I can't study any more with this head." Then she trained in ballet and qualified as a dance teacher.

I heard that she married a Yugoslav?

Yes, Dragomir Trifunovic from Beograd, who was on an excursion in Berlin and absconded to West Germany. She met him there, near Mannheim where she lived for many years. Then they moved – because he didn't have a passport, he only had a Nansen pass, as refugees did at that time. They couldn't go just anywhere with that – then they moved to Norway. Their son Per was born there, and Dragomir was happy in Norway. He learned perfect Norwegian in the course of three or four years and was an important member of the family. But what he didn't like was the long winter. He wanted to go south again, it was too cold in Norway. While they were in Norway, they lived in 8 Melumveien.

So they took over your parents' house then?

Yes, but after a few years they moved back to Mannheim where he got a position in a big architectural firm. By then he had acquired Norwegian citizenship.

Arild *(eldest son)*
I remember when we moved to Baden in 1949 I joined the Scouts. I was a year too young, but Father thought there was no point in starting as a Wolf Cub. I should start properly in the Scouts right away. I went on a winter camp up in the Alps once, using just the gear that we had already. We went up to St. Gotthard from Andermatt and stayed in a youth hostel. Obviously I was the youngest. We had skins to put on our skis so that we could climb without slipping back down, but I kept losing them. It was bitter cold, and the only gloves I had were hand-knitted mitts that the cold went right through. But I remember that I was well equipped the next year. I needed this, and I must have that.

Arild *(eldest son)*
We had skied in Norway, obviously. If you lived in Røa you were, so to say, right in the middle of the skiing terrain and there was a field a little below our house where you could also ski at that time. So we did have skis when we came here. But of course what we brought were not Alpine skis but cross-country skis. And I remember going on a Christmas holiday when we were eight or ten years old, to a place called Oberiberg. We were staying in a hotel and we still had Norwegian skis that had been waxed. We managed to go up and we managed to come down, in a fashion. We weren't given any real instruction. It was just "Stay up," for that was what Father always called to us so that we wouldn't fall. When we went skiing with our parents on Sundays Father was very good at finding places where there was a ski lift, but we always just walked up beside it.

So you didn't get to use the ski lift?

Not on the piste there, no.

You had to walk up beside it?

Yes, walk beside it. And now basically I'm glad that we weren't spoiled. Really, my father couldn't afford for us all to use the ski lift in these days.

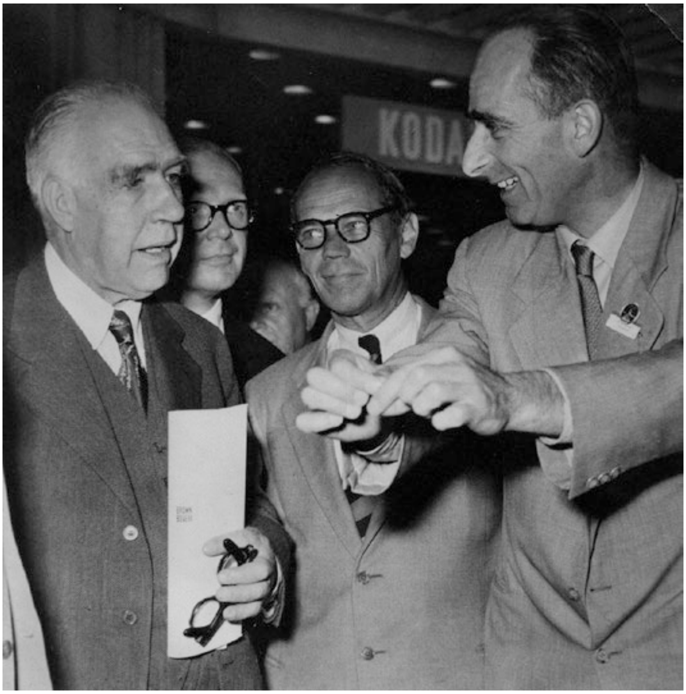
More Irons in the Fire

But that wasn't all. Relays and betatrons were only one part of Rolf's career. Already during his first five or six years in Switzerland, while he was trying to keep his head above water economically and professionally, when he had to succeed with the betatron for the hospital in Zurich, while he was hoping that Norway would place an order for a similar one and he was at the same time developing new designs for betatrons and almost as a side issue researching synchrotron technology – while all this was going on he took on another formidable task. He agreed to be a consultant for Europe's most prestigious research project, the CERN (*Conseil Européen pour la Recherche Nucléaire*) project in Geneva. After the war, when Europe was striving to rebuild itself industrially and technologically and to set up a research environment on a level with the USA, people turned to Rolf.

The idea was to set up a research centre with a particle accelerator at its core. The collaborative CERN project would be the world's biggest nuclear physics research laboratory. A huge, doughnut-shaped laboratory. A tunnel going round in a circle, a sort of model train set for physicists, so to speak, with locomotives and wagons smaller than atoms, rushing round to accelerate tiny charged particles to higher and higher energies. Then the controllers would let the particles collide with stationary targets and watch to see what happened when they crashed. Then they drove them round even faster, and then a little more. The question is always, 'What will happen next? How do these tiny particles interact? How do they decay? Are we approaching the very heart of matter? And what will happen if we just increase the velocity a little bit more? What then?'

This was indeed a very welcome and appropriate gift for Rolf. Right in the middle of his field of interest. And huge, in more than one sense. What possibilities! What consequences! Nobody had done anything like this before. His accelerators up to this time had been almost monstrous compared to today's radiotherapy machines, but had found their place in treatment rooms with slightly raised ceilings. This was something else. And not least, he would be enjoying the company of the world's leading nuclear physicists.

The venture had prestigious support both from politicians and from research organisations. Switzerland was chosen as the safe and neutral ground for former enemies to work together on what was regarded as a giant bridge-building exercise. Slogans such as 'Bridging the Atlantic' or 'Science Bringing Nations Together' were indeed apt. Preliminary negotiations had been taking place ever since the war. Neither the USA nor Europe would be content to watch Europe's leading scientists moving across the Atlantic to spread their wings in America, leaving Europe afflicted with a 'brain drain.' The project was linked to the United Nations and UNESCO. There was support both for a European organisation and for open access to national facilities. Some people, including the Danish physicist Niels Bohr , feared that the whole project would become too bureaucratic and cumbersome. Important meetings were held in Europe and also in America.



Niels Bohr and Rolf Widerøe both took part in an international radiological congress in Copenhagen July 1953. (*Photo* Ritzau/NTB scanpix)

This was the first really collaborative major project in post-war Europe. Norway and what was then West Germany were in it from the start. CERN itself was formally established in 1954. The organisation became a model for what can be achieved when nations combine resources towards a common goal. Since then, other international research institutions have been founded on a similar pattern, including: the European Space Agency (ESA); the European Molecular Biology Laboratory (EMBL); the European Synchrotron Radiation Facility (ESRF); and the world's biggest fusion reactor, Joint European Torus (JET). Some research can no longer be carried out by scientists isolated and alone in their own country.[28]

Because I Wanted to

However, the aspect of CERN that interested Rolf was physics, not global politics. His involvement in it started in June 1952, at a meeting in Copenhagen where the visions were to be given solid form and some individual projects planned in more detail. 'I was there just because it interested me. It had little to do with my job in Brown Boveri[29],' as he said himself. The European Council for Nuclear Research, known as 'CERN,' had been founded the year before. Now the laboratory was to be built. Rolf was a member of the expert group responsible for the development of the accelerators that were to be constructed there, a synchro-cyclotron and a proton-synchrotron, popularly known in abbreviated form as 'SC' and 'PS.' This was concrete, this was practical science, this was physics. It was also pushing at the frontiers of knowledge, at the limits of what anyone had managed to create or even conceive up to then. Rolf grasped the opportunity. He had taken out a patent on a proton-synchrotron six years before.

He was able to use all his contacts and establish new ones. For example, it was he who recruited the German physics expert Christoph Schmelzer. This rather worried the leader of the planning group, perhaps for slightly different reasons than one might expect:

> We were looking for good high frequency specialists for the PS project. I knew Dr. Christoph Schmelzer and persuaded him to come to CERN. I remember it well because we had agreed to meet near Waldshut in Germany. I came over from Baden and we went together to Höchenschwand in Schwarzwald. We sat looking over a beautiful hillside and I explained the basic principles of the synchrotron to him. He decided that building such a machine would be a very interesting project and he agreed to be a member of the group. But the leader of the group, Odd Dahl, another Norwegian, was worried that there were now two Germans in the group. We already had a German professor, and Dahl was worried that the Germans would feel uneasy.[30]

In his memoirs, Dahl discussed this combination of Norwegians and Germans, mostly from the point of view of how the Germans would see it:

> Obviously, the general attitude to Germans was not entirely positive at that time. So they were worried that they might not be allowed to use their talents

> fully with a Norwegian as director of the group. However, things went very well right from the start and we have maintained friendship and close contact ever since[31].

Dahl was administrator and co-ordinator for the PS project. There was another Norwegian from Bergen in the group. Kjell Johnsen, an accelerator expert and professor of nuclear physics, was also from the Chr. Michelsen Institute. He was not in right from the start, but Rolf got in touch to consult him after the first meeting in Copenhagen and he later joined the group as a permanent member. Unfortunately, Johnsen was too ill to be interviewed when I spoke to him in preparing this book, and he has since died. But many others have written about the huge construction work. Not least, CERN has documented its own history in connection with its 50th jubilee in 2004, consistently describing Rolf as an accelerator pioneer.

It was a meeting with Rolf in summer 1952 that had convinced Dahl of the need to build a proton-synchrotron at CERN. Presumably they already decided this at the first meeting Rolf attended.[32] The group then decided that the particle energy should be 10 GeV. Note that we are no longer talking of MeV. Even without understanding the technology we can recognise that G for giga is more than M for mega, 10^9 is bigger than 10^6.

The deputy leader of the synchrotron group was Frank Goward from England. He and D. E. Barnes had been the first to succeed in testing the synchrotron principle experimentally. Another Brit, a Swiss and a Frenchman were also in the group,[33] plus two Germans whom Rolf knew from before, Professor Wolfgang Gentner andf Dr. Schmelzer. Norway was well represented, three out of nine. Rolf was actually registered as Swiss, and elsewhere in the CERN history he was referred to as German, which he didn't like at all. According to Dahl, it was no accident that Rolf joined as one of the first. He had done a good job as director of research at Brown Boveri, and the pair of them knew each other from earlier. He gave credit to Rolf in his memoirs:

> In the inter-war years he had done work in Germany that pointed ahead towards the big accelerator installations, he just didn't manage at that time to develop his betatron principle fully.[34]

Dahl himself was a man of action, which may have been a large part of the reason why they found each other. A typical Odd Dahl saying was 'You must think the idea through, but without paying attention to everybody because then you'll get nothing done[35].'

American Enthusiasm

The French physicist and UNESCO director Pierre Auger was an important driving force, as was the Italian Edoardo Amaldi. Rolf knew them both. Across the Atlantic, one of the people campaigning enthusiastically for CERN was the Nobel prize-winner Isidor Rabi. During the war he had had a key role at Massachusetts Institute of Technology, MIT. After the war he was a central figure in building up the famous Brookhaven Laboratory in New York State, and he was keen to support the establishment of a similar laboratory in Europe.[36]

Now the story of CERN really takes off, and Rolf is part of the action. A group of three travelled to the USA in August 1952 to study the plans for the giant synchrotron that was being built in Brookhaven, known to the Americans as a cosmotron. The group consisted of the chairman and deputy chairman plus Rolf, who travelled via Australia where he was due to deliver a lecture before meeting up with the other two in the USA. He relates excitedly that 'We spent several days with ….' and then begins to rattle off the names: George Collins, head of the Brookhaven Cosmotron Department plus random big names, the researchers who only weeks before had developed the strong focussing method.[37] He follows this up with a long explanation of the physics. That person and that person thought this and this. His own patents were based on such and such principles. Perhaps they would be better to do it this way. Because. There is no doubt that Rolf was expressing his ideas. The photograph of the three-man group with the head of the American laboratory has since become famous and was published in the jubilee account of CERN's first fifty years as an illustration of the start of something big.

Rolf considered that what they had been talking about at Brookhaven was some of the basic principles underlying modern synchrotrons, and he drew comparisons with the ideas he himself had proposed in his synchrotron patents in the 1940s. For example at one of the meetings Livingston, who had been Lawrence's assistant, spoke about a system for positioning the magnets that Rolf already knew about and that was immediately accepted by all the others.

In 1952 a group from Europe visited Brookhaven National Laboratory in the USA as part of the preparations for setting up CERN. From the left: Frank Goward, Odd Dahl, Rolf Widerøe, Ernest Courant. (*Courtesy* Brookhaven National Laboratory)

The trio from Europe came on the scene just as the American discussions had come to alternating gradient focusing. One of the major problems was that the enormous strength of the magnetic fields required both the manufacture and the positioning of the magnets to be done with a level of accuracy far greater than had ever been attempted before.[38] The Americans proposed a revolutionary lay-out for future high-energy accelerators. By experimenting with magnets to produce alternating gradient magnetic fields, they hoped to be able to build more powerful accelerators for the same cost.

This proposal immediately became a hot topic of discussion between the European trio and the Americans. Rolf had proposed a different method to improve the focussing, that he had patented in 1943. However, he recognised that the American proposal was simpler and better, and it appeared that the same principle had been suggested quite independently by a Greek two years previously.[39] Yes, it was exciting and Rolf was in his element:

> We spent a whole week on our discussions in 1952, from 4th to 10th August, and every moment of it was interesting. I saw immediately that their proposal for beam focussing was a much better idea than my earlier lens method.[40]

The Brookhaven team had willingly shared their new knowledge. Not only that, they were prepared to help the Europeans with this relatively risky pioneering enterprise, and the CERN group travelled home satisfied with the new idea.[41] When they arrived, however, they met controversy. These were radical ideas. Rolf's enthusiastic support was a great asset at that time, according to Professor Egil Lillestøl who was associated with CERN for many years including a time as Deputy Leader of the Physics Division:

> Rolf gave a lot of personal support to the leader of the group, Odd Dahl, when the three man delegation came back from the USA and "everybody" was against the new proposal for the accelerator.[42]

This Is How We'll Do It

After two months of argument, by October 1952 everybody in the CERN steering group was convinced about the type and size of accelerator that should be built, and that the machine should be the main element in the new laboratory. It was unknown technology with great theoretical and technical challenges, but that was exactly what stimulated Rolf Widerøe and Odd Dahl. The group upgraded its original proposal to the CERN directorate and obtained approval to go ahead. Planning could now begin. Two of the Americans they had met later came over to CERN and took part in the work.[43]

Everything went ahead now at an unusually high tempo. While physicists discussed the technical details of the synchrotron, the administrators, politicians and diplomats were working to set up the formalities to constitute the new entity CERN—an international laboratory in the middle of Europe with American support and collaboration, financed by the member countries and needing to be approved by the parliaments and governments in all twelve participating countries.

The original twelve countries have now become twenty-three. CERN must have no secrets, not sell anything, have nothing to do with atomic power or military interests, not be dependent on any other international organisation. Just carry out pure research. No-one had heard of anything like it before. From today's global perspective it may appear unremarkable but from the perspective of the time, and so soon after a world war, it was extraordinary.

In October the following year the PS group started holding its meetings in Geneva. Up to then they had travelled round between Amsterdam, Paris, Geneva, Bergen, Brussels, Harwell and Oxford. Then when it was confirmed that CERN would be located in Geneva, the group was allocated a regular meeting place in the physics institute there. But it took time for the practical work of development to start. The decision-making process was still a little protracted for Rolf's taste, and he recognises that some of his colleagues considered him impatient:

> I remember that some of the participants thought that I tried to rush things too much. For my part, I thought that we should concentrate more on the technical questions rather than let ourselves be weighed down in administrative problems.[44]

He adds diplomatically that he understands that such a big undertaking does need an organisational structure. There were plenty of scientific problems to contend with too. However after four years, in June 1956, the main preparatory works for the synchrotron were ready. About 140 employees were taken on and all the important industrial agreements for supply of equipment were complete. A forward planning schedule was drawn up—handwritten. According to this the synchrotron would be ready for use in 1959. Rolf's main involvement with CERN was now over, but not his interest.

Early in 1957 the personnel and the laboratory moved into the newly built premises. Parts of the roof were still missing, but the south and the north halls could be put into use for the testing and storage of machine parts that were being produced round about in the various member countries. Two years later the first of about a hundred magnet parts for the accelerator was installed in the tunnel. In July that year the construction work on the synchrotron was complete. In August an enlarged version of Rolf's linear accelerator could be fitted, a 50 MeV accelerator that would generate the protons that would travel round in the underground 'doughnut.' The first beams started circulating in the tunnel in September. Performance was still not exactly as the constructors wanted, but that would be adjusted gradually.

And in November 1959 it happened. The acceleration generated 24 GeV. The magnets were adjusted a little more and on 8th December the maximum energy level was achieved, 28.3 GeV. An amazing, almost unbelievable achievement by the scientists and even more of a marvel to non-technical people. But what everybody could grasp was that something very small was going round very fast and that this was important for research. The significance of the world record for generation of high energy particles was yet to be understood. As for Rolf, he hadn't been able to abandon CERN before they reached their goal. He had taken part in making major decisions throughout the seven years until CERN's first machine was ready.

America Strikes Back

The proton-synchrotron machine in Geneva held the world record of being the accelerator with the highest energy for seven or eight months. Then the sister machine in Brookhaven was completed, with a higher—only slightly higher—beam energy[45]. Thanks to their visit to Brookhaven, the Europeans had been able to almost treble the energy level from the target they had originally set for themselves; from 10 GeV to almost 30 GeV.

In the 1960s the PS synchrotron was nuclear physics' state of the art research tool, one of the world's most versatile generators of particles and radiation for use in many of the centre's other accelerators and experiments. For CERN this was the start of an amazing success story that just continues to grow. The CERN laboratory's record of producing constantly better and better accelerators throughout sixty-five years is unique, and the backbone of this whole achievement has been the synchrotron. The decision to do what Rolf had advocated paid off.[46] It was 'an almost unbelievable project: a high precision machine with a diameter of 200 metres, that stretched technology to its absolute outer limits and forced into existence new initiatives and new developments in many fields,' as the former CERN director wrote in connection with the fifty years jubilee celebration in 2004.[47]

He gave unreserved praise to Rolf and his colleagues, commenting that as the decision to develop this particular type of accelerator had been made at the important meeting in October 1952, the half-century should really have been celebrated earlier, in 2002. The decision made at that time 'demonstrated not only extraordinary understanding but also foresight and courage. The original designers of CERN took a brave decision when they decided to listen to the experts.' He asserted that history would have come to be written quite differently if they had chosen the old, safe way.[48]

Rolf experienced it as an adventure and was able to see the victory in a wider perspective, for there were others also on the track. Workers at the Dubna Research Centre north of Moscow had built a 10 GeV proton-synchrotron using the traditional method, which came to be known as 'weak focussing.' He could claim proudly that the Soviet machine lost the competition on all important criteria: 'Their machine was ready in 1957, and 36,000 tonnes of iron had been used to build the magnets. This machine had the highest energy anywhere in the world at that time. For our strong focussing machine at CERN, which reached 28 GeV, we used only 3,200 tonnes of iron, less than a tenth of what had been used in Dubna. We not only reached the goal before the Americans (…) but we also seized the world record for particle energy from our Soviet colleagues.'[49]

A Workhorse

The proton-synchrotron machine still plays an important part in the work of CERN. It was their leading workhorse throughout the 1960s and continues in that role as an injector in the chain of larger accelerators. The PS technology is used in all large accelerators and has been central to all further upgrades and development in what has gradually become a whole complex of accelerators. The facility was popular and researchers flocked into use it. A new hall, the East Hall, was built to accommodate new developments. To check that it was both safe and wise to proceed, a special group investigated whether a different method of locating the magnets in the PS tunnel would increase capacity. The result was unambiguous: just as it had been built twenty years before, the machine was still the best to fulfil all the needs.

Parallel with the development of the PS accelerator, another group was working on the development of a proton-synchro-cyclotron, known as 'SC.' New acronyms and abbreviations have continued to proliferate, just as useful for the researchers as they are incomprehensible to amateurs.

The next stage after PS was ISR ('Intersecting Storage Rings'), a double proton ring that would cause high-energy protons from the PS machine to collide. The protons would circulate in opposite directions and collide head to head, releasing much higher energies. The problems were formidable and many people thought them insoluble. The Norwegian Kjell Johnsen, then director of the division responsible for construction of storage rings, led the project to build the world's first proton-proton colliding beam machine, which was put into use in 1971.

This was unique. With this particle physics machine, Europe was well ahead of the competition for the first time. It reached a completely new energy level, and many researchers were curious to see what it could achieve. In particular, many Americans came to CERN. They had helped at the birth of the organisation and followed its growth and development from the start but it was not until the 1970s when the ISR machine was put into operation that there was significant American participation in the laboratory investigations. The opportunity to work with such a machine was irresistible to American particle physicists, and Americans took part in almost half of the experiments using ISR.[50]

Rolf had taken out a patent for a PS as early as 1946. But 'Unstoppable Widerøe,' as Dahl called him, had in fact taken out a patent for its successor, the ISR, three years earlier.[51] though because of the war it was not published until 1953.[52] So the principles set out by Rolf were also the basis for CERN being able to build its first machine to collide beams of protons.

The Rest of the Alphabet

The story repeats. Even before the ISR machine was ready work had started on the next, a 300 GeV super proton synchrotron, or SPS. By now there was so much happening at CERN that a dramatic upgrade of its information technology was needed to keep control of it all. With improved data processing, all the machines and equipment could be driven in parallel. The old PS machine was still in use and could even cope with some new challenges. As an injector of protons and anti-protons for the SPS it played an important part in the experiments when the particles known as w and z were discovered, earning the CERN researchers their first Nobel Prize in 1984.[53] Not only that, but the PS was also useful in combination with the next machine for anti-protons, LEAR, and its successor, AD.[54]

The 1980s and 1990s were the high times for LEP, which was even bigger and stronger than ISR.[55] The PS was used as an injector in these decades too, in combination with SPS.[56] At that time LEP was the biggest storage ring in the world, and Rolf could say with some satisfaction that this was a result that tallied exactly with the principle in his own patent.[57] The LEP storage ring was 27 km in circumference, buried in a tunnel 100 m underground. When it was first switched on its energy 'only' came up to 50 GeV, but it eventually achieved 100 GeV. Rolf reckoned that this was the last step in the development of this type of storage ring. He thought it unlikely that a ring with higher energy than LEP would ever be built, and so far he has been right.

Then, in 2007, the physicists and scientific historians got yet another acronym to keep track of, LHC.[58] This was a new proton accelerator with two beampipes that bring particles together at collision points. The research centre provides a remarkably simple explanation in its information material: The accelerator installation at CERN consists of a series of eight machines with higher and higher energy. Each machine injects beams of particles into the next, which takes over and increases the particles to even higher energy, and so on in the same way. Now we are no longer talking about mega and giga; it is tera that describes the particle energy, with twelve zeros after the number. In the LHC machine—the latest link in the chain so far—every particle beam is accelerated to a record level of 7 TeV, which is 230 times higher than in ISR. In addition to this, each of the LHC injectors has its own experiment halls where the lower energy beams are used for research.

It was not always so straightforward. The machine also generated internal drama within CERN and media publicity beyond. This was breaking new frontiers: it would 'create miniature black holes; find new dimensions; recreate the Big Bang;' answer the huge cosmic questions by studying the smallest of the smallest particles, those that were so small that they 'didn't exist.' All the spectacular things that the machine could do were not only incomprehensible, but also mystical and thereby even more exciting. The machine is very expensive to run and was out of operation for over a year because of a breakdown. The numbers could make you giddy: over 7.5 billion euros construction costs; 30 storeys underground; minus 271° temperature. The size and potential of the LHC is almost impossible to grasp, even for physicists.[59]

Meeting with the Great and Famous

Rolf did not live long enough to follow the developments as far as this, but he was involved in the second last step, LEP, before he died in 1996. After his official engagement with CERN was over, he 'helped a little from time to time,' as he himself said.[60] He was invited to the big accelerator congresses in 1956 and 1959, and it was a feather in the cap for Brown Boveri that their own director of research and development was playing such a central role. In the course of the 1950s and 1960s he took part in altogether nineteen major meetings and conferences, but he never entirely let go of CERN. He had never been given any special brief in his work as a consultant, and he liked the freedom that this role gave him. As a freelance he could take part in meetings and gatherings, meet people, exercise influence and receive stimulation. He obviously didn't consider the work associated with this role as a burden, because it gave him so much and he was able to take part in exciting events right from the start:

> For example, on 18th December 1952 I went to Geneva with Professor Gentner and Dr. Citron to see the place where the machine was to be built. We were to decide the direction the protons should follow, so that the farms and villages in the neighbourhood would not be troubled by particles being thrown out. A protective mound was built later, known as "Mount Citron".[61]

Rolf was used to being in the company of the great and famous. He saw it as a natural part of his job. Wolfgang Gentner, for example, had been one of the leading nuclear physicists in Germany during the war. Rolf also worked with the British Frank Goward and the American Hildred Blewett on the calculations for the PS machine. At the congress in 1965 he also met Gerry O'Neill from the USA. They found that they had more in common than they had thought. This led to mutual admiration and mutual advantage. Rolf learned that the American was working on 'a little storage system with colliding beams' and that he 'had apparently not heard of my 1943 patent and had developed the principle from scratch.' The following year he visited him at Stanford, described the patent he had registered during the war and noted that 'He was really impressed.'[62]

It may have been at the same congress that he met Ernest O. Lawrence, the inventor of the cyclotron. He struggled to remember the exact occasion when asked about that later. Perhaps it was at the 'Atoms for Peace' conference that CERN arranged in August 1955. 'This popular conference would obviously have been the most suitable occasion for a friendly embrace,' he pointed out. But he adds that it might not have been until the following year that he met his legendary rival and fellow-player. Anyway, when they did meet they planned for Rolf to come over to visit Lawrence in the USA, but Lawrence died of cancer before anything came of that.[63]

The Big Questions

It is difficult to say how much of the CERN scenario Rolf anticipated. Not that it would become a whole research town with hundreds of buildings and streets named after Einstein and other great scientists. Probably not the Large Hadron Collider. But he did see that it was big and would become bigger and play an important part in shaping the future. He may also have anticipated that it would make sensational headlines in the new century that he hoped he would live to see.

'Europe takes the lead in particle physics' was the front-page headline on the prestigious American magazine *Science* on 23rd March 2007, together with a picture of CERN's latest giant installation. 'Ready for the world's biggest experiment,' wrote the Norwegian newspaper *VG*. 'The hunt for the Big Bang,' wrote *Aftenposten*. 'Preparing the world's biggest experiment to find the universe's smallest particles,' wrote *Apollon*, the University of Oslo's research journal. The academic journal *Gemini*, published in Trondheim, emphasised the huge significance of the project:

> The plan is for the new accelerator to bring protons up towards the speed of light. The collisions will then release much higher energy, which gives a bigger chance of new particles appearing. New and unconfirmed theories can then be proved – or disproved. The physicists also hope to find supersymmetric matter with the new accelerator. The theory of supersymmetry is an attempt to create a common theory for all the fundamental particles and forces, with the exception of the force of gravity. This has not been done before.

It is not easy to explain quantum mechanics in simple terms, but popular science articles can give an impression of speed, dimensions and extreme precision and of the paradox that something very small could cause something very big to happen. As *Science Illustrated* put it: 'The researchers are smashing the smallest particles they can obtain, to see what is inside them. They are looking for the universe's smallest building blocks, in the hope of finding out how it came into being.'[64]

Even though most people don't fully understand reports from CERN, they still make interesting reading. Details such as 600 million particle collisions per second. Wow! The machine expands and contracts one millimetre between low and high tides. The French high-speed train, the TGV, interferes with the experiment. For the particles to follow the bends in the tunnel and not be hurled out onto the neighbouring farmers' fields, 1,232 magnets are built into the machine. Each of these is 15 m long and weighs 35 tonnes.[65] We could go on.

On 30th March 2010, *Dagbladet* wrote that 'The Big Bang Machine set a world record' and described the twenty years of prior planning. People followed the story, and knew that this was about CERN. For a short time in 2012 the world of physics held its breath. The CERN researchers were thought to have got something to travel faster than light. This was quite soon shown to be a mistake, but it led to sensationalist headlines that even Einstein had been wrong. Physics at CERN had become a hot topic in the media. One of the people who contributed to this is Egil Lillestøl who over several years showed people round CERN and spoke with journalists. He stresses that Rolf's input was vital in creating the world's biggest particle physics laboratory:

> You could say that Rolf Widerøe was almost the reason for two Nobel Prizes. There is a direct line from him to the physics prizes in 1939 and 1984 The first was awarded to Lawrence, who never concealed his debt to Widerøe. The second was to the Italian Carlo Rubbia and the Dutchman Simon van der Meer for their contribution to the discovery of particles W and Z.[66]

Another internationally orientated nuclear physicist who has studied Rolf's input to the development of CERN, Jan Sigurd Vaagen, thinks that it says a lot about Rolf that he was called upon to take part in what has since become such a famous visit to the USA to discuss which type of accelerator CERN should decide upon.

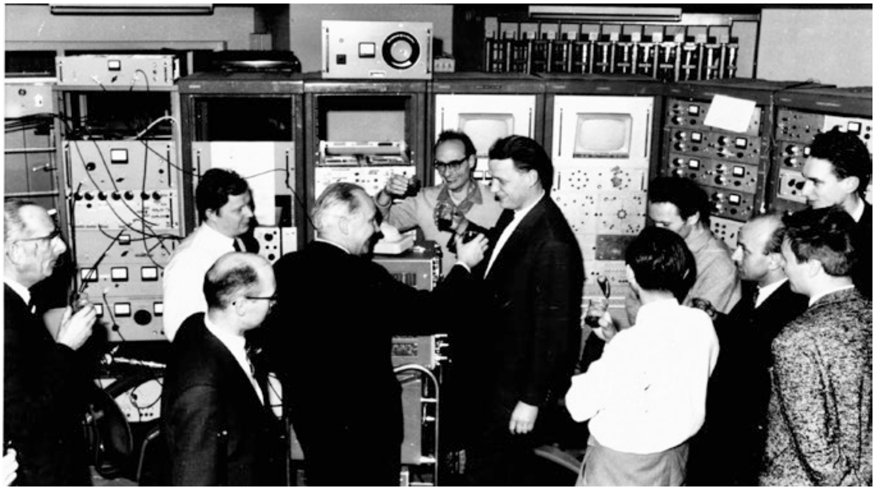
> What they brought home became Europe's flying start, when the Europeans took the opportunity to develop a principle that the Americans had discovered but nobody had really proved. What is called 'strong focussing' in modern scientific terminology enabled the laboratory to compete with the USA. Widerøe played a part in this and is credited in the history of science as one of the important players in the early days of CERN.

People associate CERN with physics. Not so many people know that the World Wide Web was invented there—as a spin-off, we could say, simply to handle enormous masses of data. In the 1980s the researchers needed an easier way to update and share information with each other, and the World Wide Web came into being. The world's first website went live on 6th August 1991.[67]

But the day came when neither their own computers nor the Internet were enough for the CERN researchers. When you need to analyse 1,000 particle collisions per second, enormous masses of measurements pile up in unimaginable quantity. A single one of the projects using the newest machine can accumulate huge amounts of raw data per year, and even the super-computers at CERN have difficulty swallowing such bulk[68]. The solution was to use and develop the "Grid' to link together tens of thousands of computers throughout the world to handle the enormous amounts of data. Work could then be sent automatically to wherever there was vacant machine capacity. Then it doesn't matter where on earth you are, or which subject area needs calculations done, from speech technology to medicine. In theory you can sit at any computer in any research institute anywhere in the world to do your work. That is perhaps even beyond what the founders of CERN predicted, with their vision of research that would 'bring the nations together.'

Doris and Petra

CERN was just the beginning. Similar national accelerator centres were subsequently built in various places, including Hamburg and later Darmstadt. Rolf was a consultant for these too. Over a period of five years while the DESY (*Deutsches Elektronen-Synchrotron*) centre was being planned he travelled there frequently and was there for several days at a time. He worked mostly with a German physicist on technical problems with the electron-synchrotron, which was to have a circumference of 300 metres and reach an energy level of 6.4 GeV.[69]

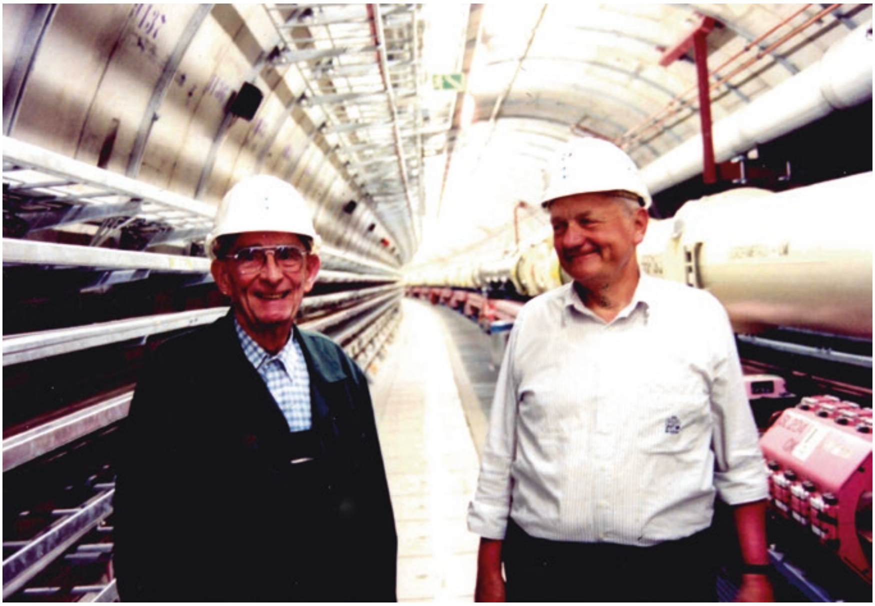


Start of the DESY synchrotron in 1964. Rolf Widerøe to the far left. (*Photo* DESY)

Stanley Livingston, who had been Lawrence's assistant and whom Rolf had met when the CERN group was in the USA, also visited DESY from time to time. Rolf also worked a lot with the head of the accelerator division and had long technical discussions with the founder and director of the centre on his favourite topic of 'storage rings with colliding beams.'[70]

This centre's first machine for colliding electrons and positrons was called DORIS (***DO**ppel-**Ri**ng-**S**peicher*; '**DO**uble-**RI**ng-**S**torage') and was completed in 1974. The second one, PETRA ('P*ositron-**E**lektron-**T**andem-**R**ing-**A**nlage*') was eight times bigger with a circumference of 2.4 km and was put into use in 1978. Then in 1991 came yet another, HERA ('H*adron-**E**lektron-**R**ing-**A**nlage*'), which was even bigger and which Rolf described as a very special machine.[71] During a visit the following year the then 90 year old former adviser was shown round the centre and was able to hear about all the details. These are obscure to most people but the description he was given can—if nothing else—give anybody an insight into size and high energy:

> Electrons or positrons of up to 30 GeV are stored in one ring and protons of up to 820 GeV in another. Both rings are installed in a 6.4 km long underground tunnel, 2.8 times bigger than PETRA. The protons in HERA need to be held in place by superconductor magnets that produce magnetic fields about three times stronger than ordinary iron magnets.



At the age of 91, Rolf Widerøe made a return visit to the DESY laboratory for which he had been a consultant in the early 1960s. On the right: Professor Gustav-Adolf Voss, director of the accelerator division at Deutsches Elektronen-Synchrotron DESY. (*Photo* Pedro Waloschek)

Rolf could add that a similar type of magnet was used for a proton–antiproton storage ring called the tevatron that was built at Fermilab outside Chicago. The tevatron was about the same size as HERA and was able to store particles with an energy level of 900 GeV.[72]

The person responsible for interpreting the work at DESY to the general public at that time was Professor Pedro Waloschek, who had already started working on his biography of Widerøe. Rolf had long since completed his work as a consultant at DESY, but Waloschek had become curious about him and had visited him in Switzerland.

Twenty Years Teaching

It seems that in the 1950s, long after he had started his work for CERN and DESY, these jobs combined with his directorship in Brown Boveri were not enough for him. He accepted another job, as a lecturer at the technical college in Zurich. This was a third or fourth job, depending on how you see it. How did he cope? His eldest son answered my question thus: 'The teaching at the college was in the afternoons and evenings.' As if the lecturing had not been any problem. Even if it had been, the children would not have noticed. Mother was there for them.

Rolf himself thought that it was both fun and an honour, a pleasure. The college is still ranked as one of the best in Europe. Einstein had been there, failing the entrance examination at his first attempt but later becoming a professor there. Wilhelm Röntgen had also studied there. In his lectures Rolf was able to talk enthusiastically about the topics he had been working on most of his life. This gave him new ways of expressing himself, and also many new personal contacts. He hadn't worked as a teacher before. 'This was a whole new feeling. I could let my imagination run free without having to think about the interests of an industrial company.'[73] But he hastened to add that Brown Boveri, where he was still an employee, was in no way negative about his work as a lecturer. On the contrary, this was good PR and it helped the sale of betatrons.

Rolf Widerøe liked to have an audience and never tired of explaining his accelerator theory. (*Photo* Pedro Waloschek)

On 12th December 1953 he gave his first lecture at ETH, *Die Eidgnössische Technische Hochschule.* He had prepared carefully, and he kept the original manuscript as long as he lived. The topic was the history of particle accelerators, a historical subject that was not obligatory for the students. So he had relatively few students in the class, but he appreciated the few all the more and he said that he was always glad to have some who impressed him with their extra industriousness and intelligence. One of these was Christian Gerber whom he later employed to assist him installing betatrons in hospitals throughout the world. For Rolf himself, there was great benefit in preparing his teaching material. At last he got time to go into things more deeply and sort out all the information about accelerators that he had accumulated. He used the opportunity to organise formulae and dig out the theoretical material needed to calculate such things as the size of particle track needed for different types of accelerator, and generally systematise his own contribution to the subject. He may not have been a pedagogue in a narrow sense, but he took to the job with enthusiasm and he loved talking to the students about the betatron.

One of his nephews, Thor Spandow, his sister Else's son, trained as a civil engineer at the college in Zurich and is now head of the Spabo Group. Rolf arranged for him to have three months of practical experience at Brown Boveri, during which time he lived with his uncle in Baden. When I asked him if he really got to know his uncle at that time, he answered as follows:

> You couldn't really get to know Uncle Rolf. Up early, breakfast at Brown Boveri, home at 12 for lunch and a mid-day rest, back to work, home for dinner before he took himself back to his study. He was a scientist through and through.[74]

Engineer Gerber, who also regards Rolf very highly, says the same:

> He was not easy to get to know if he didn't want to talk with you. But if he did want to talk, he could be really charming. At other times he could behave as if he hardly knew you.

The Art of Compromise

At home, Ragnhild was the boss. Nobody doubted that, and everybody was happy with it. She managed everything. She looked after money, house and home, in the midst of many children, a big extended family, frequent visitors and a wide social circle. When Rolf was away travelling, and indeed most of the time, she kept the domestic wheels turning. This was not an unusual pattern of domestic life in that generation, but with a man such as Rolf and with piles of documents sometimes heaped up on the double bed it was especially necessary to have somebody who kept order. For his part, he tacitly allowed her to make the decisions in the areas that were important for her.

Her sons say that their mother was both caring and well organised. When the children were old enough to look after themselves she volunteered as a Red Cross driver, taking elderly or sick people to the doctor or elsewhere a couple of times each week.

When he was asked if his mother took an interest in her husband's work, Rolf jnr. replied:

> She took an interest, and knew whether he was on the right track or in a blind alley. And of course she was interested in successful sales, for that brought in more money!
>
> *I understand that your mother managed the family finances?*
>
> That's right, my father wouldn't have anything to do with that.

She had a lot to cope with on several levels, and living with Rolf can't have been easy, but they both recognised the need for compromise and their respect was mutual. He acknowledged this himself in his speech at their silver wedding celebration. As he gallantly and diplomatically put it: 'For my part, I couldn't imagine spending time with somebody who didn't have an independent personality.' They had invited many guests to a big party on Saturday 14th November 1959, 25 years to the day after their marriage. Having started his speech in German, '*Liebe Freunde*,' 'Dear Friends,' followed by polite greetings and thanks for gifts, he switched over to addressing his wife in Norwegian. He pointed out that neither of them had been fully clear what they were starting out on but that that had hardly mattered when they married. He confirmed that it had been a happy time that had given him 'much more than I could have imagined,' and he had some thoughts about why this was so:

> I do have certain traits that cannot easily be ignored, and the art of compromise is indeed one of the secrets of a happy marriage. But respect and understanding of the other partner's personality and interests are just as important. I know that this is not an easy task and that you were in a difficult position in the early years when I totally lost interest in everything except other things that were totally unimportant and uninteresting to you.

It sounds both authentic and sober when he ends his speech with some numbers and percentages:

> I thank you for your patience with me during shall we say 90 per cent of your 25 years with me and I wish you happiness and only moderate trouble in the next 25.

What 'trouble' there had been up to then was largely the result of circumstances and events beyond his control. He had been at home in Oslo for 12 of the 25 years and abroad for 13. The war, in the middle of the 25 years, had been a particularly difficult time, and Ragnhild had been the decisive factor in drawing a line under their wartime history and settling abroad. However, the shadow cast over their lives by the war faded with the years.

Between a Rock and a Hard Place

Their son, Arild, reports that Ragnhild's father Alex Christiansen being a Nazi had been difficult for her:

> My father with so many contacts in Germany and her own father a Nazi. That was difficult for the whole Widerøe family.

Ragnhild's father was arrested two days after the liberation and held in detention until 24th November 1945. The case was concluded with a fine for having been a member of the *Nasjonal Samling* ('National Unity') party. Several members of the family, including Rolf's sister Else, have said that Ragnhild was reluctant to go upstairs in her parents' house to see her father, who mostly lived upstairs while her mother lived on the ground floor.

He was a businessman and after the war he tried to whitewash away his Nazi offences. Among other things, he wrote a book that he never succeeded in having published. Apparently his children put a stop to this project. Eventually an abbreviated version was printed as a serial in the NS Party's newspaper *Folk og Land* in summer and autumn 1958, six months after his death.[75] He wrote : 'I don't want to go to my grave before I have cleared up the web of lies that people have tried to strangle me in.'[76] He thought that he had been treated illegally and he continued writing his own defence until he died. He bequeathed much of this documentary material to his loyal secretary, with 5,000 kroner set side to pay for the book to be printed. His secretary continued the struggle on his behalf and submitted the material to the Nazi newspaper. In a postscript, he rebukes Christiansen's family as follows:

> After his death, his closest relatives totally countermanded his last wish and stopped the printing of his book which had already been typeset and proof-read twice. (…) If a deceased's legally valid last wish and his arrangements to have his reminiscences printed and published can be blocked, what is the whole of our western legal system worth?[77]

The intensity of the drama in the extended Widerøe family was maintained by Ragnhild's sister Louise marrying a man who had been captive in six different German concentration camps in the course of the war. Egil Reksten had been captured soon after graduating from the Norwegian Technical College (NTH) in Trondheim in 1941. He had been a student of the resistance fighter and heavy water saboteur, Leif Tronstad and he had been leading 'Skylark B,' the Norwegian intelligence network's Trondheim station for communication with the British, when he was arrested. Reksten's name is recorded in history alongside famous *Nacht-und-Nebel* ('Night and Fog') Directive prisoners such as Kristian Ottosen and Trygve Bratteli. Like them, he earned a reputation as one of those who by their strength of character were an inspiration to their fellow-prisoners. He managed to survive four years in captivity and was eventually freed and sent home in the white buses. Louise was a nurse at the hospital he was sent to, and the story came to a happy ending when they were married two years later.

When members of the family talk about Rolf, most of them say that he was dependent on Ragnhild. When they come to describing his character, their perspective depends on what aspect of him they have known, and more comes to light than meets the eye. Was he social or did he lack social antennae? Was he inclusive of others, or just preoccupied with himself and his family? Introvert or extrovert? A compendium of accounts from a nephew on his wife's side, a nephew on his own side, a brother-in-law and a sister-in-law illustrates the wide range of their perceptions:

My Uncle Wasn't Boring

First, some points of view from Jørgen Holmboe, son of Ragnhild's sister, Margareta:

A little 'different'

> Uncle Rolf was in his fifties when I got to know him. As a teenager I was a little unsure about this slightly eccentric man. Yes, he was an eccentric, that really exciting mixture of – should I say – a world-leading scientist and at the

same time with lots of weird ideas about medicine. My mother and father are also doctors, and it was rather funny to hear what Rolf said about his remarkable ideas of everyday medicine. We used to joke about his strange perceptions of how to take care of one's own health. Yes, he had some odd rituals, bathed in that pool of his and had some brushes to brush himself with and beat himself in various places around the body. In different numbers of times, and they had to be odd numbers. He did that! And carried it out with great bravura. There would be seven or thirteen knocks with this brush on different places. For a cold, you should drop red wine onto a spot of cotton wool and put it into your nose, yes, it was on that level. And at the same time he had honorary doctorates from several medical faculties. When I later became a doctor myself, I thought that was a fascinating combination. I started studying medicine in 1964, and by then he was famous and travelling round giving lectures, and at the same time with such odd performances in his everyday life. That huge gap between the scientist and – yes, I think that today he would have gone in for a whole heap of alternative medicine. And believed in it. I think so.

Mistrust of Conventional Methods

I've heard something about lots of vitamin pills, almost rituals?

Very odd, yes. I don't know whether he was into Linus Pauling's ideas about massive doses of vitamin C, but I could imagine that he might have been. Maybe it was based a little on mistrust of established, conventional medicine. Perhaps it was the scientist in him who saw that lots of what we do in normal medicine is poorly documented. It could be that he thought it was effective for him and that it was at least as good as anything else. Maybe that's how it was. But I couldn't say for sure.

Big ideas and small details

He was obsessed by minor details, while at the same time he had thoughts and ideas in his head that none of us could manage to follow. He brought plant cuttings home from the Far East or somewhere like that, which he had carried on flights round the world to plant in his garden. He had a test-tube in his hand baggage with some unusual plant in it. The garden was a little overgrown, though. The mixture of ideas that small things could be important but that they could be lost among the bigger things in the forest.

How long are you staying?

Did he have social antennae? Was he introvert, detached?

No, he was absolutely an extrovert. But he was perhaps a little, shall we say, self-centred. He needed space. Massively hospitable. But slightly abrupt and only slightly modest. We would come to visit on a car trip with our baggage and holiday gear. And he would say: "So lovely that you are here! How long are you staying?" From his point of view it was well meant, for then he would set out a programme for us, but it isn't really normal to be met at the door with "How long are you staying?" Yes, that's what he was like. Hospitable and extrovert, but not entirely conventional.

An exciting uncle

Some people say that he was interested only in his research. That doesn't tally with what you are saying now?

No, I don't agree with that. Hiking in the woods. Picking mushrooms. Cultivating friendships. Being proud of his garden and particular plants and his swimming pool. Yes, that's how I experienced him, proud. His interest, it was more of a general interest in everything that was going on in science, not necessarily his own specialty. I hardly ever heard him talk about his research. Not even when I was growing up and studied medicine and would have been capable of understanding a little of what he said. He didn't trouble other people by pushing his thoughts about research. Because his ideas were on a level that we others couldn't attain anyway. He seemed more interested in what he had read in the latest issue of the popular science magazine *Scientific American* or that type of journal. Then he would want to test his thoughts out on us others. Anyway, that's how I remember him.

An exciting uncle to visit …

Yes. Definitely not boring.

A Surprising Uncle

Rolf's nephew Aasmund Berner, his sister Grethe's son, was fond of his uncle and had a lot of contact with him. Aasmund formed his own impressions of Rolf over the years. One of these was of a lack of sense of humour. Sometimes too, he wondered whether his uncle really was interested when they spoke together. On his desk at the Radium Hospital he has a ring binder with Rolf's doctoral thesis and articles by and about him. He shares some memories both of Rolf and of his brother Viggo:

One or two fish

He didn't have much of a sense of humour. We were out on the hills a lot, and he did a lot of fishing. I remember well an episode at Skjæløy, the family's country property. Uncle Rolf was there. We had been out setting nets and caught a few fish and when we were about to gut the fish he asked, "Have you gutted fish before?" When I replied, "Yes, I've gutted one or two fish," he took it quite literally. Whether I have gutted 100,000 or 10,000 is irrelevant. "One or two" is just what one says so as not to exaggerate. And he believed that I really had gutted only a couple of fish in my whole life.

Did you say party-van!??

Uncle Rolf has a bit of a self-assertive streak, and not just him. The others have it too. I remember well that when I was celebrating graduation from high school I went to see Uncle Viggo to ask if I could get some advertising material for a party-van. But he wouldn't consider having any advertising material on a party-van. What's more, the idea of a party-van was just nonsense. I could take the tram, and Widerøe Airlines certainly wouldn't sponsor any party-van, he would have none of it. Rolf wasn't very interested in communicating with people who weren't like himself. He wasn't really interested in the human aspects. He was more of a technical person, and that is where these self-assertive tendencies come into play in some people who are clever in a particular field.

No reply

When I did my Ph.D., I sent my dissertation to Uncle Rolf. I never got a reply. Then when I started trying to find out if he had received it, all I heard was, "Yes, that there Berner, he is investigating something."

Did you manage to take that calmly?

I didn't fret about it. It wasn't anything to worry about. He was an old man by then. I thought he might have been interested, because he has close connections with this hospital, the Radium Hospital where I work. Betatron Number Two in Europe, which was located here, that is what laid the foundations for the hospital's activity in this field.

A Brother-in Law Who Is Both Social and Antisocial

Ragnhild's sister Louise and her husband Egil Reksten have also kindly shared their many and strong impressions. The pair of them had a lot of contact with Rolf and Ragnhild, visited them in Switzerland and were always with them on summer holidays in Norway. They also took part in family celebrations, including the golden wedding celebration in Switzerland in 1984. And Rolf and Ragnhild's eldest son came to their own diamond wedding celebration in Oslo a few years ago.[78]

Out walking

Egil: He went out walking a lot …
Louise: … but he liked to have a little following.
Egil: He didn't have a lot of ordinary social chat.
Louise: No, but he did like us to go with him when he went walking.
Egil: Yes, so that we could listen to him.

A hole in the ice

Egil: In later years he was forbidden to go in their swimming pool. At any rate in winter. He just carried on, broke the ice and bathed, even though there was a crust of ice on the water. What he did, he did properly. If he was to bathe, then he would bathe.

He liked an audience

Egil: The first time we were really together with him we made a big blunder. They lived in Switzerland and were here visiting us. At first the whole atmosphere was a little reserved. But on the second last day or sometime like that when we had a big party and a really good time, we saw that we should have done that right away, so that he would come out of his shell and we would have got to know him more quickly.
Was he really shy?
Egil: He was not …
Louise: … not really "with us."

A one-track mind

Egil: Maybe he did have a bit of a one-track mind, yes. I rather think so.
Louise: That seems a nasty way to describe him.
Egil: No, one-track minded! *Somewhat* one-track minded, then.

Domineering

Was Rolf domineering in private life?
Egil: Well, I don't know about that.' (turning to his wife) 'I don't know, was he very domineering at home? You know more about that aspect than I do.
Louise: He was a little domineering.
Egil: Worse than me?
Louise: Perhaps.

Egil: Yes, I think he was maybe a little stubborn. But you'll get a better idea about that from others.

I ask a lot of people, then try to piece the bits together.

Louise: That will be a lot of pieces.

Egil: He certainly wasn't "a man in a grey flannel suit."

Louise: No, he certainly wasn't that.

His brother was more sociable

Egil: If I were to compare the two brothers, I would say Viggo was much more sociable.

Louise: Yes indeed.

Egil: He had more to talk about, you could say.

Louise: Rolf was really happy when we came to visit.

Egil: Yes, he liked having us visit, and I could chat a little about technical things he was busy with.

Stand there!

Egil: Like probably all good researchers, he was fascinated by everything new. Child-like curiosity. I remember once when we were visiting them there in Switzerland. No sooner was I in the door than he said, "Come here! Stand there! Just there, a little further to the left. Yes, there, just stand there." He wanted to demonstrate the first stereo equipment to me. But I didn't like having to stand totally still "just there" to listen to this "wonderful stereophonic effect."

Was he interested in music, or was it the technical aspects that were important?

Egil: I think it was the technical aspects. At any rate, that's how it seems to me. He was always like that. He was very committed. Very fascinated. When he was fascinated, he was totally immersed. He was a lovely guy, but his interest was rather focussed on what he himself was busy with, for example his work in the garden. I've never known anybody so enthusiastic. He was a real researcher. What you are looking at, what you are engaged on, that's what is important and anything outside that is not so important. So I would say he was childish in a way, or rather child-like, to use a better word.

The children

Was he interested in his children?

Egil: Oh yes!

Louise: Oh yes!

Curiosity Takes New Directions

While Rolf was busy delivering lectures and developing, selling and installing new betatrons—and before anybody started worrying that the market for betatrons would one day be saturated—he suddenly shifted the focus of his own interests, from 'How to *create* radiation?' to 'How does radiation *work?* ' What does all this radiation do to the cancer cells in the body? In other words, what is the biological effect of radiation? His curiosity took new directions. He started keeping company with doctors and reading about radiation treatment and its results. As a physicist and an engineer, he took an interest in the medical effect of the equipment he had developed. He described it as a metamorphosis, but for him it was logical. Contact with the hospital environment and meeting patients and seeing how they could be helped, contributed to this change in his interests. Other 60 year olds might begin to think of retired life on a pension, enjoying some overseas travel and a little consultancy work now and again and delivering a few lectures on their life's work with speculations about the future. Nobody who knew Rolf would expect that of him.

Until now, Rolf had been interested almost exclusively in the technology. Medicine had never basically interested him before. The concept of multidisciplinary research had not yet really been invented. Rolf had concentrated on generating radiation, of as high energy as possible. But what happens to the body when the radiation meets the skin and when it passes through the skin and meets other body tissues? What effect does it have on the living cells? Diseased cells or healthy cells? From now on, Rolf spent most of his time on radiation biophysics and radiation biology. He was interested in how radiation interacts with body tissue and malignant tumours and he wanted to contribute to making radiotherapy more effective.

Professor Jan Sigurd Vaagen from Bergen says that Rolf played an important role[79]:

> There was widespread interest in radiotherapy at that time. Widerøe tried to use other types of radiation than X-rays for cancer treatment. He pioneered a type of therapy that is still in use today, albeit with protons whereas he used electrons.
>
> Widerøe had to update himself quite a lot and learn about radiotherapy and its application. That is surely one of the most impressive things about him, that he was never too old to learn something new. He seemed to me to be an eternal student and he maintained his excitement in seeing new things throughout his whole life. There was something of a young folk-tale hero

> about him, but instead of having many helpers as "Askeladd" had, Widerøe did much of the job himself.[80]

As a physicist, Rolf realised that when radiation particles penetrate into tissues and cells, they leave trails behind, rather as animals leave tracks in newly fallen snow, as he used to say. Some types of radiation lay dense trails, whereas others have long intervals between each 'footprint.' His idea was to look for a difference in the tissue damage caused when the marks were close together, compared with when the marks were further apart. This information could then be used to tell something about what sort of effect the radiation had and what type of radiation should be used for what type of tumour. The outcome of this research was that he and the others working in this field developed a theory, expressed as a mathematical formula, for the probability of cells surviving a specified dose of radiation. One of the variables in this equation is the closeness of the 'footprints,' what physicists call the 'ionisation density.'

There is disagreement among scientists about the value of what is known as the 'two-component theory.' Rolf's own dosimetry expert, Christian Gerber, says that nobody really believed in it.[81] Tor Brustad at the Radium Hospital in Oslo thinks that the theory was useful for a long time in radiation biophysics research, in radiobiological research and in deciding radiation doses for treatment of patients with cancer. He claims that Rolf has contributed to the advancement of radiotherapy in two ways, both with his development of accelerators and with his formulation of new ideas in radiobiology.

Together with the head of the radiotherapy department in the regional hospital in Zurich, a leading man in this field, Rolf wrote several articles about his findings.[82] The results that had been achieved in treating cancer patients clearly showed that the use of betatrons had been a big leap forward in radiotherapy. Rolf liked to express himself in clear, simple language and at an international radiology congress in Munich in 1959 he used a tabloid style in statements such as 'To use anything other than betatrons in the treatment of deep-seated cancer tumours should be forbidden by law!' He then spoke about X-rays and electron beams of up to 30 MeV.

At the end of his life he still thought that his strong words from that time still applied. However, it was several years before his ideas really spread and were put into use. He regretted that doctors were conservative people who didn't readily switch over to new methods of treating their patients. There obviously always came a point where they had to accept new ideas, but enthusiastic as he was, he thought that this inertia was a problem for medical research. When he first started discussing new methods of treatment at the Radium Hospital in Oslo, he felt that he wasn't being taken seriously. 'We were considered almost as charlatans at first,' he said. Even though much had changed for the better, he still thought quite brutally that many of the old methods did more harm than good.

At the same conference in Munich he had for the first time spoken officially about the treatment of cancer tumours with 31 MeV electrons. He explained that this gave more accurate delivery of the radiation doses than was possible with X-rays. The irradiation of the diseased tissue was better, and the rest of the body was exposed to less radiation. Gradually, things began to happen. The main theme at a congress in Montreux five years later was radiotherapy using accelerated electrons and the results achieved with such treatment. The conclusions that emerged from this were decisive in opening the way for high-energy radiotherapy.

Two Pretty Dresses

In connection with the marketing of betatrons, Rolf regularly visited institutions and hospitals where Brown Boveri was supplying machines. In addition there were conferences and congresses that enabled him to keep himself updated. Using a ball-point pen and squared paper, he kept a log of his travels with time, date, place, the reason for the visit and the names of the most important people he met. He maintained this from 1947 to 1991, from the age of 45 to the age of 89. Little personal notes also found their way into his travel logs, such as 'Visit to Krüger Safari Park' or the purchase of 'Two pretty dresses' for Ragnhild when he was in Beijing.

He acquired many professional contacts on these journeys. For example, he developed a good relationship with the chief surgeon in the cancer and tumour hospital in Beijing, who bought a betatron early on. Rolf visited China twice to talk about the radiation machine. On his second visit, he discovered that in the meantime the Chinese had built a machine of their own that closely resembled his, and he also noted that it worked quite well.

Another person he got to know in this way was Professor Werner Schumacher, a well-known German specialist in deep-seated lung tumours. Schumacher was one of the many with whom Rolf continued social contact after he retired, and when Schumacher retired in 1986 Rolf was invited to the farewell party and stayed with Schumacher at his house in Berlin. They had first met at a meeting of the German Radiology Association, apparently in 1951, and after that they had met fairly regularly in Berlin, where Schumacher was in charge of radiotherapy research at the Rudolf-Virchow

Hospital. This hospital bought the very first magnetic lens betatron that Rolf developed, which remained in use for eleven years until it was replaced by the moving betatron, the Asklepitron.

Professor Schumacher was more daring than others, which pleased Rolf. He tried out things that other doctors were less willing to try, and he was always looking for new and better ways to deliver radiotherapy. He was particularly interested in Rolf's specialty, high-energy radiation generated by accelerating electrons. Rolf thought that the reluctance of doctors to try anything new was a hindrance to good treatment. He once recommended, for example, that one of the staff at the Norwegian Radium Hospital should visit Schumacher in Berlin, and he went so far as to arrange a meeting.[83] When the date approached, however, the staff member wrote to tell Rolf that his boss had forbidden him to go. The senior doctors were obviously anxious about new methods, as Rolf said.

He was also very enthusiastic about a researcher he met at an international radiological congress in Evian in France, Dr. Lionel Cohen, who was in charge of radiotherapy at a big hospital in Johannesburg in South Africa. Rolf visited him there twice, and they still stayed in touch when Cohen moved to Chicago. Christian Gerber points out that part of the story is that these doctors had a certain self-interest in being associated with Rolf. Widerøe's name was well known, and he allowed himself to be named as a co-author when they wrote scholarly articles. The doctors and their patients needed Rolf's expertise in accelerators, and Rolf for his part needed support in medical circles to progress his own ideas.

> 'He was an opportunist who used people, but only clever people. All parties profited, and he was always ahead in his field,' Gerber says.

Doctor *Honoris Causa*

Yes, Rolf was a pioneer. At that time, nobody knew much about either the basic physical effects of radiation or the biological effects. Rolf was flourishing now. Throughout the 1960s and 1970s, indeed also the 1980s, he was busy travelling to meet medical experts, working with them, gathering new ideas, seeing other points of view. He also travelled to receive prizes and honours. Altogether, he was given more honours for his contributions to radiotherapy than for his original ideas and work in developing particle accelerators. He attributed this to the many lectures he delivered on radiotherapy and the many articles he wrote on the subject.

Rolf Widerøe received three honorary doctorates: from the technical college in Zurich where he taught; from the college in Aachen where he did his original doctorate; and from the Medical Faculty of the University of Zurich. (Archive photo, photographer unknown)

In 1962, after he had been teaching at the college in Zurich for ten years, he experienced a new high point in his career. The college awarded him an honorary doctorate in medicine. He became *Dr. med. Ehrenhalber der ETH Zurich*, or in Latin, *Dr. honoris causa*. Then on 10th July that year, his sixtieth birthday, he was also awarded an honorary doctorate by the technical college in Aachen where he had done his original doctorate. The local newspaper, *Badener Tagblatt*, mentions the event and adds that 'Dr. Wideröe is well known in his professional field.' In April 1964 he became an honorary doctor for the third time. The medical faculty at the University of Zurich didn't want to be out-done by the technical college.

He was awarded more and more honours. There had long been need for a translation of his doctorate thesis, and in the 1960s an English version was printed in a review of the development of accelerators.[84] He had a bit of a struggle with the editor, Lawrence's former assistant Stanley Livingston at Brookhaven National Laboratory in New York State. Livingston only wanted to publish the part of the dissertation that dealt with linear accelerators, the type that Rolf had got to work in practice, and not the betatron, the one with the round track, which at that time he had only worked out in theory. Rolf insisted 'Either you take everything, or there will be nothing.' Livingston took everything. Rolf knew that he was on firm ground. He knew where Lawrence had got the idea for the cyclotron that earned him the Nobel Prize, and he knew that Lawrence knew.

He was honoured in regular order by all the institutions associated with the development of X-rays and radiotherapy. On 3rd May 1969 he was awarded the Röntgen Medal, a very special recognition that the German town where Wilhelm Röntgen was born awards to people who have contributed in his spirit to the further development of radiology. Up to now, eight of the medal-winners have also been Nobel Prize-winners. That same autumn the newspaper *Süddeutsche Zeitung* published a special supplement about Wilhelm Röntgen and X-ray technology, with a large section about Rolf and his contribution. Then it was the turn of the town of Würzburg to honour Rolf. It was at the university there that Wilhelm Röntgen had discovered the radiation known as 'Röntgen rays' or X-rays.' In memory of the discovery, a medal is awarded every twenty-five years.[85] Rolf was the third person to receive it, on 24th January 1971. In the following year, he gave his last lecture at the college in Zurich. But he continued his activity travelling to promote betatrons. He had retired from Brown Boveri three years previously, but he was still 'the boss,' nobody else knew as much about betatrons as he did, and nobody else was as enthusiastic or as skilled in telling people about them as he was.

Come and Sit Down, My Boy

Rolf was aged 70, with three grandsons and one granddaughter, when his family circumstances suddenly changed. He had been admitted to hospital for a routine operation, but suddenly had to switch his attention from his own health to the survival and well-being of another member of the family. His daughter Unn was on her way home from visiting her parents-in-law on holiday with her husband and their two young children. As they were driving out of Yugoslavia they were involved in a full frontal collision. The only survivor was their son, Per. He wakened up in a hospital in Zagreb, having lost his mother, father and little sister. He had a grandmother and grandfather and two uncles in their thirties, all far away in Switzerland.

Lying in hospital in Zurich recovering from his operation, Grandfather Rolf immediately took command of the situation. He worked closely with the doctors both in the hospital where he was a patient and in Zagreb where his grandson was being treated, to organise the boy's treatment from a distance. His first concern was to ensure that the boy's leg wasn't amputated. This was well before the age of mobile telephones, and the practicalities of such long-distance communication were quite demanding.

The boy kept his leg, was discharged from hospital and was sent to Switzerland. But where would he live? Who would look after him? Who would take parental responsibility? One possibility was for him to go to Rolf's younger son and his wife, who already had two boys about Per's age. Another possibility was the grandparents, even though that would be considered less usual as even in Switzerland they were considered elderly.

Just try to imagine the situation. You are a fit seventy year old. Your spouse often accompanies you on lecture tours abroad, to which you usually add in a few days holiday. You are enjoying life as a very active pensioner socialising with an international circle of friends. You have had a satisfying career, earned status, received honours and you are still playing an active part both in your profession and in life in general. Life is good. You are reaping the good seed you have sown and because you are healthy and have unstoppable energy you are still able to keep going and to be stimulated by new ideas. Nevertheless, you are seventy and your colleagues are gradually beginning to become grandparents.

Sometimes the world is turned on its head. In Rolf's case that shouldn't be a surprise to anybody. He and Ragnhild adopt their grandson. An intelligent, orphaned eight year old moves into the house, with his toy cars and noisy friends. A little boy who needs to sit on your knee, be read to and be helped with his lessons. Who needs to be cared for and supported for many years to come. It is one thing to be seventy when the boy is eight, but what about being eighty when he is eighteen? What was it like at that time for Per, or for Rolf? Rolf obviously didn't know then that he would live to ninety-four and follow the boy through all stages of development until he was a well-educated man of thirty-two.

Per got on well with his Grandfather Rolf and also with his Grandmother Ragnhild. He also got on well with his uncles, who became like big brothers to him even though they were much older and had long since left home and become established. Many years later, Per—who in the meantime has become managing director in a business consultancy with clients throughout the globe—paints a picture of a not altogether usual grandfather and 'father.' We shall present the impressions thick and fast, just as the association of ideas flowed together in our conversation. We spoke in Norwegian; Per is a Norwegian citizen, even though he has lived in Switzerland for most of his life.

Acid rain

I remember when there was talk in the 1980s about trees dying from acid rain. I was seventeen or eighteen then and of course on the side of those who were worried about the environment, but he always said that he didn't believe it was really so dramatic and that the problem would pass over after a time. I think that if he were alive today he would be very sceptical about all the talk of global warming.

Atomic power

He was in favour of using atomic energy to generate electricity, wasn't he?
Yes, absolutely. He was for atomic power. But I think I remember that he only saw that as a transition. For that is just splitting the atomic nucleus, and he thought that nuclear fusion would be the solution to the whole problem.
So he thought that technology would solve the energy problems?
Certainly. Progress has its good sides, that is something my grandfather repeatedly emphasised. So many people are critical of progress and technology. He was firmly on the other side, really optimistic and positive. Perhaps a little too much so. But he was absolutely right in many things.

Detached interest

Was he also really positive as a person, or are you particularly thinking of technical contexts?
I was thinking of technology and progress. He was very positive about that. He was also very positive as a person, but at the same time he was rather distant. It's not that he couldn't laugh, but he was in his own world. For example,

it could be a little difficult for my grandmother always to find something to talk about that really interested him. And in his conversation with me it was usually topics to do with school, such as physics, science or something technical that was easiest to talk about. When I was a student – I studied data technology – he became really interested in that, and he was quite old then. Almost ninety. He was particularly interested in things he had read about in his technical journals, things that were being "hyped" at that time. Yes, he was interested in things like that right to the end.

A party animal

He was a really cheerful person. You saw that best when he was in company. It was as if he opened out then. When the audience was big enough he responded. As a family man, on the other hand, he was a little withdrawn.

He enjoyed company, then?

Very much. He was good at making speeches on festive occasions. That's maybe a little unusual for a scientist.

Impractical

He didn't do anything in the house. He was totally traditional in that. I remember once that when he needed stamps he didn't have the faintest idea where to get hold of them. So all these practical things were organised by my grandmother.

She must really have been amazing?

Yes, absolutely. It certainly wasn't easy to live with a person such as my grandfather.

You all understood that he was special?

Oh yes.

Forgot that it was Sunday

I remember that he could be very absent-minded. For example a friend of mine phoned one day, a Sunday, and asked if I was at home. "No," he replied, "Per is at school." But it was a Sunday, and he had forgotten that. Another time, a friend of mine came to visit and again he said "Per isn't at home." It was as if he was in another world.

Were you scared? Or were you angry, or …?

No, he was a "professor" type.

Forgot that he was married

I've heard a story from when Ragnhild worked in the same place, right at the start of their marriage. Your grandfather is said to have said to her late one evening "You can go home now, Miss Christiansen"[86] *He had forgotten that they were married. Is that true, or is it just a good story?*

I wasn't born then, but I think it could be true. I think the special thing is that he could be both ways, close and distant. Many people can be distant as he was in this story, but not many of them can change to being effervescent and the epitome of eloquence when in company.

Didn't dare disturb his papers

In my time, he had an office at home. He had thousands of manuscripts and documents round about him.

I assume that you weren't particularly popular when you disturbed his papers?

No, no, no. I never dared do that.

Tennis and science fiction

Did he have any interests or hobbies?

He had played tennis before, but he didn't do so after I came to the house in 1972. His biggest hobby was the garden. He did everything there. That was his domain.

So was Ragnhild not the boss there?

'No, that was his. And then he read a lot. Not just scientific stuff but also novels, especially science fiction.'

Ragnhild and Rolf

Were they like each other? Or was she a sort of opposite?

An opposite, I would say. She was a real family person. That in itself is a big opposite.

You're thinking of the core family?

Yes, she held it all together and made sure that they came to lunch every Saturday, even after they had grown up and left home.

No excuses

'It must have been very difficult – a bit of a challenge – to take me on when mother and father died.'

Surely it was a challenge for you too?

'Yes, naturally, but nor is it easy to bring up an eight year old who suddenly comes into your household. But that's what they did, and I can't go round today making excuses because of a difficult upbringing.'

The architect from Yugoslavia

What did your father work at?

He was an architect, from Yugoslavia. He was a political prisoner there. He was against the communist regime, against Tito. He was able to travel out of the country later, but he didn't have a passport and so he was stateless. Then he met my mother. They got married and moved to Switzerland, but it was always a problem that he was stateless. Then when I was on the way my mother had to go to Norway so that I would be born there, otherwise I would be stateless too. So then all three of us settled in Oslo.

Non-judgemental

My grandfather Rolf was very tolerant. Like when I had a few problems at school and received several warnings. One day I was told that if I didn't improve I would have to re-sit, and then I caused even more trouble, and so on.

Yes, it's often like that …

He was very understanding, didn't think that it was such a big deal. The important thing was to pull myself together quickly. I was amazed at the time. Some of the things I had done were more serious than others, but he didn't think that it was so bad.

Are you saying that he was good at distinguishing between big and small issues, important and unimportant?

'Hm, yes, and also that it was a question of keeping an open mind and not just thinking dogmatically that "People don't do that, and if somebody in my own family does it I must punish them." What amazes me is that even though I did something really bad – something most fathers would be really angry about and punish their sons for – he wasn't angry. I don't know why, but it seems as if he was tolerant enough to accept that sometimes people do wrong.'

Do you think he was tolerant because he himself needed …?

Perhaps his own history …

Was there an idea that you shouldn't judge people too harshly?

Perhaps. My upbringing was not really his responsibility. My grandmother took this on after my parents died. But when you do something as stupid as I had done you are usually reprimanded, and he didn't do that with me. Yes, I think he was very tolerant. And even though he was so taken up in one thing or another, he accepted that other people could have different opinions. He maybe didn't take as much interest in art and some things as many others do, but he would never say that these were uninteresting – just that they didn't interest him.

Evening prayer

I did have a rather closer relationship with my grandmother than my grandfather. What I remember he did was that he sat on my bed in the evening and we said the evening prayer.

Was he Christian, personally Christian?

I think he was Christian. Not that he said much about that. But he had always been a Christian. I think so.

Norway

Did you have an impression that he sometimes thought of going back to Norway when he retired?

Yes. I think that basically he was always convinced that one day when he was old, really old, he would move back to Norway. But he never really thought that he was old, even when he was ninety. I don ‘t know for sure, but I think it was my grandmother who said that there was no sense in moving to Norway when the children and grandchildren were here in Switzerland.

Have you had much contact with the family in Norway?

At first I went to Norway every summer. With Rolf of course, and Ragnhild. And with Rolf junior and his family. And Arild. While we were there we always met as many family members as possible, and went to the cabins they had by the sea and in the mountains. It’s a pity that I haven’t taught my own daughter Norwegian. All the Italians here in Switzerland teach the children their mother-tongue, so maybe I have been too lazy.

How have you managed to speak Norwegian so well?

We spoke Norwegian at home. But I only went to first year in Oslo, so I write it rather badly. Before we moved to Germany, I was at the Steiner School in Oslo for a year. At that time we lived in my grandparents’ house in Røa.

Not Swiss German

He must have been stubborn to insist that you should all speak Norwegian at home, half a century after he had emigrated, when everybody round about spoke Swiss German.

Yes, he was really stubborn.

He must have been very deliberate about this.

Yes, absolutely. He refused to understand Swiss German. It’s a dialect you almost have to force yourself to understand. When anybody spoke to him in Swiss German, he replied in High German. But I could always hear the Norwegian accent underneath.

Not a diplomat

Did he come into conflict with people because of his strong opinions about such things?

No.

Was he a diplomat?

No, he wasn’t really a diplomat. I think he was strong enough just to dominate the situation and the topic there and then, and then there was hardly room for any other opinion, so I don’t think he had big discussions. He just said what he thought.

Natural authority

My grandfather was special. His great power was somehow a matter of innate authority. Not everybody who is so opinionated can be tolerated, but you could tolerate him because his personality was such that you just accepted him as he was.

But I have wondered what was the secret? People accepted that that's how he was. You accepted it. Because of your situation, you could have been in real conflict with him. You could have kicked doors and walls. You had lost your mother and father and you had had to come to live with this old man …

'I think he was remarkably broad-minded, but I don't think that explains everything. It's like something you can't put into words. It's just something that **is**, an authority such as that'.

Ragnhild didn't have it, as I understand?

No, she was quite strict, but she didn't have that natural authority. She had to work harder at it.

Feet not always on the ground

He didn't always have both feet on the ground. I remember that when I went into sixth or seventh class he wanted to teach me things that were really at university level. Every time I asked him something, the answer was always so much more …

… than you could understand?

Yes, so I gave up asking him anything special.

But he thought it was good that you studied a technical subject, even though it wasn't his own subject?

Yes, and he was genuinely interested in everything that was happening in data technology and in how computer science was developing in areas that he himself didn't know much about. The furthest he went was to buy an electronic pocket-calculator for 3,000 dollars or thereabout, that would cost 100 dollars today.

Just think if he had had a PC …

Yes, he would have thought it was very exciting if he were alive today.

The brothers Rolf and Viggo

Externally, Rolf and Viggo looked very like each other. But they had quite different life histories. Viggo seemed more to have both feet on the ground.

Even though he was an airman?

Yes, even though he was an airman. Rolf flew too, though.

Did he have a pilot's licence?

Yes. Anyway, he flew. The three brothers all flew. One of them died when flying. Viggo was the entrepreneur who founded the airline. Rolf was totally unpractical in that way. He could never have founded a company.

So didn't he have any talent for organisation?
No, none at all. He just liked to work on his own and not have to think about others.
But what about working in a team?
Yes, if he was leading the team! If he was a "dictator," everything went fine. His sister Else also founded a company. Viggo and Else were both founders who saw to the financing and control of what they started. But not Rolf. He was a founder in a different way. I think he gave all the money to Ragnhild and was then given pocket-money. It seemed quite clear who was boss there.

Pressure?
Was there any pressure on his children and on you to study technology as he had done?
Not on me, anyway. They pushed me to go on to higher education, but after that it was up to me. There may have been pressure on the generation before me. Their youngest son did go in the same direction. And my own mother studied electrical engineering for a couple of years. There was undoubtedly some pressure there, but whether it was indirect or direct, I don 't know. I heard that they had been very strict parents, but they weren't like that with me; just with their own children. I think that grandfather was more involved in my time and thought that my upbringing was part of his duties.

New Triumphs

Rolf's career didn't seem to suffer from having a child in the house again. It carried on as before. In 1973 he was awarded a gold medal at the 13th International Radiology Congress in Madrid. What happened in Norway that same year was even more significant, though. At long last he was elected to membership of The Norwegian Academy of Science and Letters. It's difficult to say how much he knew about the power struggles that had taken place within the Academy. Maybe he knew that influential people within and not least around the Academy did not want him as a member. Maybe he didn't know. A scientific academy is not just a society that you sign up to join. You have to be recommended by someone and accepted.

There was a new high point in 1977, at the prestigious Smithsonian Museum in Washington, half-way along the mall linking Congress and the Lincoln Statue, that tourists pass along on their way to or from seeing the White House. The Smithsonian arranged an exhibition called 'Atom Smashers—50 Years.' 'Atom smashers' is another phrase for high-energy accelerators, and if we go back 50 years from 1977 we come to 1927, the year Rolf started it all with his doctoral thesis.

Appropriately, right at the entrance, prominent and difficult to miss, was a stand specifically about him: 'Rolf Wideroe, the linear accelerator, 1927.' On display here was the famous notebook with the sketch from his student days, the start of a whole epoch in nuclear physics and cancer treatment. Then the exhibition went on through the whole range of accelerators that followed – the cyclotron, the synchrotron, the betatron, the beta-synchrotron and the others with their various refinements and energy levels. Rolf's portrait was hung here too, alongside other great physicists who had contributed to creating and developing accelerator technology: Wilhelm Röntgen, Henri Becquerel, Marie Curie, Albert Einstein, Niels Bohr, Erwin Schrödinger, Ernest Lawrence, John Cockcroft, Ernest Walton, Ernest Rutherford Robert Van de Graff, Werner Heisenberg, J. Robert Oppenheimer, Wernher von Braun, Otto Hahn and Lise Meitner. A set of copies of the photographs on exhibit was also sent to the Norwegian Academy of Science in Oslo, but nobody there today knows what has become of them.[87]

In 1977 The Smithsonian arranged an exhibition called 'Atom Smashers – 50 Years.' 'Atom smashers' is another phrase for high-energy accelerators, and if we go back 50 years from 1977 we come to 1927, the year Rolf started it all with his doctoral thesis. (*Courtesy* Smithsonian Institute, Washington DC)

Paul Forman, the conservator who was responsible for the exhibition, reports that it was intended to be on display for two years but that it was so popular that it stayed on display for several years more. In 1980 he wrote to Rolf to ask if they could keep his notebooks 'that have a prominent place by the entrance,' for a little longer than agreed. Rolf was obviously proud to agree to this request.

The conservator had established contact with Rolf at an early stage in the planning for the exhibition, and fifty to sixty letters had gone back and forth between them in the course of the next few years. Rolf was asked how he had managed to build the first accelerator, what was special about it and was informed that 'Everything you can remember from your work on it will be very welcome.' Paul Forman received masses of material and wrote back saying that 'Reports like this give life to the objects in our collection and help us to explain the material to students and public.' The museum archive in Washington is storing and preserving scientific papers by Rolf and by Kerst, the Siemens researchers and others. There is information here about radiation treatment of cancer, information about the differences between various types of particle accelerator, and brochures from Brown Boveri with a picture of the first radiotherapy machine bought by the Radium Hospital in Oslo at the start of the 1950s.

The conservator's involvement was more than the management intended, but his professional skill was never in doubt. His written documentation in labels and explanatory texts is a history book in itself, written after going through the usual discussions between museum staff and scientists about how far one can go in popularising, what to include when a label can only have a certain number of words and whether to present an exhibition that the public understands or just to display things as they are. Museum staff understand that a catalogue is not a scientific paper. So only when all display objects and texts had been evaluated, rejected and reassembled in new arrangements and everything had been checked for outside appearance and evaluated by the experts and at last everybody was satisfied – only then could the exhibition open, six months late.

Everybody agreed that it was a success, though Paul Forman's evaluation may not be entirely impartial:

> It was possibly the best exhibition the Smithsonian has ever had,' he said enthusiastically several decades later. 'It was spectacular, it was educational, and twenty people worked for two months to set it up, in close contact with Rolf Widerøe among others.[88]

Despite the success, there was one thing Forman was not satisfied with. The Smithsonian would really have liked to include Rolf's very first betatron in the exhibition, but it was no longer in existence. The museum had written to his old professor in Aachen and to laboratories and various people in different parts of Europe, but it was nowhere to be found. The museum staff set about trying to have a copy made, but this too was difficult. The Smithsonian does not usually display copies, but on this special occasion they made an exception. As Forman explains, this was a big gamble involving great prestige. Even though the temporary exhibition was over, the Smithsonian wanted to have a Widerøe accelerator in their permanent display.

Rolf was more than agreeable to this. Lawrence, Kerst and the Siemens researchers all had their machines on display. The only questions were how to finance it and how to transport it intact over to the USA. On 4th May 1983 Rolf was able to write joyfully to the museum to say that the building of a copy had begun. Then, in July two years later he wrote that the manufacture hadn't really got properly going until 1984, but that he reckoned they could send the accelerator in August. He was a little concerned about sending the round glass tube by air and he asked the museum for a little advice, whether it could perhaps be assembled over there.

Almost two more years passed. Then on 2nd March 1987 the Norwegian Radium Hospital wrote a formal letter to four museums, informing them that in collaboration with Rolf they had had four copies of his pioneering machine made and that if the museums wanted they could each have one. The letter was signed by Professor Tor Brustad, who at that time was chair of the hospital management committee. Rolf had kept in contact with the physicist Olav Netteland in the instrument workshop at the Radium Hospital, whom he knew from before. But Netteland had a stroke before the work of building the machine had started. They then tried to have the models made by Brown Boveri in Switzerland, but that was too expensive and in the end it was the workshop in the Radium Hospital in Oslo that did the job; 'Exactly according to my specifications,' as Rolf said.

Paul Forman at the Smithsonian says that Rolf was very determined to get this done. He made the transport arrangements, which were a major issue for him. Nothing must be damaged. It ended with himself and the Radium Hospital paying for the freight and insurance as a gift to the museum in Washington, and then Paul Forman making arrangements for the Smithsonian to cover the additional costs. On 8th November 1987 Rolf was able to write to the Smithsonian with a sense of relief, to thank them for the news that the machine had arrived in Washington safe and sound with the glass tube intact.

The museum curator reports that Rolf himself visited the exhibition with his wife in 1992, when he was ninety years old. Rolf liked what he saw and was able to thank personally the people who had been responsible for the exhibition. Everything has to come to an end, however. Today the accelerator lies dismantled in the cellar of the Smithsonian.

Tor Brustad says that one of the copies is in the Radium Hospital as part of a permanent exhibition of the history of radiotherapy. Another was given to the Norwegian Technical Museum in Oslo, where it is still lying in a remote store and has never been displayed. One was sent to the Röntgen Museum in Remscheid in Germany. A similar model was later built at the apprentice workshop in the DESY research centre in Hamburg and has been on display in the foyer there.

More Prizes and Honours

In Norway too in the early 1980s there was some recognition of Rolf and h*is* achievements. In connection with Rolf's 80th birthday celebrations in 1982 the physicist Olav Aspelund wrote an almost panegyrically positive article in the newspaper *Morgenbladet*. In January the following year Rolf delivered a lecture at the University of Oslo that *Aftenposten* reported on 18th January. He also gave a lecture at an international conference in Geilo. Both of these invitations had been arranged by Aspelund.[89] The most important contribution for posterity, however, was arranged by two up-and-coming young Norwegians, research grant holder Finn Aaserud and Assistant Professor Jan Sigurd Vaagen. They organised a group interview in Oslo, a sort of seminar with Rolf and a group of Norwegian physicists.[90]

The seminar took place on Tuesday 12th July 1983, the day after Rolf's 81st birthday. Up till then, this was the only attempt that had been made to document the range of his work. It was arranged under the auspices of a research institute in Oslo and there were six or seven people taking part.[91] The interview lasted several hours and was recorded on tape. The tape-recording is now in the archive at the technical college in Zurich where most of Rolf's bequeathed papers are preserved.[92] There is a copy of the transcript in the Niels Bohr Archive in Copenhagen and another in the Niels Bohr Library and Archives at The American Institute of Physics.

An easily accessible short version was later compiled by two of the interviewers, Aaserud and Vaagen, in the journal *Nature*. This was the first attempt by Norwegian physicists to bring Rolf's contribution into wider recognition.[93] Aaserud has a doctorate in history of science from Johns Hopkins University in the USA. He has been head of the Niels Bohr Archive in Copenhagen for about twenty years and he is committed to recognising Rolf's place in the big picture. Vaagen is Professor of Nuclear Physics in Bergen and has had connections with several foreign universities including Yale in the USA and the University of St. Petersburg. When asked how he had first become interested in Rolf, Vaagen replied as follows:

> It started after both Finn Aaserud and I had been working abroad in the 1970s. When I came home, after some time first in Denmark and then in America, I found a Norway that hadn't yet fully understood its place in the world. When I was abroad I had heard about people who had been significant but whom Norway seemed to have forgotten about, and I realised that we should be interested in some of these. I heard about Widerøe, and his name

> seemed interesting. Aaserud had studied the connection between biophysics and nuclear physics as part of his doctoral thesis, and he was interested in finding out more about Widerøe from that angle. At the same time, the science of physics had fallen in popularity and some of us found that we needed to consider how to spread the message that physics is important.[94]

Was Rolf satisfied with the interview? Jan Sigurd Vaagen answered this question positively, saying that they clearly got that impression and adding that Rolf spent some time reading the transcript, checking through the wording and supplying more material. Waloschek, who wrote the biography, was not quite so convinced. He thought Rolf was unhappy that he had been presented as an inventor rather than as a full-blooded scientist.[95] Vaagen has also discussed Rolf's role as an inventor in the context of Rolf later receiving an important international physics prize:

> His lack of permanent association with distinct scientific or other academic disciplines suggests that he can best be described as an 'inventor' in a certain sense. Dealing with pure science and working in industry were both natural and compatible elements in Widerøe's career, and M. Stanley Livingston's description of him as 'the first accelerator designer' is a suitably comprehensive expression. He influenced a whole field of development. Widerøe's doctoral thesis (…) inspired Lawrence in the USA in his work on the cyclotron, and also other pioneers such as E.T. Walton in England and Jean Thibaud in France.[96]

Vaagen is convinced that Rolf's doctoral thesis supported the development of what today we call 'big science.' He maintains that this happened without his direct involvement, among his contemporaries in the Lawrence Laboratory in America, and he goes so far as to say that without Widerøe, Lawrence would probably not have been awarded the Nobel Prize.

> He can undoubtedly be characterised as an individualist who never really fitted into our homely little academic milieu. But a series of contributions based on his doctoral thesis led to the principles underlying what we call colliding particle beams. His ideas also led to the synchrotron-accelerator principle. The daring concept of the accelerator that he championed enthusiastically when CERN was being set up, enabled Europe to take part in the big science of particle physics. Since then he has played an important part in other big accelerator centres in Europe, including DESY in Hamburg, which also made use of his ideas about colliding particles.[97]

In Norway, Rolf was in the spectators' stand rather than on the track during the 1930s when nuclear physics was gathering speed. Concepts central to our modern understanding of the universe fell into place, and mankind managed for the first time to contend with nature's own radiations, Vaagen explains. He emphasises that current problems in physics and technology are being shared among researchers in many countries. Rolf had the experience several times of seeing rather similar discoveries made in different places simultaneously, and he also had the experience of seeing others possibly benefiting more from them than he did.

Nevertheless

Even though some physicists had taken an initiative in the 1980s and at least arranged an internal interview with Rolf, his fame in his native land never reached the levels of praise elsewhere. In his 80th year, in 1982, he was invited to a congress in India and Sri Lanka under the auspices of The Association of Medical Physicists of India. In March he delivered a lecture at a radiation symposium in Saudi Arabia.

The college in Zurich where he had taught arranged a big colloquium in his honour in spring 1983 with the ambitious title 'The Development of Particle Accelerators to Date and its Further Development in Future.' This meeting was publicised in Norway beforehand with a notice in *Aftenposten*.[98] That same year, he was also awarded honorary membership of *Die Schweizerische Gesellschaft für Strahlenbiologie und Strahlenphysik*. In February 1984 the European physics journal, 'Europhysics News,' published a long article about him. He travelled to Jerusalem where the newly formed association for radium treatment of cancer, ESTRO, held its meeting that year and elected Rolf to honorary membership.[99] He lectured there and later in France.

There have been many other memberships and honorary memberships over the years, named here in alphabetical order: American Physical Society; American Radium Society; British Institute of Radiology; *Deutsche Röntgengesellschaft* (honorary member); European Society of Physics; *Naturforschende Gesellschaft*, *Zurich*; *Norsk Fysisk Selskap*; *Norsk Radiologisk Forening*; *Schweizerische Physikalische Gesellschaft* (honorary member); *Schweizerische Gesellschaft für Radiobiologie* (honorary member); Scandinavian Society for Medical Physics (honorary member) and Society of Nuclear Medicine.

Around the World

Rolf still kept up his travel log with notes of workshops, lectures, conferences, meetings, seminars, congresses, interviews. Australia, Asia, Africa, America. With or without Ragnhild, but often with her after the children grew up. Always with her in the later years. Regular entry about Skjæløy with the family round about his birthday in July. Plus, every year after they had both retired, a one week visit together in February or March to brother Viggo's place in Spain. Not the usual lifestyle of most pensioners. Not typical charter tours either. 1976—six foreign trips. 1977—among other things, three lectures in Rio de Janeiro. 1978—at least three foreign trips. 1979—at least four. 1980—at least four. 1981—at least three, including Cairo and Jerusalem.

In summer 1985 he extended his summer visit to Norway with a few days at Gausdal Mountain Hotel—a place where he often holidayed—and at Rondane Mountain Hotel. So it goes on in the following years with summer tours around Norway by car. He gives himself a *slightly* easier time, *a few* more holiday trips with Ragnhild. Also, he hopes, an extra visit to Norway each year if he is invited to give a lecture, as for example when the University of Bergen at last invited him to a seminar entitled 'Rolf Widerøe—a pioneer in accelerators and radiotherapy,'[100] and Haukeland Hospital did the same four days later. Jan Sigurd Vaagen, who fetched Rolf from the airport for the two seminars in Bergen, recalls:

> As I remember the story, Widerøe arrived at Flesland Airport in the evening. Ragnhild was with him. I drove them to the Grieg Hotel nearby. But then, almost before we had come into the room, Widerøe said "How is my old friend Odd Dahl, then?" "Yes, he's living out here now," I replied, "at Fana." And then Widerøe said "Can we ring him right away." I think it was about eight o'clock by then. When I got Dahl on the phone, Widerøe said "Could I come to visit you?" "Come right away!" replied Odd Dahl. So then we were right out into the car again. When we came into that fine old Bergen house there stood Odd Dahl, with Dry Martini on the usual silver tray, ready to bid Dr. and Mrs. Widerøe welcome. They sat down and spoke politely, addressing each other formally; they really did this at that time. Then after a while
>
> Widerøe said to Dahl, "Dahl, I read with great excitement and a little surprise your book *Trollmann og rundbrenner*." "Yes," said Dahl, "That was an exciting time." Then Widerøe said "I was especially interested in the canoe trip from the Andes down the Amazon to Manaos." A trip Dahl had done as a young man in the 1920s. "That was an exciting trip, said Dahl" "Yes, I did it a

few years ago," responded 85 year old Widerøe. This story shows a little of the bold style of these two chaps.

The following Easter Rolf and his wife went for a trip on the Orient Express. He was then in his 86th year. In June he flew with a group from Brown Boveri to Stockholm and Västerås to visit ASEA in connection with the merger between the two companies. In July, a trip by car to Norway as usual. Same again the next summer. He wrote in his log: 'Drove 2810 km.' He had cause to be proud. Previous entries included 'Alfaz del Pi, Viggo' in February and 'Roentgen Museum in Remscheid, Germany, 21–22 April;' that was when he received the medal. 'By car to Norway 29th June. Gausdal Mountain Hotel. Arrived Skjæløy 17th July. 20th July Hamburg.' By then, he was 87.

The next year—1990—same procedure. Viggo in March, trip by car to Norway in summer and a trip to Brittany in September. The official engagements abroad had ebbed, but the travelling continued. In 1991 he went to his friend Kåre Backer's diamond wedding in Oslo. To Viggo in Spain in March–April. By car to Norway 24th June to 17th July, returning via Hamburg to visit old friends and colleagues and meet Pedro Waloschek, who at that time had introduced the idea of writing Rolf's biography.

Lacking Only the Nobel Prize

Physicists were beginning to realise that this man's story should be taken notice of before it was too late. One of the physicists who saw this was the Norwegian-American Per F. Dahl, Odd Dahl's son who had settled in the USA. In March 1992 he published a long article about Rolf's historical contribution to physics, in connection with an international industrial symposium in New Orleans. The article was about one of the major topics of that era, superconductors, and even though it is an academic paper, it indicates clearly that Dahl jnr. had heard good things about Rolf from his father. In an introductory summary he links Rolf directly to Lawrence:

> This year, 1992, marks the 65th anniversary of Rolf Widerøe's doctoral thesis. In it he not only describes the operating principles for the betatron, but also a working model of the first linear accelerator, constructed to his design. The linear accelerator, a resonance accelerator, gave Ernest Lawrence the idea for his cyclotron.[101]

The Americans accorded great honour to Rolf that year, and in April the American Physical Society awarded him the Robert Wilson Prize for his contribution to accelerator physics.[102] In June it was Europe's turn. One of the sessions at an international accelerator conference in Hamburg was dedicated to Rolf, and he experienced one of the proudest moments of his career. There, in that prestigious forum, was uttered the phrase that would ensure his memory. From the lectern he was described as the founder of the particle accelerator, '*der Urvater*,' 'the originator.' His reputation was now established as a Nestor in the subject. Proclaimed and confirmed. For Europeans and Americans alike. Said and written. Widerøe was the pioneer, the brain behind the invention that led to the revolution in treatment of cancer and made significant contributions to research in physics. The Norwegian Rolf Widerøe had gained his place in the history of science.

On Rolf's 90th birthday there was an article in *Aftenposten* written by the two men who had taken the leading roles in arranging the interview with the physicists. They wrote about him as 'the man who took part in giving humans the tools to control nature using Einstein's recipe,' and they described his doctoral thesis as having 'an almost immediate triggering effect on the further development of accelerators.'

Vaagen has told me that he sent Rolf a copy of an article he had written about him in connection with the award of the Wilson Prize. Rolf took a copy of the copy and sent the original copy back with a note of thanks and with a message noted in the margin, 'We fly to Washington 14th April where I shall give a lecture on 21st April at an APS meeting. Kind regards, Ragnhild and Rolf.'

> The event was the spring meeting of The American Physical Society, and I think he felt that this was a really big occasion. Not least that he could say something at an international physics conference such as this, within the academic milieu. I think he liked that.

Rolf joked about all these awards and said that the only thing lacking now was the Nobel Prize. Secretly, however, he thought that they were deserved. In July he was at Skjæløy as usual with 90th birthday celebrations at a restaurant in Oslo. His big jubilee year ended in December with a special seminar in his honour at the college in Zurich where he had taught for twenty years. He had obviously not been forgotten there, even though he had been retired for just as long.

Rolf Widerøe (90). (*Photo* Pedro Waloschek)

After that, Rolf stopped keeping a travel log. He didn't stop travelling, but the travels became fewer. He became a little less active and his hearing became a little worse. The regular trips continued, however, to visit his brother in spring and the old country in summer.

Otherwise he sits a lot in his chair by the window. Goes for short walks. Reads. Reads some more. He dies in the autumn, on 11th October 1996.

He is buried in the churchyard at Kirchdorf close to Nussbaumen, the little village near the town of Baden in the very north of Switzerland, the country in which he had lived in since autumn 1946 but never became a citizen.

Just in Time

The following year a Norwegian prize was established in his memory, the Widerøe prize. The instigator of this was Tor Brustad from the Radium Hospital. The prize took the form of a bronze statuette made by Nina Sundbye, the sculptor who had created sculptures of well-known Norwegians such as Henrik Ibsen and Per Aabel. The prize is awarded to researchers who have played an important part in the development of radiotherapy and thereby built further on the foundations that Rolf laid.

The artist has entitled the statuette, 'The Widow in Zarephath.' The symbolism is obvious; scientific results inspire new ideas and further developments again and again without ever running empty, just as the widow in Zarephath's cruse was an endless source of nourishment. Rolf had been able to see a photograph of the first draft of the statuette before he died. He was very weak by then, but his wife raised him up in the bed, showed him the picture and told him that the idea of an exhibition was also being considered. He wasn't able to talk, but his wife said that she saw a tear run down his cheek. He died the following day.[103]

The first recipient of the prize was Professor Anders Brahme from the Karolinska Hospital in Stockholm. It was presented by the then Health Minister Gudmund Hernes who spoke on behalf of the government about Rolf's place in the history of science. The Director of the Radium Hospital, Jan Vincents Johannessen, spoke about the significance Rolf's work had had for the hospital, and the Director of the DESY centre in Germany spoke about Rolf's contribution to accelerator technology.[104]

During the celebrations of the Radium Hospital's 70th anniversary in 2002, a bust of Rolf was unveiled as thanks for his part in the fight against cancer. It was mounted as part of the exhibition that was set up for the jubilee, a 'mini-museum' showing the development of radiotherapy. This too was just in time. Two years later it was decided that the Radium Hospital should be combined with the National Hospital where several other institutions had already been incorporated. Now it was not only the history of radiotherapy that was to be presented to the public. The new major hospital was to be presented as the country's most important highly specialised hospital, with the strongest medical and health-related research milieu in Norway.

So it is unlikely that Norway would have had a memorial to Rolf Widerøe if he had not already been given his place thanks to an enthusiast, the retired professor from the Radium Hospital, Tor Brustad, who had had the authority and the courage to bring about the Widerøe Prize, the exhibition and the bust.

The Same Enthusiasm

In the course of helping Waloschek with the biography, Rolf reviewed and summarised what he had contributed to science. Looking back over what he had done, he saw that there were some highlights. However, while he treasured these, *all* that he had done was important and it had *all* been fun.

> I didn't think much about the relevance or the possible future significance of what I was doing. I was happy in my work and always absorbed in what I was doing at the time. I built relays with the same enthusiasm as I later constructed betatrons. And if it was a question of something new I was especially interested and motivated.[105]

At the very top of his list—not unexpectedly—he put the work for his doctorate. The linear accelerator he had built in connection with his thesis and the design principle for the betatron that he had proposed were still the big things for him. It had been important to him at the age of 25 when he was striving to develop his ideas into formulae, his formulae into designs and his designs into the construction of machines. Now, so long afterwards, it was still important to him, possibly even more so. Then, he saw the possibilities and had faith in his vision. Now, he saw the results and he saw the possibilities waiting there for others to build on top of what he had achieved.

He thought he had been lucky. His success had come not just from his doctoral thesis but from its dissemination, the fact that it had been found and read the world over. Or rather simply put, there was not much point in being the founder of accelerator technology if nobody got to know about it and used it for something. His thesis had become one of the most cited publications on particle accelerators, and for a researcher, then as now, being cited was the most important indication that one's work was significant. Citation indexes are administered now in big, international databases and are an important part of the academic accreditation system.

However, the relative merits of 'patents' versus 'academic publications' continued to worry him, the idea that something either is of practical use in industry or a piece of academic work. It is difficult to get people to accept that something can be both of these at once. He made up a list of what he called 'Published academic works' containing 205 titles in all. Here, he included for example both the article for the Physics Society's magazine on how atomic energy can be used technically, and a lecture on the historical development of accelerator technology. Earlier, as head of department in

Brown Boveri, he had made up the list more from a sales and marketing point of view than from a professorial point of view.

In the biography, Waloschek says right out that it is a misrepresentation to label all the articles as academic publications. He analysed the list and considered that many of the items listed either were not scientific, or were not written articles, or had not been published in an academic context. He characterised sixty of the titles as lectures. In other words, an outright slaughter of the list, not because the content is not valid but because in his opinion much of it does not fulfil the criterion of what can be defined as scientific work. Waloschek, himself a professor with a doctorate in physics, emphasised that this didn't shake his admiration for Rolf's contribution as a scientist. At the same time, he asked himself why Rolf was so concerned to be recognised as a scientist.

> You could count his scientific papers on the fingers of one hand, and they were very good. He was a genius, but I think that Norwegian physicists didn't like that being called science. If he had described himself as an inventor it might have been easier for them to accept that.

Pedro Waloschek then interrupts his own train of thought:

> No, I am being too negative now. That isn't my intention; I don‘t want to be negative. But he doesn't deserve to be glorified. He deserves to be understood as he was. A really brilliant, very intelligent person who did great things.

It may be more difficult for a foreigner to judge to what extent there were other reasons why Rolf was not popular in his homeland, but after a couple of years work on the biography Waloschek was quite clear that there were various different perceptions of this Norwegian who had decided to settle in Switzerland:

> He still had many enemies, many people who had something against him. I had great respect for him; I wouldn't have used so much energy on him otherwise.[106]

It is difficult to say whether Rolf was partly self-deluded when he drew up his list of scholarly publications or whether he was driven by PR considerations. If he drew it up for academics, he misjudged his readership. If on the other hand he had the general public or potential customers in mind, it served its function well. It is certainly useful to anyone who just wants to gain an insight into Rolf and his activities, even though he would have been better to omit from prominent first position the analysis of inflation from his student days, which had nothing whatever to do with physics.

'Few people have the distinction of writing a doctoral thesis that has such widespread influence,' wrote Jan Sigurd Vaagen in his article in *Bergens Tidende* on the occasion of Rolf's 90th birthday.[107] You don't have to understand physics to see how each discovery builds on the previous one in a long, continuing line. The significance of each single link in the chain is easier to see in retrospect. Rolf himself commented as follows on the accelerator with the circular track:

> The curved accelerator tube appears first in Lawrence's cyclotron and later in the acceleration chambers in the synchrotron. The latter now seems to me much more important because the synchrotron paved the way for the storage rings. My discovery of the stabilised particle tracks may also have been quite important. But the further development of the drift tube – which happened almost simultaneously with the development of the cyclotron (…) is also very interesting. It all started with the first drift tube in Aachen in 1927.[108]

Self-important? Not hiding his light under a bushel? Bragging? Well, not really. He speaks his mind and says it how it is. Straight out, no shilly-shally. It's an almost childish innocence. Some would call it naive, but it is not naive in the helpless, ignorant sense. It's not as if he didn't know what he was saying. It's just blunt—and pardonable.

The Patent He Didn't Talk About

The achievement Rolf rated in second place was the patent he didn't really talk about until ten years later. A theory he 'saw' when he was on holiday in Norway, lying on his back on the lawn in front of the hotel in Telemark, watching the clouds floating by and colliding. It was to do with what are known as 'storage rings.' His inspiration was 'probably very important,' as he put it with poorly concealed understatement, but he decided to keep it secret for quite a long time and he has explained the reasons for this himself:

> My 1943 patent for the invention of storage rings was in fact very important, but it was kept secret for ten years. As I couldn't see any practical applications for it (because there were still too many unsolved technical problems) I didn't say very much about the invention. The first time I explained my proposal

> publicly was at the accelerator conference in Geneva in 1956, after Gerry O'Neill had rediscovered the principle. Others had then developed the idea further. I was fully occupied building betatrons for BBC. I'm very glad that I had the right idea thirteen years before my colleagues. I can't blame them for sometimes forgetting about me, though, because they had often been working on and developing their projects for years. Many very good storage rings were built while I was busy with other things.[109]

Elsewhere, he writes that the reason all the thirteen patents between 14th July and 4th October 1943 were registered in Germany was that 'Siemens were working strongly in this area and so I wanted to secure the German priority for myself, under any circumstances.'[110]

But whether this is a collection of blessings in disguise or a rationalisation for his own sake or an explaining away for other peoples' sake, or whether it simply was a concatenation of many circumstances, the objective fact is that it was wartime. The invention was subjected to censorship. The patent was formally registered in Germany on 8th September 1943 and issued on 11th May 1953 to Rolf Widerøe, with Brown, Boveri & Co. in parentheses. The subject was *Speicherringe* (storage rings).

In third place on his list were the relays. These too he discusses unemotionally and in few words, but not in any way modestly:

> I think my contribution in this area was quite good, and I also think that my relays were very useful. Even though this is not of great relevance to particle physics or to medicine, these were creative works and I am quite proud of them.[111]

In fourth place, he ranks his work on the effects of radiotherapy on people with cancer:

> The interest in radiotherapy was a logical progression in the war we were fighting against the tumour cells with our new megavolt radiation weapon. The patients needed essential help, and I took part in that with great enthusiasm.

The First Love

Even though he had worked in many fields and taken part as a pioneer in a succession of new areas, he never entirely gave up the particle accelerator. That was his first love and it remained special to him, no matter what happened afterwards. He had always continued reading physics journals and he tried to keep himself informed about what was going on elsewhere. For example, when he was employed at AEG in Berlin before the war he had already heard about the exciting things that were happening in America.

> During the war the situation was obviously much more difficult, but from the late 1940s a completely new spirit came into the scientific community. Communication between researchers was desired and welcomed. Freedom to travel, reciprocal visits and international conferences meant that people got to know about almost everything that was happening in their field. Moreover, one knew most of the participants personally. (…) Nowadays it is important to keep yourself well updated on many topics to do with your research. All it needs is time to read – and good friends. So even since I retired I haven't been able to keep myself away from studying basic problems to do with particle acceleration. Only through experiments with even higher energy will we be in a position to gather new knowledge that can eventually lead us to a comprehensive theory of the structure of matter.

He maintains that after successful engagements with cyclotrons, synchrotrons and storage rings, we are back where we started, with the linear accelerator. The experts had agreed that the doughnut-shaped rings wouldn't become any bigger, but that from then on straight-line accelerators would be built instead for this research. The reasons for this were both technical and economic, but Rolf had his own perception of the motives and thought that researchers should not allow themselves to be scared off by trivial considerations:

> It is totally different with ideas. Here, the boundaries are set only by human intellect. The theoretical possibilities of using electromagnetism to accelerate particles are nowhere near exhausted, (…) and we are astonished almost daily by technical innovations that start us on the next circuit in the pursuit of new things. Even though many of the ideas that have come from this field in recent decades have since been rejected, it is nevertheless possible that there is still a fundamental breakthrough to be made that will allow us to step up into energy levels that today are still impossible to envisage. We should remember that what we are building today was pure Utopia fifty years ago.[112]

The Impossible

One should never stop having faith in future progress, no matter how unlikely it may seem. That was the message from the ninety year old with seventy years of research experience behind him. As an example that 'the impossible' can become reality, he cited the Russian Vladimir Veksler who researched on synchrotrons. At a conference in Geneva in 1956, Veksler had presented a remarkable idea about attaining high energy levels using a new method that he called 'coherent acceleration.' This had impressed Rolf, but he thought that there was something in what Veksler said that couldn't be right, and this problem continued to vex him. Twenty years later he put together and wrote down what he had worked out so far, and even though much fell into place he still thought that the calculations seemed unrealistic.

Then, after almost another twenty years—when Rolf was ninety—he was told about the plans for new accelerators that were to be built. His method using storage rings had now reached its limit. Later researchers had discovered what the Russian had overlooked, and higher collision energies were now to be achieved using a new method. Rolf was gratified that he had already explored this when he discovered the principle behind storage rings. The lesson is that if you just believe that something really is possible, then it perhaps will become possible one day. When the science comes to a certain point, you will be able to think of other solutions that you cannot see while absorbed in the present work. He said that we should at any rate not set the boundaries at the start, and he began to wax philosophical on behalf of physics:

> No matter how complicated and Utopian it seems to us now, the possibility of protons attaining energy levels of 1,000 TeV will undoubtedly be of great interest in research physics. Today this sort of energy can only be found in cosmic radiation – and only very, very rarely. (…) One could easily come to the conclusion that accelerator- builders with such fantastic ideas are totally mad, if one hadn't personally kept up with the developments in recent years.[113]

Then he used an example something that he had hailed at the beginning of the 1990s as state-of-the-art, namely the CD, the compact disc with the 'perfect' sound that emerged as the ultimate physical format and put an end to crackling and interference when listening to music. Ground-breaking technology at that time, with its almost 100,000 distinct sounds exceeding what the human ear can distinguish:

> The accuracy that is now being applied in the production of millions of CDs would not have been thought possible a few years ago by any technically qualified person. Therefore: you should never lose courage and should continue to strive for ambitious goals, even when you think they seem absolutely unattainable.

Do the impossible! That is the old man's urgent request, put very simply. A request bordering on banality. Said sincerely and honestly. No reason to doubt that he meant it. Nobody who knew Rolf would doubt that he practised what he preached. Strive for the impossible. Keep on striving. Believe in it. Despite everything.

***

That was what he had done that August day in 1946, when he took his wife and children in the car and set out for a new existence in a new country. When he decided to put the past and the war behind him. That was over now. A new time was to begin, in a new world that was awaiting his contribution.

Notes

1. The interview with the physicists on 12th July 1983.
2. *Some Memories and Dreams from the Childhood of Particle Accelerators*, lecture delivered at the Fifth Nordic Conference for Physicists at Geilo on 12th January 1983. The text was signed on 3rd December and probably submitted beforehand. He also spoke about this in the interview with the Norwegian physicists on 12th July 1983.
3. Conversation during the preparation of the book.
4. Odd Dahl: *Trollmann og rundbrenner*, Gyldendal 1981, p. 153.
5. Odd Dahl, p. 154.
6. Odd Dahl, p. 163.
7. Odd Dahl, p. 16.
8. Interview during the preparation of the book.
9. The biography and the interview with the physicists.
10. *Historical Development of the Betatron*, in *Nature* (London) 157 (1946):90, 1946.
11. 6 and 15 MeV, based on Max Steenbeck's ideas.
12. The biography.
13. The biography.
14. The interview with the physicists in 1983.
15. The interview with the physicists in 1983.
16. The interview with the physicists in 1983.
17. '*das Synchrotron und das starke Fokussierungsprinzip für Beschleuniger*'. ('The Synchrotron and the Strong Focussing Principle for Acceleration') Nicholas Christofilos patented the idea in 1950.
18. Professor Giorgio Salvini and Engineer Fernando Amman.
19. *Laboratori Nazionali di Frascati*, south of Rome.
20. The biography.

21. Rolf's contacts in the Physics Institute at Turin University were the director, Professor Gleb Wataghin who came from Russia and had also worked in Brazil for a long time, and Professor L. Gonella.
22. The Italian L. Gonella and Dr. H. Nabholz from Brown Boveri.
23. The interview with the physicists in 1983.
24. Interview during preparation of the book.
25. Werner Schumacher, Hans Rudolf Schinz, Adolf Zuppinger.
26. The biography. Other sources say c. 300. Between 1949 and 1986 Rolf was responsible for the development and construction of 78 betatrons at Brown Boveri, all custom-made for the client and installed by himself. There were also 15 magnetic lenses. In the period 1949–1986 Brown Boveri sold 11 betatrons rated at 31 MeV for use in industry and research and 6 with energy between 31 and 35 MeV for medical use, including the first one at the Norwegian Radium Hospital. The moveable type of betatron was known as the Asklepitron. Of these, they sold 38 rated at 35 MeV and 23 rated at 45 MeV. In addition, they sold 15 betatrons with magnetic lenses.
27. Copies of these can be found, among other places, in the ETH library in the college at Zurich, in the library in the Deutsches Museum in Munich and in the 'minimuseum' in the Radium Hospital in Oslo.
28. European Space Agency (ESA), European Molecular Biology Laboratory (EBML), European Synchrotron Radiation Facility (ESRF) and Joint European Torus (JET)
29. The biography.
30. The biography.
31. Odd Dahl.
32. Lillestøl, CERN/ Bergen University to *forskning.no.*
33. D. W. Fry, Hannes Alfven and F. Regenstreif.
34. Odd Dahl.
35. *Festschrift* to Roald Dahl in his 70th birthday celebrations on 3rd November 1968, A.S. John Grieg's Printing Works, Bergen, 1968.
36. CERN Courier, 22nd March 2002: 'How US physicists first came to work at CERN.'
37. Among those he names are Ernest Courant, Hartland Snyder and Stanley Livingston.
38. Egil Lillestøl's obituary of Kjell Johnsen, *Aftenposten* 10.8, 2007.
39. Nicholas Christofilos.
40. The biography.
41. Ernest Courant: 'Brookhaven and CERN: the AGS and the PS,' CERN Courier Oct 19, 2007.
42. Interview during preparation of the book, 3rd November 2007.
43. John and Hildred Blewett.
44. The biography.

45. The Alternating Gradient Synchrotron, AGS.
46. To build what was called a 'strong focussing,' alternating gradient synchrotron as the Americans proposed.
47. Günther Plass.
48. CERN Courier Jan 27, 2004: 'CERN's heart beats as strong as ever. 50 years of CERN.'
49. The biography.
50. Gordon Fraser: 'How US physicists first came to work at CERN,' CERN Courier, CERN-US collaboration, article 12 of 20.
51. Odd Dahl.
52. Norbert Lang: '*Rolf Wideröe und das Betatron*,' *Physik Anekdoten (13), Communications de la SSP No. 35, 23–25*.
53. The W and Z particles were discovered by Carlo Rubbia and Simon van der Meer. Egil Lillestøl in his obituary of Kjell Johnsen who had been leader of the ISR Project at CERN. *Aftenposten* 10.8 2007.
54. The PS machine was also useful when it became an antiproton decelerator serving the LEAR (Low Energy Antiproton Ring). It is still supplying LEAR's successor, AD (Antiproton Decelerator) with high-intensity primary proton beams.
55. Large Electron Positron Collider.
56. CERN's heart beats as strong as ever, CERN Courier, Jan 27, 2004.
57. The biography.
58. Large Hadron Collider.
59. *Aftenposten* 3 Oct 2010.
60. The biography.
61. Wolfgang Gentner became director of the synchrocyclotron department at CERN in 1956. He had worked with cyclotrons previously in Heidelberg, with Lawrence at Berkeley and with Joliot in Paris. In 1958 he became director of the new Max Planck Institute for Nuclear Physics in Heidelberg. Anselm Citron was also one of the first physicists at CERN, and he followed Gentner in the directorship at Heidelberg. The quotation is from the biography.
62. The biography.
63. The biography.
64. Science Illustrated no. 3, 2012.
65. *Apollon* no. 3, 2007.
66. Interview during preparation of the book.
67. Created by an Englishman, Tim Berners-Lee.
68. *CERN fyller 50* ('CERN Reaches 50'), www.forskning.no, 6 October 2004.
69. Dr. Werner Hardt.
70. The head of the accelerator division was Professor Gustav-Adolf Voss. The director of the centre was Professor Willibald Jentschke.

71. HERA stands for *Hadron-Elektron-Ring-Anlage.*
72. Gustav-Adolf Voss.
73. The biography.
74. Conversation during the preparation of the book, 10 June 2010.
75. 'Power is not justice. The circumstances facing major industry during the occupation. From director Alex Christiansen's bequeathed work about his struggle for truth and justice.' One of Christiansen's secretaries, Alexander Lange, inherited the material and arranged for it to be printed in the newspaper *Folk og Land* on Saturday 28th June 1958, Saturday 12th July, Saturday 26th July, Saturday 9th August and Saturday15th November.
76. *Folk og Land*, Saturday 12th July 1958.
77. *Folk og Land*, Saturday 15th November 1958.
78. Egil Reksten died before this book was ready. The conversation was recorded on tape and was written out word for word.
79. Interview during preparation of the book.
80. In addition to Tor Brustad's article in the same issue, he refers to the Swedish Anders Brahme: 'Aspects on the Development of Radiation Therapy and Radiation Biology Since the Early Work of Rolf Widerøe,' *Acta oncologica* 1998, Vol. 37, No. 6, Pages 593–602.
81. Interview during preparation of the book.
82. Hans Rudolf Schinz.
83. Dr. Selmer Rennæs.
84. Livingston, M.S.: 'The Development of High-Energy Accelerators,' commented reprints or translations of original papers, (book), Dover Publish. Inc. N.Y. (1966).
85. '*Röntgenpreis der Stadt Würzburg und der Physikalsch-Medizinischen Gesellschaft Würzburg*' ('The Würzburg State and Würzburg Medical Physics Association's Röntgen Prize.').
86. The biography.
87. Professor Tor Brustad in a conversation during the preparation of the book. According to Brustad the photographs from the exhibition show: 'Pictures no. 1, 2 and 3 from left to right: Max Planck, Marie and Pierre Curie, Wilhelm Röntgen, Henri Becquerel, Ernest Rutherford, Rolf Widerøe, Ernest Walton, Joseph Slepian and (under Rutherford) Irene and Frederic Joliot Curie. Picture 4 shows Widerøe's first betatron diagram from1923 (with his notes handwritten in Norwegian). His original notebooks from Aachen in the period 1926–1928 and his doctoral thesis from 1927 were also shown. Picture 5 shows Slepian, Widerøe, Ernst Ising's proposal of the linac principle, Leo Szilard and Walton.'
88. Interview with Dr. Paul Forman, Curator of Modern Physics, The National Museum of History and Technology, Smithsonian Institute, Washington DC in connection with the preparation of the book, 15th June 2007.

89. The lecture 'Some Memories and Dreams from the Childhood of Particle Accelerators' was delivered on 12th January 1983 and subsequently printed in *Europhysics News*, 15, 911 (1984).
90. Both have connections with the University of Bergen. Aaserud is a physicist and writes about the history of science and is now head of the Niels Bohr Archive in Copenhagen. Vaagen is Professor of Physics at the University of Bergen.
91. The interview took place under the auspices of what is now NIFU, the Nordic Institute for Studies in Research, Innovation and Education. The main organiser was the head of the institute, Hans Skoie. In addition to Aaserud and Vaagen who had taken the initiative, the other participants were Olav Netteland from the Radium Hospital, Olav Aspelund, and Senior Conservator Gunnar Thoresen from the Technical Museum.
92. *Die Eidgenossische Technishe Hochschule, ETH.*
93. The magazine *Nature*, nos. 5–6, 1983. The print-out is dated 14th March 1984.
94. Interview during preparation of the book, 19th December 2006.
95. Interview during preparation of the book.
96. Jan Sigurd Vaagen: 'FFV Congratulates,' article in *Fra Fysikkens Verden* ('From the World of Physics') in connection with the award of the Wilson Prize in 1992.
97. Interview during preparation of the book.
98. 26th April 1983.
99. The European Society for Therapeutic Radiation and Oncology.
100. 23rd October 1987. Deputy Principal Ole Didrik Lærum: Introduction; Roald Tangen, University of Oslo: 'A backward glance at earlier Norwegian accelerator installations for nuclear physics and medicine;' Tor Brustad, Radium Hospital: 'Microscopic studies of cancer development in living tissues;' Jan S. Vaagen, University of Bergen: 'Rolf Widerøe – the first accelerator designer;' Helmer Dahl, Chr. Michelsens Institute: 'Reflections on the relationship between technology and pure science;' and Rolf Widerøe, Brown Boveri & Co., Switzerland: 'Perspectives.'
101. Dahl, P.F.: 'Rolf Widerøe, Progenitor of Particle Accelerators,' SSC-Report SSCL-SR-1186, 10 pages (1992).
102. The Robert Wilson Prize for Achievement in the Physics of Particle Accelerators.
103. Tor Brustad arranged for the photograph to be given to Rolf's wife, and she told him afterwards about Rolf's reaction. Brustad spoke about the episode in a conversation about the book, on 10th November 2008.
104. 'The First Scandinavian Symposium on Radiation Oncology. Seminar in memory of Professor Dr. Eng. Rolf Widerøe.' Rosendal Manor-house, 24–28th May 1997. The programme included:

Former Church, Education and Research Minister Gudmund Hernes: 'A Tribute to Rolf Widerøe from the Norwegian Government';
'Presentation of the Rolf Widerøe Award;'
Tor Brustad: 'Rolf Widerøe, a great, but overlooked, scientist';
B. H. Wiik: 'Rolf Widerøe, the founder of the science of accelerator technology';
Jan V. Johanessen: 'Rolf Widerøe and the Norwegian Radium Hospital';
Anders Brahme: 'The Widerøe Lecture.'
Three of the lectures were published in *Acta Oncologica* 1998, p. 37, Scandinavian University Press 1998. ISSN 0284-186X:
Tor Brustad: 'Why is the Originator of The Science of Particle Accelerators so Neglected, Particularly in his Home Country' (shortened version without footnotes);
Anders Brahme: 'Aspects of the Development of Radiation Therapy and Radiation Biology Since the Early Work of Rolf Widerøe;'
B. H. Wiik: 'Rolf Widerøe and the Development of Particle Accelerators.'

105. The biography.
106. Conversation in connection with the book, April 2007.
107. Jan Sigurd Vaagen: 'A short journey in Rolf Widerøe's footsteps,' *Bergens Tidende*, 11th July 1992.
108. The biography.
109. The biography.
110. Letter to Fredrik Møller 20th September 1945.
111. The biography.
112. The biography.
113. The biography.

3

The Dark Chapter

But what happened between 1943 and 1946 that required him to turn the page and start a new chapter in his life? There must have been fateful events that were decisive in setting the course for the rest of his life. 'If I hadn't experienced it myself, I wouldn't have believed it.' That was how Rolf rounded off the summary of his life when he was interviewed at the age of 91. He had spoken at length about curiosity and research, about aiming for apparently impossible goals, about holding the banner high in the face of opposition and doubt. He had said a little about unpredictability and chance both in research and in the course of his life, and about being at the right place at the right time—or not.[1]

He may have been surprised at the strange turns a life could take, especially during these three war years, but he never made a drama of it, either publically or privately. That was not in his script as an engineer. Nor was complaint part of his role. While this strange phase was playing out with its questions and rumours, his energy was fully taken up just in living *through* it. Later, he found a way to live *with* it. The dark chapter was the tipping point in his life, as amazing as it was frightful. It was when everything that should not happen, everything that nobody thought could happen, *did* happen. It was beyond what family, friends, neighbours or colleagues could imagine. At the same time it was one of the most creative periods of his life, when his absorbing scientific dream came true. Against the very saddest, weirdest, bleakest backdrop, this was and remained the dark chapter. The odd, painful, revenant scene.

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_3

Spring and summer 1943 were sufficiently dramatic times, even without his part in the action. The war had come to a phase when the Germans were beginning to be desperate. Hitler needed something to impress both his own side and the enemy. Nazi Germany was working to develop an atomic weapon. Britain, the USA and France were doing the same. The question was who would achieve this first.

Research into splitting the atom had been under way on both sides of the Atlantic when the war started in Europe. Atomic research now became part of the war effort. The British and Canadian atomic research programmes were joined together with the American programmes into a super-secret project code-named 'Manhattan.' Lawrence with his bigger and bigger cyclotrons was a key person in this. Working with him was the American expert in theoretical physics, Robert Oppenheimer, who later came to be described as 'the father of the atom bomb.' A dedicated laboratory was set up in New Mexico to build the bomb, with Oppenheimer as the lead scientist. The theories were in place, but it was a race against time. Would they manage to build an atomic weapon in time for it to be used in the war?

The Allied intelligence services knew that the Germans had a uranium project, and in the summer of 1943 they reckoned that the Germans would not manage to build an atomic weapon before the war was over. Few people knew what was really happening in German atomic research. Some thought it was mostly bluff and propaganda. What they knew for certain was that atomic research in Germany was under the control of the military. German science was at a high level, and the Allies assumed that the Nazis would use the new knowledge about atom-splitting to create atomic weapons.

On the other hand, the politicisation and Nazi control of the academic milieu had led many physicists and mathematicians to leave Germany as early as 1933, the year after Rolf moved home to Norway. Many others had been called up into regular war service. Moreover, many of the German scientists were Jews who had been driven into exile. So the amount of available expertise had been diminished. Nevertheless, the Allies worked intensively to get ahead of the Germans. And they knew about Rolf's work in Germany for the Luftwaffe.

The Visitation at Work

The competition to be first to develop the new technology that could decide the end of the war grew more and more acute. Nobody on the other side must know anything. Everybody was watching everybody else. The strongest weapon of all was fear. Either side could use this, whatever their position in the arms race, and it was used for all it was worth, especially by the Nazis.

This was the underlying situation as Rolf, father of three children, cycled through Oslo each day to and from his work planning modern power supplies for Norway. At home in the evenings, he continued to develop further the ideas he had proposed in his doctoral thesis.

Then one day in spring 1943 his life changed. Some Germans visited him at the office. Surprisingly, it is difficult to find out exactly when this happened. Rolf never tried afterwards to set a definite date to the event. Maybe he didn't want to? It is unthinkable that such a realist and systematic researcher didn't know the date it happened. However, he has several times described the episode that took place in the back yard at NEBB while he was fixing something or other on his bicycle. Apparently he was just about to leave for home when they turned up. The timing and location of the German visitation had been carefully planned. Suddenly, there they were behind him; uniformed SS officers from the German air force, the Luftwaffe; like a scene in a war film.[2]

Nor did Rolf say exactly how many there were, or when it was; just that it was good weather and that there were 'two or three' of them. While he is unclear about apparently incidental information, at the same time he is clear and precise about other things. Many years later, information would emerge that spreads light on this paradox, but as with so much else to do with Rolf's life at this time, some details still remain shrouded in mist.

The Germans asked him very politely if he would accompany them to the Grand Hotel, as there was something they wanted to speak to him about. They said it was to do with something that could be very important for his brother. Viggo had been a prisoner in Germany for two years, and the family had learned that his condition was steadily deteriorating. He had recently been moved to a new prison camp, a little further north. The family was worried about how the combination of forced labour, under-nutrition and disease was affecting him.

What could the Germans have wanted from Rolf? When there is war, your country is occupied and emissaries from the enemy want you to go with them, you really don't have much choice—irrespective of how politely they conduct their business and irrespective of whether they are two or three in number. Rolf gains a little extra thinking time by saying that he needs to fix his bicycle before he can go with them. Yes of course, he is allowed to do that. They appear to be on an important errand, and they want to play ball with him. To be stopped by Germans was not in itself very unusual at that time. So maybe he wasn't so surprised? It is also difficult to judge how surprised he was that they had sought out him in particular. He has never said anything clearly about that.

Why Rolf?

The war is now in its fourth year. For Norwegians, the obtrusive behaviour of the occupying powers has become a part of everyday life. People have a deep fear that a German will suddenly appear at the door, probably in the middle of the night or early in the morning. Everybody knows someone who has been taken that way. But what do they want with Rolf? Why now? Has he been arrested? What has he done? It must be something to do with his work; he has always had a lot of dealings with Germany. And his granny is German.

Rolf agrees to follow them to the Grand Hotel. There, he gets to know more. They obviously want his help towards some objective, and they obviously have something to give in exchange. We really don't know what Rolf's thoughts were in the Grand Hotel on Karl Johans Gate. He has spoken about the episode in several interviews, but has always stuck to the standard version, a sober and carefully thought out account of what happened. He has never really said what he thought or felt.

We can only speculate. We can wonder if the thought crossed his mind that they wanted to recruit him as a spy. He was a good candidate for that; he spoke fluent German, had lived in Germany for ten years and had a wide network of contacts.

The officers had taken him to a neutral location, but they still wouldn't tell him exactly what they wanted of him. It is difficult to say to what extent he thought at the time that it might have something to do with his brother. He may have thought that they were just using that idea as bait. He may have reasoned that Viggo's situation was now so bad that if there was the faintest ray of hope that he could help him in any way, anything was worth trying—even contact with the Germans. There were other possibilities, however.

The talks continued the next day. The Germans appeared to be experts on X-rays, and they had prepared well. He realised that they knew everything about his education; that he had studied in Karlsruhe and had done his doctorate in Aachen. They knew the contents of his thesis. They understood that he had worked in Germany but had moved back to Norway. What's more, they knew that he had recently published an article in the March number of *Archiv für Elektrotechnik*, the journal that had published his doctoral thesis 15 years before. The article discussed both his own and the Americans' work on radiation and included new ideas about betatrons of different sizes.

It would be no surprise that Rolf now discerned the plan. The Germans wanted him for purely scientific reasons. Thinking about his latest published paper, he realises how well-informed the Germans are. Few people understand the significance of what he has written. These officers must have contacts at the very peak of the European physics community. It is not unusual for the occupying powers to employ flattery in pursuit of their objectives. Flattery is but one among many techniques considered legitimate, but this is more than flattery. These people know what they are talking about. They are talking about his own big research ideas.

They would like to take him to a third location, to Berlin, to continue the conversation. Everything is being conducted using best espionage technique. He is still uncertain. They suggest that they might be able to help his brother. They even imply that Viggo might be released. They don't have full authority themselves, but they could have a word in the right ears. 'That was decisive for me, and I agreed to continue the conversations in Berlin,' he said later.

Perhaps they would take up his brother's case, perhaps not. Anyway, he went with them to Berlin, a city he knew well after spending almost four years with AEG. A student friend of his lived there, Ernst Sommerfeld who was now a respected patent consultant and who had helped him with several patent applications in recent years.

A Few Days Later

He should go to Berlin now. Immediately. By air. The immediacy is not unexpected, but to go by plane is more unusual. By air? Immediately? It must be important. A day or two after the first contact, he is already on his way to Germany. All planned with Teutonic efficiency.

In Berlin they come to the point, or near to it. They want a betatron built. The work is to take place in Hamburg. The authorities have assigned priority to the project. There is a possibility that they might want more and perhaps even bigger machines created later. They consider Rolf to be the leading expert in this technology and they want him to be lead scientist for the whole project. And—by the way—if he will collaborate with their plans they will do what they can do to improve his brother's prison conditions, or possibly even have him released. So they said.

When we hear tell of such an episode nowadays we may think, as many did at the time: It's war; people are being picked out, arrested, ordered to do this or not do that; we are under enemy rule. When several high-ranking, uniformed enemy representatives come on a special mission to 'negotiate,' the alarm bells ring, the sirens wail, the horns resonate, all the warning beacons flare. You know where you stand. Is that how Rolf reacted?

The Germans explained to Rolf what they already knew about the topic. They knew for example about Donald Kerst's article from 1941, the one Rolf had heard about during Professor Roald Tangen's lecture in Oslo. They knew that in the USA, Kerst had succeeded in building a working betatron with an energy level of 2.3 MeV. They had read about Rolf, who had developed the theory that the Americans had worked out in practice. They knew that Rolf had worked for many years developing equipment for the Norwegian power industry and that he had taken up his youthful idea again and started following the research developments especially closely. They also knew that he had changed his job to work in a more stimulating environment. We are talking here of surveillance, not to mention industrial espionage and commercial secrets.

The Industry Speeds up

Over the previous few years Rolf had been in contact from time to time with the Brown Boveri parent company in Switzerland. He had suggested that they should begin to build radiation transformers, and in one of the letters the Brown Boveri management remind him that he mustn't forget to patent his ideas in Germany—and in the USA and England as soon as possible after the war. They offered to help him with this, because industrialists on both sides of the Atlantic were now interested in betatrons. The Siemens factory had already started building a small, 6 MeV betatron. The X-ray specialist Konrad Gund had been selected to lead this project, which was based on the ideas and designs of Max Steenbeck, whom Rolf knew from his time in Berlin after his student days.

The German authorities were obviously following research developments carefully. They needed to be ahead of the competition, and there were abundant fantasies about what they had in mind. Through his contacts, Rolf had been carefully following the race that was under way both in industry and in research. So why should he be surprised that the Germans tried to persuade him to build betatrons for them? What's more, to build a betatron had been his youthful dream. An American had recently succeeded. Now it was Rolf's turn to build an even bigger and better one. After all, Kerst had built on the theoretical foundations Rolf had laid. And even though the job in NEBB gave him better opportunities than his previous job, he did not have access to the resources needed for an undertaking on this scale. Neither the money nor the equipment. Norway didn't have these. Certainly not now. Here facing him was his opportunity. Laboratory, staff, money; you are the boss. Do what you want. Just build a betatron, 15 MeV. And quickly.

This was the opportunity to apply his latest ideas about a betatron with high enough energy to be used in cancer treatment. He had no special knowledge of radiobiology or radiotherapy, but as a physicist he understood how radiation can penetrate into a cancerous tumour. He could foresee that high energy rays could deliver bigger doses of radiation into the tumour itself and smaller doses into the overlying healthy tissue, thereby reducing the damaging side-effects. Using high energy, radiotherapy could be more effective, especially in the treatment of deep-seated tumours. The higher the energy, the greater the effect. He probably thought that an energy level more than 15 MeV would be even better, but if the Germans wanted a 15 MeV machine, that's fine. Let them have it. It's a start, anyway. A good enough challenge, a victory in sight. And—if he was successful—a machine that could help cancer patients. Was that his motivation?

Contacts

Rolf had professional contacts with whom he had exchanged letters the previous winter. Among these was a professor in Berlin who sent him long letters full of formulae and always ending with '*Heil Hitler!*'[3] Throughout the spring, Rolf had been working on a follow-up article for the journal. The editorial staff registered it as 'received' on Monday 12th July. In the article, Rolf presents new details about how one could build not just a 15 MeV but a 200 MeV betatron.[4] The only snag was that the article was never printed. It was typeset and Rolf checked the proof-reading, but it mysteriously disappeared before going to press.[5] Censorship? Industrial espionage? Accident? Who knows what in a time of war? Maybe he contacted the editors to remind them or to ask what had happened. That would not have been odd, but most of us would say that it was unusual for a Norwegian to send articles to a German technical journal during the war, however scientific the content. He later learned that the article had been stamped '*Geheim*' ('Secret') and so could not be published. For selected eyes only. So even though the article had not been published, somebody in authority knew of its content.

The editorial office was in Berlin. In theory he could have taken the article with him and handed it in personally, but in the prevailing circumstances it is unlikely that he could have visited a publishing house. Was the editor playing a part in a wider game? These are the types of speculation that arise in the absence of hard facts.

Did the visit to Berlin make it possible for Rolf to be present in person when he registered his first German patent on 15th July? That is even more unlikely. In connection with the patent registration, he had had legal advice from his friend Sommerfeld. Did he visit Sommerfeld? We don't know how much freedom he had. If the Germans knew that he was seeking to make progress both with the article and with the patent registration, was it a particularly suitable time to lure him to Berlin? We may never find answers to this sort of question. However, it can be useful to pose these questions and consider the information we do have, because some of it seems almost too positive. Some facts are completely missing, though Rolf often informs us about things that seem less important. Though striking, this contrast is not necessarily intentional.

German Contacts

The visit to Germany may also have given Rolf an opportunity to meet another German contact who is particularly interesting in this context, namely Director Schwartz whom Rolf had got to know when he visited NEBB in Oslo several times. We know that Rolf at some time had floated the idea to Schwartz of appealing for a reprieve for his brother. Schwartz was employed in the German government agency responsible for the extension of Norwegian hydro power, and Rolf knew that he had contacts with Engineer Fritz Todt, who was the German arms minister at the beginning of the war. Rolf asked Schwartz for help to direct the appeal into the correct channels so that it would reach someone with decision-making authority. Scwartz replied that yes, he could help, but that the appeal would obviously be much stronger if Rolf could say that he had done something such as publishing an article with a pro-German attitude or donating a suitable sum to a pro-German organisation. Schwartz said that such things would be taken into account when the appeal was being considered.[6]

But do we know whether this Director Schwartz was part of the whole structure? Was he connected with the officers who came to Norway to persuade Rolf? Was he really Rolf's friend and confidant? What did the German authorities know about his contact with Rolf? Were they directing the play? There is little to suggest that, but Rolf followed the script. He already had an article he could refer them to. It could be found in *Teknisk Ukeblad* ('Technical Weekly') the previous year, no. 15, 16th April 1942, in the form of a report of the visit he had made to Germany the previous autumn as part of a Norwegian delegation to study the development of power supplies. A Director Schwarz crops up here, as tour leader and with his name spelled without a 't.' Probably the same person. The article was headed: 'Technical impressions from the Norwegian engineers' study tour in Germany 10–23 September 1941. By Dr. Eng. Rolf Widerøe.' The introduction left no doubt about who had extended the invitation:

> On the initiative of *Reichskommissar* Terboven and *Reichsminister* Dr. Eng. Todt, General Inspector for Water and Energy, *Arbeitsgemeinschaft für den Elektrizitätsausbau Norwegens* this summer invited several Norwegian hydropower and electrical engineers to a study tour in Germany to see and learn about the utilisation of German energy sources.

Rolf wrote glowingly about the people who had arranged the tour and who had 'a significant part of the credit for the fact that the power system was all so complete and effective.' He relates that 18 Norwegian engineers took part and that the tour leaders were Director Schwarz and Dr. Schoppe. These two met the delegation in Oslo and organised a dinner on the eve of departure. The article then goes on to give an account of *Reichsminister* Todt's letter of invitation. Todt – best known as leader of the semi-official *Organisation Todt* responsible for development of infrastructure—had referred to the two countries' shared interests in hydro-electric development. The letter ended with a hope that the tour would give the delegates an opportunity to form their own impressions of Adolf Hitler's Germany.

Then follows Rolf's description of the 12 day excursion, a three or four page engineer-to-engineer discussion full of words such as generators, dams, reservoirs and kilowatts. There is a chronological account: 'Next day;' 'After the lecture we visited…' But there is also praise of train rides through beautiful mountain landscapes and professional enthusiasm for the way the Germans had organised and linked their power supplies, which he warmly recommended. Finally he turns to cultural life:

> In Berlin, Munich and many other places we were very impressed by modern German culture, as manifested today in the new German building style, in the

> architectural beauty of the autobahns and the Olympic stadium, in fine art and in the deliberate effort to create assets that will last beyond our generation.

Finally, he adds that he doesn't think the war has affected the country very much, in fact remarkably little, he thinks, on the 3,000 km. they had travelled, apart from 'camouflage and other air defence precautions.'

The article and the style of writing can be analysed, interpreted and misinterpreted. You can read it rather as you read the Bible. You can say that it is written by a typical Nazi, or that someone else has been directing the pen, or that it is written by an engineer who is keen to integrate the Norwegian power systems. A Norwegian reading it today would undoubtedly consider the writer to be a Nazi sympathiser. But why he had gone on the tour and why he had written the letter remained his own secrets. For Schwartz it was the evidence he needed to proceed. Was a pro-German travelogue a clever move, or not so clever? Whatever the answer, Rolf did it anyway, went on the tour and wrote the letter. 80 kroner, equivalent to a little over 200 US dollars or a little less than 200 Euros in today's values, was donated to the Norwegian Legion, the branch of the Waffen SS that was set up on the initiative of Quisling and Terboven to fight against the Soviet Union on the Eastern Front.

In summary: Appeal submitted; money donated; article written; plus a named person in the hierarchy who promised to recommend an appeal to his superiors. The year is 1942. In the meantime, Schwartz's superiors have died. Engineer Todt perished in a flying accident after his plane fell in a mysterious accident after a quarrel with Hitler. His successor Albert Speer should have been on the same flight but decided to take a later plane.

And His Answer Is …

The following summer Rolf is back in Berlin to follow up his conversation with the Germans in the Grand Hotel. He still hasn't said whether or not he will take on the research job. If he says 'Yes,' the officers will be pleased. If he says 'No,' there can theoretically be two possible outcomes. Either the Germans will accept his refusal and send him home, or they will use harsher means to compel him to stay. They have invested so much to recruit him that the first seems very unlikely in a war situation. We can only try to imagine what thoughts go through your head when the enemy asks if you will work for them. Did Rolf see through the Germans? Was he doubtful at some point? Scared? Or on the other hand, did he think he could manage to deceive them? Maybe he thought only about his research. That is what he has implied to us ever since. Perhaps he wanted to help. Help who, and how? To win the war? To make medical equipment? Is he in somebody's service? If so, on which side? One or the other, or both?

What we do know is that it is wartime. He is intelligent, enthusiastic, socially established. He has a family, a wife and three children; a mother and father who are proud of him; three sisters who are fond of him; many nephews and nieces; a brother he has been close to for many years, who has now been captured by the Germans. He has a big and cohesive extended family, plus friends and professional connections in Germany from twenty years back with whom he still maintains contact.

In Oslo, daily life is afflicted with ration cards and blackout curtains. The soldiers of the occupying power are in the streets. Friends are arrested. Neighbours are abducted. Censorship and restricted freedom of speech—the very things that bothered him so much when he lived in Berlin that he moved home to Norway. It is difficult to imagine that a man such as he would not realise that taking a job in Germany now, when everything about the Germans was looked at askance, would make his problems worse. Nevertheless, he decides to take part in a German research project. Why? Is he too detached to understand the implications? Is his mind on other things? How does his mind work?

Does he think *idealistically*—that the research will lead to cancer treatments? Does he think *politically*—that the Germans have special military interests for which they want to recruit him? That the betatron will be used in weaponry? Does he ask himself how a machine that generates high energy, but not in a form suitable for weaponry, can be of any military significance? After all, *he* is the one who knows what it is useful for. Or does he wonder if the Germans will use it for propaganda?

Does he think *personally*—that the job in Germany can be used as a trump card to rescue his brother? He has already raised with the Luftwaffe officers the question of whether he can count on their support for the appeal for clemency if he goes along with them on the research project. Is he afraid what the possible consequences might be either for his brother or for himself if he says 'No?'

Does he think *morally*—that you just don't do that sort of thing? Don't flirt with the enemy. Should he refuse to go because it is war? Good Norwegians answer 'No' to such requests without hesitating. He is hesitating. Is he worried about what his family will think?

Is he thinking *egotistically*—that he will see what he can get out of it? The war cannot govern our lives entirely.

Perhaps he isn't thinking about it at all. Perhaps it is only those around him who are thinking, wondering whether he is out of his mind. He gives them little help, doesn't share his worries, doesn't report his doubts, doesn't assert his innocence. He doesn't assure them of his good intentions. He knows more than he says. It is war.

1943 was a catastrophic year for the German war effort. Defeat after defeat, starting with Stalingrad. On the Atlantic, on all fronts: retreat. No longer any doubt about who would win, just a question of when. There might not be enough time to develop his betatron—whether or not it was important to the war effort.

What About the Family?

Rolf systematically started sorting out the practical details and formalities. In Berlin, the negotiations with the German officers became more specific. At that time the Allies had started carpet-bombing German cities, and Rolf made it clear at an early stage that there was no question of moving to Germany with the family under these circumstances. The delegation said that the family could continue living in Norway and offered him the opportunity to commute by air. Furthermore, he could stay at home in Norway to work on the theoretical aspects of the project, though when it came to the building of the accelerator he would have to be on site in Germany to supervise the work.

So his wife and children could stay on in Røa. Rolf would continue to be employed by the Norwegian company NEBB and would just be seconded for the project. His salary would be paid to his wife and he would be supplied with a house, food and money in Germany. All the practical details were in place, but there was much that was still not clear to him. He did not know why it was the Luftwaffe in particular that had recruited him, and he understood that his status as a foreign worker didn't allow him to know that. The delegation didn't say why they wanted a betatron, though it was obvious and no surprise to him that the German authorities were involved in a race between American and European researchers. Sharp scientific competition in the development of accelerators was not new; he had taken part in it himself. Irrespective of what use the Germans intended for the betatron, it was pretty clear that they wanted to keep up with the Americans. If the official line was that the betatron project was being set up to develop more and better equipment for medical use, that was fine.

His sharp and methodical brain may have made sense of all these questions, but he tells us nothing about them. He didn't write it down. Only he can have known how much or how little he understood of the situation he was being drawn into, and even he can hardly have known enough. In Rolf's predicament, navigating the interface between his own life and global politics was like walking through a minefield. There were plenty danger signs, but no markers of a safe path. Only he could judge the relative risks of saying 'Yes' or 'No.' He has to make the decision alone, but the consequences of his decision will affect many.

He answers 'Yes,' on condition that the Luftwaffe officers will do what they can to persuade the security police to release Viggo. They promise support, but repeat the reservation that they themselves do not have authority in these matters. This is probably true. They can however use their influence to have him released, or at least to have his prison conditions modified. That's what they say. Does he believe them? Do they mean it?

Into the Labyrinth

The Germans had no time to lose. By August, Rolf was installed in Hamburg. Formally and officially he was now in German wartime terminology *dienstverpflichtet*, obliged to perform compulsory labour. In his case, however, the obligation was not just to any task but *für eine besondere Aufgabe*—for a specified task. His job was to build radiation transformers for the German air force at a critical time when German weaponry needed to be upgraded. His employer reported directly to Arms Minister Albert Speer. Rolf was really in the thick of it now.

The date when he started is a little uncertain, but we know that it was at a difficult time. Hamburg had recently been bombed by British and American planes in a long planned bombing operation known bizarrely as 'Operation Gomorrah.' After the biggest raid on the night between 27th and 28th July with over 700 planes, the city burned for days. It was described as resembling a stove, all red flame and black cinders. The population stayed awake all night to be ready to go to the air-raid shelters. By 3rd August it was all over. So when Rolf arrived, everybody was busy trying to clear up after the bombing. He got lodgings in a house in the outskirts of the city. The location was alright, but he missed his family, and the ruination round about him didn't make it any easier; 50,000 killed and a million homeless. The Hanseatic town of Hamburg did indeed now resemble the destroyed and uninhabited Old Testament towns of Sodom and Gomorrah. The only compensation was that it was now considered a relatively safe place to live, as there was nothing more left to bomb.

For that very reason, the town was deemed suitable for the Luftwaffe's new project. Moreover, there was an important factory there, C.H.F. Müller, or Roentgen-Müller. The business had been founded by the glassblower Carl Heinrich Florenz Müller. It now belongs to the Dutch company, Philips, and manufactures X-ray tubes among other things. The buildings had been more or less undamaged by the bombardment and were selected as the place for the work on Rolf's betatron, Rolf himself having been involved in the choice of location. This factory was particularly suitable both because of its glass-blowing workshop and the availability of expertise in vacuum technology. Here on the banks of the Elbe, in Fuhlsbüttel in the north of Hamburg, the first 15 MeV betatron in Europe was to be built. Nazi Germany was paying for it.

The first person he got to know was Richard Seifert, who owned and directed an internationally recognised X-ray company in Hamburg that he had inherited from his father. Rich. Seifert & Co. are now leading suppliers of materials-testing equipment for the aviation industry. The firm had long-standing connections with Roentgen-Müller. Seifert had originally ordered his X-ray tubes from them until he changed to having them made by AEG in Berlin, which naturally didn't please the Müller people. This however did not affect the relationship between Richard Seifert and Rolf Widerøe, either on a business or a personal level. The pair of them also socialised privately. Rolf developed great respect for Richard and later described him as able, hardworking and 'an OK chap who helped me a lot in my particular situation.'[7]

His Own Boss

Rolf had no direct boss. He was not supposed to know what organisation he was working for. So he still had some unanswered questions, one of which was who was ultimately and officially responsible for what he was working on. He met many people who were involved one way or another but were not directing all aspects of his work, or who had some sort of supervisory function, politically or in other spheres. Not everything was made clear to him. He himself considered Colonel Friedrich Geist from the Luftwaffe as formally responsible. Geist was the head of technical research and development in Speer's arms ministry, an important member in the hierarchy and Speer's right hand man, according to the Nobel prize-winner Werner

Heisenberg. Rolf visited Geist a couple of times at his office. 'A decent sort, quite pleasant,' as Rolf wrote, adding 'I had no other dealings with him apart from the matter in hand.'[8]

He did, however, have quite a lot of dealings with a small, semi-official company that worked as the link between him and the Air Ministry in Berlin which was financing his work. The head of this firm was called Hollnack. Nobody used his forename, Theodor. According to Rolf an odd, very pernickety, slightly excitable person who overwhelmed people with his interest in Nietzsche.[9]

But Hollnack had power. He had administrative responsibility for the betatron project and functioned as the go-between linking Rolf to the authorities. On a practical level, he was also responsible for budgetary payments for the project. Money didn't seem to be a problem, so far as Rolf understood, and he said that he and Hollnack got on alright with each other. Rolf reckoned that Hollnack appeared to be a fan of Hitler but said that they never discussed politics. Apparently it was Hollnack who put Rolf in touch with Richard Seifert, and it appears that apart from the radiation project he had various other business operations under way, to do with aluminium. Rolf was not alone in thinking that Hollnack was unusual. Whether unusual or not, he would be important for Rolf's fate over the next two years.

On a scientific and technical level, there was no doubt that Rolf was the boss. Nobody tried to pull rank on him, and 'there was no contact overhead with anybody high up,' as he said. Now there was work to be done, irrespective of why he was there. Difficult decisions or not, war or not; it was now a matter of science and technology. Now he could create the machine he had invented theoretically. He had thought through how to accelerate electrons round in a circle to a chosen speed and he was keen to see how this could be utilised.

A Strong Team

By that first autumn, Rolf already had a strong team assembled, with Dr. Rudolf Kollath, Dr. Gerhard Schumann and physics student Bruno Touschek in leading roles. They too were paid by the Luftwaffe, through Hollnack. Rolf also had the support of the experienced workers of the Müller factory. Kollath, a physicist, had previously worked in connection with the aluminium smelter in Sauda in Western Norway and had also worked in the AEG research laboratory in Berlin, though not at the same time as Rolf had been there. Life in Nazi Germany was difficult for Kollath, because his wife was of Jewish origin. So he was not eligible to be appointed to a university or to the official bureaucracy but had to remain in industry—or alternatively do other work important to the war effort. When particularly difficult problems had to be solved, young Touschek's creative imagination and mathematical skill were brought into play to make the required theoretical calculations. He presented the results of these in neat, typewritten diagrams. Rolf doesn't say so much about Schumann, other than that he did his job and that he didn't see him very much.

He does however tell us quite a lot about Touschek, the student. Austrian. Recently turned 20. Gifted. Jewish mother. Problems with permission to study. Working secretly for the Luftwaffe, i.e. for Rolf. Newly arrived from Berlin. Allowed to lodge with a professor called W. Lenz who was ill and whom he almost had to carry down to the cellar when there was an air-raid. He also had permission from several professors to attend their lectures at the university in Hamburg, though he could not be registered officially as a student. Rolf had already met Touschek that first summer, in Professor Lenz's flat, but they knew of each other and had been in contact prior to that. Touschek had worked part-time in the editorial department of the journal *Archiv für Elektrotechnik* in Berlin and had communicated with Rolf because he thought he had found an error in the calculations in Rolf's article. So Touschek knew about Rolf's work on betatrons.

Rolf started to wonder whether there was a connection here, whether Egerer the editor of the journal had brought the student to Hamburg. Previously he had had a little part-time job with the Löwe company in Berlin, where Egerer had also been employed at one time. In Hollnack's office one day, Rolf 'suddenly' met Egerer. When he had submitted his doctoral thesis to the journal editor fifteen years previously, the pair of them had only communicated by letter. We may suppose that when they now met face to face, Rolf asked the editor what had become of his second article. It is hard to imagine that he would not avail himself of this opportunity to enquire. If he didn't, that would imply that they had already been in contact in the meantime. Learning of these connections and 'coincidences' now in a historical context, it is easy to start hearing warning bells. There are just too many coincidences. Rolf never shared information with anybody else about how loudly he heard these warnings, but he has let it be known that he developed an increasing awareness of how things hung together.

Through Touschek and Lenz, Rolf also got to know Hans Suess and H.J.D. Jensen. He got on particularly well with Suess, who made no secret of his aversion to Hitler, Rolf recalled. Suess was one of the professors who allowed Touschek, who was also from Vienna, to attend his lectures. He was rumoured to be a communist.

Fringe Benefits

Rolf was well paid and had generally good working conditions. For the first two months he worked mainly from home in Oslo, with occasional visits to Berlin. He said more than once that from time to time he got 'leave to come home.'[10] At other times he seemed to imply that he could travel as often as he wanted and that he could arrange business journeys where and when he wanted. It is difficult to say how much freedom he really had, and the way he spoke about this depended on whom he was speaking to, but the fact that he was able at all to travel back and forth between Germany and Norway undoubtedly indicates that he was considered an important person. Just to travel internally by train and bus often required a specific reason and special permission. He was travelling by air, and abroad, at a time when all the commercial flights between the enemy country and his own country were gradually being closed down. There were no routine flights between Hamburg and Oslo. Little surprise that the neighbours in Røa wondered what was going on. Strange things happen in wartime.

Nowadays, in peacetime, it is difficult to imagine not being allowed to take the train where and when you will. In Norway at that time you had to have a special permit from the police if you needed to travel to stations in certain zones. These restrictions applied particularly to places near the Swedish border, lest people should escape to Sweden, and to Western Norway, from where they could escape by boat to Great Britain. Rolf was travelling to and from Germany all the time. This was obviously something special.

He has however admitted that the journeys could be problematic. For example, there was fog when he was due home for Christmas in December 1943. He had a long wait in Copenhagen and only just made it home for Christmas Eve. Some people would say that was a privileged minority problem in such times. But what are the problems that he has not told us about? Was he frightened of being arrested? Denounced? Was he ever stopped? He has not told us whether he travelled alone or whether he was followed by officers. If he was being escorted, was he frightened that acquaintances at home would see him together with somebody in German uniform? For all we know, he may have had a German uniform himself.

Everyday Life at the Factory

The leader of the section of the Müller factory working on the betatron was Alberth Kuntke. He had been an apprentice at Rich. Seifert & Co and had transferred to Müller where he trained as an engineer with support from the company. Rolf liked him, and visited him privately several times, in a house in a wooded area outside Fuhlsbüttel. Rolf described the morale in the factory as good and he described the employees as well disposed towards the incomers. Several of the fellow-workers were highly trained specialists who carried out free-standing projects for Rolf.

Among those he worked closely with were the second in command at the factory, who was an X-ray specialist, and two or three of the engineers. The second in command was clearly a specialist in something quite other than X-rays, and Rolf thought that he had been given his management position for political reasons. As a Philips company, Müller was subject to *Zwangs- und Fremdvervaltung*, the regulations governing the management of foreign workers.[11]

According to Rolf, some of the employees were ardently pro-Nazi and outspoken supporters of Hitler. One of these was the head of the development laboratory, the physicist Walter M. Müller with whom he had quite a lot of dealings. Müller always signed his name simply as 'Dr. Müller,' but he was not related to the founders of the company. Rolf described him as pleasant, clever and popular, but made a note to himself that he must be very careful in his dealings with Müller because of Müller's Nazi sympathies.[12]

Rolf often travelled around in Germany, particularly to Berlin and Mannheim, but his co-workers in Hamburg knew what they had to do. Rolf had established the framework and given general directions.

The Writing in the Sky

One of the first times Rolf was home in Norway, in late summer 1943, he took Ragnhild on holiday to Tuddal Mountain Hotel in Telemark. He hasn't told us whether the children were with them, but the job certainly was. At the back of his mind, as always, were the technical problems he was facing, and especially one that he had been pondering for a long time. As often happens with creative people, when he allowed himself to expand an idea and think around it everything he saw and heard seemed somehow to connect with what was at the back of his mind. One day he dozed off on the lawn at the back of the hotel. While he was lying there on his back, looking up at the clouds, the solution was suddenly there above him, if not written in tongues of flame at least displayed very clearly; the rays should be made to collide! Think of the momentous forces!

He has recounted many times the picture that he saw above him: a cloud had been transformed into a stationary car, and another into a car that came roaring in and collided with it. Then another picture: two cars both moving towards each other. Bang! Crash! A much more dramatic collision. Much greater damage. Debris in all directions. In Rolf's imagination the cars are bundles of particles that are accelerated and shot towards each other. They collide, and something happens. Rolf has made one of his life's discoveries, the idea of investigating nuclear reactions in a completely new way. Physicists had for a long time been interested in studying the properties of the atomic nucleus by studying the effect of shooting particles into the nucleus. The higher the energy of the projected particles, the greater the possibility of discovering something about the atomic nuclei. Now he would make a special device to store accelerated particles in 'storage rings' and shoot the rays of particles against each other. Then he would be able to observe and study the nuclear reactions.

Back in Hamburg after the visit to Norway, Rolf excitedly told his assistant about the brilliant idea he had had while on holiday. His assistant was not impressed in the least. What the boss had found out was already well known and was something everybody learned at school—indeed, at primary school. How did he imagine he could patent such an idea? Rolf, however, did what he always did. He took his idea for a patent to his friend Ernst Sommerfeld, and together they registered a patent for the principle of storage rings; *Speicherring-Patent* no. 876 279, dated 8th September 1943. This would later be the basis for CERN's decision in the mid 1960s to build the intersecting storage ring ('ISR') accelerator, the world's first hadron collider. Difficult for non-physicists to understand, but outstanding among his list of achievements. We don't always recognise the wisdom of our seniors, but somebody must have realised the significance of the idea despite the assistant's negative comments, because the censoring authorities declared it secret. Nobody asked why. It was war.

But Rolf took Touschek's comment seriously and said nothing in the patent about 'the desired energy balance from a frontal collision,' since this may have been considered as already known at the time. Touschek, for his part, felt slightly offended that Rolf had registered the patent when he had advised against it. Rolf's idea didn't really play a very big role in physics at the time. He realised that the time was not ripe to construct such an apparatus. New technologies and new equipment would need to be developed to bring it into being. It was questionable whether he would ever profit from his patent. The only particle accelerators he knew of that could be used for such an apparatus were the betatrons that Kerst had developed in America. They were basically suitable only for working with electrons. It appeared to be only a matter of time before there would be storage-ring accelerators for other types of particles, quite different from the existing cyclotrons. He didn't know then that it would be a good ten years before anyone took up the question again.

In applying for the patent, Rolf was not concerned about the not-yet-existing technology. What he was interested in was the principle. That was what he wanted to secure for himself for the future. He set aside the vacuum problem he was struggling with—at any rate until later. It had been problematic for him for a long time, and he could hardly ignore it, but for the time being it was unsolvable. An even better vacuum would be needed for particles to be stored longer without colliding with molecules of the residual gas. He also understood clearly that the beam path was not stable enough. He had been aware of this since his student days and he knew just how difficult it was to stabilise them. Kerst had been the first to find a practical solution to this problem. The challenge now would be to get particles with the same charge to go in their specified direction within the same tube. Rolf responded to this by thinking up an imaginative solution which at first he hardly really believed himself. The particles would be directed by electric fields. Then he discovered that it is easier to use two rings with magnetic fields to steer the particles. However, none of these 'little details' altered the fact that the best way to obtain energy from the accelerated particles would be to have them collide head-on. Perhaps, just maybe, one day, it could be achieved. Touschek was not so enthusiastic, but he didn't succeed at all in damping Rolf's enthusiasm.

Storage rings were not the only things Rolf was busy with. He was in a flurry of activity. Already on 15th July he had submitted his very first betatron patent (no. 889 659) about the injection system for the betatron, clearly a sequel to his doctoral thesis. On Thursday 2nd September he sent in two applications, betatron patent no. 2 for 'electric lenses' (no. 927 590) and betatron patent no. 3 for 'pre-magnetisation' (no. 932 194). On Saturday 4th September he signed the application for betatron patent no. 4 for 'counter-magnetisation' (no. 925 004). The holiday was definitely over. In the midst of all this he was working on his next big invention and also managed the following week to send in the Telemark patent, which became legendary.

He had sent off all these five patent applications since coming back from Norway. Only the patent adviser in Berlin knew about this. The Müller factory and Philips the parent company didn't get to know about it. They probably didn't hear about the next patents he took out in Germany either.[13] He registered altogether 13 patents between 1943 and 1945.[14] Nor did the Müller personnel know anything about the patent applications on similar themes, seven in all, that one of their own people, Development Manager Dr. Walther M. Müller, had written and apparently submitted. Things were happening behind the scenes. It was war.

Working from Home

Rolf's working pattern evolved. He found that when he was at home in Oslo he had peace to concentrate on thinking out new ideas, writing reports and lodging patent applications. The work on the betatron continued at the same time, but for the time being his role consisted mostly of design and calculations. Kerst's first betatron was only 2 MeV. Rolf's model was stepping up to 15 MeV, which he considered to be quite a short step. Rolf and his team really wanted to achieve an energy range as high as possible, but they reckoned that by restricting themselves to a maximum power of 15 MeV they could probably avoid some technical problems. It had already been decided in early summer that the betatron they were now building in Hamburg should be a relatively small machine. Building a bigger one somewhere near Mannheim could be considered as part of the next round of development.

During September he prepared a report in which he summarised the most important steps in the development of the type of betatron they were now building. In the report, he starts with his own ideas from when as an enthusiastic student in his twenties he thought of the solution. Now he was twice as old and in the process of realising his dream. Then on 5th October he submitted his fifth betatron patent application of the autumn. This consisted of an addition to the patent for electric lenses from the previous month, showing how magnetic lenses could be used to stabilise the beam path. This would become a forerunner to an important invention he made later; strong focusing, which would be important in the work at CERN when the war was well and truly over and the time was ripe.

Rolf kept his 1943 patents secret. We don't know whether it was the Luftwaffe who required him to do that. He might have kept them secret for his own benefit, but he did apply for German patents rather than

Norwegian. He could have applied in both countries. There is obviously someone who is not supposed to know. But somebody knows something. Brown Boveri are in the know and involved—though not with all the patents.

A Tug-of-War Over the Contract

Rolf soon learns that a German was not just a German. Some were Nazi supporters and some not, but there were also other distinctions complicating the picture. Even though the work was well under way, the contract negotiations between Rolf and the German authorities had still not been concluded. The patent rights were part of the disagreement. High level discussions were probably taking place meantime about Rolf's patent rights and terms of employment. There exists a draft agreement, probably written by Rolf, dated 19th October 1943 and put into legal language by an advocate in Essen. We don't know, however, whether this version was signed. Probably not. We don't even know whether any formal agreement was ever signed.

The draft, though incomplete, is in the form of a contract between Rolf and the 'Schiebold Institute.' The institute was run by a triumvirate of Ernst Schiebold, Theodor Hollnack and Richard Seifert. It worked for Field Marshall Erhard Milch, who was a man of some importance in the Third Reich. At that time Milch had a dual appointment, both as *Generalluftzeugmeister* responsible for armaments and other equipment for the Luftwaffe and as General Inspector of the Luftwaffe. In other words, he was one of Göring's most trusted and influential immediate subordinates.

The draft contract was ordered by Schiebold and deals with the rights and duties Rolf would have from his position as an enlisted foreign worker, someone who has *Dienstverpflichtung durch den Reichskommissar für die besetzten norwegischen Gebiete*, 'service obligation through the Government Commissar for the occupied Norwegian territory.' According to the draft, Rolf would among other things assign all his already submitted German patents and all future patents together with all further relevant technical developments to the full disposition of the institute. The contract would apply for at least three years from when it was signed. Appended to the draft there is a list Rolf himself had made of the six betatron patents he had registered up till then since coming to Germany.[15]

This indicates that Schiebold certainly knew and Seifert and Hollnack probably knew about the patents Rolf had applied for in Berlin. Irrespective of what was included in the contracts, we can understand that it was a difficult balancing act. Not everybody was to know everything, and some people may have had hidden agendas. Major industry has its own ways of pulling strings, and Rolf may have had to make concessions for other reasons.

He subsequently remained silent about the question of the contract, and he said nothing about it to Pedro Waloschek in connection with the biography. Waloschek himself has said:

> I can find no evidence that this agreement was ever concluded.' However, the conditions that are described in the draft correspond with the conditions he was actually living under in Germany. His freedom of movement, for example. The page about payment is missing, but he never complained about his remuneration.[16]

Three Phases

By November, Rolf and his team had progressed far enough with their preparations and preliminary calculations to be able to begin the actual construction of the betatron. During another trip home to Oslo he had prepared a production schedule for the manufacture of betatrons in Germany. This was a four-page document entitled: *Vorschläge über eine möglichst rasche Durchführung von Konstruktion, Bau und Aufstellung des Strahlentransformators*, in other words a betatron plan from A to Z.

He scheduled the work in three phases. The first was to do with the design and manufacture of the 15 MeV betatron in Hamburg. The second phase was to be the design and manufacture of a 200 MeV betatron, and the third and final phase would be the design and equipping of a test laboratory in Ostgrossheim for possibly even bigger installations. He specified the work plan and staffing requirements for each phase. He confirmed that the first phase was already under way at the Müller factory in Hamburg. He explained how the various components of the 200 MeV machine would be made, and that that would take 10–12 months. At the same time, preparations would be made for the research centre at Ostgrossheim so that work on the 200-machine could start there after approximately 12 months.

Rolf was writing with tongue in cheek. He mentioned Ostgrossheim, but didn't name Schiebold. He couldn't do that, because that would be to declare that he knew about aspects of his project that he was not supposed to know about. But he was informed of the existence of the research establishment at Ostgrossheim and must have cleared this with the highest authority, to be able to include it in his plans. There was however a lot he didn't know. One word he soon learned was 'death rays.' Another was 'ray gun.' If he had known the full story, what would he have done then?

Death Rays

It was difficult to know what to make of Schiebold and Hollnack. One was such a fantasist and the other such an ardent Nazi. Indeed, they both appeared to have strong Nazi traits. It was Hollnack who had introduced Rolf to Schiebold the physics professor, just as he had put him in contact with Seifert. This was a remarkable acquaintanceship. Rolf was officially not supposed to know about the top-secret arms projects, but Schiebold was responsible for the research centre that was under construction at Ostgrossheim, and he can hardly have kept the reality of this concealed from Rolf.

So Rolf did know about Schiebold's big death-ray project, the idea of creating a massive X-ray canon that would secure victory for Hitler. Formally, this was the project Rolf had been brought in to work on. The betatron was part of the whole plan. So he understood why the Luftwaffe was interested in his betatron. Ernst Schiebold was the brain behind it, the man with the wild idea of a death-ray weapon.[17] Schiebold was a specialist in X-ray testing of materials, and it was he who had launched the idea of using X-ray guns against enemy aircraft. The idea was to create an X-ray tube with high enough voltage to generate high-intensity rays even at a distance. Thus it should be possible to kill the enemy pilot or detonate the bombs the plane was carrying.

Schiebold's death-ray project was motivated by the same vision that inspired the Peenemünde project with its almost impossible levels of human and economic investment, the V1 and then the V2 rockets. Urged by a combination of desperation and war propaganda, Nazi Germany put its trust in another wonder-weapon, Schiebold's death rays. To eliminate enemy planes before they approached their target would be the dream of any air force. The idea of silent, invisible rays from the world of science fiction fascinated not only Göring in World War ll but also Khruschev and Reagan in later times. Reagan's *Star Wars* project was based on the same ideas about long-distance rays that underlay the German war-machine's project. Scientists with varying levels of belief and loyalty were part of Schiebold's organisation, and it was a curious irony that the regime's plans were dependent on many of their scientists, many of whom were Jews, being released from forced labour or set free from the concentration camps.

However, Nazi Germany was not first in coming up with the idea of mysterious, fatal rays. An Englishman had suggested it in 1935 with a proposal for strongly focused electromagnetic rays.[18] Every child who has played in the sun's rays using a magnifying lens to set paper on fire understands something about the strength of concentrated radiation. But from igniting a scrap of paper to striking down a plane from the sky is a big step. The English soon abandoned the idea as beyond technical possibility. Then several years later Professor Schiebold worked tenaciously to convince his colleagues and the authorities about the feasibility of his X-ray canon. He succeeded in persuading the key people in the Luftwaffe, and that led to Rolf being recruited to Germany.

How It Began

It had all started on 5th April 1943, several months before Rolf arrived on the scene that summer. Göring's right-hand man, Field Marshall Erhard Milch, received a strange note in which Professor Ernst Schiebold from Leipzig made a formal proposal 'for the attack and destruction of enemy planes and crew' with the help of 'X-ray and electron beams.'[19] The full title of the note is even more elaborate and striking in its tone. The content was comprehensively presented and formally everything appeared to be in order. Schiebold was known both within the Air Ministry and to Milch personally, having previously carried out assignments for the ministry. He was a specialist on X-rays, though not specifically on X-ray tubes.

In the memorandum, Schiebold described different types of radiation and ways of generating high beam energy, for example using a cyclotron, but he didn't specifically use the word 'betatron.' The goal he suggests is ambitious; a weapon that would be able to strike aeroplanes from a distance of many kilometres. This would require high energy, and to achieve that would require more research. Schiebold also provided a list of the types of specialist he would need. The first he named was Richard Seifert with his own company in the X-ray and electrical industry. Rolf is not named. The proposal was wild but alluring, and it captured the attention of the people to whom it was addressed. The first official meeting about the project was held in Hamburg as early as 17th April, when Seifert presented a three-page report claiming that it should be possible to develop the weapon within one or two years. Time was vital.

Two days later Schiebold wrote a five-page supplement, and two or three weeks after that he had been awarded the contract and provided with 150,000 Reichsmarks. The project was to be based at the Luftwaffe airfield at Ostgrossheim. By the following day, 20th April, he was given the opportunity to give an oral presentation of his big idea to Theodor Hollnack, whom he knew from a previous research contract. Milch gave full authority. Schiebold followed up with several more supplementary notes, and the project was under way. Obviously top secret. With Schiebold as scientific head, Seifert as technical adviser and Hollnack as administrative manager. However, it was not so secret as to prevent many people knowing about it, not least because Schiebold couldn't hold his tongue. Important physicists such as Arnold Somerfeld and Werner Heisenberg were among those who knew.

Components for the manufacturing site were ordered from Siemens, who made some themselves and had others made by Osram, which was part of the Siemens Group and still had some links with the Löwe company in Berlin. There was also a connection with AEG, who collaborated with General Electric in the USA, so far as this was possible during the war.

There was also a personal background to Schiebold's project, which enhanced the drama and made it even more important for him to succeed. He had previously managed a semi-official research institute at the University of Leipzig, which had been razed by the Allied bomb attacks. His house had also been destroyed. He lost nearly all his equipment and probably also the documents relating to the X-ray cannon and all the correspondence he had had with Seifert, Hollnack and Widerøe. He was left standing on bare ground, without a house and without any base for his work.

Then Schiebold turned his attention towards Ostgrossheim in northern Bavaria, quite a small town 45 km. south-east of Frankfurt. He and his colleagues took what little was left of the research institute and built up a new laboratory in temporary, bunker-like locations on the abandoned military airfield there. The main hall was completed by New Year 1944, ready for the 15 MeV betatron to be installed there once it had been built at the Müller factory. An unused X-ray apparatus was brought from a hospital in Hamburg, to be used for experiments in the meantime. Hollnack arranged the finances. Great things were to happen here. The Luftwaffe's researchers were on the offensive.

Even though much was kept secret, Rolf gradually learned more and more. Much later, when asked directly whether he knew when he was taken to Germany that the betatron was to be used in connection with weaponry, he answered ‘No.’ Quite the contrary, he was led to believe that it was a civil project.

> I didn’t suspect anything at that time about the business with Schiebold and that it was the anti-aircraft weapon that was the basis for the project. I didn’t know anything about that either, because it was so terribly secret. I was not allowed to hear anything about that.[20]

He repeated that in the biography:

> In any case, I didn’t know at that time that anybody would want to use betatrons as weapons. I wouldn’t even have believed it was within the bounds of what was possible. They obviously had a strong argument: they wanted to overtake the Americans, irrespective of whatever other use betatrons would later be put to. The official line was that all this was being done to develop new and better X-ray apparatus for medical use and for non-destructive testing of material.[21]

So whom should we believe? There are false explanations, hidden agendas. Add in a dose of mystery, a dash of wishful thinking. Spectres shimmer in the light of day. Some of the mixture is not mysterious at all, just propaganda. People going their own way appear so trustworthy that nobody suspects them of anything. Some overstate their case to the point of incredulity.

Who is who? What is real? Whom can we trust?
This is war.

Schiebold on the Carpet

A new person trusted by the ruling powers came into the picture. There is reason to take note of this man, whom Rolf mentioned several times in interviews. Professor Walther Gerlach was given responsibility for all nuclear physics and for the secret German atom project run by the ‘Uranium Club’ consisting of carefully selected researchers. In addition, and of particular relevance in Rolf’s context, he was chairman of the management board of the Luftwaffe research station at Ostgrossheim. The board was responsible for supervising Schiebold’s activities. The other members of the board were Hollnack, Heisenberg, Egerer, Geist, Esau, Fennel, Georgii and Seifert.

Quite soon, things began to fall apart. The chairman was uncertain about the development of the radiation project and turned to Professor Helmuth Kulenkampff for advice about what he called a 'top-secret' project. Kulenkampff, who had been Gerlach's Ph.D. supervisor, scrutinised the ray-gun idea in detail. He found out that the radiation did not seem to be as Schiebold had presented it. For example, it would be impossible to use the weapon at the range that had been claimed. Kulenkampff's severe criticism of the project reinforced Gerlach's doubts. As they both agreed, Kulenkampff sent a letter to the highest relevant authority, Field Marshall Milch. This was a brave move, as it showed that the chairman had failed in his obligation to keep it all secret. However, Milch replied with a personal letter expressing thanks that somebody had shown courage and come to such a clear decision about the matter.

Walther Gerlach was a key figure in what happened next. Along with Werner Heisenberg he was one of the most influential scientists in the Uranium Club. His record in the politics of research shows that he was also an important worker for Nazi Germany. From 1st January 1944 he was head of the physics section of the National Research Council and the council's agent for nuclear physics. Under the jurisdiction of the council there was a special group set up to be responsible for research in physics, with significant input from the electrical industry. So it was no surprise that energetic and efficient Gerlach was also appointed chair of the management board of the Luftwaffe's research establishment, the high voltage installation from which great results were expected not only in biology and physics but also and primarily in the form of the radiation gun.

When the National Research Council was set up a couple of years earlier, the purpose had been to bring all research together, both basic and applied. After a while, Marshall Göring became president, with the idea that he would govern the research with the same discipline and effectiveness as he governed the air force. At the same time, the council was moved from the education department to the national department for munitions, where Albert Speer who had taken the initiative for the re-organisation was himself the minister. These changes were a turning point for National Socialism's relationship to science and particularly to Jewish researchers. Till then, there had been a sort of tacit agreement that Jewish researchers must not be sent away from Germany, because the nation needed their expertise. No such grace would be shown now; Jewish scientists should be removed.

Interrupted by the Air-Raid Sirens

At the Müller factory in Hamburg, the construction of the betatron continued. Some of the equipment was supplied by Seifert's company and some by Brown Boveri. The realities of war did however impede the manufacturing process. When the sirens sounded, everybody had to go to the air-raid shelter, and the vibrations caused by the bombing were a problem for the sensitive apparatus. In the shelter, there was not much to do other than to think and to let imagination run. Always calm and positive, Rolf described this as good thinking-time. So the time in the cellar also had its advantages, or as he later expressed it laconically: the war gave him the opportunity to spend a lot of time meditating about how to improve the accelerators and thinking out new ideas. But he doesn't conceal the fact that when they came up again they were always worried about whether there was still a vacuum in the tube they had been working on when the alarm sounded.

It soon became clear that the size chosen for the betatron was correct from a technical point of view, as Rolf had thought. By restraining themselves from going for a higher voltage, they avoided some problems. Another reason was that the level of radiation in the laboratory was sometimes quite high, which could cause difficulties. On 8th February he presented a secret report both about the present betatron and about the plans for the future, massive one.

Around him, however, things were slowing down. Already towards the end of February, possibly on the 22nd, Gerlach called a meeting of the Ostgrossheim management board. As leader of the research centre, Schiebold was not a member of the board. Neither was Kulenkampff or Rolf. They could only attend when invited, but they did have the right to speak. They were at the meeting in February, where Kulenkampff was clearly critical of Schiebold's project. His criticism was set out in a written document presented to the board members, but Schiebold himself was not given a copy. He had just prepared a general progress report for the board and he was completely surprised to learn that the board was putting a question mark on his project. Admittedly, he had got into a quarrel a few days before with one of the board members, Georgii, who was also in the Luftwaffe's research management team. That was a warning, but not sufficient for him to take seriously. In a letter to Georgii on 29th February, Schiebold tried to explain the situation and expressed a hope that the disagreement would blow over. But the criticism at the board meeting created unease about the whole project, and Rolf's 'minder' in the system, Hollnack, began to sense the uncertainty.

Schiebold was informed that his institute could only remain in Ostgrossheim until further notice. The deadline was set for 1st April 1944. By then, his *Institut für röntgengen ologische Roh-und-Werkstoff-Forschung* would need to be out. Eviction was bad enough, but worse was the loss of prestige in not being the first person to know about it. It began to dawn on him that he no longer had full support and that he would need to do something to show his strength. On 4th May he wrote a new, enthusiastic account of Rolf's betatron, plus a comprehensive ten-stage work programme for the research centre at Ostgrossheim.

Another Setback for the Death-Ray Project

Gerlach immediately called a two-day board meeting in Berlin, at which the programme was cut back. Schiebold's plans for a death-ray canon were declared impractical and cancelled. Rolf's project, on the other hand, was not subjected to criticism. Many of the contemporary documents from this period are no longer preserved, but we know that there was an important meeting on 6th May and that in addition to the board members, Rolf and his colleague Schumann took part, plus Kulenkampff, Schiebold and two others.[22] As chairman, Gerlach made a note for his own use, both of this meeting and of a later meeting on 15th August. The note is dated 25th August. No other reports have been found, and Gerlach's note is not an official minute, just a personal view. Schiebold's son has later made available a photo of the six pages that Schiebold took with his own camera. Put briefly, the content asserts that Schiebold's project didn't measure up.[23]

Schiebold had been given a final extension of his deadline to 12th July to produce further calculations to try to prove that he was right. Messages went back and forth. Kulenkampff was still not satisfied. In addition to Professor Gerlach, several others began to admit that they had been sceptical. Heisenberg and Sommerfeld had also thought for some time that what Schiebold was asserting about death-rays was unrealistic. They were both experts in applied physics, looking at the matter from a practical point of view, but the theorists, such as Rolf's assistant Bruno Touschek, were tending in the same direction and three of the experts at the Müller factory have later said that they had thought right from the start that Schiebold's X-ray cannons were unrealistic. In their eyes, Schiebold was just a pompous eccentric with some high-flown and politically correct ideas. They had only been interested in the project because of the prospect of working on a contract that had been assigned high priority for the war effort.[24]

Kulenkampff led the way with his criticism, and his assessment then influenced Seifert and Hollnack, who had initially felt positive towards Schiebold's proposal. Both were now distancing themselves from the original plans. The board confirmed clearly that they wanted to proceed with the other parts of the contract. The grand project for which Rolf had been recruited was now torpedoed, and its author out of the picture. But Rolf was to continue, not with death-dealing rays but with life-giving rays, as Pedro Waloschek put it. Rolf's project was secure.

Schiebold's motives for wanting to build a death-ray weapon are unclear. Was he perhaps just a mad scientist wanting to exploit the situation to make his name with his own weird invention? For a fair and balanced judgement, we must recognise that he was originally a serious and respected physicist. The question is whether he really believed in the wonder-weapon himself, or whether he was using it as an excuse. The answers to these questions remain obscure. We may also wonder to what extent he regarded Rolf as a member of his team and to what extent Rolf was 'part of the package' in advancing his plans.

This was Rolf's explanation, many years later:

> Most people thought that this was an example of a relatively harmless man, without doing anything wrong, thinking that there could be something, if not exactly practical, that he could do so that he could perhaps get a little money, so that he can do some research. So they had expressed themselves a little vaguely about this project. Enough of that, he went to the Luftwaffe and said: "Here is a machine that can shoot down planes. We've got the death-ray. Alternatively, we can detonate the bombs up in the plane if we send enough energy up there, or we can kill the pilot or render him unconscious or something like that." The air force supported the idea, and they built a research establishment that they set up on a little airfield near Frankfurt. I don't remember what it was called, but I can find out.[25]

More Betatrons

The fact that Schiebold's project with the special X-ray tubes was finally stopped didn't mean that the Luftwaffe lost interest in high-energy radiation. Far from it. Gerlach, the national research council's agent for nuclear physics, was keen to continue and more projects followed. Siemens also had betatron projects financed by the national research council. Just a few months after the American, Donald Kerst, achieved his goal of building the world's first betatron, Siemens had already started on their first. Two further contracts followed soon after, to begin the research and development work on a rather bigger betatron, 20–25 MeV, and to start planning for a 100 MeV version. So in spring 1944 Siemens was working on three betatron contracts for the Luftwaffe. These were long-term projects considered as investments for when the war was over. Gerlach no longer thought that there would be any military use of betatrons to generate death-rays.[26]

There were also several other projects going on, though they never came to completion. In autumn 1943 the national research council had awarded Heinz Schmellenmeier in Berlin a contract to build a small, 1.5 MeV betatron for medical use. He had his own history in relation to the war. He had worked to oppose the Nazis ever since 1935 and had been in prison for several months because of his illegal activities. To avoid being conscripted into the army, he had started a private military technology company, Dr. Schmellenmeier's Development Laboratory. One of his fellow-workers was Richard Ganz, who was of Jewish origin and whom the Nazis wanted to catch. Ganz was what was described in those days as 'a privileged non-Aryan person,' and Schmellenmeier almost certainly saved his life by employing him on the project when he was already on the list of Jews destined for the concentration camps.[27]

Two others, the later Nobel Prize winner Walther Bothe in Heidelberg and a colleague, had ideas for a 10 MeV betatron but never got it beyond the planning stage. Bothe was an important member of the Uranium Club, and together with his assistant Wolfgang Gentner—with whom Rolf would later work on the plans for CERN—he had constructed the first German cyclotron, a forerunner of the particle accelerator. The cyclotron was put into use in Heidelberg in autumn 1943. Bothe told Albert Speer that the machine was for medical and biological research. In later years, Rolf came into contact one way or another with all these pioneers of accelerator development.

Time up!

The very final deadline for Schiebold's death-ray fantasy had expired. He had produced a 41 page document in response to Kulenkampff's critique, but it was to no avail. Gerlach invited him to a meeting on 15th August 1944 in Ainring in the very south-eastern corner of Germany, at the institute headed by Professor Georgii. Also invited were the physicists Heisenberg, Kulenkampff and Seifert plus another from the research council, plus Geist. At least four of them, if not all, could be said to be also representing the authorities. Heisenberg was unable to attend, and Colonel Geist sent Schumann in his place. It is unclear whether Rolf was there. The main conclusion of the meeting was that there was no indication that Schiebold's plan could be of military use. This had long been the perception, and administrative measures were now set in place following the decision. Schiebold had not fulfilled the obligations as documented. This was now formally confirmed.[28]

A final meeting was held and sharp letters exchanged. Schiebold responded to the criticism on 20th September with an angry 15 page declaration in which, among other things, he referred to his mandate from Field Marshall Milch. This stimulated an equally forceful reply from Kulenkampff. All Schiebold's followers had deserted him. It was obviously no advantage to him that his original excuse, Milch, had gone—dismissed first from his position as Secretary of State in Speer's ministry in June 1944 and then in January 1945 from his position as Inspector General of the Luftwaffe.

Rolf tells us that he was present at this last meeting, which was held at the institute in Berlin where Heisenberg was a professor:

> In autumn 1944 I was invited to a meeting at the Kaiser Wilhelm Institute in Berlin, in an amazing garden and with many physicists present. I think it was Heisenberg who had convened the meeting – or maybe Gerlach. This was an exclusively scientific conference, where we spoke freely and said exactly what we thought. As there was nobody there from the Gestapo, nothing was kept hidden.[29]

Pedro Waloschek is not so sure that Rolf really was allowed to attend the whole of this important meeting, and says that on another occasion Rolf had told him that he was only allowed to attend certain parts of the meeting and that he spent the rest of the time strolling in the garden. Rolf may have mixed his memory of this occasion with recollections of the meeting he had attended on 6th May when the issue came to a head. However, he undoubtedly understood the implications of the outcome of the meeting both for Schiebold and for himself:

> Everybody was in agreement about dismissing Schiebold's fantasies as unrealistic. However, the meeting confirmed that the betatron was a very interesting

> machine, both for medical use and for future nuclear physics research. The hopeless ”secret project” of shooting planes down with X-rays from betatrons was then (or perhaps even before this meeting) completely abandoned. However, the development of betatrons was to continue. The official basis that this was an important medical development could be retained.[30]

That is what Rolf says in the biography. In the interview with the physicists in Oslo he was invited to expand on what he had said about his part of the project being approved to continue. He was also asked if the discussion at the Kaiser-Wilhelm Institute really was entirely scientific and not political:

> Yes, purely scientific. And it was an absolutely great and OK meeting where everybody said what they thought. I mean, there was nobody from the Gestapo nor anything secret about it.
>
> *The death-ray project was abandoned at that meeting, wasn't it?*
>
> Yes, completely dropped.
>
> *But the Luftwaffe, did they then drop their support for your project?*
>
> Not at all, we were to go on building our machine. We were to complete it, and that was how things stood. It didn't really cost a lot of money, and anyway money wasn't an issue in Germany at that time.[31]

By May 1944 Rolf had progressed far enough with his project to begin commissioning the betatron as planned. It worked! The radiation intensity was not very high to begin with, but eventually the measurements showed that the radiation produced had an energy level between 12 and 14 MeV. So they were approaching the goal of 15 MeV. The team succeeded in attaining this during the summer. The first European 15 MeV betatron had been built, and Rolf was proud of what had been achieved. In addition, and possibly even more significantly, they had moved up into the same class as the Americans and could consider themselves on a level with Kerst and his betatron number two, which accelerated to 20 MeV.

Components for two betatrons had originally been ordered from the Müller factory. The first was to be used just to investigate the properties and possibilities of such apparatus. The second was for medical use. All further work with the betatrons would now be in connection with the expected advances in medicine and in nuclear physics research. Milch and Schiebold were out of the picture, but Seifert and Hollnack had full authority from the Luftwaffe to take Rolf's plans forward. So he was saved. Gerlach obviously had no objection to the Luftwaffe continuing to support the building of Rolf"s betatrons; in fact quite the contrary. Several of the members of the now dissolved Ostgrossheim board were in the air ministry and agreed with their former chairman.

But was the Luftwaffe really interested in making medical equipment? Or was that just a pretence? One possible interpretation is the simple principle that one part of the project should not necessarily be abandoned just because another part didn't measure up. The agreement, even though we don't know whether it was ever formally signed, was for three years. So in relation to that, the employment should continue. One can also think of more sinister explanations. Whatever the answer, work on both the Siemens betatron and Rolf's Brown Boveri betatrons continued.

At Peenemünde, the work on the new rockets was also continuing. On 6th September the first V2 rockets were fired on London. The war was in its final phase.

Heads Roll

From 20th September, Schiebold's name disappears completely from anything to do with the X-ray cannon. It is not found anywhere in relation to later work for the Luftwaffe.[32] From October 1944 the Luftwaffe's research station at Ostgrossheim no longer existed; it disappeared with Schiebold. However, not everybody was against him. Karl A. Egerer, the editor of the journal *Archiv für Elektrotechnik* published by Springer, had good contact with Schiebold. There is evidence for this in several letters, including one where he comes to Schiebold's defence, saying that Schiebold alone cannot bear the responsibility, as he had other scientists working with him. From the letters, it is evident that Egerer agreed with the technical advisers and the people who were close to Milch. Egerer mentions among other things that it was he who had got Milch to include Rolf's ideas in Schiebold's original research project. This confirms that there was a close relationship between the editor and Milch.

Does the solution to the mystery of the disappearing article—the one that was never published—lie here? When the editor received Rolf's second article, did he take it straight to Schiebold so that it was then stamped 'secret' and became part of the Luftwaffe's radiation project? Or was it perhaps not the editor who stopped it from being published? Moreover, why did Rolf not do anything to find out why it was not published? Or did he make enquiries that he hasn't told us about? Perhaps he even found the answer. There are still many unanswered questions, and some of these are connected with his brother's imprisonment.

A Visit to Viggo

Viggo had been moved to Rendsburg prison camp, near Kiel. Rolf visited him there; was able to meet him face to face. Viggo was not in a good way. He was exhausted and looked ill; probably a combination of malnutrition and pneumonia. Rolf's contacts had obviously not had enough influence to have his brother released. They may have done what they could, but at any rate it wasn't enough, he maintained. He hasn't said anything about how much they had managed to have Viggo's conditions improved, but Viggo had been given slightly better food and after a while he was sent on to a camp near Darmstadt where he was allowed to work out in the woods. Rolf thought that this helped him. Prior to the term in Rendsburg he had spent a couple of years in Fuhlsbüttel in Hamburg. Finally, he was sent to Dreibergen and then Dieburg where he remained until he was liberated by the Americans in March 1945.[33]

Nor does Rolf say anything about how he came to be allowed to go into the camp to visit his brother; whether the Germans saw the permission as a gesture of good will or were using it as a threat. It was hardly a random event. On the contrary, it suggests that the Nazi authorities were playing a game with the brothers. Afterwards, Rolf reported that he had visited Viggo, but he didn't embellish the misery and he didn't admit to whatever impact meeting his brother had on him. It is also uncertain whether Viggo knew at all that his brother was in Germany, when Rolf suddenly appeared in the camp. Prisoners in correction camps were subject to stricter rules than other prisoners, with longer intervals between being allowed see visitors, receive packages and letters or write to their families.

Two brothers in their forties, who had grown up together in a wealthy Oslo suburb; played with electric circuits that short-circuited leaving their German grandmother sitting upstairs in the dark; who had done ski trips together in the hills and woods around Oslo; who as youths had drunk beer with classmates during Easter holidays in the Alps; founded an airline together; married and raised families in parallel; settled in the best quarter of West Oslo; each made a career in his own sphere.

They have not seen each other now for two or three years, and here they are meeting in Germany, in a correction camp—one a prisoner of the enemy and the other an employee of the enemy. Viggo had little reason to believe anything other than the worst as he sat in prison, and it would not be surprising if in pure frustration and despair he just asked his brother to go away. What we do know is that in a letter home Viggo wrote that Rolf must never again visit him in prison. The sudden appearance of his brother, immaculately clad in suit and overcoat, might well have disturbed Viggo in his prison clothes and miserable circumstances. Whatever the two brothers may have felt, it would be naïve to think that the German authorities had not somehow and for some reason engineered the visit.

Industry on the Offensive

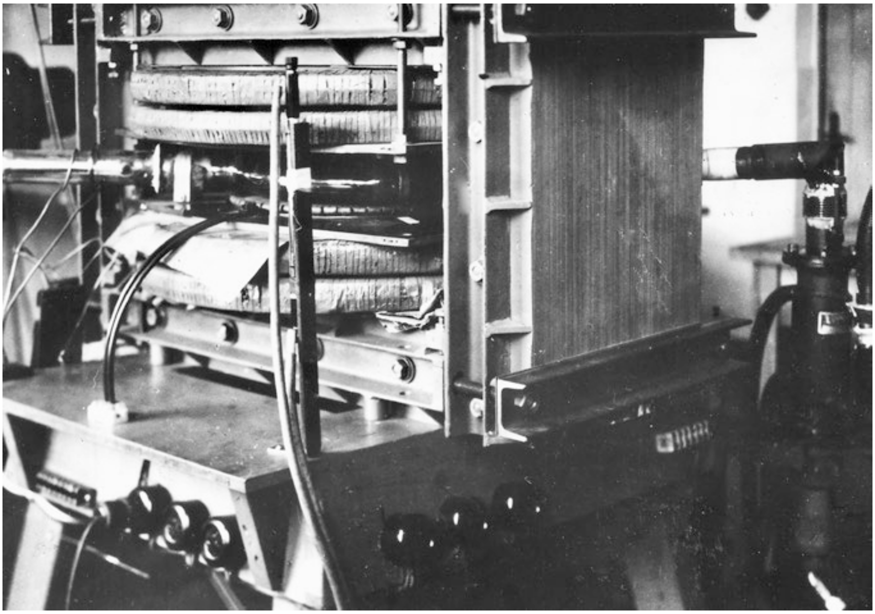
Brown Boveri had received the preliminary order for the construction of the 200 MeV betatron, and a new meeting was held in Heidelberg in October 1944 to discuss the plans. The meeting discussed the progress made both by Gund at Siemens and by Rolf at Philips/Brown Boveri.

Siemens had already been working for a long time on the construction of their first betatron. Rolf had a certain amount of contact with the laboratory in Erlangen, and he visited them on several occasions, one of which was in November 1944. They exchanged their experiences of their respective machines, but for several reasons Rolf thought that the Siemens machine would not work very well. He was particularly concerned about the material used to make the vacuum tube, a ceramic material which was a good heat insulator but which he thought was not suitable. He preferred to use a boron-silicate glass that was more resistant to damage from heat. They also discussed the question of frequency, where Rolf thought that he had managed to convince Gund that they were using much too high a frequency.[34] Rolf later admitted reluctantly that Gund had in fact already got such a machine to work in April. Pedro Waloschek thought that Rolf was always critical of Gund and was unfair to him on this point.[35]

But why were the German authorities so enthusiastic about building betatrons, and in several different places? One theory could be that Nazi Germany was playing the industrial interests of Siemens and Brown Boveri off against each other. They may have been so desperate that they backed both in order to see who delivered the goods first. They can hardly have wanted to build the machine for purely medical reasons. One of the many confusing bits of the puzzle is why Rolf visited Siemens to see the betatron Konrad Gund was working on. Why would he help Siemens by guiding them and setting them on the right track? Was he just genuinely interested and keen to help? We just don't know.

At the Müller factory, work on Rolf's betatron was going ahead at full speed. On one occasion they were visited by Professor Gentner from Heidelberg and the man who had put a stop to the death-ray project, Dr.

Kulenkampff, who praised the results. By autumn 1944 work on the machine had progressed far enough for Rolf to leave the rest to Kollath and Schumann, with Kollath as scientific leader. Schumann's role was always more diffuse, possibly more political, but both were very able physicists. They dealt with the remaining calibrations and eventually published several papers, including a comprehensive report in *Zeitschrift für Naturforschung*.



During his stay in Germany during the war, Rolf Widerøe built his first betatron, a 15 MeV machine that the Allies later took as war booty. (*Courtesy* Smithsonian Institute, Washington DC)

When Rolf told about this in his biography at the age of 90, he added that he had now finished the job and could go home. In the interview with the physicists he said that 'I got permission to go home.' The date for his departure was set for January, and we can sense in his words an awareness that the war was drawing towards a close:

> (…) in the course of that autumn the apparatus had come so far that one could say that it was ready for use. But at the same time the English were coming nearer and nearer to Hamburg, and this was well into the start of January 1945, so I got permission to return home, my job was done, and Kollath took over (…).[36]

It is difficult to say whether he had already planned to go home then. Another question is whether he had been given permission. The noose around Germany was tightening, and there was a question of how long it would be safe to keep Rolf's betatron in Hamburg.

Hollnack Recruits a Courier

In December yet another name appears in the list of people implicated in the authorities' handling of the Widerøe project. Rolf's administrative superior, Theodor Hollnack, came in contact with an apparently beautiful young man going by the name of Jan Gerrit Overbeek. They first met in a hospital in Marburg, and Hollnack appointed him as his personal courier. The story of how he was recruited to the job sounds like something from a spy novel with undertones of homosexuality.[37]

A 17 year old Dutch sailor in hospital in Marburg said that he had signed on a cargo ship in Duisburg but that he didn't want to go back there. A man came to chat with him and found out that he liked to read. The man offered to give him a book by Nietzche, which he brought the next day. The book was Nietzche's 'Thus Spoke Zarathustra.' He wished the boy a good recovery, handed over the book and left. Inside the book was a handwritten note saying that the boy should report as soon as he was discharged from the hospital and he would see what he could do for him. The note was signed 'Theodor Hollnack, Barracke Mittelfeld, Dillenburg/Dill.' This was a department of the air ministry. The piece of paper was headed: *Der Treuhänder des Metallurgischen Forschungsinstitutes des Reichsluftfahrtministeriums* ('Trusted member of the air ministry metallurgical research department').

On his discharge a few days later, the lad took a bus to the specified address. Hollnack was not there himself, but he had left instructions. Overnight accommodation had also been arranged. The young man should hold himself in readiness, and Hollnack would call when he needed him. This was all he had to do, for a salary of 400 reichsmarks per month. His colleagues were friendly and helpful and didn't know what sort of tasks Hollnack had recruited him to carry out. The former sailor knew nothing about the business either, and Hollnack forbade him to take up personal relationships either within or outwith the office—especially with young women.

The sailor travelled around a lot with his boss, who drove round in an *Opel Kapitän*, and on these trips they talked a lot together. He learned that Hollnack was from a Prussian officer's family, that he had previously been a flying instructor and that his immediate superior was Field Marshall Milch, who at the end of 1944 still had a certain amount of power. Seaman Overbeek is the same person as the author Jakov Lind, who many years later in his autobiography described the man who recruited him thus: 'He had short hair and a not unsympathetic face. Brown eyes and a rather short, squashed or high-arched nose.' He also wrote that he thought Hollnack looked like a senior official with his dark blue suit, white shirt and dark tie.[38] In the book Lind, alias seaman Overbeek, not only changed his own name but also changed 'Hollnack' to 'Kolberg.'

Pedro Waloschek has said that he was in contact with Lind later, and that Lind had confirmed both in letters and in telephone conversations that the person he described was Rolf's superior and his link to the authorities. And the 17 year old in the hospital, who later became a well-known writer in England, was not really Overbeek but the Jew Heintz Landwith, born in Vienna and sent by his parents on a kindertransport to the Netherlands as an 11 year old before they emigrated to Israel. In Netherland he had acquired false papers under the name of Jan Gerrit Overbeek, and after the war he changed his name again, to Jakov Lind.

At about the same time, in November or December, another young man was arrested by the Gestapo. This was Rolf's assistant, the physics student Touschek. He was accused of having been a frequent visitor to a library at Hamburg Chamber of Commerce where he had been observed reading foreign newspapers and magazines. He had also behaved recklessly and provocatively, for example by turning pictures of Hitler upside-down so that the Führer was standing on his head. The Gestapo discovered this and also found out that he was half Jewish. So he was arrested and imprisoned in Fuhlsbüttel, not far from the site of the Müller factory, the same prison where Rolf's brother had been when he was first brought to Germany.

Siemens Joins the Race

The international research competition was speeding up. While Rolf was proof-reading his article for *Archiv für Elektrotechnik* early in 1943, the physicist Max Steenbeck had announced the results of his attempt to construct a 1.8 MeV betatron in an apparently secret Siemens project. He claimed that he had been able to accelerate electrons to this level ever since the mid 1930s. He explained how he had thought this out, and said that he had applied for several patents. Steenbeck's findings were printed in the journal *Naturwissenschaften*, and Rolf extended his article to include a commentary on this. He also referred to the fact that Steenbeck had largely mapped out the way to get electrons to follow a stable track.

Steenbeck knew of Rolf's doctoral thesis from 1927 and had used material from it. Rolf had at that time thought about patenting this discovery, but he was busy with other things, not least the relays he was developing, and so he hadn't got round to registering a patent. Steenbeck had faced some of the same problems as Rolf in stabilising the course of the electrons. Rolf had not said anything in his thesis about the conditions for stabilising the electrons, but already in his time as a student he had laid out in his notebook a practicable theory about this, which he rather surprisingly did not subsequently make use of himself.

Siemens regarded the betatron as a German invention which Steenbeck and his boss (who was of Jewish origin) had patented for them in 1933. Siemens had made it possible for Steenbeck's colleague to leave Germany on a commission for them, and Steenbeck had then continued the work alone.[39] Many people thought that Steenbeck should be recognised as the inventor of the 'stabilising condition' because he achieved it in practice before Kerst, even though with a much smaller machine.

In research, however, every step is built on top of another. Even Steenbeck was not the first. The Englishman T.S. Walton had come across the same formulation from a slightly different direction, and we can therefore say that he was the real inventor of the stabilising condition. That happened in 1929, two years after Rolf's doctorate. But Steenbeck's theories were easier to understand, and his name still appears in the history books as the discoverer. Steenbeck had also been early in the field with similar thoughts to the American, Lawrence, and had worked on a 'synchro-cyclotron.' He wrote a paper about this for the journal *Naturwissenschaften* but it was apparently never published, allegedly because of a misunderstanding.

Siemens' wartime interest in Steenbeck's patents was primarily in what manufacturing licences might stem from them later. Steenbeck landed a rather modest commission in the first phase, for a small research model that he had to promise to keep strictly secret.

War on All Fronts

Because of the armaments race, even Steenbeck had to adjust to accepting military research objectives for his work. At the start of the war his work on the betatron was cancelled by the company management. The following year, Kerst completed his first betatron with the support of General Electric and on 13th November 1944 he submitted a patent application in the USA that was remarkably like the application Steenbeck had submitted in Germany. In Europe, however, Kerst's invention went practically unnoticed.

So General Electric ought to have asked Siemens for permission to use Steenbeck's patent that was based on the designs that Gund had used at Siemens. Steenbeck gave a different version of this. He claimed that the licence was given to Westinghouse in 1941 and that Kerst knew about the patent before he had reached his goal. But the licence didn't count for anything, because all German patents were confiscated immediately after the war. By the time they were given back and current rights could legitimately be used, most of them had already expired.[40]

Rolf has said that he was present during the rights negotiations in Mannheim and Karlsruhe in 1954 when Brown Boveri was required to pay Siemens about 100,000 DM for use of the patents.[41] Before the end of the war Siemens had registered a series of patents that were considered very interesting. An American report summarising the situation in Europe in the accelerator field shortly after the war lists a total of 14 important technical ideas that had been patented.[42]

Pedro Waloschek, who has studied both Siemens' and Brown Boveri's work on betatrons during the Second World War, thinks that the two companies did have different aims, even though both were supported by the Luftwaffe and both were allocated resources labelled 'for important war research.' He also thinks that the Siemens betatron was originally more directed towards medical use than Rolf's:

> Gund's accelerator was designed for a completely different purpose from Rolf's betatron. Possibly under the influence of Schiebold, Seifert and Hollnack, Rolf

> constructed his apparatus mainly for the production of what are called 'hard' X-rays as used mostly for materials testing and possible military applications and less for medical purposes. Gund, on the other hand, responded fully to the medical requirements that Siemens had set. Medical researchers hoped to use suitably fast electrons to reach into deep-lying tumours while causing less damage to the overlying tissue.[43]

Waloschek believes there is evidence that Gund's little betatron was not only the first working German betatron but also the first to be used for scientific work. He claims that the original objective, to draw electrons out of the machine, was attained in 1947 and that the machine seemed remarkably stable and reliable. Irrespective of the original reason for developing betatrons, the later results would depend on the situation. And whatever use was intended, the overall commercial objective for both companies was to make money.

Interest in Siemens' projects spread. Another physicist, Wolfgang Paul who later got the Nobel Prize, had also become aware of the possible uses of betatrons from reading about Kerst's machine and understood clearly that it was a hopeful development towards the German air weapon.[44] Along with his co-worker who was a professor of nuclear physics and a member of the Uranium Club,[45] he intended to bring about great things:

> We planned that as soon as the war was over or the political situation was suitable we would build such an accelerator. When we then heard that at Siemens they were currently building an accelerator for medical use, we offered our help with the testing. I then taught myself the necessary electronics and nuclear physics, built up the apparatus for this in Göttingen and did the first measurements in Erlangen in summer 1944.

Wolfgang Paul and Rolf Widerøe at an accelerator conference in Hamburg 1992. Professor Paul shared a Nobel Prize in Physics in 1989. (*Photo* Pedro Waloschek)

So finally it was nevertheless the Steenbeck/Gund project that was the big thing for Siemens and that also drew in other expertise in the field.

Medical Use

It is difficult to know when Rolf began to think of medical use for betatrons; whether it was before, during or after his stay in Germany during the war. We must remember that what he says about this does not always correspond with reality. One of the people Rolf met at the Brookhaven Institute after the war in connection with the setting up of CERN wrote in an article on the history of accelerators that Rolf had made a convincing impression. He 'spent the war years in Berlin' where he had worked on betatrons. 'The Germans supported this work because Widerøe had convinced them that it would be useful for generating death-rays.'[46]

It is difficult to decide from this whether Rolf himself believed his invention could be used as a weapon, or whether this was just something he had let the Germans believe in order to get support for his project. One of the points of detail in this article is that Rolf was said to have lived in

Berlin during the war, and this has also been claimed by others. Based on impressions from the biography and elsewhere and from conversations with Waloschek, it seems that he lived in Hamburg but that he travelled around a lot. Berlin was the capital city and the centre of Nazi power, and we should perhaps not lay too much credence on an American's statement 30 years later that Rolf lived in Berlin during the war.

Wondering what Rolf thought about the practical application of his work on the betatron, we can see possible scenarios: he believed it could be the basis for further scientific research in physics; he believed it could lead to an important weapon for the air force; or he believed it could be used in medical treatment. But what he said about this outwardly during the war—or for that matter afterwards—does not necessarily correspond with what he thought inwardly. In the biography almost 50 years later he is equivocal about this. He says he realises that the reason the Luftwaffe were interested was because a betatron could be used to achieve very high energy X-rays. That gave the supporters of the death-ray project renewed hope, and so they agreed to finance it. 'I wasn't supposed to know anything about this, and we always spoke only about the medical applications.' In a later book, Waloschek writes as follows, with Rolf as the source of his information:

> But I consider it more likely that Gerlach had such authority at that time that the political and military officials – including Speer, Milch, Georgii and Geist – followed his opinions and decisions without serious question. Gerlach did have full authority over the allocation of research resources to nuclear physics.[47]

The Betatron Must Be Moved to Safety

The war was still going on, now in its final year. Christmas was approaching, but Hamburg was being subjected to regular bombing raids by the British and Americans. There had been heavy raids every month since the end of June. Germany's biggest seaport was an important target for Allied bombers, with its oil refineries and heavy industry. Blohm & Voss, for example, built warships and military planes. The Müller factory and surrounding industrial sites were also hard hit. The cellar with the betatron was still intact, but the air ministry ordered the completed 15 MeV machine to be moved to a 'safe place' outside the city. We don't know whether the order really came from the highest level—Milch had gone by now—or whether it came from Colonel Geist or was initiated by Hollnack or Seifert.

With help from Richard Seifert, Kollath and Schumann had the machine dismantled in a couple of months and transported to safety in the remote little village of Wrist 60 km. north of Hamburg, near Kellinghusen in the area between Hamburg and Kiel. There, the betatron could be rebuilt without raising suspicion, in a building that was part of a dairy belonging to Seifert's family.

In order for the journey to appear routine, Richard Seifert's youngest daughter Elizabeth was with them in the vehicle. She recalled the dramatic journey later.[48] Rolf's second-in-command, Kollath, sat on the back seat with Hollnack, with herself on the front seat next to the driver. They were driving without lights, the roads were narrow, there were constant air raids and it was difficult to make progress. Every so often she had to get out to read the road signs, which were partly covered so that they could not be seen from Allied planes. They managed to manoeuvre the apparatus into a building with a big enough door to accommodate it. Only a few people were in the know about this. Probably also among these was Hollnack's courier, who was already in Wrist. When one day he came across a strange machine well camouflaged, he realised that it must be the top-secret betatron.

Here in Wrist they installed the machine, set it running and got it to work just as it had in the laboratory in the Müller factory. Touschek, the student, was in prison and not available to help, but some of the staff from the Müller factory helped to get the machine started and after a while Rolf's team was able to continue the testing and calibration. Subsequent events indicate that Hollnack knew more than most about the Allies' movements, and it was hardly by accident that he acted to get the machine out of Hamburg when he did. It is difficult to assess how much the others were allowed to know—or how much they worked out themselves.

By the beginning of January the courier had been supplied with papers from Hollnack saying that all police and SS personnel were requested to 'be helpful in every way possible' to the courier, who 'was travelling on a mission for the air ministry.' So the assistant spy, as he later described himself, could travel around freely. He carried maps and packages between Hamburg, Berlin, Mannheim, Dillenburg and Dresden, and sometimes to other towns. He spent a lot of time on trains, always travelling first class, and lodged in luxury suites in hotels.

Throughout the winter, Rolf had less and less to do with the 15 MeV betatron. He had been concentrating on the 200 MeV machine that was being built in Mannheim as Ostgrossheim was no longer in use. The patent applications also took up a lot of time. He still dealt with his patent adviser friend in Berlin, and it would be surprising if Rolf did not also use the services of Hollnack's courier, the lad whom Rolf later 'could no longer remember[49].' In the midst of the dramatic events of war and the industrial conflict, Rolf had his own agenda, his own contest between himself and his competitors. He applied for another two patents on 17th and 19th February 1945. He was obviously busy. However little or much he was concerned about the political manoeuvres round about him, he cannot have failed to realise that the war was drawing to a close and that from his point of view this would at the very least create uncertainty about the future of his project.

Driven by Events

In March, or possibly very early in April, the unexpected happened. Hollnack, who was in charge of finance, gave Rolf a sum of money and told him to go home. Now, and permanently. The payment was large, about 38,000 Reichsmarks, equivalent to about 150,000 Norwegian kroner at that time. Another source says that the payment was 38,000 Norwegian kroner. Whatever the exact amount, he found himself in possession of a small fortune. So we are talking about a payment of a little over 3 million kroner—alternatively a little over 800,000 kroner—in 2017 values.

According to Rolf, the special payment was 'for his services.' He later explained that it was payment for the rights to use his patents.[50] With this money, Rolf disappeared unobtrusively from Hamburg. By train. There were several stops 'because of sabotage to the track' and a stay in Copenhagen 'to put papers in order' at the consulate. He doesn't say anything about what sort of papers, but he had also stopped there on his way home for Christmas the first year, even though on that occasion he was travelling by air. We may well wonder why. He arrived in Oslo, which was still occupied and where he was still employed in Brown Boveri's daughter company NEBB. His time in Germany during the Second World War was over.

He had little idea how he would be received. Why did he take the train, when he always flew? There is no clear explanation for that. The Luftwaffe had arranged flights for him before. Did they not know that he was leaving? Obviously not many people knew. We could say that he was being smuggled out. What currency was he paid in? It would surely not be a good idea to go into a Norwegian bank and ask to pay in a bundle of German marks.

When *did* he really come home? Different dates are quoted. What had he been doing in February and March? Where had he been? In one place he writes that he was ready to return home in autumn 1944. Elsewhere, he writes that he moved in January or February. Does 'ready to go' mean the same as 'went?' In yet another place he stated that he left in March, but it can have been even later. Letters exist with his signature, dated Hamburg

12th February 1945. Can the simple explanation be that he spent a long time on the journey home for very practical reasons? It was still wartime. Or was he seeing somebody or doing something on the way, for example in Denmark?

What is certain is that Rolf managed to bring home with him documentation about the work he had been doing in Germany. During his approximately 20 months there, he had accumulated not only a number of patents but also much material that was still incomplete and required further work. Many of his theories and results were still in his head or on rough notes and had not been written up. There would be time for that later.

In Germany, the situation was becoming more and more chaotic. On 14th April American troops freed the Siemens researcher Richard Gans and took over his and Schmellenmeier's betatron laboratory that had been moved to Burggrub. What remained there was probably just ruined and destroyed.[51] All Nazi Germany's effort to create a radiation wonder-weapon came to a stop. The war was in its end phase, and events now moved quickly:

24th April:	Berlin surrounded by Soviet troops
30th April:	Hitler commits suicide in his command bunker
3rd May:	British troops occupy Hamburg without resistance
7th May:	Germany surrenders unconditionally.

The Unveiling

When the news of Hitler's suicide reached Hamburg, Hollnack's courier revealed his real identity to his boss, namely that he was Jewish and from Vienna, and not the Dutchman he had presented himself as. Hollnack took the news very calmly. He just said 'Ah' and after a little pause said that his secretary, Miss Bluhme, was half Jewish. Now it was the courier's turn to say 'Ah,' though he didn't fully grasp the significance of this revelation and Hollnack had to say plainly: 'I have done important work for the Allies.'[52]

The courier was still confused. He couldn't imagine it. He had understood something about the bits of metal in what he called the cyclotron, the grey monster that he said he had seen. He asked Hollnack what he really meant and was told: 'Wait here till the English arrive, then you will see. They are coming today or tomorrow. You have helped me to help the Allies. You will understand the value of this.' He then offered to give the young man a grant so that he could study in England or America. The ex-sailor had turned 18 and was still without higher education, but he turned down the offer. He remained in Kellinghusen several more days. The thought of serving as an exemplary Jew with Kollath's Jewish wife and half-Jewish Touschek and Miss Bluhme did not really appeal to him. He would go back to Amsterdam and his friends there.[53]

Theodor Hollnack, who was trusted not only by the Luftwaffe but also by the British, immediately made contact with an English special unit and the manager of the Müller factory. He showed films from the laboratories and workshops where the betatron was developed. All the remaining documents were seized and taken away. Any further activity in the factory was banned. Naturally, the staff were not particularly pleased about this. They knew that both their own company and Philips the mother company considered the development of the betatron very prestigious. They had devoted a lot of work to the project and didn't understand why it could not continue.

Pulling the strings as he always did, Hollnack saw to it that the British allowed the work in the dairy at Wrist to go ahead. That had very probably been arranged already even before the British arrived. At any rate, the team headed by Kollath, Schumann and Touschek could continue the work of calibrating the betatron.[54]

Quite Different Problems

In Norway, quite different problems awaited Rolf. A few weeks after he came home he was arrested and taken to Ilebu prison camp, the former Grini national prison where the Germans had held Norwegians prisoner and which when freedom came was converted to a prison for people convicted of treason. That was where his brother Viggo had been sent by the Gestapo on 21st July 1941. That was where the man who would later become Rolf's brother-in-law, Egil Reksten, had been taken on 7th July 1943. Now it was Rolf's turn, but on the other side and for a grotesque accusation of having taken part in the development of the V2 rockets.

As he was allowed to take his papers and notes to the prison, he used his free time to write up reports of his scientific work over the previous two years. In his biography he even manages to say—in a typical Widerøe way—that basically it was good that he was imprisoned, as it gave him plenty time for writing.[55] He also sent his wife a long letter with his thoughts for the future. He was no longer receiving a salary, and he was obviously concerned for the family. So he asked Ragnhild to contact the director of NEBB and seek his advice.

Things now happened fast. In June he was formally dismissed from NEBB, who were concerned about their reputation. They had to earn money, and could not carry the reputational risk of employing someone who was tainted—especially as a manager. Certainly not someone who was under such suspicion. By having him transferred to Switzerland they both rid themselves of a delicate problem and set up arrangements for Rolf's future.

Rolf immediately set about making plans. On Monday 9th July he was released from prison, two days before his 43rd birthday and after being in detention for 47 days. In his own words: 'Then in the beginning of July when I had completed my report, I was released.' That is one way of putting it. He says nothing about his experiences at Ilebu, but he does tell us about the work he has done there.

A recently published book about the troubled times of the treason trials devotes 23 pages to describing harassment, threats and accusations of violent handling at Ilebu, especially during the first weeks after liberation when the prisoners were still being guarded by people from the Home Front. Six men in a one-man cell, eight in a two-man cell, healthy and sick mixed together; people with tuberculosis, venereal diseases, cases of diphtheria, lice, bedbugs, poor food and not much of it, punishment exercises sometimes with the additional humiliation of crawling through muck, random nocturnal roll-calls where the prisoners were commanded to stand out for several hours wearing only their night-clothes. The author writes that the most serious punitive roll-call took place on 8th June 1945, which was while Rolf was there:

> The whole prison population at Ilebu was commanded to stand in a punitive roll-call assembly from half past nine in the morning until half past five in the afternoon because a couple of prisoners had managed to escape.[56]

With what is described here and elsewhere about the conditions, it is difficult to imagine that it would be possible to write up research results while a prisoner in Ilebu. More than that, to carry on a dialogue about a job with an international company overseas appears completely impossible, even for a Widerøe. We may wonder whether he had someone working for him behind the scenes. But that was how he presented the story himself.

Whatever the circumstances may have been in the course of his time in prison, he further developed his theory of how to make a new type of accelerator, the synchrotron. By doing this, he was well on the way towards being ready to submit what would be his next patent application. His thoughts were concentrated on his work rather than his immediate circumstances. This might have been an extremely goal-orientated and rational person's survival strategy. Don't just think positively, but also carry on with the business. In his defence, if any is needed, it must be said that his feet were firmly on the ground in his concern that his wife and children needed money to live and that he must therefore have a job to go to. The clear-headed, rational thinking of an engineer. He is unemployed and without an income. The solution is the job overseas, which has been in the back of his head as Plan B for a long time.

But even though he had been released from detention, he still did not have permission to leave the country. Nor did he know when his case would come up for trial. Seen from this point of view, writing up his latest research results was the most useful way he could spend his time in prison. It was not in his nature to feel sorry for himself, and it wouldn't help either himself or his family. What mattered was looking to the future.

The World Goes on

The research race didn't wait for treason accusations to be sorted out. Science has its own arenas. The cyclotron, synchrotron and betatron competitions continued after Hitler's fall, and on both sides of the fronts. First round was the struggle to get hold of the opponent's equipment. The Allies wanted the betatron as war booty, together with all the technical records. Then it was a question of recruiting the enemy's scientists. Those who had not already gone there were brought to the USA, England and the Soviet Union. Industry was on the rise. Brown Boveri, Siemens, General Electric, AEG, Westinghouse, Allis-Chalmers and others in the accelerator field needed to recruit good brains. The world was to be rebuilt. The betatron needed to be taken up and carried forward. The question was who would succeed in this. The race speeded up.

6th August 1945: The atom bomb falls on Hiroshima.

5th September 1945: An American researcher presents his synchrotron theory. Independently and almost at the same time, a Russian presents a similar theory.

11th December 1945: Rolf's former second-in-command writes a four page internal report for the British about the continuing testing of the betatron in Wrist that was still being improved.

22nd January 1946: Rolf is still in contact with the director of NEBB, even though he is no longer employed by the company. He writes to the director to say that he is working on an apparatus he has provisionally called a 'megatron,' that can generate electrons with a voltage that will 'blow the radiation transformer out of the sky.' It weighs 'only' 150 tonnes, while the massive cyclotron that the Americans are working on weighs 30 times more.[57]

31st January 1946: Rolf visits Tandberg's Patent Office to register a Norwegian patent in which the synchrotron theory is described in detail. This time it is a private patent. He has heard rumours of what is happening in the USA and has done what he can to be well prepared.

August 1946: The researchers at Woolwich Arsenal Research Laboratory in London succeed in converting a betatron into a synchrotron.[58] This experiment confirms the theory proposed the previous year by the American McMillan and the Russian Veksler. The betatron they use is one that Kerst has built using Rolf's theory. Rolf's Hamburg betatron is sent here to the English laboratory for use in further accelerator research. Thereby, two historic betatrons are now gathered in the same place.[59]

No Passport and Little Money

Professionally, the past two or three years from 1943 onwards had been a productive phase in Rolf's life, despite the world war and problems on a personal level. His rivals might say that it was excessively productive. He had registered important patents and had brought home preliminary ideas about a synchrotron, a type of accelerator that for some applications was even better than a betatron. He ardently wanted to carry on. For his family, however, the first year of peace was difficult to cope with. Rolf, the breadwinner, had been dismissed from his job, had had his passport confiscated and was facing an indictment.

> My wife remembers the second half of 1945 and especially the winter of 1945/46 very well. We had very little money, it was extremely cold and I was in Oslo, unemployed and without a passport. I used this time to sort out and write down my thoughts on what later came to be called a synchrotron.[60]

The case against him in the court dealing with accusations of treason had not yet been decided. But nobody could take away his enterprising spirit. His perseverance would be rewarded. He managed to acquire a temporary passport, valid for one month, and permission to travel to Zurich. By Easter 1946 he was in Switzerland negotiating a contract of employment with

Brown Boveri. He was to develop new and better betatrons. Officially he was not due to begin until 1st August, but mentally he was already well into the job and on 15th May he applied for his first Swiss patent, which was about the principles for making synchrotrons. In due course, he was issued with a normal passport. He also acquired access to money. The remaining 50 years of his life would be spent mostly outside Norway. That was not how his life was planned, but that was how it would work out. Norway was not interested in attracting him back, and he did not try to come back.

The previous three years had been 'The Dark Chapter:' first a year and a half in Germany up to autumn 1945; then a year and a half in Norway before he moved to Switzerland. He had been in the midst of incredibly dramatic events. Like a bad dream. On all fronts: at home and in his research. Caught between German Nazis and loyal Norwegians. Boxed in among spies and big industry in the atomic power race. In war and peace. Roaming freely and walled in. Exhausting even for a cool-headed engineer. 'If I hadn't experienced it myself I wouldn't have believed it,' as he said looking back when he was 91. That I do believe.

Then one day the nightmare passed. One Saturday afternoon, 18 months after he had been arrested, he left Oslo Police Office on Victoria Terrace as a free man. He walked out onto the street in the pale light of autumn. Relieved, at any rate apparently so. Finished with the war—perhaps. He had signed the necessary papers agreeing to pay a fine in lieu of prosecution. Case assessed; application accepted; fine paid; case against him officially closed—all in accordance with the law. The treason department could now archive case number 3418/45, and he would not have to face any further legal proceedings.

It was half past three on the afternoon of Second November in the Year of Our Lord 1946.

The strange, dark chapter of Rolf's life was over. He left Norway a few days later. Permanently. Acquitted, but stigmatised for ever.

***

Ragnhild and the children were waiting for him in Switzerland. Also awaiting him was a senior position in one of Europe's leading technology companies.

Notes

1. The biography.
2. There is some disagreement about whether or not they were in uniform. The biography says that they were uniformed. The case notes from the

treason trial refer to 'several German gentlemen.' (Document 8, handwritten 'Account of my work in Germany etc.', 24/5-45, National Archives, Treason Case number 3418/45 Clause).

3. H. Watzlawek, 23rd February, 17th March and 15 June. Copies of the letters are in the ETH library in Zurich. The letters contain references to letters from Rolf on 6th February and 1st March.
4. The interview with the physicists.
5. Pedro Waloschek in an e-mail to me on 7th June 2011. He had then had it confirmed from the printed edition of the journal in the library at DESY that another article of the same length had been inserted in the relevant pages. Dr. Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratory, Italy, was also in e-mail communication with Waloschek and me about this and uses the information in an article about Bruno Touschek which at that time had not yet been published.
6. Tor Brustad in an interview during preparation of the book.
7. The interview with the physicists.
8. The interview with the physicists.
9. The biography.
10. The interview with the physicists and the biography.
11. Pedro Waloschek: *Todesstrahlen.* The manager of the factory was Hans Ritz, with Dr. Werner Fehr as second-in-command. The two engineers were Gert Krohn and Friedrich Reiniger. A Mr. Bergmüller is also mentioned.
12. The biography.
13. Pedro Waloschek told me in an interview that he had a conversation with three former Müller employees indicating that was the case. It is however possible that the former employees Waloschek spoke with almost 40 years later had not been interested in this and so had not remembered the details. He said that competition between the major companies played a big part in events, as they prepared themselves for production of betatrons after the war.
14. Waloschek gave the number of patents as 12, in *Todesstrahlen*, p. 110.
15. Schiebold's archived papers at the University of Leipzig.
16. Interview during preparation of the book.
17. Rolf Widerøe explained the 'death ray weapon' thus in the interview with the physicists: 'Schiebold had got the idea that he could build an X-ray tube where the cathode was like a concave mirror. Then the electrons would gather on the anode and he would be able to get an X-ray beam that was partially focussed upward.'
18. The British project is described in the book 'Most Secret War' by the physicist R.V. Jones who worked for the British Intelligence Service during the war.
19. Pedro Walsochek: *Todesstrahlen.*
20. The interview with the physicists.

21. The biography.
22. Waloschek in conversation with me.
23. Schiebold's son Joachim found the film and passed it on to Pedro Waloschek.
24. Fehr, Bergmüller and Reiniger.
25. The interview with the physicists.
26. According to an interview I had with Pedro Waloschek.
27. Pedro Waloschek in an interview during preparation of the book. Richard Gans was also the teacher in Buenos Aires who was fascinated by betatrons and whom Pedro Waloschek writes about in the introductory chapter of his biography of Rolf.
28. Gerlach's notes of the meeting dated 25th August 1944 and Waloschek's *Todesstrahlen*, p. 129.
29. The biography. Waloschek: *Todesstrahlen*.
30. The biography.
31. Question to Rolf from Finn Aaserud, the interview with the physicists in Oslo 1983.
32. According to Waloschek.
33. The biography.
34. The biography and the interview with the physicists.
35. In conversation during the preparation of the book.
36. The biography.
37. Waloschek: *Todesstrahlen*.
38. Jacov Lind: *Selbsportrat*, Picus Verlag, Wien 1997.
39. Reinhold Rüdenberg was a pioneer of high energy radiation whom Rolf had known about while he himself was working at AEG in Berlin long before the war.
40. Kaiser, H. F. (U.S. Naval research Lab., Washington, D.C.): 'European Electron Induction Accelerators', Journal of Applied Physics 18. 1–17 (1947) Per F. Dahl: 'Rolf Widerøe: Progenitor of Particle Accelerators', Superconducting Super Collider Laboratory, Dallas, Texas, March 1992.
41. Waloschek: *Todesstrahlen*.
42. Kaiser.
43. Waloschek: *Todesstrahlen*.
44. Wolfgang Paul: http://nobelprize.org/nobel_prizes/physics/laureates/1989/paul-autobio.html.
45. Hans Kopfermann.
46. John P. Blewett: 'Reminiscences about Accelerators', Brookhaven Lecture, October 15, 1980.
47. Waloschek: *Todesstrahlen*.
48. In a letter to Pedro Waloschek in 1994. Elisabeth, whose surname is now Samisch, is the third generation in the family company and has for many years been owner and managing director of Rich. Seifert & Co. The

company, respected in the field of X-ray technology, was bought by Agfa in 2001 and is now part of the GE Group.
49. Waloschek: *Todesstrahlen.*
50. Waloschek: *Todesstrahlen.*
51. http://germansecretweaponsnazi.devhub.com/blog/category/exotic/page-3/.
52. Waloschek: *Todesstrahlen.* Overbeek/Lind's autobiography, p 158.
53. Waloschek: *Todesstrahlen.*
54. Kollath: *Notat* 11 December 1945, ETH-Library Zurich Hs 903: 28.
55. The biography. The interview with the physicists.
56. Ingrid Hagen: *Oppgjørets time. Om landsvikoppgjørets skyggesider,* Spartacus 2009.
57. Letter from Widerøe to Solberg 22 January 1946, ETH-Library Zurich Hs 903: 80.
58. The physicists D.E. Barnes and Frank Goward converted a 4 MeV betatron to an 8 MeV synchrotron. This was the first experimental proof of Veksler and McMillan's synchrotron principle.
59. E.J.N. Wilson: 'Forty Years of Synchrotrons,' CERN, Geneva.
60. The biography.

4

Treason Case Number 3418

1996. Fifty years have passed. Very few Norwegians other than members of the family recognise the name of 'Rolf Widerøe.' But *one* person remembers him. Tor Brustad at the Radium Hospital in Oslo cannot forget the man in the white coat with a screwdriver in his pocket, standing on his head in the radiotherapy machine. The retired professor thinks now as he did then as a new employee, that there is something odd about Widerøe's reputation. So unrecognised in Norway and so acclaimed in professional circles elsewhere. Now he wants to get to the bottom of the matter, find the truth. There must be somebody or something that can explain what wrong this man had done. He was imprisoned, but what was the crime? Setting popular rumour aside, why was he sentenced? He wasn't a member of the Norwegian Nazi *Nasjonal Samling* party.

So what had he done to help the German war effort? Was it true that he had taken part in making weapons for them? Brustad the academic did what he usually did; sought out original sources. He went to the National Archives to look at the case documents.

Before describing what he had found on the shelves in the archives, Brustad indicated the background picture of the public mood in Norway after five years of occupation. There was ill-feeling towards everything to do with Germany and Germans. This ill-feeling was also directed against Norwegians who were known to have collaborated or suspected of having collaborated with the Germans. Brustad was old enough to know about this. He was just 20 when freedom came, and two generations later he felt the need to remind people of the particular atmosphere of that time. He had

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_4

taught so many complacent students who had been born after the war. It had been difficult in those days to be unmoved by the public mood, and it was still difficult for those who had lived through it. He felt it himself.

So he took this into consideration when making his own assessments, and helped younger generations to increase their awareness. At a time when the author Knut Hamsun was still controversial, the name of the opera singer Kirsten Flagstad still had undertones and Hanna Kvannmo's 'youthful sin' of serving in the German Red Cross on the Eastern Front had still not been forgotten; at a time with more books about the Second World War than ever before; at a time when the film about resistance hero Max Manus was inspiring new, young admirers who were beginning to become interested in their parents' and grandparents' wartime experiences, finally the time was ripe to approach the delicate topic.

In 1996, the year that Rolf died and half a century after the case against him was concluded, Tor Brustad asked the authorities for access to the documents. Yes, that's fine. The National Archive would allow access to the specified documents if the family agreed. The family answered 'Yes.' Go ahead. There was nothing they wanted to hide.

The case against Rolf appeared to have been considered in thorough detail. The folders on treason Case no. 3418/45 contained several hundred pages of documents stamped as confidential. So far as he knew, nobody had looked into them or browsed through them since they had been archived. He had read Waloschek's biography of Rolf when it was published in 1993, but this had seemed only to increase the mystery and had made him even more curious to find out what had really happened. He wanted to know more and he decided to go through the documents one by one. He wanted to be clear about the whole sequence of events throughout a year and a half, the 18 months from May 1945 to November 1946.

What was in the formal case papers? What dictation had secretaries typed onto sheets of thin typewriter paper with carbon copying paper in between? What other documents were appended and what collected statements had been included? Had Rolf himself submitted any written statements? Who had been involved? Were they Norwegians? Or Germans? Or Allies? Brustad was hunting for the plain facts of the case. Interpretation, possible moral condemnation or defence, doubt or belief could follow later. The business now was to unearth whatever documented facts were buried in the papers in the National Archives case-folder. The only things he really knew were that Rolf had been in prison, as Rolf himself had said, and that somebody had reported him, which he had also said. Professor Brustad started from the beginning, following step by step as the case had gone through the legal processes.

Reported

It all started with a sensational report alleging that Rolf had taken part in the development of the German V2 rockets that had been brought into use towards the end of the war. These had been Hitler's trump card, his retaliatory weapon, *Vergeltungswaffe 2*, as Propaganda Minister Goebbels called it. 3,000 of these ballistic missiles had been fired during the winter of 1944/45, causing many deaths and much damage in London and Antwerp. Rolf had come home from Germany to Norway in April 1945, several weeks before Norwegian liberation. On 20th April a handwritten, unsigned note was handed into Oslo Police Station. The note was rough and ready, but the allegation was clear:

> Engineer Rolf Widerøe, *Norsk Elektrisk og Brown Boveri*, Skøyen, made important inventions in connection with the V-bomb. It was he who invented the gyroscope on the V2.

The complainant was alleging, in other words, that Rolf had developed the steering mechanism for the super-rockets. The allegation was very plain and could hardly be worse. The police and the prosecuting authority had to react. The case-file does not include the original hand-written note, but there is a typed copy signed by a witness. The note continued:

> He was very well treated, was given everything he wanted, travelled frequently to Denmark and was for a time stationed at Peenemünde and in Hamburg where he built his things. He always travelled in German planes, and he was not allowed to travel via Sweden.[1]

Arrested

On the basis of the anonymous report, an 'Order for imprisonment/charge/search/seizure' was raised soon afterwards. This was dated 23rd May 1945 and quotes the reason for the order briefly: 'Has made important inventions in connection with V-bombs.'

The very next night—the night of 23rd/24th May—the police came to his house in Røa, confiscated his passport and took him away. The note of the police decision read as follows: ‘Imprisonment for 30 days, as authorised in accordance with the decree 26/2–43 § 3-4-5-6.’ The transport order read: ‘Sent to Ila for imprisonment.’ Signed for the Chief of Police by a Junior Police Prosecutor.[2]

Remanded in Custody

Rolf was immediately remanded in custody at Ilebu National Treason Prison. The arrest order was signed by the detainee ‘Received 24/5 00.10 h.’

There were almost 3,000 prisoners in the camp. The Home Front and the Norwegian authorities had set up lists of people who were suspected of collaboration, and arrests had begun as early as 9th May. A total of 28,750 people were arrested. The first preparations for legal proceedings were started by the government-in-exile in London. Later denunciations were mostly made on the initiative of the leaders of the Home Front.

The day after his arrest, Rolf prepared a hand-written note replying to the questions that had been put to him. He began at the beginning. Here are the main points:

> In autumn 1922 I invented the radiation transformer. (…) Graduated Ph.D. in Aachen in 1927 with an experimental investigation of this, which unfortunately gave a negative result. Kerst, an American, got the apparatus to work in 1940/41. In 1942–43 I made a number of inventions in this field that among other things significantly improved the performance and effectiveness. In this context, I should point out that the apparatus, which brings fast electrons up to a tension of many millions of volts, is exclusively of scientific interest. (…)
>
> At the end of September 1943 I was visited by several German civilian gentlemen who asked me about these matters, claiming to be from an academic company specialising in research on X-rays. The following day, I was compelled to fly to Berlin. In Germany, it was made clear to me that from now on I was to work on these things with German factories. A contract was drawn up with a Mr. Hollnack, which I signed. Among other things, they promised to set my brother free from ten years of corrective detention. This promise was not kept. The relationship with Director Solberg was set up under a compulsory service order.
>
> Then from October ‘43 to April’45 I worked intermittently on the development of the said transformer in Hamburg and later in Kellinghusen. A 15 MeV transformer was built and made to work. Immediately before the

> collapse of Germany I was given permission to travel home and fortunately I was able to bring with me all the important documents relating to my work.
>
> It is now my intention to complete a comprehensive presentation of this work and apply the results in Norwegian scientific research. I have referred to Prof. Hylleraas and Dr. Wergeland at the university. The latter described my work as enormously important for scientific research and said that this work must be saved for Norway. (…) Moreover, the Swiss firm Brown Boveri owns certain rights to these inventions. (…) I therefore request that I may have the opportunity to complete my work first. If this cannot be done at home (I can of course report daily if necessary), I ask to have my books and papers, so that I can work during the time I am held in prison.
>
> I am willing to provide all the information that may be required for the resolution of my case.
>
> Finally, I would like to mention that I do not recognise the reference to the V-bomb or other military matters. My work was of no significance for the war and could to some extent be described as scientific sabotage, as it diverted people away from war service and war industry.'

The document is signed: 'Yours faithfully, Rolf Widerøe.'[3]

On Friday 25th May he was called to a meeting at NEBB, by whom he had been formally employed right through the war. Director Solberg informed him in the presence of witnesses that he must leave the company. According to the director's own notes this was confirmed in writing there and then. The same day, Solberg sent a long letter to the criminal police.[4] It is difficult to believe that Rolf could leave custody to take part in such a meeting, but whatever the truth of the matter we do know that NEBB immediately stopped paying his salary. However, this does not necessarily mean that he ceased having contact with the director and the company.[5]

A Defence Lawyer

Oscar de Besche, an Advocate to the Supreme Court from the legal firm Besche & Co., was appointed as defence counsel. Besche had formally requested this appointment in a rather long letter to the police, dated 16th June. In the letter, he wrote about Rolf, among other things, that 'What can be said about him must especially be that he was blindly interested in his subject and his science, without taking into consideration other factors that might have been more important.' A letter dated 20th June from the prosecuting authorities informed de Besche that his letter had been received, that an order for remand in custody had been applied for the same day and that when the court session had been scheduled he would be notified to attend the hearing.

There is relatively little information in the National Archives about the defence lawyer's role in the case, and the firm of advocates, which is now part of the firm Arntzen de Besche, no longer has the papers from that time. Rolf has subsequently said or written almost nothing about him, neither how or why he was specifically appointed nor what he contributed to the case. From other sources, however, we know that Widerøe Airlines also used his services.

Charged

The formal charge was lodged a month after his arrest, on Wednesday 20th June 1945. It accused Rolf of contravening Paragraph 2 of the special Treason Decree that had been approved by the *Storting* (the Norwegian Parliament) on 15th December 1944. The legal document applying for judicial examination and order of imprisonment reads as follows:

Case no. 3418/45 AB—Dreyer

Widerøe, Rolf, b. 11/07/1902. Residence: Melumveien 8, Røa. P.t. Ila Prison Treason.
Despatched with attachments according to the list of documents to Oslo Court of Examination and Summary Jurisdiction with application for a court hearing and an order of imprisonment to be imposed on Rolf Widerøe, b. 11/07/1902 in Oslo, residence Melumveien 8, Røa, *pro tempo* Ila Prison, as charged for contravention of the Treason Decree of 15th December 1944, paragraph 2 in that he:

(a) worked in Germany as an engineer, thereby giving support to the enemy;
(b) is suspected of having made an important invention concerning the V-bomb and made this available to the enemy.

The order of imprisonment is requested to be imposed in pursuant of str. prg. 240, Jfr. 228 pkt. 2 and 3.
For the police to be able to gather the best possible information about the punishable circumstances, application is made to request that the limit of the custodial detention be set at 120 days.
We ask to be informed if contrary to expectation the court decides that the accused must be released.

Oslo Criminal Police, Treason Department.
Oslo, 20/06/1945.

For the Chief of Police
Gustav B. Dreyer
Junior Police Prosecutor

The wording in the arrest warrant was: 'Has made important inventions in connection with V-bombs.' In the charge document this had been changed to:

'Is suspected of having made an important invention concerning the V-bomb.'

This implies that involvement with the V-bomb was no longer regarded as a fact but had been moderated to a suspicion.

The arrest warrant was issued 'in accordance with the decree 26/2–43 § 3-4-5-6,' but the charge was based on 'the Treason Decree of 15th December 1944, paragraph 2.'

Interviewed

Rolf voluntarily made statements to the police, even though a person who is being charged with an offence is not obliged to say anything and cannot be punished if he gives a false statement. Several of the interviews took place without a lawyer present, including one on 25th June when the note of the interview states, among other things:

> The accused maintains that far from having helped the enemy, on the contrary his activity had diverted from the enemy's war effort workers who otherwise would have served in the German military, especially two engineers who were excused from the armed forces to be his assistants. Regarding point 2, he firmly denies knowing about any invention being made available to the enemy.[6]

The note in the legal records continues with a standard pro-forma where the appropriate text is inserted in blank spaces (as underlined below):

> On the basis of the above information there are reasonable grounds to suspect the accused of <u>treason.</u> The conditions for detention on remand under the law governing legal processes in criminal cases §240 cf. §223, 2 and 3 are considered to have been met.
>
> Conclusion: The accused Rolf Widerøe is to be held in custody until otherwise decided by the court or the prosecuting authorities, though not beyond <u>Monday 9th</u> <u>July 1945</u>, within which time preliminary investigations must be applied for or prosecution instigated. The decision has been read out. The accused has been informed of his right of appeal. The court witness had no comment to add. The court rose.

So the request by the police for imprisonment for 120 days was not granted.

Released

Rolf now wrote several detailed requests to be released, including one that was presented to the preliminary court on 25th June. In this, he referred to a note he had provided at the police office in Kronprinsens Gate the first day after he had been arrested, and to the interviews in Ila Prison during the days following:

> From these questionings it is clear that the accusations against me are totally unfounded, obviously a product of pure fantasy.
>
> I can present completely valid written evidence of the work I did while I was in Germany. It will be apparent from the evidence that this purely scientific work had nothing to do with the war or war-related industry. This can immediately be confirmed by any expert. Therefore, in my opinion there are no grounds for a charge, nor for imprisonment. However, I am obviously keen for a thorough police investigation so that the circumstances can be clarified and so that I can be rehabilitated, but in the meantime in my opinion it is not necessary to keep me in prison.
>
> As I pointed out to the criminal police, there are vital reasons why I must be released as soon as possible. I have worked on several inventions since 1922 and the results of my work are recorded in several patent applications that are now being submitted. If I cannot have these patent applications presented to the patent authorities as soon as possible I risk missing priority and thereby losing out on a whole life's work. I couldn't submit these patent applications in Norway while the Germans were here and I was on the point of completing them when I was arrested. This task requires collaboration with a patent authority and cannot be carried out in prison.
>
> Moreover, I emphasise that the public interest requires my immediate release. My scientific works and results are of the very greatest importance for scientific research and it is vital that I come into contact with Norwegian scientists as soon as possible so that together we can utilise this work for Norwegian science. It would be sad if a continued, prolonged imprisonment here at Ila were to squander important and valuable research.[7]

In his first case document, dated 5th July and addressed to Gustav B. Dreyer the official in charge of the case, the defence lawyer stated that the inventions were of no military significance:

> According to my enquiries it is quite clear that the inventions on which Widerøe was working were to do with instruments for scientific research in physics (mainly important for the treatment of cancer) and that they were of no military significance, at any rate for the ongoing war. It should perhaps also be noted that this was not a new field of research that Widerøe was going into, but the same topic that he had been working on for years prior to the war.[8]

On Monday 9th July, 47 days after his arrest, Rolf was released from remand, but with a requirement to report on Mondays and Fridays at Piperviken Police Station. There was no longer a risk of evidence being tampered with. The decision was taken in Oslo Preliminary Court and the release order written on 7th July.[9]

There was a long queue of treason cases. A year and almost four months passed. It was uncertain when the case would come to trial.

An Expert Committee Is Set up

Not very much happened in the case during that first autumn. The prosecuting authorities needed expert assistance to clarify what Rolf had been doing in Germany during the war. On 24th September a proposal was made to set up an expert committee. The mandate for the committee was agreed on 21st November and consisted of two parts: to establish what type of work Rolf had done; and to assess the importance of that work for the German war effort.[10]

Four members were appointed to the committee, all of them recognised scientists. Three of them were connected with the Physics Institute at the University of Oslo: Egil A. Hylleraas and Harold Wergeland, who were both professors of theoretical physics; and Roald Tangen, professor of nuclear physics. Wergeland and Tangen had worked on atomic and nuclear physics at what was then the National Technical College in Trondheim where they had taken part in the construction of Norway's first Van de Graaff accelerator, and in 1942 they had continued that work at the University of Oslo.[11] The fourth and youngest member of the committee was the astrophysicist Gunnar Randers, who at that time held the rank of Captain. Hylleraas was appointed chairman. Rolf had had previous dealings with all of them.

All the members of the expert committee had worked with the resistance. Tangen had been arrested when the university was shut down in the autumn of 1943 and had been kept prisoner in Grini until August 1944. Wergeland had been a member of the secret organisation XU.[12] Randers had served with the Norwegian Defence Forces High Command, as a member of a panel recruiting Norwegian researchers and engineers to British military research.

In his recommendations for nominations to the committee, the official in charge of the case had noted that Hylleraas and Randers had both assisted the Norwegian Defence Forces High Command by serving on an expert committee to advise on the question of the atomic bomb. Randers had particularly relevant experience, having worked in Allied Security investigating German atomic research. He wrote that 'with the occupation of Germany the Allies obtained full information about Rolf Widerøe's work in Germany.' The case manager also recommended that 'the question of the utilisation of patent rights should also be taken up, with possible securing of these by taking out patents where this has not been done.'[13] He also specified that two of the documents he was attaching were on loan from Captain Randers on the condition that Rolf Widerøe must not get to know that they came from him.'[14]

The Committee's Report

On 14th February 1946, after four months work, the expert committee delivered its report. This was an eight-page document with two appendages of one and six pages respectively, making fifteen pages in all. The final text was drawn up by the committee chairman, Egil Hylleraas.[15] The document is entitled 'To Oslo Police Office Criminal Division (Treason) 14th February 1946.'

The report started with a list of the case documents that had been sent to the committee: a 70-page submission written by Rolf in prison, explaining his scientific work; two articles published in *Physical Review* in 1941 by Kerst, the American who had been first to get a betatron to work; and a list of 10–12 different articles written by Rolf's colleagues and other German physicists. Six of these articles were by his assistant, Bruno Touschek.[16]

The experts approached their task from a historical point of view, starting with Kerst's articles which they considered as 'the basis for Engineer Widerøe's alleged inventions.' Then they quoted the lecture 'On the technical problems of nuclear physics' that one of the committee members, Tangen, had delivered at Oslo University, where he had referred to the American and Rolf, who was present, had 'come to know of Kerst's work.' The committee report presented this as a starting point and continued the story:

This apparently aroused Widerøe's interest enormously. He had in fact already (developing on some work from 1928) tried to build a high tension generator in 1927-28 using essentially the same principles – his idea is moreover said to date from as early as 1922.

—regarding his motives: At least three

The committee then discussed Rolf's motives for his scientific activity:

Evidently, Engineer Widerøe straight away took up the task of copying and possibly improving on Kerst's "betatron." Naturally, there were various motives for taking up this work. Widerøe undoubtedly had a purely intellectual interest in the problem. Second, he may have wanted to recover some sort of recognition as the inventor of the betatron, by improving the design. Third, he may have hoped to benefit from commercial use of patented inventions in connection with the betatron. This last motive even led to him applying in 1943 for German patents for his reputed inventions.

At the bottom of page 2 the report takes up the question of why Rolf's contact with Norwegian physicists was broken off during the war:

The case documents say that Mr. Widerøe discussed his invention with one of the committee members (Wergeland) in 1943. These discussions were confined to a few simple questions about the basic principles of the movement of electrons. Neither Wergeland nor others were any longer particularly keen to have too much to do with Widerøe. Widerøe had been an interested member of the Physics Society, where he had given a talk in spring 1941 on the electricity distribution system in Eastern Norway, and he had taken a leading part in supporting a collection for the re-launch of the Society's journal. On a couple of occasions, however, he made comments which showed that in addition to having travelled in Germany he was inclined towards German sympathies – or at least admiration. This was disappointing, and together with the threat about control of associations it led to the Physics Society later suspending his membership until the war was over. Because of all this, contact with Widerøe was stopped and the committee members did not know about his patent applications in Germany in 1943 or his later work in Germany until after the German capitulation when we heard that he had been arrested and charged.

—regarding the betatron: His own attached papers

In the next pages, the report outlines the scientific principles on which the betatron was built and discusses 'the experimental work in Hamburg.' It points out that after the building of the 15 MeV betatron 'Engineer

Widerøe linked his claimed inventions to purely theoretical proposals, with a view to a 30 MeV accelerator and another with a maximum voltage of 200 MeV.' The committee refers here to Rolf's own submission which has been presented to them. A more 'intensive evaluation' here 'would normally not be of much relevance to the case,' but the committee nevertheless includes it as an attachment to their report, on the following basis:

> Widerøe and his defence lawyer have however tried to present his inventions as especially important, even for Norway's national interest. His work and his inventive ideas have indeed aroused considerable attention here at home, not least because of the Germans' interest in his projects.
>
> The committee has therefore felt obliged to give a more detailed critical evaluation of his theoretical proposals in a special attachment. It has also given an explanation of each of his patent claims listed in the case documents.
>
> —*regarding the patents: Of no interest to Norway*

The committee then considers the patents in detail and concludes that they cannot see 'that there would be any benefit to Norway in securing Engineer Widerøe's possible patent rights for the nation':

> Engineer Widerøe's new Norwegian patent applications may be considered of little interest. His possible patent rights in Germany are obviously confiscated by the Allies and are now property of the Allies, and it is very doubtful whether the patent authorities can grant him new patent rights on the same ideas here.

Regarding patent rights priority over Kerst, the committee says that this 'can only be decided by physicists after the relevant literature has become available.' However, the committee does make a couple of points:

> The committee considers it a nonsense for outsiders to try to obtain patent rights on technical details in connection with inventions that others have achieved and that are undergoing rapid development through the work of various researchers. In Widerøe's defence it can be pointed out that he considers himself as the real inventor of the betatron and that his own interests as an engineer are towards benefitting from his inventive talent economically and commercially.
>
> The fact is however that Kerst is the first to have made clear the necessary and sufficient theoretical foundation for the betatron and to have constructed the first working betatron on that foundation. As his work has been published in one of the major physics journals and moreover includes a very comprehensive theory for acceleration of electrons by magnetic induction, which among other

things also includes such a special feature as the premagnetisation of the steering field, his prior rights in relation to any patent applications from others are undoubtedly very strong. We must also consider that any theoretical propositions from Widerøe that may be of interest have already been studied and tested.

—regarding Rolf: Not professionally qualified

About Rolf generally as a person, the report reads:

Apart from the patent rights and their value, Widerøe appears to think that by making his ideas available he could contribute towards giving the country a leading position in a limited area of atomic research. The committee wishes to warn strongly against this view. For the design of bigger and more expensive apparatus for atomic research, all the preliminary stages must be well known and all the plans must be evaluated from both theoretical and practical points of view. This can only be done by trained physicists, as happens in all leading countries and not least in America. Engineer Widerøe does not have the necessary qualifications to lead a project of this type.

Engineer Widerøe has a fertile inventive fantasy, but he has not demonstrated ability to explain his ideas sufficiently clearly or support his theories robustly. His unsuccessful attempt in 1928 depended on theoretical insights that were not yet available and that did not become available until 1941 following Kerst's work. But even with knowledge of this rational basis, his theoretical explanations are very complex and unclear, even though – as it would appear – he has had considerable help from German fellow-workers in refining them.

His ideas are often alternative in that one excludes the other. The committee considers it doubtful whether he has prospects of progressing his ideas to the appropriate solutions for building a betatron himself. His most important contribution ought to be the premagnetisation of the steering field. On the other hand, in his explanations of the use of stabilising electric and magnetic lenses he comes to quite misleading conclusions.

—on the question of guilt: We won't say anything, but

On the next page the committee write that they don't want to have anything to do with the question of guilt:

'The committee of course wishes to have as little influence as possible on the question of guilt or innocence, which it thinks must be decided on the basis of approved judicial and human rights considerations that only the court is competent to decide. The committee does however consider itself obliged to provide such information and guidance as it can offer.'

—regarding the V-bomb: Nothing to do with the V2 rockets

In the next section the committee states that it has not found any connection with the V-bomb:

> 'Even though one of the committee members (Randers) has taken part in the subsequent investigations in Germany, no information has come forward to indicate that Engineer Widerøe has had any connections with the work on the V-bombs. So the committee finds it reasonable to believe that what took up all of his time during his stay in Germany was the realisation of the plans for building betatrons.'

> —*regarding Schiebold's death-rays: One word against another*

The committee writes that the question of whether Rolf 'has given support to the enemy' is a legal-judicial matter, but it adds:

> It is clear that Schiebold's fantastic ideas about "death-rays" (to be directed against planes) must have been a contributory factor in the Germans' decision to recruit Widerøe. Besides this, the wish to compete with the Americans in a new field that could be important for atomic physics and thereby possibly also for atomic weapons may have been part of their motivation.
>
> Against this stands Engineer Widerøe's claim that he only came to hear about Schiebold's plans later and that he had always been clear that the betatron was of no military importance – plus the reality that his work in Germany (We are assuming that this was limited to the betatron.) was of no military use to the Germans. Another consideration is obviously how big a danger Widerøe faced in being appointed to this work and how adequately he assessed this risk.

> —*regarding the background: Not significant*

Towards the end of their submission the committee takes up the question of how Rolf came to be in Germany during the war. The committee goes through Rolf's explanation and indicates that this is one of the questions they consider to be outwith their mandate, but they do offer some thoughts on the matter:

> Widerøe claims to have been taken to Germany by force. The committee considers the validity of this claim to be irrelevant. What is more important is Widerøe's reaction when he arrived in Germany. He appears to have made only weak objections and at any rate not refused to work. On the contrary, he acquired very favourable contracts which according to the case documents resulted in payments amounting to 38,000 *Reichsmark* or presumably

> double that sum in Norwegian kroner. According to further information from Widerøe himself, he has been paid about 150,000 kroner in total.
>
> Widerøe's diary for 1943 shows that he corresponded actively with a German engineer called Sommerfeld and that he travelled to Germany several times in the spring and the summer of that year, presumably to prepare and arrange his patent applications. This must inevitably have brought him to the attention of the Germans. On the other hand, it also shows that, unlike others, he must have thought that German patent rights would be of significant value in the future. In other words, he must have hoped, wished or expected that Germany by one means or another would eventually win.
>
> *—regarding his attitude: Unpatriotic*

The report ends thus:

> The committee must therefore assess his attitude as unpatriotic. Apart from its view of the civil and economic value of Engineer Widerøe's activity, the committee finds the size of the payment strongly suggestive of military involvement. Whether these payments were made straightforwardly by the German state or disguised in the form of gifts of manufacturing licences, they must therefore be regarded as profits from the war.
>
> During the course of the case, Engineer Widerøe has informed the committee about patent applications for new inventions. Having devoted so much time to advising on Widerøe's case, the committee cannot devote any more time to going through these new projects. Nor are they of any interest to the court, as they are new works that cannot have any connection with his work in Germany other than that they are to do with related problems.
>
> For various reasons, the committee has put a lot of effort into coming towards the best possible assessment of the scientific value of Engineer Widerøe's work, and has also discussed this in meetings with Professor Trumpy and Engineer Odd Dahl from Bergen. The committee is however of the opinion that the technical and scientific value of his work should not have any influence on the judgement of his case, but that this should be done on the basis of purely judicial considerations. Therefore it also believes that further scientific discussion in this respect would be superfluous.

The document ends with the place and date: 'Blindern V. Aker, 14th February 1946'; and the signatures of all four members: 'Egil A. Hylleraas, Gunnar Randers, Roald Tangen and Harald Wergeland.' Two appendices are attached. Appendix 1 is the list of the articles referred to. Appendix 2 is a six-page document entitled About "the radiation transformer," written and signed by the committee members themselves.

The Committee's Conclusion

The expert committee concluded that no evidence had come forward to indicate that Rolf's activity had been connected with the V2 rockets. He had only worked on the betatron, which was of no military use to the Germans. They strongly doubted his professional qualifications.

The defence lawyer went through the experts' evaluation point by point. In a long document to the police office he stated that he would not enter any discussion of Rolf's professional qualifications, but just mention that 'It appears to me that the committee is taking unnecessarily strong sides for the American inventor Kerst, and even though the committee has such great admiration for this inventor, I think it is quite unfair to characterise Widerøe as an "outsider" in this field, with the rather derogatory sense commonly implied in that word.' He adds:

> One can regard Engineer Widerøe's qualifications however one wants, but I consider it very significant that the world-renowned Swiss company Brown Boveri wants to work with him and that he is cited in most modern publications on atomic physics. Whatever view one takes, it is obvious that there are other opinions than the committee's on whether he can be expected to reach practicable results.[17]

He went on to write that Engineer Sommerfeld with whom the committee claimed Rolf had 'corresponded actively' was a 'fervent anti-Nazi,' and that 'his father, who was one of Germany's leading physicists, was dismissed from the university because of his opposition to the Nazis.' Sommerfeld jnr. was both an engineer and a patent advocate and through him Rolf 'could have his patent applications processed for use by Brown Boveri.'

Regarding the most important point, the question of whether Rolf's work in Germany had been of any importance for the war, he wrote that 'The committee's words should be clear and straightforward:' No evidence had been produced to indicate that he had been connected with the work on the V-bomb, and his work had been of no military value to the Germans. The defence lawyer maintained that:

> So far as can be seen, the committee accepts the fact that Widerøe was taken to Germany by force in autumn 1943, and anybody who knows of his attachment to home and family will also be convinced that he would never have gone of his own free will.

He forthrightly rejects the charge of lack of patriotism. Rolf had not aided the enemy in any punishable way:

> First, the work was entirely harmless. Second, what was done was largely carried out under compulsion. That cannot be the reason for any form of punishment. (…) Widerøe has always taken a clear standpoint regarding the Nazis, of whom he has always been an opponent. It may be that he has expressed his admiration for branches of German science. That was both unnecessary and unwise in time of war, but punishable it was not.

More Interviews

'Not a member of the *Nasjonal Samling*' is one of the pieces of personal information about Rolf in the heading of the report of an interview that took place in the office of the Chief of Police on 15th March. During the interview, Rolf explained the circumstances of the study tour he undertook in autumn 1941 with a group of Norwegian engineers, led by the German Director Schwartz whom he knew from his time in NEBB. He again states that his brother had been arrested that same year and condemned to ten years corrective detention.

> I used the opportunity to send a plea for leniency to *Reichsminister Todt* through Schwartz, who knew Todt. Schwartz advised that to be able to recommend this application he would need to refer to some indication that I was favourably disposed towards Germany.[18]

Then he explains something he never spoke about during interviews later in his life:

> After the study tour in Germany I had written a purely scientific article for (the Norwegian engineering journal) *Teknisk Ukeblad*, but Schwartz asked me to change it a little. I revised it then so that some of the sentences could be interpreted as showing me favourably disposed towards Germany.
>
> I never got any response to the plea for clemency, but I did learn that it had been refused.
>
> In this connection, I did also donate 80 kroner to NSH, but I know nothing about this payment coming to The Norwegian Legion.

In the meantime, the procedures for appointment to a post in Brown Boveri had been following their course. Rolf had travelled to meetings in Switzerland, and on 24th May the company confirmed in a letter that Rolf was appointed from 1st August. The letter was given to the police as documentation.[19] Then in June the Foreign Affairs Department communicated with the police, asking to be kept informed. One of their people in Switzerland had contacted them to say that he had had news that the Norwegian Engineer Widerøe had lived in Germany during the war and had worked on 'special assignments.'[20]

In connection with Rolf having been in Switzerland, the defence lawyer sent a note to the prosecuting authorities to remind them that Brown Boveri 'considered it of utmost importance to get started as soon as possible' on the production of his 'radiation transformer for cancer treatment.' He referred to information that Siemens, who had previously met 90% of the demand for X-ray apparatus, were now able because of the circumstances to deliver only about 5%. It was urgent, therefore, for Rolf to make a start. He also appended excerpts from the correspondence between NEBB and the Swiss parent company dated from spring 1943 onwards, 'which clearly shows and confirms what was maintained earlier, that Widerøe was in communication with the Swiss company before he moved to Germany in 1943 and therefore had no thoughts of exercising his patent rights in Germany.' A letter from NEBB to the advocate confirms that 'As early as 1942 Dr. Widerøe was seeking links with BBC for a collaboration on his invention.'[21]

On 4th July Rolf had a further interview with Police Prosecutor Dreyer. The prosecuting authority was still trying to establish whether there was any connection to German weapons research. The note of the interview states:

> The radiation transformer could not have any relevance to atomic bomb research. Such knowledge about nuclear fission as one could obtain would be of no practical use. The interviewee had also discussed this with some scientists he had met in Hamburg who worked on atomic fission research, Dr. Suess and Professor Harnack, who had confirmed the interviewee's opinion, likewise Dr. Jensen.[22]

The next point was salary and expenses:

> The interviewee's earnings were arranged so that his NEBB salary of 17,750 kroner was paid to his family here in Norway. In Germany he got ca. 500 *Reichsmark* per month + travel expenses.

There was also discussion about the taxation of money he had been paid for patent rights, and about negotiations with BBC in Switzerland in spring and summer 1943 so that through Switzerland they could be registered in an English-speaking country. This possibility had been lost when the Germans confiscated the patents, and Rolf thought that this had significantly reduced their value.

Then he comes back again to talking about his brother and he also speaks about Theodor Hollnack, who had been the link person between Rolf and the Luftwaffe.

> The interviewee stated that he was allowed to visit his brother several times in Germany. Hollnack managed to have him transferred to a better prison when he was poorly. Hollnack and Rolf W. visited him there too, and saw to it that he was well treated.

The report of the interview goes on to say that the application for clemency on Viggo's behalf 'was granted in February 1945 but came rather too late as he had already been freed by the Americans.' Finally:

> The interviewee wishes to add that during the negotiations in Berlin in October 1943 the Germans also promised to release several of the NEBB officials who had been arrested. Of about 20 whose release was promised, only two were in fact released.

On 6th July the defence lawyer sent a new letter arguing that the confiscation payment by Rolf must not exceed 100,000 kroner. He was of the opinion that the case should be settled with the payment of such a fine and the prosecution should be waived.

> I think this is typical of the sort of case that should be settled in this way. If Widerøe has come out of it badly, it is only because of biased scientific interests and his love for his brother. He has certainly never intended to be either a traitor or a criminal. He has surely been punished more than enough already. And I think there can be a role for him in the future.[23]

A written statement from Viggo may also have contributed to the resolution of the case. This was addressed to the officer in charge of the case, Police Prosecutor Dreyer. Advocate de Besche had informed Viggo that the police wanted to interview him in connection with his brother's case. Viggo was due to go to Stockholm the following day to start work in the airline, SAS. He wanted to send a written statement instead of meeting personally. If that was not sufficient, they could reach him at the address he gave. The statement gave factual information about his situation during the war and how Rolf had reacted to it:

> I was arrested in May 1941, sentenced to ten years corrective detention in November and sent to Hamburg in January 1942. Was later moved to Rendsburg where my brother visited me autumn 1943. He told me then that he had been forced to work in a factory in Hamburg making high-voltage equipment.
>
> I was later moved to Bützow where the conditions were very bad. I had had diphtheria and caught bronchitis and went down to 41 kg. (Normal weight 85 kg.) My brother visited me there too and asked –through the prison governor – for me to be given work out of doors, as cell life was cracking me up.
>
> Soon after, I was sent to a work camp in Dieburg where the conditions were significantly better and where corrective detention prisoners were not usually sent.
>
> Following a visit by my brother in summer '44, when he and a German called Hollnack spoke with the head of the camp, I was given work on a big farm and my health improved.
>
> I also became the representative for all the Scandinavians in the camp and was thus able to help my comrades. Later, we were even allowed to receive packages.
>
> Freed by the Americans 26th March 1945.
>
> My brother's help, which resulted among other things in the transfer to Dieburg and the work out of doors, certainly led to my survival during these four years in prison.
>
> My state of health from autumn '43 onwards was very poor because of confinement, illness and under-nutrition.[24]

This statement, which was written as Viggo was on his way to a new job in Stockholm and was not available to attend in person, could have been a pro forma composition, a necessary gesture from brother to brother, something arising from the situation and without deeply felt intention. But it could also be deeply sincere. Only the two brothers themselves could know what lay behind the words. We don't know whether Rolf ever read the document or whether he even knew of its existence. Nor do we really know how it came about. One conceivable scenario could be that Rolf sat there and thought 'I need Viggo to confirm in a formal statement that I helped him; that will strengthen my case,' and then through the defence lawyer got

Viggo to write the necessary lines. Or the defence lawyer might have formulated it himself. Or another scenario: *Viggo* sat there and thought 'Rolf needs my help now, I must confirm that his intervention was decisive for me,' and then wrote and sent the statement.

On 31st July Viggo was back in Oslo and attended a meeting at Victoria Terrasse Politistasjon. 'The witness was shown his letter of 8th July 1946 to Police Prosecutor Dreyer, which was read and accepted by him as his evidence to the police.'[25]

The Main Charge Is Dropped

What next? A full year has passed. The experts have had their say. Their report was an important consideration for the prosecuting authorities in deciding whether or not to bring the case to trial in court. The defence lawyer has made his comments. Rolf has provided explanations. Witnesses have given evidence.

What happened was that the prosecution, in line with the expert committee's conclusion, dropped the serious main charge, of having aided the enemy. On the second point, about the V-bomb, the committee had established that Rolf had devoted all of his time in Germany to the work on the betatron. The bomb was no longer mentioned. Here too, the prosecution followed the experts' report.

There were two possible ways to deal with the remaining parts of the charge:

The authorities could decide to bring the case to court, either as a confession case (if the accused has admitted the charge) or for a full hearing with the case for the prosecution led by the police or by the state prosecutor.

Alternatively, the authorities could seek to avoid the time and cost of a court hearing by serving on the accused a document known as a *forelegg*. This document specifies the criminal charge against the accused person, the range of penalties prescribed by law and the penalty (usually a fine) proposed in this particular case. The accused then has the option either to accept the criminal charge and the proposed penalty, or to refuse. If he refuses, the case goes to a full trial. If he accepts the charge, pays the fine and signs the *forelegg* document, the case is concluded. The accused can then get on with his life, though now technically with a criminal record.

This latter method was and is commonly used in Norway for minor offences. At the time of the post-war treason trials the number of cases to be decided was so great that it was extended to deal with charges that would not in normal times be considered 'minor.'

No Prosecution

The authorities chose the latter procedure, deciding that it should all be settled with a fine. One possible reason for this may simply be that there was a long queue of treason cases waiting to be resolved. Another may be that the official in charge of the case intervened. Also, the range of activities in the accusation had obviously diminished. The case did not come to trial in court.

In this instance, the official in charge of the case had come into play like a Joker in the pack. In a letter to the prosecuting authorities on 11th July 1946 he had laid out his proposals for the main details of the *forelegg* document. Tor Brustad tells us that the senior official thought that the case had now gone too far and that he added a personal note. He commented among other things on the size of the payment to be confiscated. During the work on the case it had appeared that Rolf would have received compensation of 140,000 kroner for the use of his patents. The official proposed that the confiscation should be reduced to 120,000 kroner, as he reckoned that 20,000 kroner should be subtracted in respect of expenses. He was also in favour of deleting both the section about loss of rights of citizenship and the fine.[26]

Professor Brustad thinks the official's reasons are worthy of note:

> My possibly rather lenient attitude to Widerøe arises mainly from my opinion that he will be one of the more useful people to hold onto. Too severe a punishment might lead to him emigrating, or at any rate to working abroad, which would not serve the interests of our national economy. Also, the main serious charge has already been dropped.

In a note dated 22nd July to the official in charge of the case, The Chief of Criminal Police commented on Rolf's contact with the German Sommerfeld. He pointed out that if the whole of the Sommerfeld family was as anti-Nazi as Rolf claimed, they would automatically have been put under observation, and that exchange of letters abroad would have been censored anyway. So one could assume that the content of any such correspondence would have been made known to the German intelligence service.[27]

He recommended that Rolf's notebooks and private papers be carefully examined and that Rolf be asked to explain the various notes he had written in the course of 1943–1944.

If the result of this examination were to turn out in Rolf's favour, the confiscation should be kept at 140,000 kroner, plus a fine of 5,000 kroner. But if it were to be shown by these new enquiries that collaboration with the German authorities had been closer, the whole case should be taken up again, including questioning of Germans who were interned in Norway or imprisoned in Germany.

A little under two months later, on 14th July, the official referred the case back to the police chief again, commenting: 'I recommend a fine of 5,000 kroner and confiscation of 120,000 kroner, as it seems reasonable to me that his confiscation payment be reduced by 20,000 kroner in respect of various expenses he had incurred in Germany.'[28] Rolf was called into another interview on 5th October. The question at issue now was the money that had gone to the Norwegians fighting alongside the Germans on the Eastern Front. The report of this interview records that 'The interviewee (…) denies any knowledge that he had donated 100 kroner to The Norwegian Legion in summer 1941.' The connection was described thus:

> The previously discussed group visit of engineers to Germany started in September 1941. The interviewee apparently first heard of the tour early in 1941. Schwartz in the *Reichskommissariat* had set up an arrangement for the delegates, whereby each of them could make a payment to him in Norwegian kroner. They would then be paid out spending money in Germany equivalent to what they had paid in, probably about 100 *Reichsmark*. The only explanation the interviewee can think of is that Schwartz may have donated 100 kroner to The Norwegian Legion in the interviewee's name.[29]

Another month and a half passed, but then the prosecuting authority decided that it was not worthwhile to investigate the case further or call more witnesses. The *forelegg* document was drawn up.

Forelegg Agreed

Rolf received, accepted and signed the f*orelegg* document, well aware that an indictment of this type when accepted by the accused is legally equivalent to a conviction by a court. This formality was completed when he signed the document at Oslo Police Office on 2nd November 1946.

The document itself—form 'LS. no. 13. Fine and limited loss of rights, with confiscation and compensation'—starts with the calamitous words about punishment for treason:

> *FORELEGG*
> Name: Rolf Widerøe, born: 11.07.1902, residence: Melumveien 8, Røa is hereby served a *forelegg* for punishment in accordance with the provisional decree of 15th December 1944, Sect. 3, cf. section 2 no. 4.

Then follow references to the relevant paragraphs, together with a list of the three points of the charge and finally the statement of the penalty:

> The regulations in Sect. 2 provide:
> Can be punished in accordance with this decree:
> *(Points 1, 2 and 3 are scored out.)*
> 4.
> Anyone who after 8th April 1940 has done anything that although not covered by the regulations 1–3 is within the scope of any regulation in criminal law ch. 8 or 9 or in the war articles in military criminal law, cf. criminal law Sect. 86 which sets penalties for anyone who during a war in which Norway is taking part supports the enemy with advice or assistance.
>
> The regulations in Sect. 3 provide:
> Crimes under Sect. 2 are punished with a prison sentence or compulsory labour of up to 3 years, fines, loss of civil rights, cf. section 11, or restricted loss of rights, cf. Section 12, or with a combination of these penalties. A ban on visiting specified areas can also be imposed as an additional penalty, cf. section 13.
>
> The grounds for the *forelegg* are:
> 1. The accused wrote a propaganda article in *Teknisk Ukeblad* 16th April 1942 about the conditions in Germany and the effects of the Allied bombing raids.
> 2. The accused made a contribution of 80 kroner to the Norwegian Legion on 3rd May 1942.
> 3. The accused worked as an engineer with a German electrical factory from October 1943 until April 1945, using his patent rights to develop radiation transformers. As compensation for the utilisation of his patent rights the accused received 140,000 kroner.
>
> The penalty is set at:
>
> **I. A state fine of 5,000 kroner:**
> In setting the fine, the fact that the accused has been imprisoned and/or detained in custody for 47 days has been taken into consideration.
> (Sect. 8 of the regulations provides …)
> (Sect. 9 of the regulations provides …)
>
> **II. Loss of the following rights:**
> 1 Loss of voting rights in public affairs
> 2 Loss of the right to serve in the nation's armed forces.

In pursuance of Sects. 15 and 16 of the regulation he is further summarily sentenced to:

Confiscation of illegal earnings of 120,000 kroner:
(Sect. 15 of the regulations provides …)
(Sect. 16 of the regulations provides …)

<u>The grounds for the confiscation demand are:</u>
The confiscation payment is in respect of earnings the accused received from the Germans for making his patent rights on the radiation transformer available to German interests.
(Sect. 25, part 1 of the regulation provides …)

The accused is required to state within 5 days of receipt of this notice whether he accepts the *forelegg*. The acceptance can be submitted to: Junior Police Prosecutor Dreyer, Treason Dept., Victoria Terrasse 5/7, room no. 254, either verbally or in writing, with one copy of the indictment being signed and returned.

If the *forelegg* is not accepted, the case will be sent for trial in court. Within the same time limit as named above, the accused is required in that circumstance to name what witnesses he wants called.

The document is stamped 'Oslo Police Office' and signed by Junior Police Prosecutor Gustav B. Dreyer. On the same day, 2nd November 1946, it was signed by Rolf Widerøe with the signature witnessed by Dreyer.

The Points that Were Scored Out

The three points under 'Sect. 2 of the regulation' that were scored out and that therefore did not apply, are as follows:

1. Anyone who after 8th April 1940 has been a member of or sought or agreed to become a member of:
   (a) *Nasjonal Samling* or an organisation connected to it;
   (b) Another organisation that has worked contrary to any regulations in criminal law chapter 8 or 9 or in the war regulations in the military criminal law.
2. Anyone who after 8th April 1940 has supported such organisations as are named in no. 1 or supported punishable activities initiated by them.
3. Anyone who after 8th April 1940 has carried out or taken part in commercial or professional activity for the enemy in such a way or in such circumstances that the conduct may be considered improper. The conduct should generally be considered improper if, for example, the person carrying out the activity has initiated the relationship with the enemy or worked in close understanding with him or sought enemy help to hinder or impede investigation or legal action or has acquired other improper benefit or earnings or other improper advantages.

Point 4, which is the one that applies to Rolf, is a general category for activities that are not covered under the three points that have been crossed out.

In the final citation, punishment is imposed on Rolf not under the provisional regulation of 15th December 1944, Sect. 2, parts 1, 2 and 3, but under Sect. 86 of criminal law which sets the penalty for those who support the enemy with advice and assistance during a war in which Norway is taking part.

The Penalty

The signing of the citation ended the legal proceedings. Done. Case concluded. A fine, loss of voting rights and loss of the right to be a Norwegian soldier; that was the punishment. And the crime: an article in *Teknisk Ukeblad*; money to the Norwegians at the Eastern Front; patent earnings in Germany. Rolf said 'OK,' signed the form. That was that; or so he thought.

Having accepted the citation, Rolf got his passport back, though initially only with permission to travel to Zurich. And the first thing he did was just that; moved to Zurich—for good. He had gone there earlier that same autumn with his wife and children, and the family was already installed in a flat there. He had then returned to Oslo on his own to sort out 'the past.' The past could be left behind, he reckoned.

Over-reaction

Professor Tor Brustad, however, did not content himself with just studying the handling of the case and the writ serving the *forelegg*. He read through all the documents. His conclusions were sharply critical, especially of some parts of the expert committee's work but also with the system for dealing with the case. His main conclusion was that there had not been grounds for Rolf's arrest. Also, the time was by now well overdue to give Rolf his place in history as a pioneer of accelerator technology. In Brustad's opinion, Rolf should now be considered cleared of the serious treason accusations and finally given his place of honour in the history of science.

Brustad made his factual discoveries and his personal assessment of them known at an international cancer seminar in Hardanger[30] in May 1997 and published them the following year in an article in the scientific journal *Acta Oncologica*.[31] The academic community had now been informed, but the general public still didn't know who Rolf Widerøe was, let alone anything about the accusation of treason and the subsequent restoration of his reputation. This was the point that Brustad expanded upon in several conversations during the preparation of this book:

> Rolf Widerøe's work in Germany during the war and the legal proceedings against him have cast far too long a shadow over what an excellent scientist and technologist he was. His capabilities earned him an honorary title abroad as 'the founder of accelerator technology,' but among us here in Norway he has become a mere footnote in the history of physics. It is a paradox that he is almost overlooked in his homeland. The main explanation for this lies in legal procedures based on false information about what he had been working on in Germany.

He criticises the members of the expert committee, saying that 'at the periphery of, if not to say beyond, their mandate' they had sown seeds of doubt even about Rolf's abilities as an inventor and a scientist. They disliked the fact that Rolf had pointed out in an interview that one of the committee members had earlier described his work as enormously important. So in their report they had down-played this expression, implying that the comment only applied to 'a few simple questions about the basic principles of the movement of electrons.'

Brustad shows them little mercy in his article:

> There was a serious defect in the basis for Rolf's prosecution, and the record needs to be corrected. Right from when he was arrested in May 1945 and until the expert committee submitted its report in February the following year, the case was based on an extremely serious allegation that Rolf had developed the steering mechanisms for the fearsome German V2 rockets. In addition to the fact that the allegation came from an *anonymous* source and was the *only stated justification* for Rolf's arrest, it was also obvious that it was false, completely baseless. If the case against Widerøe had been managed in accordance with the basic principles of Norwegian law, the anonymous accusation would obviously never have been pursued. In that case Widerøe would almost certainly not have been arrested and in any event the whole case would have followed a different and more balanced course.

Brustad remained critical of the legal process, as his further comments show:

> When it then also became known that Widerøe had spent all his time in Germany developing a working betatron, and that this work was of no military use to the Germans, it was clear that the whole process against him was an over-reaction by the authorities.

A completely opposite point of view was given by Finn Lied, former industry minister and long-serving director of the Defence Research Institute, when the case was referred to him a good 60 years later. His comment was short and sharp:

> If Rolf Widerøe worked for the Luftwaffe, he got off bloody lightly.[32]

Lied said that he knew of Rolf as a physicist and knew that he had worked in Germany during the war, but admitted that he did not know about the details of his activities, nor about the legal sequel in Norway. He was however quite clear about the punishment and he repeated gravely that if it was indisputable that Rolf was employed by the Luftwaffe, then the penalty—a monetary fine—was very slight in relation to the crime.

Brustad pointed out that the expert committee had significantly influenced the outcome of the case, particularly in an appended document that was pure physics. Here the committee casts doubt on whether what Rolf had done really was something new and tenable, or whether it was just wrong. The text is permeated with scepticism both about Rolf's professional competence in general and about his work building a betatron in Germany. For example, it says:

> Though none of the committee members has been able to check all the complicated and obscure calculations about lens effects in this presentation submitted by Engineer Widerøe, one of the members has made separate calculations. These show that neither electrical nor magnetic lenses will provide any noticeable enhancement to a betatron that is already sensibly constructed. Contrary to this, Widerøe has …

The committee's paper then continues with their own scientific explanation. In the three concluding sections they deliver a barrage of powerfully stated deprecations:

> completely meaningless
> neither here nor there
> so has misunderstood the whole theory
> whether Widerøe or his co-workers appear to have been aware of the circumstance that …
> complications that are altogether ignored in the presentation
> nor does he mention the question of how the discharges (…) could be avoided.

As if to seal the criticism, the final sentence delivers a decisive blow:

> The idea of electrostatic lenses therefore appears so little thought out that it altogether cannot be taken seriously, quite apart from the errors in the calculations.[33]

An Intelligence Officer Visits

Such a salvo of rejection and disapproval from professional colleagues makes one curious. What did they mean by this? Did they not understand, or did they not want to understand, or was that just what they did?

Before the expert committee was appointed and while Rolf was still sitting imprisoned in Ilebu, the Americans had been in the picture. An intelligence officer had visited Rolf in prison, and Rolf was released the same afternoon. The visitor was identical with one of the four who later became members of the expert committee. So we have another mystery.

The visitor was Gunnar Randers, who since autumn 1944 had been working for American military intelligence as part of 'Operation Alsos,' the codename for the section of the Manhattan Project that was investigating how far Hitler's Germany had come with the atom bomb. He was based in Paris, but travelled round Europe most of the time. So one July day in summer 1945 Randers was in Ilebu State Prison, where he had come to find out what Rolf knew. There was a total solar eclipse that day, and the astrophysicist did not miss such a phenomenon. He had brought a smoked glass through which they could look at the sun. This may have softened the mood, but anyway Rolf interpreted it as a good omen. The eclipse was due to happen about one o'clock, and the two scientists were able both to watch the eclipse and to talk physics. Little did they realise that they would have more dealings with each other, and not just once.

Rolf has said that he told Randers about his work on the betatron, but apart from that no other details of the meeting are known, neither the reason for it nor what came out of it. Nor has any question been asked officially about the meeting and the release from prison. It could be thought that the visit was just a friendly gesture, visiting a colleague who was inside, and Rolf's release the same afternoon could be seen as just a coincidence. Or on reflection, it could be thought that the visitor might have had good contacts and perhaps put in a good word with the prison authorities or the police. As simple as that.

What only the initiated knew was that the conversation in the prison was written down word for word and sent to the USA. In the archive at The American Institute of Physics in Maryland, outside Washington DC, there is a thick folder labelled 'Rolf Widerøe Papers, 1942–1945.' Contained within this is a file on the outside of which Gunnar Randers has written by hand: 'Visit to Widerøe in Oslo. July 1945.' and 'Capt. G. Randers.'

Professor Brustad had hit the mark when he went through the material in the Norwegian National Archive and wrote in the article:

> The Allies had for a long time been carrying out extensive investigations of all the German military research activity. Norway had been taking part in this and had been represented by Gunnar Randers, who at that time had the rank of Captain.[34]

Brustad asserted that through this work Norway had 'had full surveillance of Widerøe's work in Germany.' The information about intelligence activity in research milieus was probably not so remarkable for a professor with long experience, and he didn't expand on it. Nor did anybody appear to be interested in the connection between Randers' visit and Rolf's release. Neither at the time, nor since. Nor did Rolf say much about it, other than that he thought he had been released thanks to Randers and his friend and colleague Odd Dahl, and assumed that the pair of them had managed to convince the authorities that there was no reason for him to be in prison while he was waiting for his case to come up. The only thing Rolf says about Gunnar Randers in the biography is that 'He had been given the job of speaking with me, probably because of the V2-rockets.'

The strange thing here is that nobody has followed up on what Rolf is on the point of saying, namely that the Allies knew of Rolf's dealings with the German weapons industry and that it was understandable that he was being investigated. And if it was the case that the Allies were aware, what would be the consequences of that? In what direction would that influence the question of guilt or innocence? Did it strengthen the case for finding him guilty or was it a mitigating circumstance? Nobody has looked into that. But even more, one must wonder why he himself didn't make more of it.

Did he not know better? Again we are faced with one of those questions of which there are so many about Rolf. I read through the text in the biography again and check what he has said elsewhere on the subject, including in an interview that Pedro Waloschek carried out when he was preparing the biography. Then I listen again to the recording of the interview and conversation that some young physicists arranged in Oslo when Rolf was 81 years old.[35] I think about what Rolf says in the interview and what he allowed the author of the biography to write. I read the corrections and deletions in the drafts he was given to look through. What remains is content he vouches for, almost identical word for word in the book, on video and in the tape-recording. Like a lesson learned by rote. When I repeat the sentences to myself, an imaginary and slightly reproving dialogue plays out in my head as Rolf tells me about the time when Gunnar Randers visited him in the prison:

> He came straight from America, tasked with finding out what was going on. I explained everything to him exactly, and he immediately understood that I had had nothing to do with Peenemünde. And obviously he then set about having me released.
>
> *So it was as simple as that, you were just released after he had been there? How was that possible?*
>
> I was given the opportunity to explain the circumstances around my work in Germany and – at least for me – it seemed to me as if we had got on well together.
>
> *You were set free the same day, but you didn't mention that. Why are you not clear about this? It would surely be an important thing to include in an autobiography. Was physics more important?*
>
> He had been in America for a while and had come back to Norway to go into astrophysics and nuclear physics.
>
> *<u>That</u> is what you are talking about! But don't you see that you are concealing his connection with American intelligence services by drawing attention towards physics and a new career in the homeland? Was there something you had promised to keep quiet about? Was there something the Soviets mustn't get to know about? And then the big question that I always come back to: Why did you not use this in your defence? Why did you not say "Listen, there are mitigating circumstances." Weren't there any? Or did you try such a plea? An intelligent man like you must understand that things like this give rise to conspiracy theories.*

I never did get to say that to him, and there is now no possibility of having my comments repudiated. However, he had a good spokesman in Tor Brustad.

Biased

The professor at the Radium Hospital did not conceal his criticism of much of the expert committee's work. One could almost say that he bore a grudge against the whole committee, whom he considered were complicit in having

Rolf relegated to a 'footnote' in the history of physics in Norway.[36] He was particularly critical of the attitude that appeared to him to permeate the committee's report:

> Unfortunately the committee was influenced by the feelings and attitude that were so prevalent in 1945-46 and were very negative about anything concerning working with the Germans.

He did however give the committee credit for one important point, namely that they did contribute to the clarification that Rolf had had nothing to do with the development of the German V-bombs. This point is worth looking into further. In his article Brustad summed up and commented upon it thus:

> Despite the fact that the main conclusions in the report are scattered in different parts of the report and sometimes wreathed in long and difficult formulations, they can be summed up in three sentences:
>
> 1. Widerøe had had nothing to do with the V2 rockets.
> 2. Widerøe had used all his time during his stay in Germany on the work of developing a functioning 15 MeV betatron.
> 3. Widerøe's work in Germany had not been of any military use to the Germans.[37]

Brustad commented further that even though these conclusions were inevitable the experts should be given credit for them, when one takes into consideration the resentful anti-German feeling that prevailed in Norway at that time. Nowadays, we know that point no. 2 is not entirely accurate. On this point the committee was too lenient, whether knowingly or unknowingly, and so was Brustad. For Rolf did in fact do other things. In a sense the committee was right, though, because the only machine that physically came to be built was the15 MeV betatron, even though at the same time he was working theoretically on ideas for different and bigger machines. It is difficult to know how well the committee was informed on this matter.

Serious Omissions

Brustad also raised the question of why the experts had not mentioned some of Rolf's achievements, but seemed to be obsessed by what he had not achieved. Why did they say nothing about his success in constructing the world's first linear accelerator? His patent for the principle of colliding beams? His patent for the basic principles of the synchrotron, which he worked out while he was imprisoned in Ilebu? Nor had the committee attached any importance to the fact that Rolf had taken out patents and offered to work with Norwegian authorities in giving access to the knowledge and information he had brought back from Germany.

Tor Brustad was of the opinion that even though the expert committee had detailed knowledge of Rolf's work in Germany, they gave only a vague explanation of why the Germans wanted to engage Widerøe in the betatron project.[38] He pointed out that only two reasons were given in the report. The first of these was that high-energy radiation produced in a betatron could be used to disable the enemy's aircraft. Brustad comments on this as follows:

> The committee did not make it clear to the prosecuting authorities (who obviously were not knowledgeable about this technology) that these plans were totally unrealistic. How could a slender beam of radiation from a colossus of a 1944 betatron be aimed at an enemy aircraft flying high and fast? How could radiation of ludicrously low intensity for such a mission deliver a dose sufficient to kill the pilot and/or disable the radar system?[39]

The second of the two reasons suggested by the committee, Brustad tells us, was that the Germans 'may have wanted to compete with the Americans in this new technology that might have been important for atomic physics, and indirectly for the atomic bomb.'[40] The committee left it to the prosecuting authorities to assess the significance of these two arguments. The report just said that:

> It is clear that Schiebold's fantastic ideas about "death-rays" to be directed against aircraft must have been a contributory factor in the Germans wanting to secure Widerøe's talents for themselves. Besides this, the wish to compete with the Americans in a new field that might be important for atomic physics and thereby perhaps indirectly for atomic weapons, may have played some part.[41]

So in Brustad's opinion not only was the content of the committee's report biased; the omissions were equally serious.

Illogical

Brustad goes even further, pointing out flaws in the committee's logic. He thinks that the committee had implied, without presenting any evidence, that the German delegation had been involved in a possible military use of the project, and that they had insinuated that Rolf might have agreed to take part in something of this sort. Brustad maintains that such a suggestion would have been firmly rejected by Rolf. It would in fact have been quite illogical for the delegation to ruin their plans by mentioning possible military applications. Rolf would have exposed the whole weapons project as nonsense and his confidence in the betatron project and in the negotiators would have been weakened. Mention of military aspects would quite unnecessarily have aroused Rolf's national feelings, which the Germans wanted to avoid.

Brustad considers that both the prosecuting authorities and the expert committee saw Rolf's participation in the Hamburg project as evidence of a lack of national loyalty. It seems as if the only excuse they could have accepted for agreeing to such collaboration would have been evidence that he had been exposed to threats or violence. Brustad expands on this view:

> Rolf was so important for the German security services that they would never have allowed him to fall into the hands of the Allies. They knew all along that they would succeed in keeping him under control and working on his betatron project because they held the trump card, a partly concealed threat that would guarantee them success without having to turn to violence. If he had refused to collaborate on the project – let alone work with the Allies – or if he had omitted to return after visiting his family in Oslo, the security services would almost certainly have persuaded him to reconsider without delay. They would just have tightened the thumbscrews on his brother. So the security services would never agree to releasing Viggo from prison. By holding Viggo as a hostage they held control over his much more important brother. So the two brothers were hostages for each other.

Professor Brustad is in no doubt that the expert committee knew that the Germans' death-ray project was technically a hopeless wild goose chase. So all that remains of the reasons for the Germans wanting Rolf to work for them is the airy argument about competition with the Allies.

> But the committee itself concluded that Rolf had used all his time in Germany on the development of the 15 MeV betatron, and that this work had been of no military benefit to the Germans. If the Germans' motive really was to engage Widerøe on a project of no military value, it is difficult to understand why he was appointed to lead the project and given authority to carry it forward as he wished.

Brustad asserts that Rolf had confirmed that he was in charge of the project, as shown by notes Rolf wrote to Oslo Police Office in answer to specific questions from the expert committee. In point 6 of document 15 the committee asks: 'What requirements did the Germans place on the results of the work?' Widerøe replies: 'No special requirements, except that the development should happen as quickly as possible.' I was in charge of the science and technology.'[42]

In general, Brustad thinks that the committee report failed to answer many questions: Why was Rolf sent to Germany without apparent use of force?[43] Why was he so generously provided with economic, personnel and industrial resources? Why was he given so much freedom during his stay in Germany and such good opportunities to travel to and fro between Oslo and Hamburg? Indeed, why did he start working with the Germans at all?

What Happened?

With the benefit of hindsight, we can see that the experts' report had a dramatic effect on the whole process. However, there must have been several other factors influencing the outcome.

Something happened between Rolf's arrest in May and the *forelegg* in November of the following year. A man is arrested on suspicion of having helped to construct one of the world's most dangerous bombs and ends up with a fine, as if it were a minor traffic offence. Even with a reduction the fine was considerably bigger than it otherwise would have been for a breach so slight that one just paid a fine. If the accused accepts the grounds and pays up, the case is now off the prosecuting authorities' books.

Even though it was considerably moderated in relation to the initial denunciation, the charge against Rolf was still very serious. Yet it did not finally come to court. No official prosecutor arguing the case for imprisonment. No jury, no judge, no main hearing, no sentencing in court. After one year and six months it is all settled in the simplest possible way, with agreement to a *forelegg*. The Central Statistical Office's official count of treason cases in the years 1940–1945 explains why this was a common way of resolving cases soon after the war.

> A *forelegg* can generally be used for minor cases where the offence is punishable by a fine, possibly combined with confiscation. (See Criminal Procedure Law of 1st July 1887, ch. 287.) An agreed *forelegg* has the same effect as a sentence. The facility to conclude a case with a *forelegg* has been widely used in treason cases. In his letter of 25th November 1947 to the Ministry of Justice about the restriction of the treason settlement, the Director General of Public Prosecution says, *inter alia*: An important means of speeding up the legal

process by simplifying the procedure was the regulation introduced by law no. 2 of 22nd February 1946 about authority for the prosecuting authority to apply an agreed fine in preference to a prison sentence of up to 1 year.[44]

Rolf was in the category eligible for a *forelegg* and a fine. He had been in prison for a month and a half, not under sentence but detained in custody awaiting prosecution. The final outcome of the case showed that there were no grounds for a prison sentence but that a fine was considered appropriate. That should have been enough to settle the matter, but why did the whole process start so viciously? Do we really know the whole story? Did the authorities know something that has been withheld from us? Rolf had undoubtedly been working on a project sponsored by the Luftwaffe. And he had earned money from it.

A long time passed between the submission of the expert committee's report and the prosecuting authority's decision on how to conclude Rolf's case. There is no known documentation to indicate whether this was just because of the long queue of cases waiting to be resolved, or whether his case was particularly difficult. There certainly was a large number of cases to be dealt with. Over 90,000 people were charged with treasonous offences. About 30,000 were arrested. It would inevitably take time to work through all these. At least half of the people who were charged under the treason paragraph, Constitution Paragraph 86, were given penalties, of which half were fines. In other words, a quarter of the cases concluded with a fine.[45]

The Passport Question

While the legal case was proceeding in relative peace and quiet, the question of whether or not to return Rolf's passport was a big issue. He had been offered a position at Brown Boveri's head office in Switzerland, to lead the technical development of betatrons on an industrial basis. The firm wanted him to start the construction of a machine for the hospital in Zurich as soon as possible, and naturally enough they wanted to arrange a meeting. However, the Norwegian they were head-hunting had not only been imprisoned, but had had his passport confiscated and was unable to travel abroad even after he had been released.

On 1st March 1946 Rolf wrote to the official in charge of his case, Gustav B. Dreyer, asking to be allowed as soon as possible to travel to Switzerland to meet the Brown Boveri management. He cited two reasons in support of his request. First, he couldn't start work on the betatron the Norwegian Radium Hospital had ordered until he had conferred with the laboratory in Switzerland about important details of the construction. Second, he needed to discuss matters concerning one of the patents in which there was great interest, especially from the USA.[46]

The question of whether or not to return Rolf's passport would turn out to arouse much wider attention than the fact that he had been arrested for treason. He couldn't travel to any meeting at Brown Boveri in Switzerland without a passport, but it was difficult to get his passport back so long as the case against him had not been resolved. Tor Brustad points out the irony that while the Swiss were offering him an attractive research and development position on the basis of the competence he had built up through his work, the Norwegians were holding him under arrest for the same work and the same competence.

The Radium Hospital Intervenes

Around this time, The Norwegian Radium Hospital had started working on plans to acquire new radiotherapy equipment. High energy, accelerator generated radiation was the very latest thing in cancer treatment, and the director was determined that the equipment to be bought should be so advanced as to place the Radium Hospital in the forefront of the revolution that was about to happen in radiotherapy. The question was where to obtain the best equipment.

Together with the manager of NEBB he sent a letter to the prosecuting authorities, asking that Rolf be given the opportunity to travel to Switzerland to take part in a preliminary meeting about the development of new radiotherapy technology. They said that this work would be of great public importance, as it would lead to more effective treatment of many cancer patients.[47]

The Official in Charge Intervenes

When Rolf heard about the intervention from these two, he sent further requests in the autumn and in the winter to have his passport restored. Brustad tells us about this and expresses amazement about what happened next.

> The official in charge of the case then made a surprising move. He brought in the expert committee. The four scientists who had been appointed to assist the prosecuting authority with technical questions about physics were now also expected to express an opinion on the passport question. This created further dramatic complications. The committee advised firmly against all the applications and therefore opposed any release of the passport.

In the article Brustad quoted one of the replies from the committee, to 'illustrate the committee's attitude, both to the release of the passport and to Widerøe himself':

> As will be evident from the committee's report, Eng. Widerøe's planned journey to Baden (Switzerland) should not be seen as of any public benefit, but merely as serving his own personal interest. The question of the passport is a police matter for which the expert committee will take no responsibility. The committee will however comment that such a visit would give Widerøe unrestricted opportunity to promote his view of the case – also regarding hypothetical Norwegian interests – among his foreign contacts. The request from Brown Boveri should undoubtedly be considered to have come about on Widerøe's own initiative.[48]

The committee said that it wanted to have nothing to do with the question as it was a matter for the police, but then they offer their opinion and suggest that Rolf has orchestrated it all. Brustad then goes on to tell us of a new twist in the passport question:

> Then the official in charge of the case at Oslo Police Office intervened. Again. For when it became known that the accusation of dealings with the German V-bombers were a fabrication, he decided that the whole case against Rolf Widerøe had been of such a minor character that he could on his own authority give permission for the passport to be released to allow Rolf to take part in his meeting with Brown Boveri.'

It is easy to imagine the ignominy and loss of prestige and public reputation that Rolf would have suffered if he had not been allowed to travel. His own prosperity, future job and respect and honour were at stake. So there can be no doubt that he set great store on being able to make the journey. It was just a matter of formalities – or maybe a little more than that. The point is that he didn't give up, and he finally succeeded. After repeated applications, several rejections and pressure from various quarters he succeeded in obtaining a temporary passport in spring 1946. Then after Easter he went on a two week visit to Brown Boveri's head office.

He was now concentrating more and more on making a start on the betatron he was to build for the Swiss, and he was beginning to become impatient with the slow progress of the legal case. On 7th June 1946 he wrote to the police in Oslo and Aker, asking that his case 'be resolved as soon as possible.' He said that he had had meetings with the senior doctor at the hospital in Zurich and that what the doctors had said was 'very alarming.' They anticipated that 'within the course of the next year there would be a catastrophic shortage of X-ray tubes for cancer treatment in European hospitals.' Siemens was unable to meet the demand for X-ray tubes. Before and during the war the company had supplied more or less the whole market, but because of the situation in Germany they could now deliver only about five per cent of their normal production. His radiation transformer could solve this problem, because the apparatus could 'replace at least 5–10 normal X-ray tubes,' and so it was 'of very greatest importance to be able to provide apparatus ready for hospital use as soon as possible.'

In his letter, Rolf also referred to the director of the Norwegian Radium Hospital, who thought that a modern radiotherapy machine should be installed there as soon as possible. He went on to emphasise that this was 'a case whose significance was not limited to Norway.' It affected many other European countries. He then ended his letter with a peroration:

> Therefore I appeal to you to take into consideration the major humanitarian interests that are involved here and to make the best possible efforts to ensure that your work is not delayed. I ask for my case to be dealt with as soon as possible so that I can start the work in Baden in August this year' Signed 'Yours faithfully, Rolf Widerøe.[49]

Not a word about the details of the case or its possible outcome.

Four weeks later he wrote another letter, addressed directly this time to the Chief of Criminal Police in the Treason Department, Lars L'Abée Lund. He attached a cutting from the newspaper *Neue Züricher Zeitung* about Brown Boveri's investment in his radiation transformer and wrote that it was very urgent for him to start on the work:

> The construction of the apparatus has now reached the point where my personal presence is required and the company is therefore asking me to come to Switzerland as soon as possible. In this context, I urgently request you to speed up the consideration of my case as much as possible so that I can travel on 17th August with arrival in Baden on 21st August to take up my post as planned. Yours faithfully, Rolf Widerøe.[50]

Nor is there here any attempt to argue or clear his name; just an appeal about the progress of the case so that he can move on.

He did go to Zurich in August. From there, he wrote to his defence lawyer to ask if it really was necessary for him to travel back to Oslo to be present at the conclusion of the case later in the autumn. If it was just a matter of formalities, could it be settled by the advocate and by letter? Then he took up the question of a permanent passport. The rest of the letter is about the apparatus he is working on and thinking about, planned to be of 1100 MeV and possibly to be built at the expense of the Swiss Government.[51] His mind was fully on his work and he didn't seem to worry about being accused of treason. However, other people took a different view of his situation.

The Media Intervene

Now the only ingredient missing for the passport question to explode was the intervention of the media. Inevitably this happened, and not unexpectedly what lit the fuse was the visit to Switzerland. When it became known that a person who had been charged under the treason regulations had been allowed to travel abroad, there was an outcry. The members of the expert committee were pilloried, even though it was not they who had authorised the passport request. The problem was that people could believe the committee was responsible for the decision, and the committee members felt they had to clear their names as quickly as possible. No good Norwegians could tolerate lenient treatment of traitors. When it became known during the summer that Rolf had been issued with a passport vicious outburst erupted, not least in *Dagbladet*, against those the newspaper thought responsible, even though the Police Chief had made a statement to the press that the passport was only valid for travel to Switzerland, was only valid for one month and could not be extended.

It started with an article on 6th September, when *Dagbladet* demanded to be informed who had been responsible for Rolf being given his passport so that he could leave the country. Front page headlines declared 'Norwegian Nazi Atomic Expert Goes to Switzerland' and 'Fine and Confiscation Await Rolf on his Return Home.' The text continued very emphatically:

> One of the things that we were *sure* during the war would *not* happen, that just after the war we *hoped* would not happen and that we now *fear* will happen *regularly in future*, *happened* recently. The authorities issued a passport to

> a prominent pro-German, one of the many who have narrowly succeeded in avoiding prison. (…) Dr. Engineer Rolf Widerøe has travelled to Switzerland taking his whole family with him, and the whole of the Røa district, where he lives, is understandably in an uproar. From what *Dagbladet* understands, he has said that he hopes to emigrate to Switzerland and he has taken his car and equipment with him. But the police tell us that he cannot have his passport extended abroad and that he therefore has to come back.

Then *Dagbladet* refers to the pro-German article Rolf had written for *Teknisk Ukeblad* during the war. They point out that an active member of the Nazi Party had taken over as editor, and that submitting articles was considered by good Norwegians to be disloyal. The paper is sticking the knife in, but it does admit:

> From the information available we cannot raise an action against him for spying, but he must answer to the law for his article in *Teknisk Ukeblad* and other sins, for which a significant fine and forfeitures can be considered.

The Experts Intervene

Now the expert committee joined in the action, engaging actively in the press debate. The chairman was worried that people would think that the committee had had something to do with Rolf getting his passport back. He wrote in *Dagbladet* on 11th September, making it clear that the committee was not responsible for this. This was front-page news again, under the headline 'The Widerøe Case.'

Another committee member, Gunnar Randers, turned to the paper again on 17th September:

> We have not recommended any travel. Nor is there any scientific justification for his visit to Switzerland. We recommended that he should be treated as a traitor and face the consequences of that. That was all we said.

That was how it was presented. Double-underlined. Nobody should be in any doubt. The committee had not recommended any travel. There was no important scientific matter that absolutely had to be attended to. Moreover, traitors must take the consequences of their actions. Highly respected men could not leave any grounds for doubt about where they stood on the case. Traitors were traitors. That was how it was.

Professor Brustad is very critical of the committee's intervention in the press debate:

> It is worrying when members of an expert committee go to the press and engage in rather strong pre-judgement of the accused just before the case is due to come to court for final decision. This was particularly bad in light of the prevailing public mood during the treason trials, when the will to advance the accused's points of view was not given high priority.

No Mitigating Circumstances

Tor Brustad was also concerned about the human aspects of this time of stress and conflict. Nine months passed between Rolf's arrest and the submission of the committee's report, and a further nine months until the case was concluded. This was a time of continuous humiliation for Rolf and his family, and eventually all they wanted was to have the case ended as soon as possible, so that they could start their new life abroad. Brustad thinks that Rolf hoped his stay in Germany during the war would be understood as Rolf himself saw it: a humanitarian project of public benefit; a technological development to improve the radiation treatment of patients with cancer. Instead, his work in Germany was interpreted as a flaw in his patriotism. In support of this view, Brustad refers to the confiscation of income from patent licenses:

> The normal procedure would have been for the tax authorities to assess both the initial and the subsequent taxation of extraordinary income and assets. This procedure was not followed. Instead, the prosecuting authority simply confiscated the income from about thirty of Rolf's patents.

Brustad also refers to the situation of Rolf's brother:

> I think the fact that Rolf's desire to save his brother was not recognised as a *force majeur* is illustrative of the public mood at the time. None of the steps that Rolf had taken to bring about ameliorations in Viggo's prison conditions were recognised as mitigating circumstances. On the contrary, two of them were explicitly included in the list of charges in the *forelegg* document.

According to Brustad, Rolf's obligation to help his brother—which might have been the trump card in the case for his defence—appears to have carried little weight with the prosecuting authorities. It does seem strange that Rolf does not appear to have used this argument. We may wonder whether he might have had an even better card up his sleeve.

Blackened and Scarred

Professor Brustad's clear opinion is that the expert committee contributed to blackening Rolf's reputation. He points out that the committee itself wanted to restrict its mandate and to have the least possible influence both on the outcome of the case and on the question of whether Rolf had assisted the enemy. However, the committee had not maintained its neutrality in these matters, as he asserted quite bluntly in his paper:

> In the light of its mandate and of its self-imposed additional restrictions, I am deeply disappointed to have to state that the expert committee did not use only pure scientific arguments in their report, but unfortunately also inserted a number of subjective, very offensive opinions about Widerøe as a person: for example, it instructed the prosecuting authorities that Widerøe's work *till now* had not included anything *original* that was worth mentioning, and that *nor were there grounds* to believe that his future work with the betatron would be crowned with success, for as a *physicist* Widerøe was an *outsider*, with minimal understanding of *theoretical physics* and moreover with *limited ability* as a *manager*.

Fifteen to twenty years later, Brustad stood by his assessment and thought that the committee's severe criticism was much of the reason for Rolf's loss of reputation in Norway. He attributed heavy responsibility to the expert committee for the outcome and consequences of the treason case. He did that when he published his findings, and he still did it at the time this book was being written, even though he admitted that in the 1990s he may have gone slightly too far in his defence of Rolf and in his criticism of the committee. He admitted that he could have expressed his opinions more moderately, and that in his eagerness to find good arguments in Rolf's favour he might have been biased and blind to the counter-arguments. But that does not contradict the main conclusion from his findings in the National Archives. He stood by that, and it is noteworthy enough: The documents showed that Rolf had done nothing of military value to the Germans.

Brustad says that the experts also lacked relevant specialist competence:

> We can take into consideration that the committee lacked competence in radiological physics and therefore didn't understand that by his work Rolf had made important contributions to revolutionising radiotherapy, an area of science that was directly related to the committee members' own special areas of nuclear physics.

He adds that the elements he criticises in the expert committee's report not only harmed Rolf but also reflect badly on the experts' own reputations and—what is worse—on the legal system itself:

> Having studied the documents in the National Archives, it is with sorrow I maintain that both the parties involved in this case, both the legal system and Rolf Widerøe, emerged scarred from the process.

But What If … ?

However, we can also consider whether the committee wrote as they did in order to *help* Rolf. Not everything should be taken literally when there is a war on. The report could also have deliberately been written ambiguously for a particular purpose. Professor Brustad in his stern criticism has either not identified or has chosen to ignore such an interpretation. What if the intention was to underplay Rolf's significance in order to make him appear harmless, in order to help him? Then, for example, reducing him to 'Engineer Widerøe' would be a clever move rather than a sophisticated insult. It is worth noting, at least as a matter of curiosity, that the committee consistently refers to Rolf as 'Engineer Widerøe.' He had a doctorate, but for the committee members he was nevertheless 'Engineer.' His degree was 'Doctor of Engineering' from a technical college, whereas the committee members' doctorates were from the university.

We cannot be sure that there was any deliberate downgrading in the choice of title, but to call him just 'Engineer' sounds a little condescending when we read it today. If we want to interpret the committee's report in the worst sense we can admittedly describe the choice of wording as a domineering technique, a deliberate attempt to belittle him. On the other hand, at that time it was almost impolite to refer to somebody using just a surname. Something or other had to come before the name, such as 'Mrs. Jensen' or 'Teacher Johansen' or in this instance 'Engineer Widerøe' from sheer good manners, as there had to be some sort of title. A kind interpretation could therefore be that 'Engineer' is just a practical abbreviation for 'Dr. Eng.'

I prefer the first version, that in the committee's eyes he was a technician, whereas they were intellectual academics.

Insulting and Demeaning

Danish Professor Søren Bentzen at the University of Maryland School of Medicine in the USA, knows of Brustad's work to restore Rolf's reputation. He shares Brustad's professional opinion that it was because of bad feeling that such a significant Norwegian scientist as Rolf Widerøe had not been recognised in Norway.

> I think in fact that many people never want to mention his contribution. It's like the attempt to have the Nobel Prize-winning author Knut Hamsun declared insane, an attempt to diminish somebody in order to be rid of him. It's a stain on his reputation, and I think that's what Brustad found offensive about the expert committee's report.
>
> *What is your own assessment of the expert committee's evaluation?*
>
> I think it was purely political. We can say that if anyone mixed science with politics it was the committee, not Rolf. There was a political motive for diminishing Rolf's significance. I share Brustad's sense of offence, because it is obviously nonsense to say that Rolf did no important scientific work in the past and would not do any in the future. It's a professional misjudgement that shows a lack of insight into Widerøe's real importance. I'm quite sure that they were politically motivated, in the same way as the Nazis tried to downplay the significance of Albert Einstein's work.
>
> *Did the investigating commission know enough about his research to have informed opinions about it?*
>
> I don't know. I don't know enough about the circumstances and I don't know if they really had the necessary expertise. Widerøe was working in a very specialised field. But I do think that by that time Widerøe should have been recognised for purely scientific reasons. I think people were mixing up science and politics.'
>
> *The question is whether they were mixing them up deliberately?*
>
> I don't know if they were doing it deliberately. There could be two possible theories. One theory is that they really did want to have Widerøe released. We could speculate that the committee was trying to do Widerøe a service by diminishing his importance, but that is rather a devious logic. I think that from a professional point of view they did a poor job. The professional kick in the teeth that they gave to Widerøe was totally unnecessary and totally unacceptable. But whether there was someone directly pulling the strings, whether somebody somewhere or other said "Listen now, we need to say that Widerøe

isn't really so important;" that I don't know; somebody guiding the committee's hand as it wrote. It may be more that they were trying to knock Widerøe off the scientific pedestal by belittling his importance. Now, with the benefit of hindsight, we know that Widerøe had got the science right and that his principles were the starting point for a whole industry. Nevertheless, I do think that the expert committee should have acknowledged his work from a purely scientific point of view.

Five Physicists

The four committee members all had doctorates in physics. They were members of the same physics society, they subscribed to the same physics journal, they wrote articles for it, they were developing their careers. Like Rolf. Then they wrote their report about Rolf to the prosecuting authority. Signed by all four.

The fifth man—Rolf—was also a member of the Physics Society. He too read the members' journal, wrote for it, had a doctorate and was focussing on his career. He was and was not one of them. He found himself in the wrong place at the wrong time. How much insight did the four committee members have into this situation? How much were they swayed by the national mood at the time? To what extent are they responsible for the outcome of the case? Is it because of them that Rolf was not acquitted on all charges and his reputation restored? Or, on an alternative interpretation: Is it because of them that Rolf did not get a more severe penalty, such as Finn Lied would have preferred.

They would meet again later. Their interests and talents were not really so very different. Rolf met Tangen and Randers and Wergeland again. He exchanged very courteous letters with Hylleraas, who had chaired the committee. Randers would invite Rolf to take part in creating a research institute in Norway after the war, and both he and Hylleraas were extremely active in promoting the case for Norway to take part in CERN, when Rolf served as a consultant while it was being established.

A Guilty Conscience

Brustad and Waloschek have both told me that it seemed as if one of the committee members, Roald Tangen, subsequently had a guilty conscience about what he had been involved in.[52] Tor Brustad had at one time been a student at Oslo University, with Tangen, as his academic supervisor. He said that Tangen had always wondered about having been able to put his name to the content of the expert committee report. The two of them had spoken about this again when Brustad was a scientific assistant at the university in the 1950s, and Brustad understood that Tangen felt uneasy about having signed the report.

Pedro Waloschek had got the same impression from his correspondence with Tangen. In the course of writing Widerøe's biography he was in contact with Roald Tangen, who was then the only living survivor of the expert committee. Tangen helped by obtaining original case documents from the National Archives, including the *forelegg* document. Waloschek had also written to the archivist, and either as a direct response to this request or via Tangen, the National Archives sent him a roll of microfilm with copies of the settlement document and the committee's report. In the biography, discussion of the legal case is limited to just a few excerpts. Waloschek was not particularly interested in the details of the *forelegg*. The Norwegian legal term *forelegg* is difficult to translate into other languages. Tangen helped him with this, and Waloschek's main focus in what he wrote about the case was to try to explain this concept of an agreed summary sentence.

Waloschek thinks that the reason Tangen sought out information in the National Archives was that he was genuinely concerned about the committee's work and its influence on the case, and that he wanted to make his contribution to the book as accurate as possible. Tangen's comment about the committee's conclusion was as follows:

> The documents in the archive showed that the committee's work had led to the first point in the charge, the one about Rolf's involvement in the construction of V-bombs, being recognised as baseless. This meant that the charge was reduced to a general allegation of having worked for the occupying power.

Interestingly enough, he adds:

> The expert committee had no role at all in the legal process that took place much later (in November 1946).[53]

If it is the case that Tangen regretted having signed the committee report, this weakens the possible argument that the committee was trying to defend Rolf in what they wrote. Another interpretation, less flattering to Tangen, would be that he was retrospectively trying to put a gloss on what he had taken part in, by saying that he regretted it. He had experienced that in other contexts, but both Brustad and Waloschek were of the opinion that Tangen's regret was genuine. However, that is not the end of the story. The committee's report had been unanimous. In a book Waloschek wrote later about German arms development during World War II, he refers to his correspondence with Roald Tangen and writes, among other things:

> Tangen assured me several times that the expert committee's report was mainly about freeing Widerøe from the charge of having collaborated on the V2, and that in this they had been successful. On the other hand, the committee's very negative assessment of Widerøe's purely scientific work in Germany was both unjust and sometimes incorrect. But the powers of the time and the supervising courts did not take that into consideration.[54]

Waloschek has discussed this with me in more detail. He said it could appear that Tangen had a guilty conscience about what he had been involved in. This is confirmed by nuclear physicist Olav Aspelund, one of the participants in the interview with the physicists in the 1980s, who referred to something Tangen had said on that occasion:

> I have always regretted signing that, but I was junior at that time and had great respect for these senior professors at the University of Oslo.

Tangen had also approached another member of the expert committee, Gunnar Randers, at a social gathering. Randers had replied 'So have I,' confirming that Tangen was not alone in how he felt about the affair.[55] Following Tangen's comment during the interview, Rolf had referred to the overheated mood after the war and expressed a desire to move on. Nevertheless, later in the interview Aspelund returned to the topic of Tangen's embarrassment about the committee report. The report was not scientifically valid, and the chairman had quite improperly mixed in politically motivated content.

Let Bygones Be Bygones

Not over-surprisingly, Rolf himself has a relaxed view of the committee's work:

> For my part, I didn't take these investigations very seriously, but I am not very sensitive about such things. Someone may have made negative comments about me, but either I didn't understand that or it didn't bother me.

I assumed that the prosecuting authorities just wanted to have experts to answer the questions they couldn't answer themselves. I consider that quite natural under the circumstances, but the mood in Norway was a little heated at that time and things were not always thought through or considered coolly and calmly. I don't bear any grudge, but at the time I was glad that I would soon be able to go to Switzerland to continue my work.[56]

He gives no good explanation of how he came to be in such stormy waters, other than that as an employee of NEBB he was 'called up' to work in Germany. Nor does the committee give any simple answer. Tor Brustad's conclusion after going through the case documents was that 'Neither the expert committee nor Allied Intelligence ever found the real reasons for Rolf joining the betatron project in Hamburg in late autumn 1943.'[57]

Others have also tried. In the interview with the physicists in Oslo when Rolf was 81 years old, one of the things he was asked about was his experience with the legal system and his view of the expert committee's work. The tape-recording from the conversation was typed out by a secretary, but the copy was never released and is no longer available at the research institute where the meeting took place. There is, however, a copy in the USA.[58] Apart from the organisers, the only person who really took an interest in the conversation was Rolf himself. He carefully proof-read the 116 typewritten pages and completed the text with an attachment. Then he single-handedly translated it all into German for Waloschek, writing with a blue ballpoint pen on his usual square-lined jotting paper. Waloschek later passed on to me his whole Widerøe archive, including the translation of the interview meeting.

Well into the interview the physicists come to the topic of the legal case. Parts of this are quoted below. It is useful to remember that it is an old man who is speaking; some things may have been forgotten, some suppressed and some embellished in the course of the years. But the fact that he committed himself so much first to the print-out and then to the translation and then approved it as the basis for his biography, indicates that he also acknowledged the statements in the light of hindsight and wanted that to be what remained when he was no longer.[59] It is worthwhile to look at how he chooses his words and which questions he passes over quickly. The theme of the meeting was his contribution to physics, but other topics also arose. Rolf firmly took control of the interview when he was asked how long he had been in prison:

Rolf Widerøe: Yes, I don't remember, it was a couple of months, I think, or something like that. And I got a passport, and I travelled to Switzerland. (…) And I was clear that it was quite out of the question to build the betatron in Norway, there was no sort of basis for vacuum technology or glass technology or anything such as that. Anyway, I didn't know of any. (…)

Jan Vaagen: Were you employed by Norwegian Brown Boveri all throughout the war?

Rolf Widerøe: Yes.

Jan Vaagen: Did that help to shorten your stay in Ilebu when you came back here?

Rolf Widerøe: I don't think it was possible to do anything about that. But there was something odd. Randers, he got the job—he was away in America then—to travel to Norway to question me. So I met him at Grini, and we were good friends and we talked about all sorts of things. For remember, the reason that I was in Grini was that the neighbours in Røa, they knew that I knew about relays and so they thought that I was the inventor of the V2 bomb. And that would have been a dreadful business, naturally. And that was why I was in Grini. And that was why Randers came to Norway to ask me about that. And I was able to explain to him quite quickly—naturally I told him everything just as it was, and he understood immediately that all this about the V2 bomb was just nonsense. So after that there weren't any major difficulties for me.

Then Vaagen wanted to know if he had had contact with Norwegian colleagues when he was in Norway after the war.

Rolf Widerøe: I was, and I spoke with Hylleraas [the committee chairman] and he was very sceptical about me. He said 'You can't pretend that this was a scientific work.' He said something like that to me. But otherwise I had very little contact with Wergeland during the war, and he was very reserved towards me. To begin with, first time, he was very friendly and we talked freely about all sorts of things, but later he was very reserved. And I think that was because people had been talking about this and that. So I was probably marked as a rather bad person. (…) By the way, is Hylleraas still alive?

Olav Aspelund: No, he's dead. He must have been dead for you to be proposed for membership of The Academy of Science and Letters here in Oslo, I can say that quite bluntly.

Rolf Widerøe: Oh well, that's how it is.

Jan Vaagen asked if the committee report had been produced to order and what might have lain behind that. Rolf doesn't go into speculating about this, but hurries on to what *he* thinks is important.

Rolf Widerøe: I assume it was simply that the prosecuting authorities needed expertise in a matter they couldn't judge for themselves. And I don't think there was anything odd about that, and I haven't felt any grudge towards any of these people since, for the one thing that was good and fortunate, was that I got permission to go to Switzerland and get started on my work there as soon as possible. (…) And of course I realise that for purely political reasons the mood in Norway was very difficult at that time. It was overheated, and you couldn't expect things always to go properly and smoothly and nicely for yourself. I can understand all that, and I have put it all behind me and forgotten it all. So for me to talk about it here now is superfluous.

Olav Aspelund said his impression was that the academic reputation of Oslo University didn't come out of it very well.

> I can say that, for I know the mood in the Physics Society. I too had to break down a barrier when I invited you there. But it went very well. Among others, Tangen performed like a man.

Jan Vaagen was concerned about the principle of somebody whose talents are mainly in technical activity being evaluated by an academic committee whose area of competence was quite outwith his field. Both Rolf himself and several others agreed that the committee members were theoreticians without experience of experimental physics. Aaserud wanted to bring the discussion back on track and summed up: 'There are many unknowns here.' Rolf agreed:

Rolf Widerøe: I think we should let bygones be bygones. That's the best we can do.

Jan Vaagen: Yes, I think we should come back again to the interesting scientific points. That episode has after all had repercussions in certain quarters that I gather were unpleasant.

Rolf Widerøe: I haven't noticed anything, though. But I am really so insensitive in these matters that it may well be that people have said insulting things where I either haven't noticed the insult or simply haven't bothered about it.

Jan Vaagen: I think we can go so far as to say that there is something in the book about Lawrence and Oppenheimer to the effect that your right to Norwegian citizenship was in danger at that time. Something like that.

Rolf Widerøe: Not a trace, not a trace. (…) And I had no difficulty getting a passport for example.

Are Facts the Same as Truth?

What Rolf said about getting a passport can safely be described as a retrospectively embellished version of reality. He was adjusting the truth when he said that he couldn't remember how long he had been in prison. The *forelegg* document that he signed stated the exact number of days that he had been detained, namely 47. Does one forget such things? Does somebody who works with numbers forget such things? He was able to explain to Randers how things stood, and 'after that there weren't any major difficulties for me.' That must be the world's biggest understatement. It is difficult to judge whether this is caused by repression or by a conscious desire to give a well-styled presentation. Maybe a little bit of both. As an elderly man, he had developed a consistent way of reciting these events—or a rather selective memory if you prefer to see it that way.

That was also apparent ten years later, when Pedro Waloschek worked with him on the biography. Rolf said that he had been *freigesprochen*, found not guilty. Waloschek has told me about this in more detail:

> It is on record that he said that. But he didn't always tell the truth.
>
> *You must explain what you mean by that.*
>
> Well, this bit of the story doesn't reflect well on him.
>
> *Go on.*
>
> The fact is that he insisted that he had been acquitted –'*freigesprochen*' – in Norway. And when he told me that during a video-interview I was doing with him, his wife called me into the kitchen and said, "He's not telling the truth. He accepted the summary sentence. He signed it. He got a fine. He was banned for life from serving in the Norwegian army, and he has never been reaccepted. He knows all that very well. The summary sentence was accepted. And he, inside his head, has changed that to *Freispruch*, acquittal."

Then Waloschek went on to say that he thought Rolf's wife was telling the truth when she immediately said 'Stop! That's not true.' This was why he began to investigate further, he said, and obtained copies from the Norwegian National Archives, especially the *forelegg* document with Rolf's signature.

But perhaps Waloschek is being a little severe here. Acquitted of what? Of all charges? No. Not of writing the article for *Teknisk Ukeblad*; not of giving money to the Norwegian Legion; not of having worked in the enemy's country. Well, maybe not. But acquitted of the appalling main charge, of having worked on the V2 bomb.

'Acquitted' in his own head, but not fully in the eyes of the law or in popular judgement or in Ragnhild's opinion.

Most people took little interest in the legal proceedings. The media had taken an interest in the question of the passport but not in the case as such. This is partly because when a *forelegg* is accepted and signed, all the case documents are automatically stamped 'secret.' In a normal court case, on the other hand, the public can more easily follow the proceedings in court and become informed both about the nature of the charge and about the arguments advanced by the prosecuting and defending counsels. In Rolf's situation, the papers were merely archived.

Years passed. More facts became available. He was *there*. He did *that*. Together with *them*. So now do we know what happened? We know something about what he has said and written, yes. And about what others have said and written. But we only know about what has been found. There may be more; more documents in various countries; more people involved; more people who have promised or who for one reason or another have chosen not to say anything.

The National Archives have been visited, the documents from treason case no. 3418/45 have been read and interviews have taken place. What has been written about the case in the past, is known. Comments have been made public. Important and illuminating facts that nobody had managed to discover have come into the light of day, thanks to two physicists, one in Oslo and one in Hamburg. Brustad, the professor at the Norwegian Radium Hospital, wrote his article in a journal about the treatment of cancer, *Acta Oncologica*. He arranged a conference, initiated the Widerøe Prize and placed a bust of Rolf in a glass case in the vestibule of the hospital. Waloschek, the professor in Hamburg, published his book and had it translated into English and Russian.

The international community of physicists had been given the message: Rolf should never have been arrested. He had not aided the enemy, had never had anything to do with the V2 bombs. The facts were on the table. Good, so do we know everything then? Why he went to Germany in 1943 and why he suddenly returned home in April 1945? Do we understand more of his reaction when he 'fled' to Switzerland after the legal case? Have we gained insights into what it felt like to live with the consequences, in exile for fifty years? Do we understand more about Rolf Widerøe as a person? So do we know him now? Yes and no.

Are facts the same as truth? Well, maybe. And even if they *are*, can we really be sure that we have found all the facts? We can choose to wonder about such things in retrospect, but life has to be lived in the here and now—with wife and children and job and elderly parents back at home. Can everything be converted into factual data that can be worked out in an equation? The law may see things in black and white, but life is often lived in shades of grey. Other people's wild assumptions and loose rumours muddy the waters more than necessary, stirring up further questions and confusion. Looking back from a detached historical perspective, we wonder how he managed to find his way through this.

The people closest to him probably thought that what he did was not so strange. That was how he was, wholly absorbed in his research. Unusual. For his part, he just shrugged his shoulders and left again, in 1946...

***

... with back straight, head high and eyes fixed far ahead on a point somewhere out there in the wide world. *Komme was wolle. Quoi qu'il arrive. Komme det som komme vil.* Come what may.

Notes

1. Dokument x. O. Pk. VJ 3418, 46–47. Rapport A, nr. 1029. Riksarkivet, Landssviksak nr. 3418/45 (Clause).
2. Dokument 2, 1003, 24.5.45, Riksarkivet, Landssviksak nr 3418/45 (Clause).
3. Dokument 8, handwritten 'Redegjørelse for mitt arbeid i Tyskland ("Account of my work in Germany") etc.', 24/5—45, Riksarkivet, Landssviksak nr 3418/45 (Clause).
4. Tor Brustad: 'Why is the Originator of the Science of Particle Accelerators so Neglected, Particularly in his Home Country?' Extended version. Scandinavian University Press 1998. ISSN 0284-186X. (An abridged version of this paper, without inter alia, is printed in Acta Oncologica 1998, 37.) Offprint of complete article, p. 10.
   Letter from Engineer S.A. Solberg, A/S Norsk Elektrisk & Brown Boveri, 25th May 1945 to the Criminal Police in Oslo, Møllergt. 19, Oslo.
5. Letter from Rolf Widerøe to Director Solberg 22nd January 1946, ETH-Library Zurich HS 903:80.
6. *Dokument 11 Rettsbok for Oslo Forhørsrett*, dated 25th June 1945, held at Ila Prison. National Archive, Treason Case no. 3418/45 (Clause).
7. *Dokument 18. O. Pk. V, sak 3418* Explanation presented to the preliminary court 25/06/1945, National Archives, Treason Case no. 3418/45 (Clause).
8. Oscar de Besche case document, dated 5th July, addressed to Junior Police Prosecutor Gustav B. Dreyer, National Archive, Treason Case no. 3418/45 (Clause).

9. *Dokument 17. O. Pk. V*, Oslo 7/7 1945, *Løslatelsesordre* ('Order for Release'), National Archive, Treason Case no. 3418/45 (Clause).
10. *Dokument 19. Rettsbok for Oslo Forhørsrett*, 21/11 45, National Archive, Treason Case no. 3418/45 (Clause).
11. In 1942 this work continued at the University of Oslo. The professor who had led the development, Johan P. Holtsmark, had been appointed professor there and the two of them followed him to Oslo. It is stated in several places that Holtsmark was also a member of the expert committee. But the four appointed members who also signed the final document were Hylleraas, Wergeland, Tangen and Randers.
12. Per Chr. Hemmer and Ivar Svare '*Linjen for Teknisk fysikk ved NTNU og dens videreføring 75 år 1932–2007*'.
13. He was a member of the scientific intelligence organisation 'Operation Alsos,' also referred to as 'The Alsos Mission,' in the USA.
14. Communication dated 24/09/1945 from Junior Police Prosecutor Gustav B. Dreyer to Senior Prosecutor L'Abée-Lund, National Archives, Treason Case no. 3418/45 (Clause). The two attached documents were number 14 and 15. Ref. extract in the next chapter of this book, 'But there was more,' in relation to Randers' work for American Intelligence Services.
15. Among other sources, this is from one of the members, Roald Tangen, in conversation with Pedro Waloschek during the preparation of Widerøe's biography.
16. The others are by Herman Dänzer, Walter Müller and the later Nobel prize-winner Walther Bothe.
17. Document 25, dated 11th March 1946. Addressed to Oslo and Aker Police Office, Treason Department, Viktoria Terrasse 5/7, from High Court Advocate Oscar de Besche, National Archives, Treason Case no. 3418/45 (Clause).
18. Document 27, dated 15th March 1946. Report to Oslo Police Office submitted by Crime Assistant John Strand, National Archives, Treason Case no. 3418/45 (Clause).
19. Document 33, dated 24th May 1946 from Brown Boveri to Rolf Widerøe, National Archives, Treason Case no. 3418/45 (Clause).
20. Document 45 with attachment, letter from The Royal Foreign Department to the Chief of Police, Oslo, dated 12th June 1946, 'Dr. Eng. Rolf Widerøe's activities during the war,' National Archives, Treason Case no. 3418/45 (Clause).
21. Document 28, dated 29th June 1946, O. pk. V.J.5154, written from Advocate O. de Besche to Oslo and Aker Police Office, National Archives, Treason Case no. 3418/45 (Clause).
22. Interview of Rolf Widerøe conducted by Police Prosecutor Dreyer 4th July 1946, National Archives, Treason Case no. 3418/45 (Clause).

23. Written from Advocate O. de Besche to Oslo and Aker Police Office, National Archives, Treason Case no. 3418/45 (Clause).
24. Letter from Viggo Widerøe to Police Prosecutor Gustav B. Dreyer 4th July 1946, National Archives, Treason Case no. 3418/45 (Clause).
25. Document 32, Report to Oslo Police Office, 1st August 1946 submitted by Police Prosecutor Gustav B. Dreyer on 31st July 1946, National Archives, Treason Case no. 3418/45 (Clause).
26. Tor Brustad: 'Why is the Originator of The Science of Particle Accelerators so Neglected, Particularly in his Home Country?' Extended version. Scandinavian University Press 1998. ISSN 0284-186X. (An abridged version of this paper, without inter alia, is printed in *Acta Oncologica* 1998, 37.) Special printing of complete article, p. 8, footnote 17. Note dated 11th July 1946 from Police Prosecutor Gustav Meyer to the Chief of Criminal Police, Oslo Police Office, Treason Department. Area: AB 3418, National Archives (Clause).
27. Note (separate folder) Eng. Rolf Widerøe, case 3418/45—AB, dated 22.07.1946 probably from L. L'Abee-Lund to Gustav B. Dreyer, National Archives, Treason Case no. 3418/45 (Clause).
28. Letter from Gustav B. Dreyer to Chief of Criminal Police L. L'Abee-Lund 14/9-46, case Rolf Widerøe, National Archives, Treason Case no. 3418/45 (Clause).
29. Document 52, Report to Oslo Police Office, dated 11/10/46 by Junior Police Prosecutor Gustav. B. Dreyer, National Archives, Treason Case no. 3418/45 (Clause).
30. The First Scandinavian Symposium on Radiation Oncology. Seminar in memory of Professor Dr. Eng. Rolf Widerøe. Rosendal Manor, 24–28th May 1997.
31. Tor Brustad: 'Why is the Originator of The Science of Particle Accelerators so Neglected, Particularly in his Home Country?' *Acta Oncologica* 1998, p 37, Scandinavian University Press 1998. (Shortened version without footnotes) Two other contributions about Widerøe that were delivered at the seminar are published in the same issue. These were written by Anders Brahme and B.H. Wiik.
32. In conversation on 16th September 2009. Lied died on 10th October 2014.
33. Appendix: 'Regarding the radiation transformer'
34. Brustad: 'Why is the Originator …'
35. Waloschek's video interview was recorded over two days, 22nd and 23rd October 1992 and shown as part of an exhibition in the Museum for Design in Zurich from 3rd March to 2nd May 1993. The interview was conducted in German and was used as the basis for the biography.
36. Brustad: 'Rolf Widerøe: Eminent scientist—a Footnote in Physics in Norway?' *Forskningspolitikk*, no. 3.1997.
37. Brustad: 'Why is the Originator …'

38. Brustad: 'Why is the Originator …'
39. Brustad: 'Why is the Originator …' , complete article, footnote 20: 'Schiebold was a German physicist who had proposed that if, by technological development, one could generate X-rays with high energy and intensity, it might be possible to aim a pencil-beam of X-rays at enemy aircraft. The enemy pilots might in this way be given fatal radiation doses, and the beam might even interfere with the radar system of the enemy so that aircraft would lose track of their targets and have problems "finding their way home".'
40. Brustad: 'Why is the Originator …', footnote 21.
41. The expert committee's report, p. 7.
42. Documents 14 and 15 presented to the expert committee, Treason Case no. 3418/45, National Archives.
43. Tor Brustad is referring here to footnote 21 in the article 'Why is the Originator …': In the book compiled and edited by Pedro Waloschek, 'The Infancy of Particle Accelerators, Life and Work of Rolf Widerøe,' Vieweg 1994, (ISBN 3-528-06586-9), Widerøe states "So I agreed to go to Hamburg or, to be more precise, I was 'subjected to compulsory work' via more or less voluntary agreement (and obviously that of my employers, NEBB)."
44. Norway's official statistical reports, XI 179. Statistics relating to treason 1940–1945. Norwegian Central Statistical Office, Oslo 1954 (footnote 1).
45. Regarding the outcome of the treason cases. Report from the Justice Department to Parliament, 11th January 1962. The official figures are as follows: A total of 92,805 people were accused of offences in connection with treason, 342 with war crimes. 28,750 people were arrested, and the highest number of prisoners was in July 1945, with about 14,000 distributed in 200 camps. 30 people were condemned to death for treason and 15 for war crimes. About 17,000 were sentenced to prison, about 25,000 were fined, about 7,500 received other forms of punishment, about 14,000 were acquitted at final trial, about 5,500 prosecutions failed and about 37,000 cases were dropped for lack of evidence.
46. Tor Brustad: 'Why is the Originator …', complete article, footnote 13. (This is the first time Rolf makes any mention of the Radium Hospital ordering a betatron. It must refer to the 15 MeV betatron, an order that never come to anything. It was not until the 1950s that they ordered and received their 31 MeV betatron.) Document 24. Letter from Rolf Widerøe to Junior Police Prosecutor Dreyer, dated 01/03/1946, O. Pk. J. 3418, 46–47 'concerning Dr. Widerøe's application for permission to travel', National Archives, Treason Case no. 3418/45 (Clause).
47. From an interview with Tor Brustad. He is probably referring to the Chief Engineer, Torleif Kaulun Torstensen.
48. Reply from the expert committee to Junior Police Prosecutor Gustav B. Dreyer. Headed 'National Archive Document.' Tor Brustad: Acta Oncologica 1998, 37.

49. ETH Zurich Library, Archive, HS 903:239 Rolf Widerøe, letter to Oslo and Aker Police, Røa, 07.06.1946.
50. ETH Zurich Library, Archive, HS 903:239 Rolf Widerøe, letter to the Head of Criminal Police, Røa, 02.08.1946.
51. ETH Zurich Library, Archive, HS 903:239 Rolf Widerøe, letter to Oscar de Besch, Zürich, 03.09.1946.
52. Conversations during the preparation of the book.
53. The biography, box 11, p. 99.
54. Waloschek: *Todesstrahlen.*
55. The interview with the physicists in Oslo 12th July 1983, NAVF Oslo, now The Norwegian Academy of Science and Letters. Rolf writes in his German translation that it took place on11th July, which was his birthday. It was probably in fact the 12th. The print-out prepared by the research institute is dated 14th March 1984.
56. The biography.
57. Brustad: 'Why is the Originator …'
58. Niels Bohr Archives, American Institute of Physics.
59. The Norwegian Academy of Science and Letters set up the interview. The participants (with their titles at that time) were: research fellow Finn Aaserud, assistant professor Jan Vaagen (University of Bergen), Olav Netteland (The Norwegian Radium Hospital), research associate Olav Aspelund and senior conservator Gunnar Thorsen (Technical Museum). The head of the academy, Hans Skoie, was in the wings.

5

But There Was More …

What secrets did Rolf take with him when he travelled to Switzerland to start his new life? The documents in the National Archives in Oslo contain nothing about that. The archives from Brown Boveri say something about the ideas he had in mind for what would become an industrial success story lasting many years. Patent documents in several countries can tell us about theories needing legal and economic protection. But it is not technology we are talking about now. A Norwegian who started working for the Luftwaffe in Germany during World War II on a top-secret arms project must have left traces in many contexts and many archives. Or did he manage to avoid that? If so, there must be an explanation for that too. As I discovered new sources, the question arose: How much did he know himself about what he had been drawn into? If he knew a lot, that is interesting. If he knew only a little, that too is interesting.

What did he know but not say? For example:

– ***that he was nearly arrested and sent to England?***
– ***that the project was taken out of the hands of the Nazi authorities?***
– ***that he knew his assistant would be set free?***
– ***that Hollnack & Co. fetched him from Oslo?***
– ***that Randers was working for the American intelligence services?***
– ***that Brown Boveri were in the picture all the time?***
– ***that there was a whole spider's web?***

Did he know but not say

– ***that he was nearly arrested and sent to England?***

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_5

Rolf said nothing about the fact that when he left Germany shortly before the country capitulated, he only narrowly avoided being arrested. He said nothing about the fact that he and Hollnack had been under surveillance by the Allies. Hollnack, who knew that the British were approaching, gave him money and said 'Run! Go home while you have the chance.' The choice that faced Rolf in April 1945 was between travelling back to Oslo with the risk of being arrested by the Norwegian authorities, or staying in Germany with the probability of being arrested by the British and sent to England. Leaving Germany involved the same Catch-22 dilemma as had the original request to go there. Whatever he did would be wrong. Rolf never said anything subsequently about his difficult choices but as before, he decided to go.

Theodor Hollnack was a key person in both situations. He would have preferred to go to Norway with Rolf, but the German military authorities ordered him to stay.[1]

Also, he was an important agent for the British army and would secure the betatron, which for security reasons had been moved north towards the Danish border.

So who was Hollnack? Four years younger than Rolf, only 32 when the war broke out. Born in Halle outside Leipzig.[2] An all-rounder. Had studied both science and social subjects and also specialised in administration and marketing. He had been a fighter pilot early in the war, and when he came across Rolf he described himself as a businessman on a mission for the Luftwaffe.[3] Rolf had no clear picture of the man's activities outside their shared project, but it was obvious that he had many irons in the fire. He owned and managed a business in the aluminium sector and he had a number of good connections with high-ranking people in Berlin. He stressed that he had never belonged to any political party, but he had access to the right circles and a network of contacts with widespread ramifications.[4] Moreover, he was in a position where he issued or negotiated contracts to companies and individuals both for the Air Ministry and for other official organisations, and he knew about the authorities' interest in everything to do with atomic research and accelerator technology. He was also up-to-date on what the American, Kerst, had achieved on the accelerator front and he was excited about his own success in 'getting Field Marshal Milch to take a personal interest in this whole field.'[5]

With his wide background and organisational skills, Hollnack was perfectly suited for the role of head of administration in the group that was to develop the Luftwaffe's radiation-gun that the fantasists believed would be able to neutralise bombers—the scheme that would later end up as Rolf's betatron project.

Dinner with Hitler

Another person who had good connections in the higher echelons of the Nazi establishment was Ernst Schiebold, the professor who wanted to make X-ray cannons. At the start of 1943 the Air Ministry in Berlin was under pressure to produce a trump card. The timing was perfect for Schiebold. It is said that Field Marshal Milch dined with Hitler on 5th March 1943 and that the pair of them sat discussing war strategy till quarter past three in the morning. The defeat at Stalingrad had shocked them, and Milch's clear advice to Hitler was: You need to bring about something decisive to get Germany out of this war. It's still not too late, but it's urgent.[6]

So when an offer of help arrived on Field Marshal Milch's desk a month later, it was as if the trump card had been produced to order. In a pathetically courteous letter, Professor Schiebold said that he wanted to 'contribute his knowledge to the defence of the country as part of the total war effort,' something that Propaganda Minister Goebbels had been calling for. Several hundred of Schiebold's X-ray weapons could protect a whole city against allied bombers, and several thousand could defend the whole of Germany. Milch was impressed, gave the green light to proceed and allocated money. Schiebold had done work for the Air Ministry previously and was leader of a research institute in Leipzig, and Milch already knew him personally.

The ministry gave Schiebold permission to mention this strictly secret project to his friend Richard Seifert, proprietor and manager of the company Rich. Seifert & Co. that produced X-ray equipment for medical and industrial use. There was a condition attached to this permission, namely that the conversation would take place in the presence of engineer and Luftwaffe Captain Kurt Fennel. Schiebold and Seifert met on Saturday 17th April, with Fennel present. They decided that Schiebold would be scientific director and Seifert would be responsible for the technology. The purpose of the project was camouflaged behind the coded title 'X-ray inspection of armour plating.' The work was to start immediately, depending on official approval. A hand-written report was signed by all three, and a three page formal report with various attachments was put together afterwards.[7]

Things now happened quickly. The following Tuesday they were at a meeting in Milch's office in the Air Ministry where Schiebold presented his ideas and there was a request that Hollnack should also be present. There and then, an official research contract for the Luftwaffe was set up, with all four—Schiebold, Fennel, Hollnack and Fennel—jointly responsible. The contract was considered so vital for the war effort that it was given

Dringlichkeitsstufe, priority grade, DE 6224/0109/43. Hollnack was selected as administrator of Schiebold's top-secret project. Seifert was realistic enough to doubt whether it would be possible to have all the equipment and necessary accessories ready in the course of one to two years according to plan. Fennel was there as a matter of course. He appears to have been a wild card in the pack but he should not be ignored, even though—or perhaps exactly because—his role was unclear.[8]

Did the ray-gun fantasist Schiebold believe in the weapon himself, or did he just want to use the war effort to acquire research funds? Was he perhaps a servant of the Nazis wanting to show the required loyalty to atone for having helped a Jewish family? Pedro Waloschek, the retired particle physicist who wrote Widerøe's biography, had been researching for ten years when in 2004 he documented the story of Schiebold's death-ray idea.[9] Even he didn't find the answer to these questions, though as a reviewer wrote he 'partially lifted the cloak that had been cast over this obscure history.'[10]

The Death-Ray Weapon Becomes a Radiotherapy Machine

Whatever Schiebold himself may have thought, his colleagues soon realised that the machine that was supposed to be able to shoot down planes was just completely unrealistic fantasy. So the idea was dropped. Oddly, however, the project continued with a major change of direction. From now on, it was to concentrate entirely on building Rolf's betatron. The Germans' death-ray project had metamorphosed into Rolf's project. The objective was now no longer to fire lethal radiation at aircraft, but to fire lethal radiation at cancer cells to save the lives of patients. The change happened in autumn 1944 and the scale of the operation was apparently far beyond what Rolf had ever anticipated, irrespective of what reasons he had originally had for taking on the job with the Luftwaffe. Schiebold himself, whatever his intentions had been, probably also realised that his original proposal was totally impracticable.

The rationale for Rolf's ideas being incorporated into the military death-ray project was that it would require particles to be accelerated to very high energy. This was exactly what Rolf's betatron was intended to do. So the development of the betatron became an important part of Schiebold's project, and when the project was abandoned the Luftwaffe was still sponsoring

Rolf's betatron, which was being built at the Müller factory in Hamburg and would later be taken out of the city to a place of relative safety.[11]

That was how the relationship between Rolf and Hollnack started, but how did it end? When the betatron was moved from Hamburg to a safer location, where was Rolf? Was he in Wrist? The author of the biography says that he asked Rolf specifically about his several times and that Rolf had answered explicitly that he had never been at Wrist and therefore had not seen the betatron in its new location.[12] However, there is something not quite right here. In recently published letters from Rolf's assistant, Touschek, to his parents, it is stated that Rolf was both at Wrist and in the administrative office in Kellinghusen.[13] Touschek's relationship with the authorities in Berlin had been difficult since the beginning of 1945. They didn't like his involvement with the betatron project, and he made many telephone calls to Rolf to seek advice. From this, Rolf concluded that his own situation at the Müller factory had become too problematic and he decided to move out of the city to where the betatron was being installed.

On Thursday 15th March Rolf acted on his decision and moved to Kellinghusen where Touschek had a flat. An abrupt letter from the Müller management two days earlier may have precipitated this. The letter requested him to ensure that a folder with the construction plans was returned immediately. It had been removed without notice and it belonged to the company, not to him.[14] The letter was addressed to '*Arbeitsstab Dillenburg, zu Hd. Herrn Dr. Wideröe*' at '*Wrist/Holstein*.' So the Müller management knew that the calibration of the betatron was now taking place in Wrist and they reckoned that Rolf was there with his closest colleagues.

Touschek returned to Hamburg on the Friday evening. After a rather dramatic journey in a rickety lorry with an inexperienced driver, bomb alarms and various mishaps he reached home about midnight. At half past seven the next morning he was awakened by two Gestapo officers and arrested. He spent the next six weeks in various prisons in and around Hamburg.

There has been uncertainty about when Rolf came back to Norway, but around 11-12-13th April he was still in Germany, as he visited Touschek in prison during that time. It was probably soon after that when Hollnack gave him money and advised him to get out of Germany. Then on Monday 30th April Hollnack got Touschek out of prison. British troops took Hamburg on Thursday 3rd May, and a few days later they also controlled Kellinghusen and Wrist.

The End of the Double Game

Theodor Hollnack, who had been working not only for the Luftwaffe but also for the Allies, now turned immediately to the British special unit with whom who had been in contact, and followed the officers to the Müller factory. He showed them the laboratories and offices where the betatron had been developed. All the documents that were still there were confiscated. All activity within the factory had been banned, and the employees were not very happy about the situation. Having already invested heavily in betatron development, Philips the parent company was keen to carry on, and the management found it difficult to accept that activity had now been stopped.[15]

In Wrist, however, Rolf's team was allowed to carry on. Hollnack had arranged this with the British even before they arrived. So Kollath, Schumann and Touschek were able to continue testing equipment and writing reports in relative peace and quiet in Seifert's remote dairy. The activity was classified as a state secret by the British authorities, the only disadvantage of this being that Touschek couldn't use the material in the dissertation he was working on.[16] They did however face the same restrictions as everybody else at that time, in that they were not allowed contact with researchers at other German universities and institutes. Otherwise, the situation was as before.

Seifert was responsible for supply of materials, including transport. Hollnack managed the money and still had 200,000 Reichsmarks remaining in his budget when the war ended. Since the move to Wrist in March he had also been responsible for providing accommodation for all the staff. We don't know how long the funds from the Luftwaffe sustained the business, but it is reasonable to assume that the authorities in Berlin now stopped financing the project and the British more or less took over. Richard Seifert & Co. probably contributed money and contacts to ensure that the work continued and the Müller factory probably also had interests in contributing resources. In addition, the team at Wrist tried to generate income by developing and patenting products and continuing production. The situation in war-torn Germany was chaotic, and it was a question of finding whatever means possible to keep things going for these scientists, whose interest was first and foremost to continue their accelerator research.

In August Touschek travelled to Hannover and Göttingen where he had been invited to work on betatrons, but because he had come into conflict with Hollnack the British decided that he must stay in Wrist until his situation had been clarified. In October the professors who wanted to recruit him, Jensen and Gentner, came to visit. In December the British decided that the betatron should be taken to England after New Year, but in February the decision was changed: The betatron was to be taken to Hamburg, together with the key workers in the project.[17]

In a monthly progress report covering the period from mid November to mid December, Kollath wrote that so far as he knew there was no further money in the budget from 1st January 1946, and without a guarantee that he would be able to pay salaries he didn't know if he could hold the team together in Wrist much longer. We don't know to whom the report was sent, but he did ask a Hr. Barns for written confirmation that it had been received, either directly or via the English.[18] This may have been a mistaken spelling of the name of a researcher at Woolwich Arsenal, the laboratory in England where the betatron was later sent as war booty. The physicist D. E. Barnes played a central role in all this. From what Rolf says in the biography, it appears that he himself thought that the machine had already been sent to England in December 1945.

The important thing was that the betatron was secure, rescued from both the Germans and the Russians, and that Rolf and his fellow-workers were safe. He had managed to get to Oslo shortly before Germany collapsed. The British were on the trail of both Rolf and Hollnack, and both of them had been put under surveillance.[19, 20]

Then one day Hollnack's double game came to an end. On 31st January 1946 he was arrested by the British and the following day he gave his full report to Colonel F. Read in BAOR, The British Army of the Rhine.[21] Theodor Hollnack had been working for the Allies for a long time. He had kept in with both sides, the Germans and the British. Now the game was over. All the cards were on the table, and the British grasped them eagerly.

In the National Archives in England there is a folder entitled 'Hollnack,' with the catalogue number FO 1032/230. It had very probably not been opened since it was put together in 1946.[22] Previously, access to most documents of this type was restricted for 30 years, and therefore many of them were listed for release in 1977. Some were to remain unopened longer, but when the Freedom of Information Act came into force in 2000, this changed. The thirty year rule was abolished, and documents were now assessed individually.[23] This led to an almost continuous process of previously closed archives being opened over the subsequent years.

In 1946, however, the documents were new, events were moving fast and the intelligence officers at British Army Headquarters in Germany who were working on the case looked at the contents of the documents as soon as they came in. Hollnack's report of his activities was written in German, and the note sent to the translation office on 6th February 1946 said that an English version was required by the evening of the following day, 'as it is very urgently required.' The translators managed to meet this deadline, but in their covering letter they stress that 'because of the time pressure we have not had the translation thoroughly proof-read or edited and it therefore must be accepted that there may be both typographical and grammatical errors.' This is evident in the text, but the content was now accessible.[24]

Hollnack apparently reports quite freely—about the betatron and Rolf and everybody involved. The report contains a mass of information about things Rolf has never mentioned. What we are *not* able to know is whether Hollnack also knows more than he tells. As a double agent he was naturally exposed to huge pressures. It is difficult to judge how much his response at the time was influenced by this. He seems to have been a complicated person, kindly and argumentative at the same time. Capable, and with a sense of justice that could sometimes take the upper hand. But it would be a mistake to describe him as difficult, for to move in as many circles as he did he must have been adaptable.

'Kellinghusen's Mussolini'

Towards the end of the war and in the time immediately after, the people around Hollnack started reacting against his activities. The youth who had been recruited as courier subsequently admitted that he had suspected Hollnack of supplying information to the Allies. Rolf's assistant, Touschek, wrote in a letter to his parents that Hollnack had started having 'grandiose ambitions,' that he 'went to the media if he didn't get what he wanted,' and that some people actually referred to him as 'Kellinghusen's Mussolini.'[25] Hollnack probably did have a part in securing Touschek's release from prison, but Touschek wrote that he probably did not have as big a part as he claimed.

In the end, Hollnack himself was arrested by the British. It was all over when two officers from the Research Division in the British Military Section in Bad Oeyenhausen visited the laboratory in Wrist on 29th January 1946. They were the Head of Security himself, Dr. Ronald Fraser, and Colonel F. Read from the Allied Control Commission Their purpose was clear. They were there to 'look at the activities of Dr. Hollnack, who was Head of Administration and had been appointed by General Milch.' When he wrote his report, Colonel Read did not conceal his aversion to the man, whom he described as 'a truculent character and resentful of the fact that his activities should be questioned.'[26] In the same report, he also wrote about the interrogation of a member of the Uranium Club, Dr. Kurt Diebner, who was considered suspect by the British occupying forces' local security office and who was among those later brought to England. But the British Research Branch Control Officer didn't think that Diebner was bad enough to be arrested and he just imposed a reporting order on him. He was, however, interested in Hollnack and he requested him to give a full account including details of all the employees and a complete list of the equipment for the Widerøe project.

Having interviewed the scientific personnel at Wrist and formed a first impression, the two officers agreed that 'the attitude of Dr. Hollnack was most unsatisfactory.' Fraser was concerned that he might try to sabotage the equipment. The next day, Read requested that arrangements be made to arrest both Hollnack and his 'male secretary.' This was set in hand, and the arrest was carried out next morning, 31st January 1946. The 'male secretary' was the courier, the youth who had claimed to be Dutch and operated under various identities.

On 4th February Colonel Read travelled to Hamburg again, to discuss Hollnack's interrogation. He learned that Major Coleman in the security office had personally interviewed Hollnack and had spoken with him on two or three occasions. Coleman 'didn't think that he was at all dangerous,' but he had got him to write his life history, as was usual with people who had been arrested. Read sent the biographical information together with several reports on the betatron project, the staff and the equipment to his superior officer. In the accompanying letter he said that he had decided to set Hollnack free but forbid him to enter the laboratory.

Read then went back to Wrist where he met Kollath, Rolf's deputy who was now also serving as chief since Rolf had left. Colonel Read wrote in his report: 'I explained everything to him and informed him that the place was to be closed and the staff were to be dismissed, apart from the few undermentioned: Dr. Kollath, Dr. Schumann, Dr. Touschek, Fräulein Bernhardt (Dr. Kollath's Secretary) Herr Schultz (Mechanic), Herr Shaelke (Mechanic), Frau Gärtke (Typist), Herr Gärtke (Cleaner).'

This inner core of named personnel was to be retained, and the Sergeant of the Watch was given orders that only these few should be given access to the building. Finally, Read advised Fraser that he would see to the 'disposal' of the betatron.

Hollnack was released quite quickly, but removed from the betatron project. He felt hurt and sad and, not least importantly for himself, he was without income. Two weeks later he complained to the security services that

Read had given orders that his personal finance should also be controlled by Kollath, who moreover was by then in process of leaving and had delegated the job to Hollnack's successor.[27] However, according to a letter Read wrote to the security section, they had no interest in Hollnack's private assets and had in fact never given any instructions to Kollath to freeze them. He made this clear in a letter to Major Coleman: 'Should Hollnack's assets be frozen, I should be very much obliged if you would take steps to unfreeze them.' He ended the letter by saying that he hoped they could have the site in Wrist closed the following week or thereabouts—that is to say, by the end of March 1946.[28]

Contact with Rolf Is Renewed

A year had now passed since Rolf had left the group in Wrist. It had been a busy and uncertain time for everybody, and neither he nor they had made contact in the meantime. Then on 30th March 1946 Kollath wrote a letter to Rolf. He said that it had only recently become possible to send letters abroad and he stressed that he hoped receiving post from Germany would not cause Rolf any difficulties. This letter is the first of several that Kollath wrote to update Rolf on the events of the previous year. Touschek had written the day before. He and Kollath had agreed that they should both write, independently of each other so that Rolf would get information from several viewpoints. Touschek's letter didn't reach Rolf until over three months later, on 8th July, by which time Touschek had already written two further letters. Seifert also wrote to Rolf and the four of them—Kollath, Touschek, Seifert and Rolf—now tried to piece together what had really happened. They had been close colleagues, and their need to tell their stories and release pent-up curiosity now boiled over. There are three main themes in their correspondence, and the letters say a lot both about the post-war chaos in Germany and about the close bonds between them.

Personal relationships: There is mention of food packages that Rolf and his wife sent to them, for which they are very grateful. Kollath's secretary has also received a very welcome parcel, and Touschek expresses thanks for the cigarettes and overtly asks for more. Sometimes they also mention their disappointment and concern about packages that have *not* arrived. Kollath asks Rolf for help to get his sick eleven year old son into an institution abroad where he can receive nutritious food and good care. Touschek asks for advice about a job offer from England. He says that the Englishmen have really helped him, that Rolf has helped him even more, and that he is in many ways attracted to the idea but that he is wondering what it will be like to come to England as an ‘ex-enemy.’ Another factor he must take into account is that ‘Without food you can’t work.’ All things considered, the three German colleagues are glad that it is now possible to renew contact with Rolf and they write that they hope they can arrange to meet when circumstances in Europe have returned to normal.

Updates: What had happened in Wrist since Rolf left them in 1945? The sequence of events was not immediately apparent from the correspondence. Replies to previous letters were crossing new letters in the post and nobody knew whether they were being censored or when they would be delivered. In fact, Kollath and Rolf started numbering their letters K1, K2, W1, W2 and so on. They were especially interested in the elusive Hollnack. Touschek expressed in strong terms how difficult Hollnack had been in the final days. Kollath, more diplomatically, wrote that Hollnack had caused him many headaches and had now broken all contact in a manner that left Kollath with no interest in taking it up again. He had tried for a long time to mediate between Touschek and Hollnack but had finally had to take a firm line. The core of the disagreement was who should manage personnel and resources.

The work on the betatron had in itself been difficult since May 1945. First it had had to be dismantled and hidden in a cellar. Then it had had to be reassembled in very difficult circumstances, though Kollath wrote that he would spare Rolf the details of that. He had also asked Sommerfeld the patents adviser to delay visiting them in Wrist until things became clearer. There were still bills that had not been settled, and he wanted to seek Rolf’s advice about that first.

Research: Their day to day work, however, was in physics. Once they had been able to express their feelings of frustration and anger and had updated Rolf with their situation, gradually more and more of the content of the letters is about the application of their findings and how they could develop the betatron further. Another theme is their competitors at Siemens. The reports from Rolf’s former co-workers indicate that the year had not run as smoothly as he later stated in his biography. They maintained professional contact for several years, and at one time there was talk of Kollath coming to work with Rolf in Switzerland. Seifert also wrote frequently. As a businessman he had a scent for possible sales opportunities, and he quite quickly suggested the USA as a potential market.[29]

Kollath was in Wrist until April 1946. For a year after that he was based at Hamburg University, working among other things on a project to build a 50-60 MeV betatron. He tried to stay in contact with former colleagues both in the universities and at the Müller factory. A professor in Heidelberg was invited to come to Hamburg but eventually chose to go elsewhere. Kollath was also in communication with representatives from Brown Boveri Mannheim, whom he tried to persuade to come to a meeting with his former boss. Rolf's patent adviser was also involved in questions about when and how to apply for patent s. In June 1947 Kollath moved to England to work in the laboratory at Woolwich Arsenal where the betatron was now located. In February 1948 he moved back to a professorship in Hamburg.[30]

To Whom It May Concern

However, it was still a while after Kollath had left Wrist before a line could be drawn under the matter. In July the British Security Office issued a document 'to whom it may concern,' stating that the case regarding Hollnack had been 'satisfactorily concluded with full knowledge and approval from this office.'[31] Fully concluded it was not, however. The man was obviously a nuisance to the British, and on 25th July a sharp letter was sent to Kollath with orders that 'Herr Hollnack's personal papers must be returned to him immediately if there are no good grounds for keeping them.'[32]

However, by October Hollnack had still not been given back private possessions, papers, manuscripts and even clothes that had been confiscated in April. He complained again to Read, stating that his protest to the section in Kiel dealing with custody of confiscated assets had not helped, even though the head of the security office had assured him shortly before that there was no intention of doing anything with his possessions that they were holding. Hollnack emphasises that all he is concerned about is getting back his private papers, and he offers to have them always available for inspection. His tone has become sharper, and he now asks for a written response.[33]

Hollnack then disappeared from the picture for a while, until Rolf received a telephone call from him in 1947 asking to speak with him privately. They met in Germany, on a plain near Waldshut close to the Swiss border. Hollnack asserted that he had some claim over the patents that Rolf had taken out in the second half of the war and that now seemed to be quite valuable. But the German, who now called himself Kolberg, couldn't prove his claim. Rolf explained to him that the rights to the twelve patents from 1943 to 1945 belonged to Brown Boveri in Switzerland, where he was now employed. Hollnack, alias Kolberg, for one reason or another didn't want to have anything to do with the company, and Rolf later said that Hollnack left rather taken aback. It is very unlikely that Hollnack—of all people—didn't know what Rolf's relationship with Brown Boveri had been during the war. He had probably just wanted to try his luck and he was not alone in the confused buzz round the war-time patents. This was the last time the two of them are known to have had anything to do with each other.

Hollnack was in poor health and appears to have become more and more desperate for money. In 1948 he turned to his old contacts in The British Army of the Rhine with a letter to the Regional Research Office in Kiel asking for a job. He received a standard reply to the effect that they had no suitable position available at the moment but that they would keep him in mind if anything cropped up.[34] He then disappeared from any connection with physics in Germany. He had managed to stir up quite a lot of activity and confusion in his wide circle of acquaintances and finally around his own person. People had not quite known where they stood with him or where to place him. The reply from BAOR signalled his exit from the scene.

In brief: So much confusion. So many different interests. People in transit, interrogated, imprisoned. People despairing, defending themselves, disappearing. Nobody is quite sure who is on what side among Jews, Nazis, allies and security services. Rolf is in the middle of it all. Without him there would have been no betatron project. He too was under surveillance, but he avoided arrest—only just. When the Allies arrived, he was already out of the country but his assistant and his boss were both arrested. Did he say anything about this afterwards? Did he recount the drama? No.

But there was more. In the report that led to Hollnack's arrest, two organisations are named in which Rolf was involved but about which he said nothing in his biography. This is remarkable when we see now how significant both organisations were in everything to do with his time in Germany during the war. He either didn't know about them or didn't want to tell about them. Both explanations appear strange, but one of them must be correct. Hollnack the double agent and '*Treuhänder*' had had several cards up his sleeve.

Did he know but not say

– ***that the project was taken out of the hands of the Nazi authorities?***

Rolf never mentioned that the name of the betatron project was changed in spring 1945. From then on it would be called '*MV-Forschungs-Vereinigung/MV-Research-Association*.' The full name was written thus, with an oblique slash and four hyphens, but it was generally shortened to 'Megavolt Association.' Even before the name was changed officially, the betatron group had often been called '*MV-Forschungs-Vereinigung*' or similar names that combined the concepts of high energy and research.[35] More commonly it was referred to as 'The Widerøe Group' or '*Arbeitsstab Dillenburg*.'

The first half of the new name was in German, the second half in English. This was not just Teutonic attention to detail, but a clear signal of something new. It was not just a change of name, but the title of an Association with its own memorandum and articles of association and its own protocols. It had previously been a research project under the auspices of the Luftwaffe, set up on the initiative of the country's highest research council. Now it was to be a free and independent organisation with its own board of management. The change happened on 4th May 1945, just days before the German capitulation.

Why did Rolf not mention this? Did he not know about it? His name was on the distribution list for all the foundation documents and reports. The organisation was to concern itself with 'the construction of betatrons according to Widerøe's ideas and instructions.' But Rolf was out of the scene: somewhere in Denmark; on a train; at home with his family in Oslo; held in prison together with thousands of other Norwegians suspected of treason. He was somewhere or other, but not in Wrist. How could he know anything at all about what as going on there? The Allies probably knew much more than he did. It later became apparent that there was something he did know. What reason did he have for keeping silent?

One simple reason might be that if he revealed that the betatron project had been taken out of the hands of the Nazi authorities, he would have had to say more about how he came to be involved in the first place and he wanted to say as little about that as possible. Many of the sources indicate that Rolf didn't even mention it to Waloschek when he was writing his biography.

But there are other sources than the main protagonist himself. For example, Rolf's assistant wrote to his parents that they had tried to save the betatron and that he thought this would be possible. He mentioned in this context that they had set up a new organisation.[36] In a later letter he said that he had gone with Hollnack to Wrist and Kellinghusen where Rolf's other colleagues were already located. The aim had been to promote the continuation and further development of the project. To Rolf, he wrote that there was not much to do during these first months after the end of the war. The 30–35 employees in Wrist were writing weekly reports and putting them on Hollnack's table for the sake of appearance, and he had been giving them a lot of help with translation into English.[37]

Serving the Scientific Interests in the World

At the beginning of June 1945, four weeks after the establishment of the Megavolt Association, Hollnack put together a folder of documents for the British military authorities, describing how the organisation had come into being, who was behind it, what had been achieved and, not least, what future he and the others wanted for it following the German capitulation.[38] Rolf was named as the person in charge and was included on the distribution list. But at that point Rolf had been incarcerated in Ilebu since 24th May and he was hardly up to date with events. The folder is thick, and it includes a long covering letter, dated Kellinghusen 9th June 1945 and written in German.[39] In addition to pointing out that the new organisation is a further development of Rolf's project—though now taken out of the hands of the German authorities—the documents also cast light on Rolf's original Hamburg project and all of Hollnack's dealings with Rolf.

In the documents, Hollnack also refers to points from a previous letter, including the wish to continue the work on the betatrons pending a final decision from the Allies. He had also requested the necessary freedom of movement and approval to start negotiations about international agreements. He points out that it is all based on Rolf Widerøe's ideas, and that for the past couple of months he had been unable to make contact with the German patent office to discuss the rights. He stresses that he is acting as '*Treuhänder von Dr. Widerøe, Oslo*' and not as a representative for his own country, and asks that this be borne in mind in reading the documents. Finally, he confirms that everything is now in the hands of the Allies.

One of the documents he sent was a copy of the protocol constituting the new organisation. This was dated 4th May 1945, the day after Hamburg capitulated, and it took as its starting point the fact that Germany had now suffered defeat by the Western Allies. So science and technology now faced a new situation in relation to international connections and interests. This applied to the betatron project. The document emphasised that it was important to continue the development work in accordance with the original agreement with Rolf from 1st November 1943 and that the activity must be carried out in accordance with international scientific and economic obligations. What had up to then been formally called '*Arbeitsstab Dillenburg*' should be dissolved with immediate effect. It was a matter of making a start as soon as possible to solve scientific and technical questions together with physicists in other countries, and damaged equipment needed to be repaired as quickly as possible.

The protocol goes on to say that from the foundation date onwards, the work on the betatron should continue under the auspices of the Megavolt Association. The professional staff were in Wrist, and all the members of the original project committed themselves to entering contracts of employment with the new organisation. The Megavolt Association would guarantee 'scientific development opportunity independent of personal and industrial interests.' The organisation would resume relationships with the researchers who had been involved and ensure that all theoretical works and construction facilities would be restored. Then when contact with Rolf was resumed they would be ready 'to serve the scientific interests of the world.' The protocol is signed by Hollnack, with copies for Rolf, Kollath, Werner Bartelt the new business manager and 'other fellow-workers.'[40]

Who Is Doing What

A separate note attached to the protocol sets out a basic allocation of duties and responsibilities. Rolf heads the technical-scientific management, with his Oslo address given and with Kollath as second in command, followed by Schumann who is also a physicist, and Touschek the assistant. Also named are a workshop foreman, a laboratory engineer, a laboratory assistant, a mechanic, an instrument maker and an office worker. In addition to these, Hollnack has his own administrative secretariat of six or seven people including his personal secretary and the courier.[41] The legal responsibility will be clarified 'at a later date' and 'in agreement with Dr. Widerøe.' The note goes on to say that Hollnack will fill that role until formal arrangements have been completed. He will also attend to the question of continuing finance for the project once the political situation in Germany becomes clear. Finally, the note mentions the needs for Allied approval of the work schedule, for personnel recruitment and for continued contact with Rolf's patents adviser, Sommerfeld, about legal questions.

It is emphasised that the purpose and task of the organisation is to continue the research and development work on Widerøe's betatrons. As before, it is a matter of continuing the development of the 15 MeV betatron and the plans for the 200 MeV machine, and of starting work as soon as possible on the 30 MeV betatron in Wrist. Repeated assurances are given that everything will be done according to Rolf's designs and with his agreement. The document also says that necessary parts will be bought from Seifert's company. In respect of the 30 MeV machine, it is particularly specified that contact will be established with both science and industry in Germany.

Scientists from abroad are also being included, such as Niels Bohr in Denmark, Bragg in England and Serber in the USA. In addition, the document recommends contact with representatives from industrial interests, such as Brown Boveri in Switzerland and General Electric in the USA.—and 'if it is desirable,' the same applies to Russia.[42]

Still a '*Treuhänder*'

Another of the attachments to Hollnack's report is a three page document about the relationship between Rolf and himself. He says plainly about his own role: 'In 1943 I was given responsibility for research on the radiation transformer as built by Widerøe.' He gives an account of his work as '*Treuhänder*' and offers a high-sounding explanation of the proposed future programme:

> Following the end of this war it seems to me to be our obvious duty to make the results achieved till now available without restriction to scientific communities abroad. (…) Leading German scientists such as Professor Heisenberg in Berlin, Professor Bothe in Heidelberg and Professor Jensen in Hannover are being brought into the project, with guarantees of being able to work freely and independently.

He writes about Rolf's role thus:

> In1943, I was involved in engaging him to work in Germany. The motives for approaching him may call for a personal explanation. They are however honourable, as the conditions of the arrangement were such that a personality such as Dr. Widerøe could accept them with thought to his international reputation. As *Treuhänder*, I am under an obligation to continue to comply with the agreements we made, especially with Norway and Switzerland and thereby possibly with England.

He points out that the work is of interest for the whole of nuclear physics and he makes three requests to the British Military Government:

1. for opportunity to meet with authoritative officers and scientists in 2nd British Army to arrange all the agreements about rights etc. to be able to resume the work that had been interrupted by the British Military Government;

2. for approval to travel to Hamburg to set up international agreements;
3. for everybody working on the project, including himself, to be given freedom of movement within Germany to renew contacts, engage theoretical workers and obtain construction documents. He points out that the 200 MeV betatron is particularly dependent on this.

Hollnack declares himself willing to submit to control and supervision by the British Military Government. He also proposes that the activity in Wrist and Kellinghusen be protected by a guard and he adds: 'I am moreover prepared to undertake any journey within Germany under escort.'[43]

He attaches detailed technical documentation with diagrams and theoretical calculations, together with a copy of Rolf's doctoral thesis—plus both the articles submitted to the scientific journal during the war. He had written the formal documents himself. The more practical and technical descriptions of the work in progress were put together by Rolf's second in command.[44]

Hoping They Say Yes

By 26th May the organisation had its own official notepaper, and the acting scientific leader Kollath and the administrative manager Bartelt composed a document setting out plans for the organisation of the business. The first requirement was to set up a scientific board. A governing body had been set up a year before, but the needs were now different. Former political, scientific, and industrial interests among the membership must be done away with. It would now be possible to include people with the required professional skills from both within Germany and abroad, in a way that had not been possible during the war.[45]

By 29th May they were sending letters to Professors Heisenberg and Bothe, referring to discussions between them and Rolf and inviting them to join the board. The letters confirm that the intention had always been to reach out to a bigger circle of experts in fields such as nuclear physics, electrical engineering, biology and materials testing, but that the requirement for secrecy during the war had hindered this. The intention now was to set up a broadly based, scientific board, and the organisation's job in future would be 'to work for free and independent research and development.' Documents with guidelines for the work programme are attached, and the letter is signed by Kollath for the scientific management and Bartelt for the administrative management.[46] Ten other German professors and several international big names also received invitations, including Bohr in Denmark, Bragg in England, Joliot in France Serber in the USA.[47]

Copies of the letters to Heisenberg and Bothe are included in the folder Hollnack sent to the British, together with proposals dated 26th May for the constitution of the scientific board. These proposals specify how many members should be on the board and their term of office, require minutes to be taken and give the members the right to know about all the activity.[48] There is also an invitation to the British to nominate a scientist to take part in the combined project 'to develop betatrons according to Dr. Widerøe's designs.'[49]

What should we make of this? Were they building castles in the air? Was the setting up of a new organisation intended as evidence that those sponsoring it had cut off links with their past? Or were they just doing the only sensible thing, reorganising to demonstrate that they were serious researchers?

Rolf's assistant, Bruno Touschek, also had a part in this. He was meeting an obligation towards Hollnack to take part in setting up the Megavolt Association, but he contributed only half-heartedly. His letters to Rolf and to his parents reveal that he was not really so interested in the new organisation, which he considered to be an ego-trip by Hollnack. Touschek still had three months of his contract of employment to fulfil and he would remain loyal for that time, but he restricted himself tightly to matters dealing with acquiring patents to ensure the finance. He was also responsible for contact with the English, i.e. with 'T-Force 2, British Army,' to whom Hollnack had sent all the information about the Megavolt Organisation. Touschek wrote:

'I took it upon myself to handle the negotiations with the military regime, and for a short time I acted as interpreter, and I also succeeded in having the project taken up by T-Force, something that seemed necessary in a situation beset by plundering and vandalism.'[50]

Top Secret

So what was this 'T-Force,' that Touschek refers to and to whom Hollnack had sent documents? Rolf tells us nothing about it. T-Force's activity was all either 'Secret' or 'Top Secret.' Until the late 1980s almost nobody had heard of this secret intelligence organisation that hunted for anything of scientific or military value that should be taken from the enemy. Its operations sometimes resembled those of the fictional secret agent, James Bond.

This resemblance was not just coincidental, as the originator of the Agent 007 stories, Ian Fleming, was also involved in the setting up of T-Force. Fleming was working with the defence services at that time, and he later used elements from that experience in the book 'Moonraker,'[51] a spy novel about the big rocket England was going to build. The technicians working on the rocket, however, were German and when a notebook disappeared shortly before the test flight it emerged that the rocket with an atomic weapon at its nose was programmed to land in Central London, and that the team leader was a German war veteran seeking revenge. It was obviously forbidden to reveal sensitive information at that time, and some of the people involved around T-Force have subsequently claimed to recognise themselves in certain episodes in the spy novel.

In due course the archives were opened and documentary books began to be written about T-Force. The British newspaper, 'The Guardian,' brought new material to light, and a new chapter was added to the history of World War II.[52] In brief, the story was as follows:

The responsibility for getting hold of the German scientists was given to a special British unit known as 'T-Force.' The unit was set up soon after D-Day, 6th June 1944, as a lightly equipped and very mobile force that went forward in advance of the Allied troops to identify objects of importance for science or for the intelligence services, before they could be sabotaged by fleeing Germans or captured by advancing Russians. The combined purposes were to build up the British economy after the war and to prevent Soviet Russia from getting hold of the Germans' scientific achievements.

So Target-Force, known as T-Force, was an elite force of the British Military Government, in charge of scientific and military intelligence. The British wanted to make as much use as possible of Germany's commercial and scientific abilities. The force consisted of scientists, bomb experts, engineers and technicians. Their missions were decided by the Combined Intelligence Objectives Sub-Committee, CIOS.[53] As soon as a group from T-Force took control of a factory or a site, CIOS was informed and investigators were sent immediately. When it was rumoured that the spies from T-Force were on their way, German scientists tried to remove as much as possible of their equipment and documents before they arrived. Tons of papers were burnt, hidden, buried in the ground or moved to less obvious places.

The British Army, Field Army 2, to whom Hollnack sent his reports, crossed the Rhine on 23rd March. They reached the River Weser on 4th April and the Elbe on 19th April. The army came to Lübeck on 2nd May, Hamburg capitulated on 3rd May and on 7th May they met the Red Army.

The German capitulation followed immediately after that. When peace was declared, T-Force was given the task of arresting German researchers. About 1,500 scientists were taken to England, where they were interviewed by their competitors, British colleagues in science and industry. Then as the Cold War developed it became increasingly important to prevent the Soviet Union from benefitting from the Germans' scientific and industrial secrets, and T-Force remained active for two years after the end of World War II.

Two organisations were responsible for carrying out abductions of personnel and information in the British controlled zone. These were BIOS (British Intelligence Objectives Sub-Committee) which reported directly to the Cabinet and FIAT (Field Information Agency Technical) which was a combined Anglo-American military intelligence unit that ear-marked researchers for forced evacuation from the American and French zones and from Berlin. FIAT travelled round with copying equipment and mobile microfilm apparatus to secure the best possible documentation. About 1,000 researchers and technicians, mostly in the fields of rocket science and atomic research, were recruited to the USA.[54] Most of these went over on their own initiative, but about a hundred were probably subject to compulsion.

When information about T-Force began to emerge towards the end of the 1980s, it was thought that German scientists had mostly gone over to the enemy willingly, in order to get off lightly. Then came reports indicating that the opposite may have been true[55]; that the British were desperate to get hold of the Germans' technical knowledge and were very eager to recruit these researchers. There were tales of nocturnal kidnappings and Gestapo-like methods.[56] Other, more moderately worded accounts are of persuasion, removal for interrogation and then return to Germany. Gentle pressure and not always entirely voluntary co-operation, in other words. Some British investigators have since been accused of being at least as much interested in acquiring their industrial rivals' intellectual property as in discovering more about the Nazis' military secrets. Personal reports also came to light, some to the effect that not all Germans were rabid Nazis whereas others said that they had been 'horribly' and 'shockingly' dealt with. It went both ways.

Rolf's assistant, Bruno Touschek, is one of those who reckoned it was all one whether he was in the hands of T-Force or the Gestapo. He had experienced both in the spring and summer of 1945. In fact, it appears that being taken prisoner by the British Army's T-Force was what made most impression on the young Jew. In a letter to the much older and greatly respected Professor Arnold Sommerfeld, he describes his internment by the British diplomatically, saying just that T-Force would not release him until the

Allied Commission had taken over the betatron.[57] To his father, however, he complains about his handling both by T-Force and by the Gestapo:

> I won't be allowed to leave Kellinghusen until the Allied Commission has made a decision about the betatron. So I am detained in Kellinghusen virtually as a prisoner. The food is bad, I have a cold and as before I am given very bad food and have hardly any clothes. The Gestapo have stolen many of my possessions and here there are only useless ration coupons. The German officers are only working for the Nazis, and the Englishmen clearly don't concern themselves with such trivia. Obviously there are exceptions.[58]

He had also felt that there was something wrong from the moment the betatron had been moved. There were people he didn't like, 'a group of not particularly pleasant people whom Hollnack had brought with him to Kellinghusen from various special agencies.'

The Link to Rolf

Northern Germany with its armaments factories and heavy industry, especially around Kiel and Hamburg, was an attractive target for the Allied intelligence services that were on the hunt for valuable scientific information. A T-Force report on investigations in Northern Germany between 2nd and 10th May 1945 states:

> The surrender of the German armed forces has opened up targets at almost overwhelming pace. The two main areas, Hamburg which had 104 listed targets and Kiel with 50, are proving of great value despite the severe air raid damage. Their assessment and detailed investigation is expected to take some time.[59]

The companies listed in Hamburg include the following: C. H. F. Müller and Philips; Shell; Standard Oil; and the arms giant Blohm & Voss. The section on the Müller factory, where Rolf had started building the betatron, said that research was being carried out on a 15 MeV appliance that was lying dismantled and that 'X-ray tubes of very fine design' were also produced. The report is addressed to several people within the army. The National Archives stamped 'Closed until 2046' on the cover, but the clause about secrecy for 100 years was later cancelled, and the original stamp has been over-stamped with 'Cancelled.'

A later report, for the period 19th and 20th May, includes a list of the places where items of interest had been found in the previous twelve days. Among these are Wrist and, once again, Hamburg. The entry about the research site at Wrist reads as follows:

> The "Megavolt Research Association" is a self-styled "anti-military, anti-industrial" alliance of physicists who were devoting themselves to pure atomic nuclear research. They had established numerous connections in neutral countries and were proceeding with very advanced research into nuclear physics using betatrons of equivalent voltage of 30 million volts. Their aim was to achieve a level of 200 million volts before getting on with what they called "more serious work." They also claim to have a good knowledge of general German research into atomic activity.

The Müller factory in Hamburg is specially mentioned and the head technician was interned. His specialty is given as 'many types of X-ray tubes & equipment for medical, industrial & scientific use.' Over 400 sites are reported to have been investigated since the crossing of the Rhine, and ca. 190 investigators are still at work in 21 Army Group's territory.

A report specifically about the Müller factory was sent from T-Force to the higher command in CIOS. This too is marked 'Confidential,' and the formal details are stated with military precision:

> Evaluation report no. 63.
> Target: C. H. F. Müller AG.
> Target no: 1/132e.
> Location: Hamburg-Fuhlsbuttel, Rontgenstrasse 24.
> Condition: Undamaged. All apparatus, documents, etc. are there.

The report confirms that watch is being kept in accordance with regulations and that the factory is being guarded by a T-Force troop. This is a very important case. The priority field is marked 'Top Priority.' Then there are lists of names of people who *have been* interviewed and people who *should* be interviewed.[60]

It states that the factory is owned by the Philips Group, and that the main product is X-ray equipment. That explains the finding of various types of X-ray tubes and diverse equipment for the manufacture of medical, industrial and scientific apparatus, high-voltage and electron accelerator equipment for nuclear research and relevant test apparatus. The production of high-voltage equipment of up to 15 megavolts is particularly mentioned, plus the fact that a nearly complete installation of this type was still on site:

> A small circular-path accelerator of unknown performance, possibly used by Dr Wideroe, who is believed now to be in Oslo, was found in the factory.

The investigators also made arrangements for X-ray and high-voltage physics experts to come to take a closer look at the equipment, and name and dates for these inspections are specified.[61]

In Eminent Company

The report on activity at the Müller factory is in eminent company; it shares a folder with evaluation report no. 53b dated 18th June, of the interrogation of Albert Speer, Munitions Minister in Hitler's government from 1942 to 1945. Speer said plainly that he thought the Americans were well ahead of the Germans in developing an atom bomb. The Germans had indeed done quite a lot of research in this area, but nothing very practical had come out of it. 'They needed another ten years,' he said, referring to the research that had been led by Heisenberg in Berlin and Bothe in Heidelberg. He was also able to confirm that he had given high priority to the building of two cyclotrons in Heidelberg, and he referred to Luftwaffe Colonel Geist as formally responsible for several details of that project.[62] Geist was also the person whom Rolf thought was the most senior person responsible for his own project.

The same location in the archives also contains evaluation report no. 159 dated 30th June, an interrogation of Professor Walther Bothe. The machine he was working on is described and the report confirms that he had obtained parts from Krupp, from Siemens and from Brown Boveri in Mannheim. It also confirms that Bothe's machine was not significantly different from cyclotrons that had been built in America. It points out that Bothe had visited cyclotron installations in the USA before the war and that he appeared to know about Lawrence's work. Bothe had said that he had been working secretly on and had begun to construct another type of accelerator, the kind of apparatus that later came be called a betatron, but that this work had been cancelled because of the war. The three officers who signed the report also provided several other comprehensive technical reports about Bothe's work. The British and American intelligence organisations attached great importance to this.[63]

Several further investigatory visits to the Müller factory took place the following autumn, including one on 8th October. The report of this visit was also labelled as closed until 1977. Siemens and I. G. Farben were surveyed at the same time.[64] Siemens had a long-running rival betatron project, and I. G. Farben was the company that had taken over the running of the heavy water production plant at Vemork in Norway during the war. A further report on the subject of betatrons was also submitted to the Field Technical Information Agency, FIAT, as late as 1948.[65]

The investigations at the Müller factory and in Wrist are also discussed in Sean Longden's 2009 book about T-Force. He describes the Megavolt Association and tells that when the investigators checked the factory in Hamburg they came upon various pieces of X-ray equipment that were sent to England, including a prototype15 MeV betatron. He wrote that two had been ordered and one had been taken out of the city, so this must be the other one. He goes on to say that because of the heavy water project in Norway T-Force had been quick to undertake investigations in Norway and that these confirmed what other military intelligence services—both British and American—had all discovered: that the Germans had made 'little or no technical progress' in atomic research. Longden wrote that the people working at the betatron laboratory in Wrist maintained that they were engaged exclusively on pure research without military application. He also pointed out that this was research at a very advanced level.

The main source of information about the relationship between Rolf and the intelligence organisation T-Force is Theodor Hollnack, the man who was also Rolf's link with the Luftwaffe leadership. Hollnack also sent his reports directly to T-Force. We don't know when that started, but there are reasons to believe that he was communicating with them as early as December 1944.[66]

It is difficult to say who took the initiative, the British or Hollnack himself, but we can state confidently that he stayed in contact with T-Force for several months and supplied them with quite a lot of information about nuclear physics work in Germany. The most interesting question to us is where and when Rolf came into the picture and whether he himself was 'in on the game.' We could invent an exciting story of conspiracy, with Hollnack recruiting Rolf to team up with the British so that when Rolf signed up with the Luftwaffe he was doing so to become a British spy. As a pure researcher without political commitments or affiliations he would have been suitable for such a role. However, there is no foundation for such a story. Quite the contrary. What is in no doubt, is that Hollnack was using Rolf. Whether or not Rolf knew that is another question.

Hectic Peace

During these first weeks of peace, there was hectic activity in the hidden, temporary betatron laboratory in Wrist. In Rolf's absence, Kollath wrote a progress report in which he also summarised the whole history from 1943 onwards. The document is dated 6th June and describes the prior history of Rolf coming to Germany, the work at the Müller factory in Hamburg, the reconstruction of the machine after they evacuated to Wrist in Schleswig-Holstein in March and the programme for further work, mentioning the small, medium-sized and large betatrons. He emphasised that it was now extremely important to start work again on the agreed programme.

Only the smallest, 15 MeV, machine was ready, and at least two more of these were to be built. One was to be used for biological research on the effects of the radiation both on animals and on humans. Another was to be used for materials testing. Because of the hostilities, parts of the 15 MeV equipment had had to be packed away again after they came to Wrist and the design work on the bigger models had had to be stopped. It should now be started again. Above all, Kollath wrote, the work on the 30 MeV machine should be set in hand as soon as they had the necessary equipment. This machine would have adjustable energy levels and would be used for nuclear physics research in institutions. The actual construction of the machine could possibly be transferred to a company in Hamburg, such as Rich Seifert & Co. who would be supplying parts. But building it in Wrist was also being considered. The intention was to develop several different prototypes of this model.

Kollath's report also advises that planning for the very biggest machine, of 200 MeV, should also be resumed as quickly as possible. This machine should be built in Heidelberg, both because of the industrial contacts there and because Professor Bothe and his institute were there. The project team in Wrist was the same as it had been in Hamburg, but with several additional employees. The work schedule also points out the need to recruit the required tradespeople and scientists, such as glass-blowers, biologists, laboratory staff, instrument-makers and specialists in the development of the particular type of tube they needed and various other tools, etc.[67]

Alongside this, Kollath drew up a longer technical document describing the development of the betatron up till then, plus the future development plans. The title of this document is *Bericht über den Strahlentransformator nach Wideröe* ('Report on Widerøe's Radiation Transformer') Everybody who had anything to do with the project used this phrase, '*nach Wideröe*.' This applied to German officials, the project's own employees, and others. At that time they still referred to the betatron as a 'radiation transformer,' which was Rolf's own expression.

Kollath's technical report also included sketches and equations and two interesting attachments. The first, stamped *Geheime Reichssache* ('State Secret') is the article that Rolf sent to the German professional journal, where it appeared in print in spring 1943. The second attachment is article number 2, which he submitted in summer 1943 but which was never printed.[68] Whereas the first has a line at the top of each page with the issue and page numbers, these are understandably absent from the second.[69]

Also associated with the technical report is a note tracing the threads of Rolf's work back to his predecessors such as the Americans Kerst and Serber, thereby setting it in a wider historical perspective.[70] All these are documents that were gathered together by Hollnack and sent to the British in early summer 1945, about eight months before he was arrested. The new organisation was in effect a continuation of the old one, but with a more clearly defined structure and strategy and, not least, an emphasis on independence.

In practice, things would not work out exactly as the reports and strategy documents predicted. In August Touschek was invited to Hannover and Göttingen to work on betatrons, but Hollnack forbade him to go. Then in September Hollnack created a new organisation, WTO, *Wirtschaftstreuhandorganisation* ('Economic Agency Organisation'), of which the Megavolt Association became a daughter company. Kollath was trying all the time to have normal work on the betatron resumed, but Hollnack insisted on leading in his own way even though he didn't officially have authority to do that. At the same time, Kratzenstein and Flegel were asserting themselves. They had both been Hollnack's fellow conspirators at the start of the project, and now they were trying to exclude Kollath from important decisions.

Then at New Year 1946 Hollnack was imprisoned. The others in the project thought at first that Kollath was to blame for Hollnack's arrest, and Hollnack's wife accused him directly of this. Kollath was later appointed trustee for the development work in Wrist.[71]

In brief: There is so much material—and more yet—to be found about the Megavolt Association, the new name for the Widerøe Group: in an archive set up by an American intelligence organisation (Alsos); and in documents addressed to a British intelligence organisation (T-Force)—sent there by a German (Hollnack) who was Rolf's boss in Germany on behalf of the Luftwaffe.

In other words, in Allied possession there is extensive documentation of the organisation '*MV-Forschungs-Vereinigung*/MV-Research-Association,' but the speech and writing of the main character himself contain no trace of it. No mention. Nothing about rearrangement or liberation from the Nazi authorities. Not once have I found the tiniest little hint of it between the lines. Yet Rolf is part of it, with his name listed in practically all the documents. Everything is 'according to Widerøe,' 'in agreement with Widerøe,' 'in understanding with Widerøe.' He is glued to the project and is on the copy distribution list of all the documents handed over to the British.

Did he ever see these papers himself? Maybe. He was out of the country—'for the time being,' it was stated. But he never came back. Communication between the previous occupying power and the previously occupied country of Norway was minimal, and his own situation with the treason case hanging over him and his passport confiscated made such communication improbable, if not to say impossible.

Did he know but not say

– ***that his assistant would be set free?***

Rolf must have known that Touschek was about to be released from prison. When he visited Touschek in prison before departing for home, Rolf told Touschek that help was on its way. Touschek later recounted that during one of his last visits to him in prison Rolf had reassured him that a courier was on his way from Berlin with release papers.[72] This visit probably took place on 11th April, which was a Wednesday. But where did Rolf get this information? He must have had contacts. Probably through Hollnack. Rolf never explained why he could be so confident that it would not be long before Touschek was released from prison. Rolf obviously knew that a reprieve was in hand. He may even have played a part in this process himself. Touschek writes something to this effect in a letter to his father, in which he first complains about the poor conditions in the various prisons where he had been kept and about the Gestapo's methods, the SS, inadequate food and a lot of marching. Widerøe, Seifert, Kollath and Hollnack are named as the only rays of hope in his situation. The leaders of the betatron project had come to the 24 year old student's support, especially Rolf who always brought cigarettes that could be used, among other things, to bribe the guards.

The three were already supporting him when he was called in by the Gestapo. All of them, including Touschek himself, were strong personalities who played their cards as best they could. Touschek had told Rolf of his wish for a single cell, and Rolf had made it clear to the official in charge that none of them 'would take the responsibility' if Touschek was put in a communal cell. The colleagues had explained to the Gestapo that 'The nation's future for better or worse' depended on the research that Rolf had started. They also insisted that Touschek should be allowed to smoke, read and receive visitors.

Touschek's letter to his parents continues at a fast pace and with great intensity:

> On Friday I wanted to hang myself, and on Sunday Widerøe came to see me. From then on the situation got better. I had a 'decent' cell on the first floor and Widerøe brought me "Heitler's Quantum Theory of Radiation" and I started to read up about research on radiation-damping. W[iderøe] never forgot to bring me a packet of cigarettes inscribed with the important sign "Propellant for you." (…) I was treated relatively well because the frequent visits by important people earned me a certain respect.

Touschek was one of the lucky ones. He later said that he had not been treated as an ordinary prisoner and that, amazingly, he was allowed to continue his work for Rolf while he was in prison. 'We helped him as much as we could,' Rolf explained, 'though we couldn't get him released.' Rolf also provided him with food and even an occasional *schnaps*. Touschek was as diligent as his boss and he managed to write several reports on the betatron while he was inside, including one that he wrote with invisible ink in the margins of the physics book.

Touschek had a sanguine nature. In the letter he describes a forced march when, sick and miserable, he was ordered to walk all the way to a new prison with a heavy bag full of books, and then he continues:

> In the meantime people had come to see whether I was dead or alive. I tried to find a telephone to call Seifert and ask him for a car. Meanwhile, my head felt terrible and I managed to walk to the hospital in Langenhorn, I needed help. Thanks to Widerøe's message I didn't worry about that.[73]

This experience made a painful impression on him and it is the first thing he told Rolf about when they resumed contact with each other after the war. Touschek had great respect for Rolf, and there had been talk of him coming to Norway for further studies when the war was over. His plan was to do a Ph.D. in a Nordic country, probably in Oslo, and he said that Rolf had already mentioned this to Professor Hylleraas during the war.[74] Rolf and Hylleraas already knew each other *before* the Oslo University Professor was nominated to the expert committee to advise the prosecuting authorities in the treason case against him after the war. So Hylleraas must have known something about what a resourceful person Rolf was.

Hollnack also supported young Touschek:

> A few days before the occupation of Hamburg, Hollnack came to take me out of prison, even though that was not done entirely legally. It was high time, as otherwise I would have been shot, at the best. Then I went to Kellinghusen by car and I am still there.[75]

But he is not over-enthusiastic about Hollnack and thinks it is an exaggeration when the German 'without having done anything for him for three weeks' maintains that he can take the credit for him not being shot.

Here is live human drama, with false names, arrests and releases, interactions with the Gestapo, operations at the edge of the law, money from high in the Nazi hierarchy, compassionate employment of persecuted Jews, a Luftwaffe representative linked up with the British Military Government—and a Norwegian who, apparently unaware, was named as the leader of an international research organisation that after the war would undertake free and independent research on betatrons, irrespective of national boundaries; an organisation founded in his name while he himself was fleeing from American and British authorities, and possibly from German and Russian too—right into the arms of the Norwegian prosecution.

How did Rolf get mixed up in all this, when all he wanted to do was research? One man knew more about this than anybody else, namely Theodor Hollnack. Eventually he told the story. Recorded it, what's more, in documents he gave to British officers in T-Force, who used it exactly as such information is used in the intelligence service. Then it came to rest in the National Archive of War Records and Military History. And there it lay—but only after the Americans had got a copy.

Delicate Manoeuvring

In a bulky collected document addressed to named officers, Hollnack writes about himself and what he is doing, especially in connection with the betatron project.[76] In his usual, systematic way he begins at the beginning and goes forward step by step. His personal report is at the same time a narration of Rolf's Luftwaffe project from start to finish—a finish that was dangerously close even when the project was only half-way through—and a story that was not entirely as simple as Rolf made it appear. Whether Hollnack's account is objective and 'true' is difficult to prove. He appears as the snake, the apple and the redeemer in one and the same person.

His Interest

Hollnack claims that his main interest in the project is the finance and the associated scientific and technical problems. He says that the matter is complex and requires professional and effective management of all aspects. He adds that whoever is to manage such a big combined scientific and technical project must be independent of industrial connections. He says however that he runs an office that includes engagement in diverse fields: a company for setting up businesses, managed by himself; an office equipment company, in which he is a shareholder; a sub-committee of the German Metallurgical Association, where he sits on the board; and not least, the Betatron Project.

His 'Credo'

In elevated and rather self-important turns of phrase he expresses his management philosophy:

> The profit motive plays a decisive role for all companies, but there are some research and development tasks that cannot be measured by that standard. For reasons such as these, tasks of this kind are devolved to suitable institutions connected to particular industrial groups. In most situations the institutions do not control sufficient means to deal with such big tasks. Industry operates overwhelmingly with badly directed research and must therefore also adopt a corresponding standard.

His Role as 'Treuhänder'

He explains his role as *Treuhänder*, an administrative function to do with acting as a trusted negotiator between two parties. This is difficult to translate into English but possibly described as 'go-between' or 'honest broker,' though Hollnack appears to have brought to the role a large measure of his own entrepreneurial initiative. Hollnack tries to describe the delicate balancing act:

> … there are wide-ranging and important tasks whose undertaking cannot be justified purely on the basis of financial profitability. I therefore maintain the

> standpoint that there is a duty to defend science and technology in its own right, both as a stimulus to business and as an economic benefit to society. But it is not possible to carry out a major research and development enterprise without also having dedicated people who attend to the economic perspective and are committed to that. A '*Treuhänder*' is the intermediary between them, one who attends to the financing which is necessary to carry out far-sighted technical-scientific tasks.

In retrospect, we may wonder whether it may rather have been to save himself that Hollnack had reinvented himself as a humble go-between for Rolf and felt obliged to make himself useful as an administrator for the much more famous Norwegian.

His Background

What Hollnack writes about himself is infested with self-praise. He relates how from the experience of his earlier scientific and more general technical work in 1942 he came upon an interesting technical problem, 'a metallurgical process that would only succeed economically if I could apply my very sketchily businesslike theory also to this enterprise.' Yes, really. He then points out that during the war the only way he could continue was by teaming up with the Ministry of Armaments and War Production.

> Because of my work before the war, I had connections with the decision-making authority in the ministry, namely the head of the technical department, whom I knew personally. On 20th August 1942 the ministry gave me the task of carrying out this project.

He says that he got rid of unsuitable people and inappropriate outside interests among those involved, took care of what was viable, established industry and set up a sub-committee in the Metallurgical Association where he sat on the board. He reminds us that it was a matter of research and development work of a far-sighted type, where the Americans and the English were world leaders.

His Assessment of Schiebold's Ray-Gun

Before narrating his dealings with Rolf he rambles around a little, apparently because of a compelling need to go into detail about what he had done before and what contacts he had established, including contacts with Speer's ministry and the Air Ministry, and how this led to a new, major contract. He knew how to adapt. He knew that the government had a special interest in the particular field of atomic physics and the construction of apparatus such as cyclotrons and betatrons to generate high-energy particles. He also knew that all research in physics was now under the direction of the National Research Committee which included influential scientists, Nobel Prize winners and others, including Walther Gerlach, Chair of the Research Committee. And not least, he knew the X-ray expert Schiebold, who wanted to build high voltage X-ray tubes to generate radiation of such intensity that it would be effective at very long range; an X-ray cannon.

> With this idea – that later turned out to be scientifically infeasible and was therefore dropped – I succeeded in getting Field Marshal Milch to take a personal interest in this area. I was given full authority to set in motion everything that was needed to carry out the project. I kept myself fully independent and avoided any integration into the ministry.
>
> My aim was to set up a research and development group that was independent of the responsible authorities, i.e. the National Research Committee. To avoid personal difficulties, I gave some rights of inspection to Professor Dr. Gerlach and to the head of research in the Luftwaffe. [namely, *Reichsminister der Luftfahrt und Oberbefehlshaber der Luftwaffe, Hermann Göring*]

His Main Achievement—Rolf

With the help of his contacts he found the man he needed, well aware that the big thing in physics at that time was the development of apparatus to produce high-energy radiation. Siemens were working on it, and AEG had the same ambition. He also knew about Kerst's betatrons and he had links with Heisenberg. Hollnack may be giving himself a more active role in the initial phase than he really had, for it is unclear who took the initiative, Hollnack or Heisenberg.

> I came across the name 'Widerøe' for the first time in a communication from Professor Heisenberg. In 1928, Widerøe had published his findings on radiation transformers, which were the starting point for Kerst's subsequent constructions and experimental work. So this appeared to be a very important man.
>
> Through a colleague, Dr. Kratzenstein, I got in touch with the secretary of VDG [*Verein Deutscher Giessereeifachleute* ('The German Metallurgy

> Association')], Berlin, Dr. Karl A. Egerer. He drew my attention to Dr. Widerøe's submitted but as yet unpublished work, parts 1-3, from 1943.
>
> From the work submitted it appeared that Rolf had already designed a 15 Mev and a 100 MeV transformer and that he also considered it technically and scientifically possible to build a 500–600 MeV machine. I then made personal contact with Dr. Widerøe in Oslo.

So it was Heisenberg himself, expert atomic physicist and Nobel Prize winner, who had recommended Rolf, and Hollnack was on safe ground both professionally and in terms of status when he entrusted his project to the Norwegian.

His View of Rolf's Motives

Hollnack then discloses that he had sensitive information about Rolf's family and gives his interpretation of Rolf's motives for coming to Germany. He had set a honey trap, linked moreover with an alluring organisational arrangement at arm's length from the German authorities:

> Widerøe had reasons to accept my offer for him to come to Germany. These were of an honourable nature, especially for a person such as Widerøe with regard to his international reputation. (…) Considering my professional experiences of solving major scientific and technical problems, I didn't wish to bring him into any sort of dependency on German industrial groups or ministries, and therefore I made a contract between Widerøe and myself with myself as '*Treuhänder*' on behalf of the state.
>
> Dr. Widerøe started his work in Germany. One of the first scientists to be recruited to the project was Dr. Eng. R. Kollath from Danzig. At that time he was working compulsorily in Norway. Moreover, I built around Widerøe a group of people whom I considered would faithfully and without self-interest contribute to this man's success.

His Break with the Luftwaffe

Towards the end of 1944 Rolf's 15 MeV machine was almost ready, and it had been confirmed that his ideas of how to construct it were correct. So far so good, until suddenly they hit an obstacle. Somebody was starting to oppose the project. The Luftwaffe wanted to reorganise it and put it under new management. Rolf should be taken off it. At best he would have been made redundant, at worst arrested by the Nazi authorities, as Hollnack later wrote to the British:

> Through contacts with the Air Ministry, particularly the head of research in the Luftwaffe [Hermann Göring] and also with support from the National Research Committee, people in certain quarters tried to stop the work of the Widerøe group. This led to unfriendly opposition between the Luftwaffe and me. Widerøe's work was to be taken over by the Siemens factories and Widerøe himself dismissed or, if difficulties arose, arrested.

According to his own report, Hollnack calmed the situation down but realised that it was no longer possible to bring about any fruitful collaboration with the Luftwaffe. The stand-off dragged on for several weeks, until Rolf was due to go home to Oslo on holiday:

> When Widerøe was to take his agreed and pre-arranged holiday in Oslo, the Air Ministry forbade me to allow it. (…) Because of the tense relationship with the Luftwaffe that had now been going on for several weeks, I got in touch with Col. Dipl. Eng. Geist, head of the development department in the Arms Ministry. Colonel Geist was a very far-sighted and positive person, and he promised to take over responsibility for the technical-scientific aspects of the work.
>
> Then it came to a complete break from the Luftwaffe. The link to Speer's ministry was very loose and was apparently based on just one person. "*Arbeitstab Dillenburg*," which was the title being used at that time for Widerøe's project, now continued its activity under my sole direction.

Such was Hollnack's summary report to T-Force after the war about the disagreement, but he had already reported it to them six months before, making them aware that the project had been saved by Geist and Gerlach, both of whom were closely connected with it as members of the management board for the research institute at Grossostheim for so long as it had existed. At that time, Hollnack had written:

> In December 1944 relationships between the Luftwaffe and myself became strained. The Luftwaffe withdrew and left all further work to me. The technical responsibility was taken over by Col. Dip. Eng. Geist as a member of the board of the research centre at Grossostheim. He was head of development in RfRuk. That ensured research and development for several years to come.
>
> Professor Gerlach sent a proposal to Colonel Geist about the future organisation of the development group, recommending that I should take over the

> commercial leadership. (Letter dated 22.12.44) Taking into consideration my earlier experience, I couldn't accept Gerlach's proposal right away. The necessary discussions couldn't take place at the beginning of 1945 because of the way the war was going. The 15 MeV installation in Hamburg was almost ready.[77] Professor Gerlach had required a 200 MeV machine as the next project. Professor Bothe in Heidelberg was particularly interested in this project. In the meantime, the order for the construction was given to Brown Boveri, Heidelberg.[78]

Hollnack needed his friends, both powerful Gerlach in the National Research Committee and Geist, who was described by American intelligence as 'perhaps the only really capable liaison official who understood the various aspects of Germany's research needs.'[79] Hollnack gave no reasons for the opposition that had arisen in the Luftwaffe, and didn't say who in the Air Ministry or the National Research Committee had back-tracked. Stress levels were high in many quarters in Germany in the winter of 1944-1945, and Hollnack himself was not always an easy person to deal with.

It is difficult to say whether Rolf ever got to know how nearly the project had come to being abandoned, not to mention the personal danger he had been in. Perhaps Hollnack liked playing the big shot so much that he kept it to himself. Perhaps he had tactical reasons. Anyway, Rolf never mentioned any threat of being arrested by the Germans, nor that he would have been in danger of being taken by the British or the Russians. Maybe the talk of Rolf possibly being arrested by the Germans was just a dramatization that existed only in Hollnack's imagination. A man who had been brought to Germany with Heisenberg's and Speer's blessing was hardly at risk of being arrested by the Nazi authorities. Hardly anyone other than Hitler himself could displace someone who was under Speer's wing.

His New Offensive

Germany was syteadily approaching the inevitable collapse, and we may reckon that the time was ripe for Hollnack to make contact with T-Force, the intelligence organisation that was advancing relentlessly with the Allied troops. Perhaps he was driven by a duty of loyalty—but if so, to which side or what cause? In retrospect, Hollnack manages to make it appear like a planned operation: find Rolf in 1943; use him; secure the results; get him away to safety. He states that towards the end of the war he considered it his duty to ensure the safety of the betatron installation, the construction records and the staff. In March 1945 he moved the administration office for the whole Hamburg project to Kellinghusen and Wrist in Schleswig-Holstein. Then he goes on to say that two new 15 MeV machines would be built by Müller and that were also plans for other, bigger betatrons, including a 30 MeV machine that would be developed by Rich. Seifert & Co. in Hamburg.

His Colleagues and Equipment

Hollnack was in full control. An organiser and fixer, wheeler and dealer and man of action with a network of contacts. Staff, equipment and formalities all taken care of. From what he says he appeared to be fully in control—unless he was bluffing:

> Seifert has been adviser on X-ray technology to the undersigned for the past few years. With a few exceptions, all the staff of the Widerøe group are now in Kellinghusen or Wrist. These are people without personal or political interests, who are in the project only to carry out their technical and scientific duties. What's more, there are some among them, such as for example the mathematician Touschek, who have been under observation by the Gestapo for a long time because of Jewish ancestry. Staff member Jan Gerritt Overbeek in my secretariat is of Jewish origin. He has been hiding from the secret police for years. Although he later decided to acquire a Dutch passport, he is originally German and is currently looking for his relatives in Holland.
>
> At the time when I had to plan for the possible effects of active hostilities in Schleswig-Holstein, I was working to secure the safety of the whole site. On 4th May 1945 it became clear that there was no need to fear fighting there. That same day, I decided to give Widerøe's development group a structure that was better suited to resolve the actual technical and scientific problems it was then facing. The '*Arbeitsstab*' was dissolved and the Megavolt Association established, under the technical and scientific leadership of Dr. Widerøe and his deputy Dr. Kollath. The day-to-day manager is Dip. Eng. Werner Bartelt. In addition, I am the *Treuhänder* with the task of securing and implementing international agreements.

His Agreements Concerning Rolf

He expands on the contract he had made with Rolf and also an agreement between himself and the German state defining his own position:

> I had money allocated from the *Reich* on the basis of an agreement between the *Reich* and myself in my capacity as *Treuhänder*. I was responsible for appropriate use of the resources. It was also my duty to guarantee the work and ensure compliance with the contracts.

It appears that a change had now been made to the system of payments, and that latterly Hollnack had waived personal remuneration and in addition, according to himself, met all payments. He may have been in a weakened position and trying to earn sympathy. Finally, in this long report, he points out that neither in its earlier nor its current form had the betatron project been about anything that was 'burdensome to people or to the situation.' Should that nevertheless be the case, he adds, 'I have been solely responsible.'[80]

The document is signed 'Hollnack' and dated 'Kellinghusen, 9th June 1945.' It is mainly about Rolf and the betatron, though Hollnack expresses himself as if he 'owns' the whole project. However, Rolf surely has a stake in it too, and they both had some rights.

Despite all that Hollnack says about what motivated him, all he knew and all he achieved, his motives are confusing. Was he a calculating, ice-cold businessman? Was he an opportunist who exploited the situation, an eccentric idealist, a narrow-minded petty bureaucrat, a power-seeker? A Nazi, an anti-Nazi or a chancer? Or was Hollnack just a self-important and slightly pathetic man with grand ideas of his own importance? The answer would undoubtedly be interesting, though it is not really of importance in trying to understand Rolf. But everything that can be documented about him is within Rolf's characteristic descriptions of him as 'remarkable' and 'somewhat overstrung.'

Hollnack was undoubtedly an ambitious man who acted powerfully and with great self-confidence. Otherwise he could never have achieved what he did. Clever in many things, but not in everything. Determined and purposeful. Cynical at times. But not just devious, also loyal. Sympathetic. He didn't have to help Rolf's assistant Touschek to get out of prison. He hadn't needed to offer to obtain a stipend for the courier, Overbeek, to study abroad. He hadn't needed to fight for the survival of Rolf's project when people were working against him. He probably chose to press for Rolf to be allowed to go home on his holiday as agreed and escape the risk of being arrested by the Germans. Nor had he needed at the very end to protect Rolf from possible arrest by the British so that he could go home to Norway for good.

In brief: Safely home, Rolf kept quiet about his sources of information about what he did know; for example the story behind the release of his assistant. But that he had visited him in prison, taken books to him and put cigarettes in his pockets—that he did say. He explained about Touschek's Jewish background and that he had been arrested because he had sat in a library reading foreign journals. But any discussion of the more practical matter of collusion or conspiracy to have him freed by the use of cunning and contacts? No. Not a word to say that he had pleaded his case with the Gestapo. Perhaps he can be excused from saying how closely he had been involved.

Did he know but not say

– *that Hollnack & Co. fetched him from Oslo?*

How could Rolf, a sober and respected citizen of Oslo with a wife and three children, become embroiled in such dramatic events? Not just a personal drama, not just during a world war, but right in the middle of one of the major issues of the war, the race between Germany and America to develop a nuclear weapon. Somebody must have had inside information about his research and realised that he was the man Germany needed. It sounds extraordinary, but that's how it was. But did Rolf say anything about that? No. He didn't say who contacted him that day in 1943, for example. Admittedly he didn't know the full story himself, but even so, he didn't tell all that he did know. Such reticence generates mystery and rumours.

What he has given us to work on is the little he declared when being interviewed by Waloschek for the German biography. He was taciturn and vague about how he came to be engaged by the Luftwaffe, and Waloschek who was writing the biography was obviously respectful of his fellow physicist and did not press him too hard. But if we read carefully we can read between the lines. The old man apparently said exactly what he planned to say and what he had always said, formulating his account just as he had done throughout the years since it all happened, until he came to believe it himself; that was how it should be said, that was how he remembered it, that was how it was.

At the very start of the story, Rolf is vague about exactly when he was contacted, and he 'doesn't remember' whether it was two or three Luftwaffe officers who came to Oslo to persuade him, but on the other hand he mentions a trivial detail of having to fix something on his bicycle before he could accompany them. Fair enough, but if my theory of who came is correct, at least two of them were people with whom he subsequently had dealings. So it seems unlikely that he 'didn't remember.' Not wanting to tell is another matter, and quite understandable from his point of view. If he had named them, he would have had to divulge the whole history. What he said was:

> Shortly after my article had been printed, something strange happened. One day – it must have been in March 1943 – some officers from the Luftwaffe came to NEBB wanting to speak with me. (…) I no longer remember whether there were two or three.[81]

If your country is occupied and enemy officers come looking for you in broad daylight, you will know clearly whether there are two of them or three who talk with you outside your office and then at the Grand Hotel. You will also remember whether it was in the month of March or at some other date. However, Rolf does indirectly give us a clue by putting together two pieces of information that would appear to the uninitiated to be unconnected. When he talks about the articles he sent to Egerer's journal in Berlin, both the first and the second one that he sent in July—and here he gives the date exactly—he then goes on to say something that makes it worth looking at the text and the context again:

> *Shortly after my article had been printed, something strange happened.*

Then follow the sentences saying that he had been visited and that it was either two or three officers who came:

> *One day – it must have been in March 1943 – some officers from the Luftwaffe came to NEBB wanting to speak with me. (…) I no longer remember whether there were two or three.*

He links the journal articles with the visit. At first glance this juxtaposition might seem coincidental, but not in the light of other knowledge and further reflection. Previous biographies may well have had a more epic and unquestioning tone, and we should remember that the interviewee was 91 years old, but these excerpts exemplify the slight naivety that characterises parts of Rolf's own account of his life. Rolf surely didn't reveal to the interviewer more than he wanted to, and Pedro Waloschek accepted his reticence. Today's generation of investigative journalists would have called this approach servile and uncritical. Waloschek, when he himself was almost 90, later expressed to me a more nuanced and critical view.

Rolf Widerøe took an active part in preparing his biography which was published in German in 1993. (*Photo* Pedro Waloschek)

However, there are other sources. What can we find in the newly opened British and American archives about this first wartime meeting between Rolf and representatives of Nazi Germany? Here we can read about a man who on behalf of Arms Minister Speer went to Norway to recruit Rolf to a secret German weapons project. The man was Theodor Hollnack. He was accompanied by two men who both had doctorates in physics; SS officers on a special mission. Just another wartime operation—but how did Rolf come into the picture?

As the discussions in Oslo appear to have been of a friendly nature, we may suppose that the delegation sent to recruit Rolf might have included a German expert already known to him. He could have slapped Rolf on the shoulder and said that he looked forward to working with him in Germany. One person who could have filled such a role was Rudolf Kollath. He was a promising accelerator expert who in 1941 had been sent compulsorily to Norway to work at the aluminium works in Sauda. He had done his doctorate at about the same time as Rolf before they both started working for AEG in Berlin. There must have been a basis for fruitful scientific collaboration, for they also continued working together after the war.[82]

Another person who may have been a member of the group sent to recruit Rolf was Hans Edvard Suess, a chemist and nuclear physicist. He was Germany's consultant for the production of heavy water at Vemork, and he lived for a while in Norway, seconded from his employment at the University in Hamburg. He was rumoured to be a communist, and according to Rolf was one of the people who said openly that he was an opponent of Hitler. 'I could speak freely with him,' Rolf said. 'He gave me the impression that the researchers were doing everything in their power to prevent the atom bomb being built in Germany. The only potential they saw in splitting uranium was as a possible future energy source.'[83]

Suess' anti-Nazi position is confirmed by the designer and manager of the heavy water plant at Vemork, Jomar Brun[84]:

> During one of my conversations with Suess (out on one of the balconies of the factory so as not to be overheard), he said that out of respect for my conscientious scruples he would tell me what the heavy water really was to be used for. It was not to do with weapons technology. The aim was to construct a uranium reactor for power production—based mainly on principles that had already been patented by Joliot-Curie (and which I also knew about). People reckoned that this would take so long that the project would not be completed until after the war, as it would require about 5 tonnes of heavy water. Suess asked me to keep absolutely quiet about his information, but after the war he said he had reckoned that I would pass it on to my friend Tronstad in Great Britain. This I did, though not until July when I was visited by a courier.[85]

Status

Connections with Rolf must have been considered prestigious, as several people claimed to have the idea of recommending that he be recruited to the German war effort. Among these were Seifert the factory owner and Egerer the journal editor. Richard Seifert could in theory have been in the group that went to Oslo, but there is no record of him having had any contact with Rolf before the war. During Rolf's time in Hamburg they became good and trusted colleagues, and this friendship continued for the rest of their lives.

Sources within the X-ray company Rich. Seifert & Co. claim that Richard Seifert junior played a major part in bringing Rolf to Germany, possibly even *the* major part.[86] Egerer maintained that he himself was the one who had given Field Marshal Milch the thought of including Widerøe's ideas in his *Aufstellungsbefehl* ('Deployment order') for the research programme.[87] Egerer was an adviser to Milch at that time and may have been the originator of the idea, but it could also be that the idea had been given to him by somebody else. In such a case, the most likely person would have been Seifert, who had wide-ranging authority to negotiate on behalf of the Air Ministry and who was connected with the Widerøe project from the start.[88]

Rolf was always on his guard not to say who took him to Germany. The ubiquitous Theodor Hollnack, absolutely not reluctant to talk about the matter, confidently claimed the honour himself. It was *he* who had made arrangements for Rolf to be brought to Germany and had actually gone to Norway to persuade him. So he said, and so he wrote in his report to the British T-Force.[89] He said that not only Heisenberg, but also Kratzenstein with whom he had worked previously, had pointed out Rolf's work. Kratzenstein put him in contact with Egerer, who knew Rolf, and Hollnack then got hold of Rolf[90]:

> In October 1943 I engaged Widerøe to work in Germany after I had visited him together with Dr. Kratzenstein and Dr. Egerer (Secretary of VDE Berlin). The contract was signed in Oslo 1.11.43.[91]

Yes, that is what it says. It could not be stated more clearly:

> *In October 1943 I engaged Widerøe to work in Germany after I had visited him together with Dr. Kratzenstein and Dr. Egerer.*

Hollnack may have been lying about who went with him to Oslo, but there is no known evidence that it was not Kratzenstein and Egerer. Also, it is difficult to imagine what motive Hollnack could have had to falsify the names of his companions. These two were respected physicists, as Rolf immediately recognised.[92]

(After the war, both of their names appeared on a classified list of German research that American investigators thought was useful to American business and industry, in a report prepared for the Library of Congress. Under the heading 'X-ray Equipment' there is a study of materials testing by H. Kratzenstein[93] and an article by Egerer about X-radiation.[94] Even more interesting is that both their names appear in a more recent listing of Germans who had opposed the Nazi regime.)[95]

Otherwise, Kratzenstein seems rather anonymous. Egerer, on the other hand, pervades Rolf's life like a nemesis, from when his doctoral thesis was published in 1928 in the journal he edited, through a couple of articles Rolf had published there in the 1930s and the two articles he had submitted during the war and on until the visit to Oslo, the flight to Berlin and the time when Rolf comes across him in Hollnack's circle of acquaintances in Hamburg. The organisation of which Egerer was secretary was an important technical and scientific association specialising in electricity and electrical engineering, with the rather complicated name *Verband der Elektrotechnik Elektronik Informationstechnik* ('Association of Electro-technical Electronic Information Technology').

There is a lot of evidence to indicate that the three Germans who came to Oslo were Karl Egerer, Hermann Kratzenstein and Theodor Hollnack. Rolf knew the first of these from before. The second was apparently unknown to him. The third was the one who became his 'minder.' But all three of them knew a lot about *him*. They had done their homework, and they had a clear plan to fetch him, supported by orders from the highest level.

A weak point in the evidence of their identity is that Hollnack is the only source of the information he gave to the British. Another snag is that the biographer, Waloschek, states that Egerer was never in Oslo. Sadly, Pedro Waloschek died in spring 2012, before I could ask him about that in more detail. On the other hand, Egerer performed a role as an editor that a person such as Rolf knew about and could be reckoned to be interested in having more involvement with. However, what is more important than exactly who was in the delegation is the fact that they had influence and were sent by people who had influence, because it was important to recruit Rolf. Probably because of his circumstances at the time, Rolf must have had his own reasons for never saying who came for him.

The Griffin

In the history of wartime spying there is a famous parallel to Egerer. We now know that this was another editor in the same well-renowned publishing house, Springer. Paul Rosbaud was scientific editor of the journal *Naturwissenschaften* ('The Nature of Science') and operated under the code-name 'Griffin.' Editors of scientific journals develop a good knowledge of the academic scene. They know which researchers are in the ascendant at any given time and which topics are 'hot.' So they can be useful in a war situation. Griffin gathered information from Norwegian Nazis and elsewhere, and with the help of resistance workers in the Norwegian Home Front he kept the Allies informed about German weapons development. It was he who gave the Allies vital information about the biggest threat of all, the work to develop a German atom bomb.

Speculation about Griffin's identity continued for over 30 years. His range of knowledge was such that not just anybody could have filled the role, and it is correspondingly surprising that his identity was not discovered. But the American physicist and author Arnold Kramish eventually managed to unravel the remarkable story and unveil Griffin's identity. In 1986 he published the book, 'The Griffin. The Greatest Untold Espionage Story of World War II.' The book had all the ingredients of a spy novel, but this was for real.

A Griffin is a fabulous animal, a mixture of a lion and an owl that has been used in many cultures throughout 5,000 years as a symbol of vigilance and attentiveness. Rosbaud lived up to the name in which he was cloaked, and Kramish's book was presented as 'the story of one of the best preserved secrets of the Second World War.'[96] The story of a forgotten hero, scientific editor, close friend of the leading physicists of the time, apparently a good Nazi pillar of society—but also a spy.

Arnold Kramish was an expert in nuclear research who had worked in the Manhattan Project. He had also had connections with the CIA, working on Soviet espionage. He was able to relate that Rosbaud had alerted the English at an early stage that a 'Uranium Club' had been set up in Germany with the task of creating an atom bomb. More importantly, however, he was the first to advise the head of scientific espionage in MI5 in England, R. V. Jones, that the German efforts to make the atom bomb would come to nothing.[97] He also knew that the Norwegian student, Sverre Bergh, was one of the couriers who smuggled Rosbaud's reports from Germany to Norway.

A few months before Kramish died, I managed to ask him whether he knew about Rolf. He did indeed, and he sent me an e-mail from hospital replying that 'I have always been interested in Widerøe's pioneering work on nuclear accelerators.' Sadly, he was too ill to take part in an interview and he wrote that he was sorry he didn't know very much about him. In his last e-mail he encouraged me to continue my research to find out more about Rolf and about what he called a 'most interesting project.'[98]

War Is War

Kramish's book includes people and events that cross Rolf's path from time to time and convey a picture of the world he lived in, without referring to him directly. In describing the setting in which Rolf and others were working, the book says something about how rumours arise and facts become uncertain in time of war. So healthy scepticism is also appropriate in assessing reports about Rolf.

Many people who were involved in the Second World War said nothing about it afterwards. When we had almost come to believe that there were no more stories left to publish, out came a book in 2006 about the Norwegian Sverre Bergh's double life as a student and an agent. After a fifty year silence he finally told his story when he was very ill, shortly before he died. He had taken seriously his vow of silence to the secret organisation of which he had been a member. The organisation was XU, later described by Kramish as 'the best organised and most productive intelligence organisation operating during the Second World War.'[99]

Some people thought that the vow of silence lasted for life, some for 30 and some for 50 years. There could be another war, and it would not be wise to disclose methods of operation. Berg hadn't signed anything, but he had an enduring loyalty and the work of intelligence services didn't suddenly stop when World War II ended and the geopolitical situation gradually morphed into the Cold War. There are still people coming forward to talk about what they have kept concealed for so many years for reasons that are more or less understandable to us—to us who were not them, there and then where war is war.

The book about the engineering student's contribution through XU to the British Intelligence Service ran into four editions the autumn it was published. People wanted to read about the 20 year old who took on the role of a spy, revealed the development of the German V2 rocket bomb and provided important reports about Hitler's atomic bomb project.

To the same extent as the heroes are reluctant to tell their stories, people are eager to learn about them. It has emerged that at the end of the war XU had about 1,500 agents throughout the whole of Norway and had developed a sophisticated courier system to pass information through Sweden and on to Britain. This mass of intelligence information gave the Allies a good knowledge of German forces in Norway. Most of XU's activity remained secret right up to 1988, and even after the then Norwegian Defence Minister, Johan Jørgen Holst released the members from their vows of silence, many continued to keep their contribution secret. It was a means of survival with memories that nobody else might understand, or that they could not talk about easily.

Young Sverre Burgh, alias Sigurd, was studying engineering in Dresden and had been instructed by his spymaster to find out everything about the Germans' atomic bomb programme and rockets. He was given a contact in the Springer publishing house in Berlin, in a department that published scientific articles about a range of subjects including atomic physics. The contact person was Paul Rosbaud. Along with Rosbaud, Bergh was the very first agent to report about the V2 rocket, its shape and size and the exact location of its launching station. Through radio transmissions from Britain, Bergh learned that the report had come through and he assumed that everything was in order. But then the British made a fatal error—they didn't believe it. He had risked his life, uncovered sensational information and ensured that the message got through—and had not been believed. He then lived to the age of 85 before the story became known to the public. The only people who had been in on his secret were his wife and an uncle who was a journalist, *Aftenposten's* foreign correspondent.[100]

Bergh was not the only agent to be recruited because of studying in Germany. The scientific editor at Springer, Paul Rosbaud, alias Griffin, had been in Oslo in 1939 before the war and discussed the founding of a new journal with Odd Hassel, a Norwegian chemist. They knew each other from when they had both been doctoral students in Germany. Rosbaud appears to have started using Hassel as a courier to the British intelligence service during the war, apparently without Hassel realising this himself at first. The material passed on in this way included what was known as The Oslo Report.

When Rosbaud came to Oslo in 1942, wearing Luftwaffe uniform and with permission from a high-ranking Nazi general, his official purpose was to visit another Norwegian chemist who was a good friend.[101] His real purpose was to pass on information about the development of the German atom bomb through XU to British intelligence. For this he used Hassel, who now appeared to have understood and accepted his role as an intermediary. However, the contact was broken off early in autumn 1943.[102]

During his visit to Oslo Rosbaud had also met the nuclear physicist Harald Wergeland—also in XU—and told him that there was no danger of a German atom bomb. Wergeland had the information passed on to Leif Tronstad, the man who planned the attack on the heavy water plant at Rjukan.[103] Wergeland was later one of the expert witnesses in the case against Rolf after the war.

The Oslo Report

Editor Paul Rosbaud also had a long connection with the 'Oslo Report,' one of the most spectacular military intelligence leakages of the Second World War. The report brought together details of weapons and technical accessories developed by the German arms industry, including planes, torpedoes and radar equipment and the rockets being built at Peenemünde. The report was posted in two anonymous letters to the British Embassy in Oslo and sent on from there to MI6 in London for further analysis. The head of SIS, R.V. Jones, later commented in a book that the report must have been written by someone with a good scientific and technical background, and that it stood out from all the intelligence information he had seen so far. The identity of the source, however, was still a mystery to him when he published his book:

> Inevitably, the question will be asked regarding my own ideas about the identity of the Oslo author. I believe that I know, but the way in which his identity was revealed to me was so extraordinary that it may well not be credited. In any event, it belongs to a later period, and the denouement must wait till then.[104]

Sixteen years later the Norwegian resistance worker Arvid Brodersen wrote about how British intelligence received the report and he was able to reveal new details. The Oslo report and the story surrounding it was at that time not yet generally known about in Norway:

> The report took the form of two letters, posted in Oslo on 1st and 2nd November 1939 to the Marine Attaché at the British Legation, Captain Hector Boyes. The letters were unsigned, and the identity of the sender remained an unsolved mystery for many years. When the head of the Secret

> Intelligence Service, Dr. R.V. Jones, received and read the report he was immediately impressed by its high level of technical and linguistic skill and he was convinced of its authenticity. So the SIS complied with the sender's request for a coded receipt in the BBC News on a particular day.[105]

Then in 1967 Jones received a further letter, signed 'The Oslo Person,' in which the author of the report explained his motives for the apparently treasonous action of revealing secrets about German weapons: From his knowledge about the German military forces' new equipment he thought there was a risk that Hitler might win the war, and he wanted to prevent this. The report really had revealed secrets of great value to the Allied war effort. It was a breakthrough in scientific intelligence and it gave the British a good foundation on which to develop countermeasures against the weapons it described. When Jones wrote his book on British scientific intelligence services in 1978 he had good reason to include in the dedications 'The author of the Oslo report,' even though he didn't yet know his identity.

But Jones, head of scientific espionage in MI5, didn't give up. In a later book he was able to reveal the story of the author, who turned out to be the Technical Manager at Siemens, Dr. Hans Ferdinand Mayer. He had been on a business trip to Oslo, staying at the Bristol Hotel where he had written the report over two days on the hotel porter's typewriter.[106]

Cryptic and Conspiratorial

Rolf's rival and colleague Max Steenbeck at Siemens published his articles in *Naturwissenschaften* where Rosbaud, alias The Griffin, was editor. For a certain period of time Rosbaud had orders from his superiors not to publish material about the betatron. Like Rolf, Steenbeck had also submitted an article that wasn't printed. Rolf's editor in the same publishing house, Karl Egerer of the journal *Archiv für Elektrotechnik* was just as much a key person as Rosbaud, in a position to get hold of sensitive scientific information. Egerer had printed articles by Rolf in the 1920s, 30 s and 40 s and obviously knew the content of the latest article, the one that 'disappeared.' He can hardly have shown it to many people, but two people who would have known about it were Hollnack and Kratzenstein.

It is difficult to say how much Rolf knew about what was going on and whether they had previously met personally, but if the editor had as I believe visited Rolf in Oslo shortly after receiving the latest manuscript, Rolf must at any rate have known that. And if Hollnack was the one who provided money to Rolf and administered his project in Germany, as they both confirm, then Rolf obviously knew that Hollnack was one of those who came to Oslo to recruit him. But Rolf said nothing about Hollnack having come to Oslo, nor about Kratzenstein, whose name he has never publicly mentioned.

It would be no surprise if sometime in the future somebody were to find a link to Rolf as an active player in the game he was caught up in. It would not seem unlikely, in the light of what else we know about wartime spying. No trace of any such link has been documented, however, and in fact Widerøe and the decisions and coincidences that directed the course of his life are just as interesting without it. If he had Nazi convictions it would not be surprising to go to Germany to contribute to weapons development during the war. Whether he was a declared Nazi or an Allied spy, he would have had a planned strategy and a programme to follow, and if he were a double-agent he would have had even less room to manoeuvre. Without such ties he is an ordinary person trying to get through as best he can, an illustration of how complex life can become. In an extraordinary situation a person of great talent can face correspondingly great challenges, especially if someone else wants to use him—and there are many who do.

Sometimes it is not easy for anybody to know what's what. In wartime, information is gathered and disseminated in the strangest ways. Giving it, obtaining it or just having it can be either lifesaving or lethal. It should be passed on to those for whom it is intended and to nobody else. Channels must be selected with great care, even cunning.

For example, in folder FO 1032/230 in the National Archives in London there is a cryptic note labelled 'Case: Hollnack,' written by Donald Fraser, Head of Security at the British Military Government's head office outside Hamburg. In June 1945 this T-Force officer was sent a strange, three-page text with obvious relevance to the matter he was working on, Rolf's betatron project. The text was artfully composed and contained an apparently heartfelt political message. It contained no specific names of people or places, but it was carefully written in a stylised form, as a play with two characters: a Norwegian and a German. The Norwegian is described as a technician and scientist; no description is given of the German. Time and place: 'Oslo, a house in the hills, October 1943.' Title: 'Conversation in Oslo October 1943.'

What was this about?

In the forwarding note that was addressed to Colonel Read and dated 10th February 1946, Fraser says that he has read 'with considerable interest' the proof copy of an article that he had been given to look through before it was to be printed in the little magazine, *Der Kreis*, ('The Circle'), and that he specially wanted 'to draw your attention to two sentences on page 22, second paragraph.' Fraser had not taken time to send the German text to the translation office, and so had translated it into English himself:

> The German Government has proclaimed its right to play a leading part in Europe. Within my self-imposed limits I have made it clear to leading people in Germany, and will continue to do so, that to make demands for such a leadership cannot permanently be based on bayonets, but that first we must show the world what we stand for.[107]

Fraser had written a significant note in German in the margin of his own copy: '*Also! Marschiert DOCH das Herrenvolk!*' That is what people called the Nazi anthem, '*Die Fahne hoch! Marschier'n im Geist in unser Reihen mit.*' ('Raise the flag! March in spirit with us in our ranks.') In the covering letter to his superior, Read draws attention to the commentary he has written in the margin and he expands on what he means by adding:

> In other words, out of the morass of self-pity and masochism with which this production is filled from cover to cover, emerges this unmistakable indication of an utter lack of conversion to the idea of Germany taking her place in the world in equality with other nations – on the contrary, it is now through the power of thought and through cultural-humanistic propaganda that Germany shall dominate the world.

When Colonel Read received the letter, he consider the matter so important that he immediately sent a copy to Major Evans, with a commentary in the covering letter:

> This, of course, in no way means that our friend was or is a Nazi. It is merely indicative of the indigenous mental sickness that afflicts the German people.

From the context, there can be no doubt that 'our friend' refers to Hollnack. The article under discussion is no longer attached to its covering letter, but there is a copy of an English translation in American archives.[108] Alongside that is a letter that Fraser had received with the article, written and sent by—yes—Theodor Hollnack.[109]

The famous text was from the June issue of *Der Kreis* in 1945, which was published a month after the German capitulation and at the same time as the Widerøe group and Hollnack were in Kellinghusen summing up the betatron project. The publication date was 6th June. Three days later, Hollnack wrote one of his very wide-ranging letters to the British with a big bundle of attachments, telling them about Rolf's project from A to Z. There, in the very last section of his ever so correct letter to T-Force 2, British Army, written on Hollnack's own notepaper, an attachment is mentioned that clearly differed from all the others. Hollnack's letter leaves little doubt that this remarkable text is about Rolf's betatron project:

> I am also sending you a copy of an article that is ready for printing in the magazine *Der Kreis*. To the people producing the article, it is about fellow-workers in MV-F.-V [The Megavolt Association]. The magazine is apparently for internal use and it indicates the ideas the group stands for. Moreover, approval will be sought from the British Military Government in Itzehoe before official publication. I venture to draw your attention particularly to "Conversation in Oslo 1943," on page 20.

Reading the text oneself, one experiences several revelations during the three and a half sides of dialogue. Rolf is definitely here. I have provided the English version, but from the context it appears to have been originally written in German:

Excerpt from the journal "DER KREIS" June 1945
Conversation in Oslo in 1943
Persons:

1) a Norwegian, a technical and scientific man
2) a German

Place and time: Oslo, a house in the mountains, in October 1943

The Situation:
Germany had pushed forward with a gigantic war-machinery and a dynamic never seen before, since 1939 in the East South and West. World seemed to be overcome. Germany seemed to be certain of its affair. Beginning 1943 and in the course of it Germany had to change from offensive into defensive and retreat began in the south and east. This, even to a critical German, could mean planning and self-restriction. The German press did the rest. From the point of view of the adversaries of Germany, the occupied and neutral states it was clear: the point of culmination of the German aggression had been exceeded. Here going back at all fronts, and therewith slow, but sure exhaustion; there a power of offensive of all rivals of German raising from month to month. According to this judgement the break down of Germany was still only a question of preparation and start of the invasion by England and America in the West. Even to the most non-critical member of a country occupied by Germany

it must appear a considerable risk to continue existing connections at the limit of its ability of aggression and, in the end, could not resist a pressure constantly getting greater. In October 1943 the dice against Germany had already been thrown from the point of view of foreign countries.

The Norwegian: I shall come to you to Germany, work there and realize my ideas. I am an engineer, my brain and my heart belong to mechanic and science. Except my wife, my children and my relations, work means everything to me. This work is my task of life. I believe that I have to give the world something and I have to fulfil my mission sooner or later.

The German: Man has in life only one duty, to recognize his mission and to fulfil it. The thorny way of mankind is called development. It can only be reached by giving away oneself without the rest to one's destination and by personal sacrifices. I shall give you the possibility to fulfil your duty to yourself to science and mechanics. Come to us to Germany!

The Norwegian: I know all that you tell me. Often enough I have examined myself. But just as to my work, I am connected to my wife and my children. Consider well, what you are offering me: certainly the immediate realization of my thoughts, but what does Germany mean to me! Germany is in war with nearly all the world. Till now Germany shed much blood, it has brought much suffering, misery and destruction to human being and the nations whom I am related to. It has invaded our country. The king, the leader of our nation had to escape and with him many of my compatriots. Thousands have been put to death, thousands dragged to a tribunal, only because they were good Norwegians. Your own compatriots have condemned my brother to 10 years in a house of correction only because he wanted to help good friends of his, he was accused of conspiring with England. My parents nearly broke down by that. And now you, as representative of this Germany, are coming to ask me to come to you. Surely, I like Germany. I know the Germans, and in your country I have many friends whom I appreciate very much and whom I would like not to loose. In Germany, I have studied and worked. Besides I know that it is not the real Germany which is causing this inferno to the world. It is just the depth and impenetrability of German soul made this people able and ready to give into the dynamic pressure of jugglers and hazarding creatures. Can you now imagine the conflict into which you are bringing me?

The German: You have showed Germany to me how it really is and like one can only judge men and things if one has the necessary distance from them. It must seem to everybody who does not know this people, that this land is the seat of the apocalyptic riders and that for cultural nations there is no more holy mission than to burn away this blister on the body of Europe. You see, I am a German and I like my country and my people just as you like yours. To love one's country does not mean to destroy that of other people. The more I am fond of this country, the more I can imagine and understand the virtues and faults of my nation, the more I am able to understand all human being that live under the same pains and sorrows. I do not see only their conflict, but I knew my own one, and I know that many Germans recoil at it the same myself. What are we to do? Shall we destroy the men who misuses a whole nation and who have founded their government on the most primitive instincts in man? This, and the possibilities hereto, no outsider can easily imagine. Not considering that I believe that such problems cannot resolved by the destroyment of single men. Or are the German who overlook the evolution of things, to leave home, wife, children and their relations and join the army of the allied nations? Or shall we fight with ink and pen from a safe port and put the rotation-press of all countries into a furious movement against spiritless and tyranny? Or shall we be sitting during the act of this immense drama that now hurries over the stage of the world, as spectators in the parquette, tired and disinterested, terrified or intoxicated, applauding or rising tiresom, as if all this would be nothing to us? It would be more simple and straightforward, but not courageous and resolute. I do not see a martyr in a man who leave his nation in order to bring itself into safety. I believe that the real German grows up to the sense of sacrifice to know all this, to undergo the consequences of this attitude, and still to remain at his place and to do what duty demands from him.

The Norwegian: I must admit that I have not yet seen things in the way you are showing me. But if you please, what do you think to be your duty?

The German: I have said it already: to endure and to work, to undergo and suffer the horrors of this war, the bomb-nights same as millions of my people to whom help is necessary. To soften physical or soulish wounds of those families who lost their home, their relations or at least of some of them. To help people who are pushed out by reason of the politics of races, and thus are considered pariahs, only if it can only be a single one to whom one can be of use.

The Norwegian: That may be all quite right. But you spoke of the work. How is it possible at all to work in Germany under the existing conditions and how can one think of starting a task, which almost does not belong to the present development of war at any rate? Besides: Doe not every work lose its real sense and every justification under this point of view, in the present Germany?

The German: My answer to this shall justify my attitude stated above and that of any German as well. My own responsibility engages me to the following: to arrange for a problem, the results of work of which are highly exceeding the frame of the present war, to act for the solution of a matter which keeps its importance also after the end of the war and that really for all nations. Besides, we have to consider that after the end of this war Germany will be a poor, destroyed country. Therefore I consider it a demand of the hour that every German works according to this as far as his abilities and possibilities enable him. The German government has claimed to the leading in Europe. I have explained to leading persons of Germany and shall continue doing so that a claim to such a leadership ought not to be supported by bayonets for all time, but we have to prove at first our spirit to the world. Besides I know so well as you that one can be master of a people and likely of all the world for long years by force, but that at last justness will triumph. Besides I am seeing the time coming when present dream of a 1000 years' empire breaks down on account of its lack of supposition and conditions and that with this event new leaders are brought up, tolerated or moved by ambition; or nobody's blessing, neither for that of a real Germany nor for that of the world. Then we need creatures grown ripe by afflictions who have learned to keep silence and also can be silent, and speak only when truth and justice demand it. I follow the politic of the "Trojan horse" and hereby and in persecution of my zeal I make use of every means; every lie in this connection means a holy lie to me. I use those forces which I cannot and will not destroy, but I do not allow anything to make use of me.

The Norwegian: So you seem earnestly to believe that such an immense problem of research and development, as my work represents, could be executed with result in Germany?

The German: Yes, I am even convinced that, for the time being there is no better possibility of realizing your work of life than in Germany.

The Norwegian: This I do not quite understand.

The German: I will declare it to you. Germany, nearly without any exception, works on preparation-equipments. All proposals which are not in any connection to the war, are not allowed to be executed. A certain part of research and development, however, is kept, and those ideas which for the time being are executed, are carried out most urgently. Besides, my method guarantees a preferring attending to your problem, and moreover you will always meet at the responsible places some persons with whom a working together pays out. Please consider the difficulties arising for a researcher in most of the countries, same as formerly in Germany to execute a founding work which possibly requires a lot of money, and the many years which a researching personality sometimes has to spend useless before getting to the zeal of his desires.—All of us know the desire and the necessity for an inquirer to be and to remain independent. In each technical or economical connexion there is an extreme danger to one's own research and the evolution of it. Anyhow, I am absolutely convinced that considering the possibility that you could bring your problem nearer to a realization and that thus you would render inestimable service to your country as well as to other nations. I am fully aware of the fact that you will not find any especially good personal conditions and that you are put to certain dangers by your eventually working in Germany. Please also think of your brother whom possibly you might be able to help. My request to you "Come to Germany" means a sacrifice to you. But this sacrifice you ought to bring to your work, to Germany as you know it and as it really is, and besides to the world.

The Norwegian: Well, I am ready. I am coming to you to Germany.

How shall we begin to try making sense of this? First, three preliminary observations:

The role-play is written by someone who knows the topic well, either because the author was present at the conversation or because he has been thoroughly briefed on the subject. The German's responses are long and didactic, the Norwegian's short and personal. There is no doubt that 'The Norwegian' is Rolf and that the piece refers to an actual event. One obvious question is: 'Who is the German?' From what is known so far about who visited Rolf in Oslo, there are three possible candidates: Hollnack, Egerer and possibly Kratzenstein. But it is difficult from the content of the text to envisage any of these standing out as first choice for the role of the German. Another possibility is that all three are combined into a fictitious character as a literary effect.

Another question is: Who can have written a piece such as this? One possibility is that 'The German' is the author, someone who himself took part in the discussions in Oslo. Another possibility is that somebody who had heard the story retold it in his own way. In either case, the author has applied the literary technique of combining the people who were present at the real event into one character, 'The German.' Even though the text is not finely crafted literature, whoever wrote it knew about dramatic form. The content does have a certain philosophic sound, which leads us to think of Hollnack with his interest in Nietzche. Egerer with his editorial skills could possibly have been the author, but it is difficult to find indications of this. The other possibility, that someone put the story together without having been there in Oslo, opens up numerous possibilities.

It is not easy to throw light on this question by analysing the text, but one probable interpretation is that the source of the narrative was somebody who went to Oslo to fetch Rolf, and that this person was also the author. Hollnack, who also submitted the text to the British, is the most likely candidate. We don't know whether the British knew the identity of the author, as there is no documentation to that effect in the British security archives. However, two letters that Rolf received from his former assistant Touschek after the war state plainly that the author was Hollnack.[110]

The next question is: What did somebody want to achieve by publishing this? What message was somebody wanting to send, and to whom? I don't know whether the British officers who received the text knew about the magazine in which it was intended to be published. Hardly anybody knew about it, and that was the whole point; it was a closed forum. Only the Swiss editor and one other person would have had the list of subscribers, which amounted to only 200 people.

Der Kreis—Le Cercle—'The Circle,' which was its full name, was a magazine for intellectual, homosexual men and had an ambitious political and artistic aim. Homosexuals were suspect in Hitler's Germany and would be rooted out by the SS along with Jews. The subscribers comprised a secret club in which the magazine was an important channel of communication. At that time it published articles in German, English and French. Very many of the members and writers operated with pseudonyms. The editor and leader of the group was a playwright and wrote many of the articles himself.[111] He worked under several names, but in the magazine he always used the pseudonym 'Rolf,' a coincidence that might easily confuse us. On the other hand, it is conceivable that he could have been the author of the drama about the German and the Norwegian.

It is significant that Hollnack gave the text to the British, when there was no need for him to do so. What did he want to achieve, and by what means? Why did the author want to have it published in this way, in this very specialised magazine, and why would Hollnack bring it to the attention of the British? It seems odd that the British Military Government's office in Hamburg would recognise an article for such a publication. It suggests that somebody had a specific intention with it and wanted to report to somebody about the content.

I haven't found evidence that Hollnack was homosexual, although there are things that suggest this. Evidence to the contrary includes the fact that he was married. But his courier, the teenage boy with the many names, was homosexual, as he has said himself. Hollnack may have had a strange effect on those around him, but the courier's role seems even more mysterious. In his autobiography many years later the courier wrote that he had been Hollnack's *Günstling* ('Favourite') and that the others had therefore treated him with a certain respect:

> Nobody knew why I was there. So there must have been a very good reason for me being there.[112]

The courier himself thought that it was all very strange, and he was unhappy that all he basically had to do was to travel round delivering envelopes. After the war, when Hollnack tried to explain the situation by telling him about his work for the Allies and started talking about the members of his office staff who were Jewish, he didn't follow what it was all about. Then when Hollnack went on to assure him the English would value his contribution, he understood even less. He wondered what his role had been in the imbroglio, and whether he had been Hollnack's 'private Jew.' Though the thought crossed his mind, he didn't say anything about it at the time. He had obviously been kept in the dark, and he realised that the information he had been given was just spin.

He also realised though that he himself had been helped and that after the war, to be fair, it was his turn to show magnanimity and to protect his boss if necessary. 'Perhaps he had really been assisting the Allies while he was working for the Germans—and himself.'[113] This comment seemed like a significant revelation, though he didn't expand on it further. Kellinghausen had been full of British soldiers, and he had noticed that above the door of his lodgings there was now a notice: 'Eighth Army, T-Force, Keep Out.'[114]

After the war the courier moved to England and became a recognised author under the name Jacov Lind. His work has also been translated into Norwegian. His autobiography is a strange mixture of eroticism, rockets and a sort of politics, marking him out as a possible candidate to have written the pompous text for the homosexual magazine. However, he was only 18 when the war ended and at that time he hardly had the knowledge or the skill, or indeed the interest, to write about how Rolf came to Germany. So we must eliminate him as a possible author of the strange, dramatic dialogue.

The whole story about homosexuality may just lead to a blind alley, but everybody who receives a copy of the text and sees the accompanying notes both on the British security chief's covering letter and Hollnack's own, needs to ask: Why does the dialogue between 'The Norwegian' and 'The German' appear in a magazine such as this? Was it just a cloak of concealment for a channel being used to deliver information that should be kept hidden from anyone other than those for whom it was intended? That may be the case, but if so the question remains of whom the author was trying to reach and what he was trying to say. It is not immediately obvious, for example, where 'The German' is going with his quasi-philosophical reflections:

> Then we need creatures grown ripe by afflictions who have learned to keep silence and also can be silent, and speak only when truth and justice demand it. I follow the politic of the "Trojan Horse" and hereby and in persecution of my zeal I make use of every means; every lie in this connection means a holy lie to me.

Formulation such as this can point towards the mysterious Hollnack, who among many other things included public relations and marketing among his areas of expertise. This would confirm what Touschek had written to his parents. The literary technique of combining the real participants into one fictitious character in the narrative illustrates the conflict and sharpens the message.

But why in *Der Kreis*? That question will have to remain unanswered meantime. Even though the relevance of the dramatic text to our own story is unclear we have to mention it, because it is so clearly about Rolf. If nothing else, the text shows how complex and strange life round about Rolf was during the war. Perhaps one day an explanation will appear of why it was intended for that particular magazine.

The covering letter that Hollnack sent to the English security chief gives us no help in this, but clues are available if we delve into old archives and find Touschek's letters to his former boss. We read there, in the first letter that Touschek wrote to Rolf after the war, that the play was indeed about a dialogue that was supposed to have taken place between Hollnack and Rolf, and that Hollnack himself was the author. Its purpose was to protect Rolf from accusations by the Allies. Touschek had protested against this at the time, he wrote, saying that 'If I were in your position I would decline such a justification.' In a later letter he was even more critical of the text, which he thought contained only hot air and moreover was badly written. In fact the whole magazine was full of bombastic writing, and Touschek had refused to write anything for it. But Hollnack obviously thought that it was important to do this, and he had persuaded several of his colleagues to submit articles, including Kollath—which surprised Touschek.[115]

In brief: It is well known that homosexuals were persecuted by Hitler's regime, and obviously a homosexual magazine with a very limited and defined readership could be a safe channel to pass on information one didn't want to go astray. In this context, the question of whether some of the Germans involved in or around the betatron project were themselves homosexual is immaterial. The interesting thing is that the story printed in the homosexual magazine was Rolf's story. Somebody knew it, was concerned about it and wanted to pass it on. For reasons unknown. Those who received it directly were members of a little group of intellectual homosexuals whose names were on a list known only to two people.

In addition to these, someone else received it indirectly; a security chief in the British Military Government was able to read it because Hollnack, who was probably the author, had sent it to him. The security chief sent it up the hierarchy to the control officer, who sent it further up to the Major. It was no less than the story of how Rolf Widerøe was taken to Germany to work in the Luftwaffe.

It was just as Hollnack himself had told T-Force; the story of three men—probably Hollnack, Kratzenstein and Egerer—who had travelled to Oslo to persuade Rolf to come to Germany. Just told slightly differently, in a separate document that also ended up in a folder in the USA among material classified as secret, collected and archived by the American intelligence organisation, Alsos.

Did he know but not say

– ***that Randers was working for the American intelligence services?***

Gunnar Randers crops up in the strangest times and circumstances of Rolf's life. It is difficult to say how long Randers had been shadowing him, but that was part of his job as a member of the scientific intelligence organisation Alsos, to discover as far as possible what progress the Germans had made in atomic research. Who was closest to building an atom bomb, the Germans or the Americans? Books are still being written on this topic.

Alsos was set up to find out about German activity in this area and it started work in 1944. In July the following year Captain Gunnar Randers was in Norway to interview Rolf, who was detained in prison at the time. The Alsos agent came away from the interview with a thick folder of information about the betatron and about Rolf's work for the Germans.

Norway is a small country in a big world, but that is not the only reason why these two men's paths later crossed several times. They were both expert scientists at an international level, working in closely related fields. Their first meeting was when Rolf had recently returned to Norway and was in prison. Rolf was asked questions, answered them, handed over documents and was set free. Surely a major life-event for anybody? Rolf says hardly anything about this, nothing more than he has to. In the biography, Randers' visit to him in prison is described on page 100 in seven lines: three to explain who Randers was and why he came; two to describe the solar eclipse that day and the remaining two to tell us what Rolf said and what he thought about the meeting:

> I had a visit from the Norwegian physicist Gunnar Randers who had been in America for a while and then in Norway and had been working in astrophysics and nuclear physics. He had been given the job of speaking to me, apparently because of the V2 rockets. It's easy to find the precise date, because there was a solar eclipse that day and he had brought a smoked glass to look at the sun. I explained to him what I had been doing in Germany and – as I understand it anyway – we parted on good terms.

This short and practical extract from the biography could have been a minimalist statement of a sequence of events in an Old Norse Saga—if it were not for the human interpolation between the dashes at the end. 'Alsos' is not mentioned. No emotion. Dry. Factual. Mission accomplished. Message delivered. I've given the biographer what he wants. I was asked some questions. I explained what was what. We watched the eclipse. That's how it was. Nothing more to be said.

Really?

Rolf said everything and nothing, quite cunningly. He can't be accused of not mentioning the episode. Had he planned beforehand that was what he would say to his biographer and no more? Or did he tell all he knew in good faith. As the biographer didn't press him any further, we can find no more help from that quarter. Alsos was not generally known about at the time of the interview in Ilebu prison. It was known about half a century later when Rolf was over 90, but he still didn't mention it.

When I Was Ready I Was Released

Nor did Rolf say anything about intelligence services and the hunt for German scientists when he took part in the seminar with Norwegian physicists in Oslo in the 1980s. In the verbatim transcription from the tape-recording of that interview he is either suppressing a very disturbing memory or simply describing the sequence of events:

> But there was something odd. Randers, he was given the job – he was away in America – of coming to Norway to question me. So I met him in the prison and we became quite good friends and we talked about all sorts of things. For you see, the reason I was in prison was that the neighbours in Røa, they had known that I knew about relays and so they thought that I was the inventor of the V2 bomb. That would obviously have been a terrible business. And so that was why I was in prison in Grini. And that was why Randers came to Norway to question me about it. And I was able to explain to him quite quickly, of course I told him everything just as it was, and he understood immediately that all this about the V2 bomb was just nonsense. So after that there were no great difficulties for me.[116]

As before, according to the record he had described his stay in the prison at Ilebu with a mere fifty words. The whole story of the report, his arrest, imprisonment, his feelings, the conditions. It could have filled a whole book of one humiliation after another. But this is how it was:

> And so I came home to Norway and when liberation came, then I went into Grini and I was very lucky because I was allowed to take all the notes about the betatron, and I sat there in Grini writing a paper about the betatron. And then when I was ready I was released.

Gunnar Randers had been on a scholarship in the USA before the war, but he moved to England in 1942 at the age of 28 to take part in the Norwegian Government-in-exile's work with the Norwegian forces. He was a pioneering astrophysicist who had been highly commended for his university exam, and he had a knack of being where things were happening, or perhaps of being where he could make things happen. Later in his career he was one of the founders of the nuclear research reactor at Halden in Norway and he took part in establishing both the Norwegian Institute for Energy Technology and the Norwegian Defence Research Establishment. He had followed the race for the atomic bomb closely and he already had inside information about the American project when he joined Alsos as an intelligence officer and was assigned to Headquarters in Paris. As the Allies advanced, groups of two or three officers were sent forward from there to the front lines to look for both large and small German laboratories and find out what work had been going on and how far German scientists had come in their atomic research.[117]

Colleagues Meet

The Chief Scientist in Alsos, Professor Samuel A. Goudsmit, has described the particularly unusual situation that arose when the investigators and those under investigation were former fellow-students and colleagues.[118] He described for example what it was like to have to interrogate the legendary Professor Bothe, whom he knew well and who he thought was a declared non-Nazi and Germany's leading experimental nuclear physicist. That was in mid March 1945, when Alsos, close on the heels of the Allied troops, had crossed the Rhine and reached Mannheim and the university town of Heidelberg. This was an important target for Alsos, as it was the workplace of a big group of physicists around Bothe and his cyclotron—the milieu where Rolf's assistant, Touschek, was employed after the war. Alsos' first task here was to occupy the laboratory. Goudsmit was nervous and uncertain how to handle the situation. Fraternisation with the enemy was strictly forbidden:

> Here I was going to meet the first enemy scientist who knew me personally, a physicist who belonged to the inner circle of the German uranium project. (…) But how could I be authoritative with Bothe, who was not only an old acquaintance and colleague, but certainly my superior as a physicist? How did one command an older and respected colleague to turn over his papers?[119]

The Alsos Chief Scientist's task was to gather information about the Uranium Project, and his success in this depended largely on how this first meeting with Bothe worked out. Would he need to get soldiers to arrest him? Would he need to extradite him to the USA? How did one order a senior and respected colleague to obey ones will?

However, it wasn't easy for the German colleague either. They both fumbled:

> Bothe greeted me warmly, and we shook hands, which was against the non-fraternizing rules.
>
> "I am glad to have someone here to talk physics with," he said. "Some of your officers have asked me questions, but it is evident that they are no experts on these subjects. It is so much easier to talk with a fellow physicist."

Goudsmit tells how he was shown round the laboratory and that they spoke about the work being done at the institute and the latest research results. Not least, they looked at the cyclotron that Bothe was obviously proud of, the only German cyclotron in operation as compared with the approximately twenty that were in use in nuclear research in the USA. Goudsmit was amazed at how much pure physics had been done during the war. There could hardly have been much time left over for military research. And then he came to the point:

> Finally I popped the question: "Tell me, Herr Kollege," I said, "how much did your laboratory contribute to war problems? It is obvious that not all your time was spent on the interesting work you have explained so far."
>
> Professor Bothe became nervous. "We are still at war," he said. "It must be clear to you that I cannot tell anything which I promised to keep secret. If you were in my position you would not reveal secrets, either."
>
> There was little I could say to that. I argued that the war in Europe was almost over anyway, and I dropped a few hints that I knew a lot about the uranium problem already. But the more I insisted, the more excited and angry Bothe grew. Plainly I was not getting anywhere with him.

Goudsmit changed tactic and tried to get hold of documents instead:

> Bothe shook his head. "I have no such papers," he said. "I have burnt all secret documents. I was ordered to do so."

The Alsos professor didn't believe him. He could have burnt official documents, but it was hard to believe that a physicist would have burnt the results of his elegant research however many times it was stamped '*Geheim*' and '*Secret*.' The German maintained that he was speaking the truth. He regretted his action, he said, but the order was clear.

Finally Goudsmit had to admit that his suspicion was ill-founded. Counter-espionage and a thorough search of the locality showed that Bothe *had* been telling the truth. In his book, Goudsmit maintains that Bothe was a man of his word and could be trusted. Nor did Bothe reveal anything more until the war was over. Then he wrote a report, but he obviously knew that the Americans knew much already. Goudsmit ends his assessment of Bothe by concluding that he was "a loyal German, but never a Nazi." He had lost his professorial chair at the University of Heidelberg when the Nazis moved the teaching programme to their capital city. He was given a position instead at the Kaiser Wilhelm Medical Institute, which was also in Heidelberg and where party politics had less influence.

The interrogation of Werner Heisenberg was another important occasion for Goudsmit. Allied intelligence had been hunting for Heisenberg for six months, but the meeting between the two professors was less dramatic than expected when it finally took place:

> I had just returned to Heidelberg when Heisenberg was brought in. I greeted my old friend and former colleague cordially. Purely on the impulse of the moment I said. "Wouldn't you want to come to America now and work with us?" But he was still too impressed by his own importance and that of his work, to which he ascribed his internment.
>
> "No, I don't want to leave," he said. "Germany needs me."[120]

It was sad and ironic to hear. Goudsmit felt sorry for the man who had visited him in the Netherlands when they were young and also several times later in the USA, most recently in July 1939 when he had even stayed in his house. He wrote that Heisenberg was dazzled by his own role but that he was still Germany's greatest theoretical physicist and one of the greatest in the world. He reminded himself that Heisenberg's contribution to modern physics was on a level with Einstein.

Goudsmit's meeting with Walther Gerlach in Heidelberg was rather different. They also knew each other but when they had last met, at a conference in England in 1938, Gerlach had been evasive and frightened to talk about anything connected with the political situation in Germany. Now he was much more open. He was another of the prominent physicists whom Goudsmit himself chose to interview. Gerlach explained how when he was appointed head of all physics research in Germany he had tried to speed up the research, which had stagnated under his predecessor. Gerlach was not a Nazi, Goudsmit concluded, though he did think that his judgement could sometimes be faulty. His only aim was to promote German research independently of the political regime.[121]

In one way it is easy to understand the relationships between these fellow-scientists when they meet. In another way it is more difficult. That's how things are in war. It is not for us to pass judgement. My intention is to try to sense and communicate a little of what it was like for people in these situations; what it was like to be a world-class researcher in atomic physics and accelerator technology during the race for the atomic bomb—during a world war.

Randers had the task of interviewing Rolf, who was in detention in prison by the time the interview took place. Despite the seriousness of the topic, the interview took the form of a friendly meeting between colleagues. Professionally they were on speaking terms and Captain Randers was genuinely curious about the betatron. Like his colleagues in the intelligence service, he probably had an outline plan for the interview. This started with a friendly approach based on the interviewee's scientific background, and particularly on the fact that it was not unusual among German researchers to realise that the battle was lost and that their only chance to continue their research activity in the next couple of years was to be on a good footing with American researchers. Thereby they could have the possibility either of carrying out new research in Germany after the war, or of being invited to join a research programme in America.[122]

> … after a couple of days discussion, I not only knew more about betatrons than before but also had become so interested that I had started thinking of including the building of a betatron as a research instrument in Norway as part of our plans in FOTU.[123]

The Atomic Age Comes to Norway

This was a high-level plan for collaborative research. FOTU stands for *Forsvarets Overkommandos Tekniske Utvalg* ('Defence Forces High Command Technical Commission'). During the war this organisation recruited many Norwegian researchers and engineers to work in British research laboratories. This activity was important for the rebuilding of Norway and the Commission became the forerunner of the Norwegian Defence Research Institute. Randers and Rolf were both enthusiastic and imaginative men, and it is no surprise that they came together.

Norway entered the atomic age in the early post-war years, and when the experimental nuclear reactor at Kjeller was completed in 1951 it was an international event. The names of the main participants in this are worth noting in relation to Rolf's role. The work had high status, and the research that was carried out there received more public support than other scientific research, thanks to the Resistance Leader Jens Christian Hauge who became Defence Minister in 1945.[124]

> Hauge played a key role in the early phase of the Reactor Project. It was he who gathered the necessary funds and who together with Fredrik Møller, Gunnar Randers and Odd Dahl saw to it that atomic research in Norway was given a practical objective. (…)
>
> Through his discussions with Møller and Randers, Hauge had been convinced that it was of decisive importance for Norway's future security that the country acquired independent technical competence in the area of nuclear physics.[125]

The Reactor Project is considered to be the nearest that Norway came in the 1950s and '60 s to what physicists call 'Big Science.'[126] In a study of the growth of nuclear physics in Norway Rolf is spoken of alongside Randers and Dahl. All three were entrepreneurs who made things happen. Randers was described mainly as a research politician, an administrator of nuclear physics installations, whereas the two others were described as research technologists:

> Dahl played a leading role in building nearly all the nuclear research installations in Norway. Widerøe influenced accelerator design and development significantly and is often called 'the father of modern particle accelerators.' In contrast with Dahl, however, Widerøe had hardly any influence on the development of particle accelerators in Norway.[127]

The powerful people behind the building of the reactors at Kjeller and Halden and the establishment of the research institute at Kjeller wanted to include Rolf and they made contact with him. Gunnar Randers was one of these. Another was Fredrik Møller, an electrical engineer who had taken part in military technology research in England during the war and who had now taken over as leader of FOTU. Rolf responded positively. Nobody saw the potential benefits of atomic research for industry and society better than he did. Just six weeks after his release from prison, on 23rd August 1945, he wrote a long letter to Møller about his idea of establishing a research institute, inspired by the Niels Bohr Institute in Copenhagen. He puts forward his ideas in unrestrained 'Facebook' style about what he has achieved so far and how he can contribute in future to the benefit of industry and society. This is not the language of a defeated man. His patents, the 30-betatron, the 200-betatron, the competition and Brown Boveri are all mentioned, including what he calls his forced removal to Germany. He argues that 'the industry together' should finance 'a new research institute which above all and on a broad basis should work on nuclear physics:'

> The new research institute that you and Dr. Randers have mentioned to me seems to me in many ways to offer possibilities for a solution to the tasks that I have listed here. At present I know too little about the new plans to be able to comment, but I did think that it could be of interest to you to have an insight into my own plans for these things before we have discussions together with Randers and Dahl about how we can best carry the matter forward.

Suddenly there was silence. The initiative that Randers and his colleagues had invited him to take part in was not followed up from their side. The active protagonists of research in general and in atomic power in particular suddenly stopped turning to Rolf. The Norwegian Defence Research Institute was established at Kjeller the following year, in April 1947, with Fredrik Møller as Director. This was a totally new type of research institute, quite different from the establishments in Bergen, Trondheim and Oslo.[128] Møller was an important member of the circle around Hauge who wanted to use research and technology to create new industry, and he became Chairman of the newly established Central Institute for Industrial Research in Oslo, now a part of SINTEF in Trondheim. He also became Chairman of Kongsberg Weapons Factory and Raufoss Ammunition Factory, among others—and Knight First Class in the Order of St. Olav.

Møller was succeeded as leader of the Defence Research Institute by Finn Lied, who played a central role in the politics of Norwegian research, industry and oil throughout the second half of the twentieth century. Lied followed Jens Christian Hauge as Chairman of Statoil [now 'Equinor'], and throughout three decades was a member of the Norwegian Technical and Scientific Research Council, which played an important part in the postwar development of research. He was also a Commander in the Order of St. Olav and a holder of the Defence Service Medal with Laurel Branch.

Rolf had been in good company until he ceased being part of the circle.

Alongside and always in close collaboration with the Defence Research Institute, the Institute for Atomic Energy (now the Institute for Energy Technology) was set up in 1948. This was the parent organisation of the Halden Project in which Gunnar Randers was the prime mover and Director. When the Atomic Branch of the Research Council was created just before that, Randers was obviously included, along with the three others who had sat on the expert committee advising on the treason case. All of them were among the great and the good who would rebuild the country after the war on a basis of research and technology. Gunnar Randers, Odd Dahl, Fredrik Møller, Finn Lied. All reappointed to numerous scientific advisory committees and institutional boards of management over the next decades. Plus Tangen and Hylleraas and Wergeland from the expert committee.[129]

But not Rolf. Electrical engineer. Doctorate. Industrial contacts. He wanted to create a research institute to develop Norway, together with Møller and Randers and Dahl and the others but was no longer one of them. Not a word has been found anywhere to indicate that he resented that. There were other arenas. If not, he could create one. Problems are there to be overcome. The same Randers who had allowed himself to become fascinated by the betatron research that July day in Ilebu prison had a soul-mate.

Much of the information that is available today about Rolf's activity in Germany can be found in the material that Alsos had gathered with the help of Randers and others. Much of the information about the betatron that was confiscated by the British T-Force also ended up in the care of Alsos. But about co-operation between the two men to build up research and industry after the war, there is nothing to be found.

Hard Facts About Alsos

Operation Alsos, or Alsos Mission, was a top-secret operation set up jointly by the USA and Great Britain as a consequence of the Manhattan Project, the Americans' own atomic bomb project. The troops engaged in Alsos followed closely behind the front line, first through Italy and then through France and Germany, looking out for people, equipment, reports, material or sites that might have been involved in the development of atomic weapons. Their task was to map where any such evidence was found, ensuring that the Western Allies got news of it—and preventing it from falling into the hands of the Soviet Union. Or put another way: 'preventing what everybody most feared, that Hitler might deploy an atom bomb in a last desperate attempt to save his regime.'[130]

Alsos is sometimes mistakenly written with capital letters, on the supposition that it is an acronym. But *alsos* is Greek for the English word 'grove' and the name is a reference to the military head of the Manhattan Project, General Leslie M. Groves. The Chief Scientist was Robert Oppenheimer, and it is illustrative of how small this circle of experts was that Oppenheimer's competitor for the job was the physicist from Berkeley, Ernest Lawrence, who had built upon the concept of the cyclotron in Rolf's doctoral thesis.[131]

Already on 29th November 1944, several months before Goudsmit's interviews in Heidelberg, members of the Alsos mission in Strasbourg had already arrested the first of the German scientists who had been working under the auspices of the Uranium Club.

In the course of spring 1945 Alsos took in many of the Germans who were on the wanted list. The Alsos agents confiscated documents and equipment, and destroyed what they could not take with them. In May 1945 they at last found Heisenberg, at his country house outside Munich. Not until the month of July did a little group get permission to enter Berlin. They were then able to put into place the last pieces in the jigsaw puzzle, which merely confirmed and did not alter the big picture.[132] Their main target was obviously the Kaiser Wilhelm Institute for Physics where the uranium research had started almost simultaneously with the start of the war. This was one of the few buildings that were still intact. But it was empty. The Russians had been there and had removed everything of value including the light switches and the electric cables.[133]

By the end of July 1945 Alsos' work was more or less complete. Even though German scientists had destroyed a lot of material, the Americans got hold of important reports and correspondence. The documents were mostly stamped 'secret' or 'top secret' and had had very limited distribution. All this material was now transferred to the USA to be examined and assessed. Taken together, it gave an overview of German atomic research. The material was returned to Germany in 1970, and since 1998 the Alsos material has been preserved in the archive in *Deutsches Museum* where it has been catalogued and made accessible. Historians and scientific historians have made use of the material and interpreted it in various ways. It demonstrates to the whole world that the fear of Hitler's atom bomb was greater than the real danger. Theatre and film have also gone to town on the topic, demonstrating that it has an appeal far beyond scientists' range of interest.

Operation Epsilon

Alsos' final task was given the code-name 'Operation Epsilon.' The ten German scientists whom the Allies thought had worked on Nazi Germany's nuclear research programme were taken to England and interned in Farm Hall, an almost palatial country house near Cambridge.[134] They were held there for six months, from 3rd July 1945 to 3rd January 1946, well beyond the range of Russian intelligence services. Concealed microphones enabled everything that happened to be recorded and monitored. The personnel charged with the task of listening in were able to share in the internees' concern for their families, readings aloud from Dickens, Heisenberg playing Beethoven sonatas and the reaction of a Nobel Prize winner who only learned about his award when he read about it in the newspaper.[135] His whereabouts were unknown, and even the Swedish Academy was unable to send him a congratulatory telegram.[136]

The purpose of the exercise was obviously to listen to their conversations to find out more about how close the Germans had come towards constructing an atomic bomb. Few atomic secrets were revealed, but what did become apparent was that the German researchers were divided in their opinions and sometimes quite angry with each other. There were all shades of opinion from full agreement with Hitler to full opposition.

There was also much disagreement between those who wanted the project to succeed and believed that it could succeed, and those who had worked to hold it back.

In the midst of all this came news of the Americans' use of the atomic bomb over Hiroshima on 6th August 1945. This news came as a shock to the residents of Farm Hall. Again, opinions were divided. Some were disappointed that they had not managed to make an atom bomb for Hitler; others were glad that they had not succeeded.

Transcriptions of the conversations were sent to British military officers and on to the U.S. Department and then to General Groves in Washington as part of Operation Alsos. The transcriptions were declassified and published in February 1992 and were later dramatised on BBC Radio 4.[137]

Goudsmit, who had been Chief Scientist at Alsos, had already given his candid account in a book he published in 1947. He started from the point of view that the atom bomb was top secret and was a mystery even to high-ranking members of the military. The work of the Alsos organisation had therefore had to be shrouded in secrecy, but now he could tell the story and express his opinions quite freely. He acknowledged Germany as the most technically advanced country in Europe, and his key question was how the German research programme could fail, whereas the Allies succeeded. He was in no doubt about the answer:

> I think the facts demonstrate rather well that science under fascism was not and probably never will be on a level with science in a democracy.

He considered that the root cause of this was hero-worship and he illustrated this using Heisenberg as an example:

> Werner Heisenberg, for instance, was the foremost atomic physicist in Germany, a scientist of world repute, and no good young German scientist would think of questioning the word of the master. But science is not authoritarian, nor can scientific thought be dominated by a boss, however gifted he may be.

Others thought that Goudsmit had been too quick to jump to conclusions and pointed out that the idea that research couldn't flourish in a totalitarian regime did not tally with German advances in other areas. Who had developed the Messerschmitt Me 262, the world's first operational jet fighter? And the V2, the world's first ballistic rocket? The Soviet Union's development of nuclear weapons some time later was also cited in the debate. Whatever one's view of this, the point is that the Germans had not made much progress towards an atomic bomb. That was what Alsos and the other scientific intelligence organisations had confirmed.

Moreover, Heisenberg had visited the USA shortly before the outbreak of war. He had given lectures at the University in Michigan and had lodged at home with Goudsmit. He had shocked everybody by saying that he must return to Germany before the war started, a statement that has since been interpreted in many different ways, like much else of what he said and did during the war.[138]

Alsos' conclusion was that the Allies had overtaken the Germans in the nuclear arms race by 1942. The German Arms Minister, Albert Speer, confirmed this himself when he wrote his memoirs in 1970. He wrote about events in 1942:

> We abandoned the attempt to develop an atomic bomb, on the advice of our nuclear physicists. (…) Taking the costs into consideration, it would have been impossible to assemble everything that would be needed in the form of materials, workers and facilities.[139]

The Big Failure

Historians have given very varied interpretations of what the German scientists themselves thought about their project at the time. Goudsmit, however, shows little sympathy in his cynical description of the attitude among the German scientists while they were interned in England:

> It was then that some of the younger men hit upon a brilliant rationalization of their failure. They would turn that very failure to their advantage by denying that they had ever tried to make an atomic explosive. (…) They would stress the fact that they had been working only on a uranium machine, and forget that they had thought this would lead directly to the bomb. They would tell the world that German science never, never would have consented to work on such a horrid thing as the atom bomb.[140]

Gunnar Randers, the Norwegian, had thought along similar lines as the Alsos officers advanced through Germany:

> I gradually realised that the Germans had made considerably less progress than the Allies. Indeed, in reality they had apparently abandoned the project sometime after the sabotage operation at Vemork which deprived them of the heavy water production.[141]

He gave his opinion about why the Germans did not succeed in making an atomic bomb:

> It has since been claimed that the Germans refrained from building atomic bombs for moral reasons. Their active project in the first years of the war clearly shows that this was not the case. It was a combination of a lack of technical and economic investment and lack of scientific leadership (…) which led to the project never going beyond the laboratory stage.

It may seem curious that Randers wondered why all Alsos missions were carried out by agents wearing uniform, though he himself used his Norwegian badges of rank to the utmost. He explains this in his autobiography:

> It may seem strange that we were travelling about in uniform when our task was espionage, but it was really the only sensible way. Scientists shouldn't really spy, they should gather information in discussion with researchers. To travel in the vanguard wearing a hat and a suit was almost impossible. One would have stuck out in the crowd and risked problems of identification both on one's own side and with the enemy, and especially with the Allied transport organisations. German uniform was obviously not suitable for our purpose, so the solution was to wear our own uniform.
>
> So as not to stand out as a foreigner when we were in the field, I used an American battledress and helmet and carried a Colt 45 pistol like a normal American soldier. But it was better to transfer over my Norwegian badges of rank, as I wasn't really an American officer. When wearing battledress, the only

> badge of rank was often fastened to the helmet. I was now a captain, and so I put the three stars on the front of my helmet. This was sometimes very helpful for me among Allied troops, as three stars were the insignia of the highest rank of general, apart from Eisenhower himself, and without resorting to anything other than appearing important I could often acquire overnight lodging and transport that otherwise would have been unavailable to me.[142]

With even more enthusiasm than Randers, Goudsmit lambasts the organisation of German research and the fact that 'everybody had to be a director of something.'[143] The Luftwaffe was the exception:

> In contrast to the Army research it must be said that the German Air Force research under Goering was excellently organized and highly successful. There are several reasons for this, the principal being that the Air Force was interested in results and not politics. The committee in charge of Air Force research was selected on the basis of ability. With one lukewarm exception, the men were not Nazi party members. The men in charge were also aware of the great shortcomings of the other German research organizations and avoided as much as possible any contact with them. Thus, research on practically all subjects of interest to the Air Force was done by their own organization; they had divisions on radio, radar, aircraft engines, airborne armament, and so on.[144]

He also has something to say about Schiebold's vision of X-rays, and rather surprisingly he reaches out towards those who had opposed the man:

> The genuine physicists had a time of it not only in keeping ideas out of the fumbling grasp of the charlatans, but research funds and apparatus as well. They fought successfully a fantastic scheme promoted by the X-ray scientist, Schiebold. This gentleman wanted to use a new high-voltage X-ray machine, the so-called Betatron – an American invention – against allied bombers. For this pipe dream, he had actually obtained the support of Air Marshal Milch, not to mention his diverting important apparatus from the uranium project.[145]

This—no less. The great race to be first with the atom bomb. This was what Rolf had become caught up in. Not because he worked on the bomb, but just because he was who he was and did what he did. The folder that Randers delivered to the Alsos leadership after his mission includes a report of his conversations with Rolf after the liberation. The cover was labelled, 'Important.'

The report, which naturally enough was written in English, showed that Rolf had spoken much more clearly with Randers than he did later in his biography. This was certainly tactical, and perhaps he didn't really have very much choice. Perhaps he was told something like 'If you don't co-operate the Allies will come to arrest you, so just tell me.' Rolf was worried that American researchers might get hold of his results. Supported by his advocate, Oscar de Besche, he had a lot of discussion to and fro with Randers about which documents he should hand over. The discussions about that—or perhaps 'negotiations' would be a better word—went on for several days, not just a single day as Rolf implied in other communications. It also appears that Randers did not believe everything Rolf told him and that although Rolf could then be released from detention in custody pending trial, the talks did not release him from the risk of a possible prison sentence.

Here is an abbreviated version of the ten points in the report:

Captain Randers' Report

<u>Report on visit to Widerøe in Oslo, July 1945</u>

(Summarised and with headings added)
<u>Dr. Widerøe and the German betatron development</u>

(*Death rays*)

1. The German betatron project appears to have started from Professor Schiebold's rather fantastical idea of a powerful X-ray apparatus to be used against enemy planes. The radiation would be directed against the pilot, not the plane.

(*The American, Kerst*)

2. Rolf Widerøe—who at that time was employed in the Norwegian branch of Brown Boveri—had written his doctoral thesis at college in Aaachen on the topic of radiation transformers and had studied and lived in Germany for eight years before the war. In 1942, having read about the American Kerst's betatron project, he wrote two articles about radiation transformers and submitted them to *Archiv für Elektrotechnik*. Not all of the content of the first article was published in the journal. Some technical details and discoveries were omitted, but the whole text was printed as a secret military research report.

(*Got hold of Rolf*)

3. People in Germany who were interested in Schiebold and had heard of Kerst found that Rolf Widerøe's radiation transformer was exactly what they needed. They made contact with Widerøe and invited him to build his transformer in Germany, with German support. It may very well be true, as Widerøe says, that he was not informed at all about Schiebold's plans. He may have been compelled to go to Germany, as he himself maintains, since more or less all German invitations at that time could be understood

as commands. Nevertheless, my impression of Widerøe is that it didn't require much persuasion to get him to accept the offer. He is so absorbed in his work that even when he was in prison it seemed as if he was more concerned about having his new ideas tried out than about being released from captivity. The fact that he took up this work in 1943, when everybody with Nazi connections in Norway was frantically trying to come away from them, showed that he had poor judgement of the political situation. He also demonstrated this in his conversations with me, when for example he tried, through me, to renew contact with his German working partners while he was still in prison exactly because of his work with them.

(*Thumbs down for Schiebold*)

4. Widerøe said that he only came to hear of Schiebold's project accidentally, after he had been working in Germany for some time. The impossibility of Schiebolds' plan was apparent both to him and to most of the others relatively early, but the betatron project was continued with undiminished support. Professor Gerlach appears to have been mainly responsible for that. The reason was probably to a large extent the general interest in the development of betatrons, with obviously the secondary consideration of the possibility of making progress in the research work on atomic energy. It also seems that the fact that America was putting money and investment into betatron research was of great significance, at least in persuading the authorities that the work was worth the investment. Widerøe's insistence on the therapeutic value of his research may have been partly self-defensive and partly economic, as it appeared to be the only way he could ever expect to earn much money from his patents.

(*Successful work*)

5. The work at Widerøe's institute appears to have progressed rapidly. The 15 MeV transformer was built rapidly and gave results exceeding everybody's expectations. The 200 MeV transformer to be built at BBC Mannheim was only at the planning stage. My understanding of what Widerøe said was that he expected difficulties with the big transformer, and that the time required to build it would be significantly longer than assumed. Comprehensive reports of the progress on the technical side are provided by Hollnack, Kollath and Touschek in addition to Widerøe himself in the attached material and do not need to be evaluated here.

(*Arrested*)

6. When Widerøe left the job, and Germany, several days before the liberation of Norway, he took with him to Norway his own papers and all the correspondence for which he had obtained a sort of courier pass. I think the thought behind this was that even if everything that was left in Germany were to be destroyed, he would still have all the material he needed. Soon after the liberation, Widerøe was arrested, accused of having worked on the building of the V2 rockets. He was taken to Ilebu prison camp outside Oslo, where he applied himself to his 'collected works' on the radiation transformer and researched his as yet untried idea of magnetic 'supplementary fields' to bring electrons into an acceleration tube.

(The *latest ideas*)

7. His latest ideas, which he considered extremely important, on 'focusing of electrons,' are described in his own note 11.7.45, 'Arrangement for Introducing Electrons into Radiation Transformers' (written in Norwegian) and in the patent description (also in Norwegian) of the same date. The Norwegian texts are also attached, as the language in the patent description is practically impossible to translate into English.

(*A complicated case*)

8. Widerøe was released from prison while I was in Oslo. This does not mean that the case is concluded, but just that he is not considered to be a dangerous or serious criminal. Provided that his advocate can persuade the court that Widerøe can be considered as a 'forced labourer' in Germany, the charge against him will be fairly light, along the lines of having published articles in German journals, etc. This complicates the relationships a little, because I could have come into difficulties simply by taking the papers from him. Widerøe is very concerned about his patent rights and the information about his work. I had to argue with him and with his advocate for several days before they would give me full information. Their argument (which *can* have had support in Norway) was that Widerøe wanted to have his rights established before any information came out to the Americans—to be sure that his work didn't go straight to American researchers who would take out patents on his discoveries. By presenting the issue as a sort of patriotic concern for Norway's interests, he could perhaps have stopped me, or at least delayed me from sending on the documents for several months. On the other hand he is in a rather weak position, as I also said to him, as a statement from the Allies that his work was of great importance for the war would land him right back in prison. Finally I got all his papers, including the material that was not written in Germany and therefore was not in any sense work for the enemy. For my part, I promised not to allow his work to be published without acknowledging the source.

(*To remain in Norway*)

9. Widerøe said first of all that one of the reasons he didn't want the Allies to have his papers was that he feared being sent to England or to America to have to continue his research there. He wanted to stay and work in Norway. He wrote a letter in which he made it clear that he was willing to work for the Allies, but only if the work could be carried out in Norway. After his release, when he saw the way he was treated by neighbours and friends there, he became less convinced of his desire to stay in Norway. His wife—who was a very agreeable person and who had experienced two months as an outcast from society—strongly desired to get out of Norway.

(*Doubtful support*)

10. Widerøe was very curious about what the researchers in America were doing in his field. He appears to be a very able man who will undoubtedly do all in his power to be in a position to continue his work on the betatron one way or another. In the meantime he seems to be hoping for some Norwegian support to do this. Personally, I think that is very doubtful.[146]

The last point in Randers' report says it all. Rolf was talented, followed the research race closely, was obsessed about continuing his work on the betatron, and had wishful thoughts of Norwegian support which he would not get. The meeting with Randers had apparently not been so simple as Rolf made it out to be.

The Interview in the Prison

The account of Randers' interview with Rolf in the prison is just as interesting reading as his formal report. The discussion was about what the Germans wanted from Rolf and what Rolf wanted to achieve by going there. The transcript of the conversation is now stored together with the report in the Alsos folder in the Niels Bohr Library and Archives at The American Institute of Physics. It consists of seven questions and answers, dated 10th July 1945.[147] Randers visited Rolf in prison on 9th July, the day he was released. The note of their meeting appears to have been lightly edited by Rolf so that the technical details would be correct. He probably spent some considerable time on that. One of Rolf's documents that is included as an attachment in the folder is dated 11th July. So the two of them must have been in contact again after Rolf came out of prison. Rolf explains himself here more extensively than in any other known document:

INTERVIEW WITH DR. WIDEROE IN OSLO

July 45

1. What did the Germans expect of the development?

Dr. Wideroe—When I was brought to Germany, I was told they would use the betatron (*Strahlentransformator*) for scientific research generally, as well as for testing materials and for therapy. About the end of December 1943, I discovered by chance the pre-history and origin of the development which had been kept secret from me. In 1942, Professor Schiebold (Leipzig) suggested building an immense X-ray machine that would emit strong enough X-rays to hurt the crew of an aircraft. Professor Schiebold had received some support for his theory, but it was soon realized that the plans were impossible to carry through. By my articles in *Archiv für Elektrotechnik*, attention was brought to my betatron (*Strahlentransformator*), which the people interested in Schiebold's project believed might be used for the purpose. My first investigation, after I got to know about it was, of course to see whether such possibilities existed. I found that even under extremely favorable conditions all that might ever be

expected would be a faint and harmless radiation at a few hundred meter's distance. Independently, Professor Kuhlenkamp (Jena) came to the same conclusions in a thorough study (copy of which was in Wrist).
When these things became known,, the whole fantastic Schiebold story was buried in the beginning of 1944. At the same time it was, however, decided (Professor Gerlach) that the work with the betatron should proceed with undiminished energy in order to reduce the American lead suspected in this field, and to help physical research generally in this new and relatively unknown field.

2. Why did the Germans finance it?
Dr. Wideroe—The original reason follows from 1. Why the Germans continued to spend money on it is difficu1t to answer, and Hollnack would do that better than I can. My personal opinion is that everything that had any faint connection with nuclear physics was supported because one supposed that such investigations might sooner or later lead to results concerning the exploitation of nuclear energy. Among the scientists with whom I discussed, the opinion seemed to be that such results could hardly be expected during this war, and that the betatron would not bring them in any case. However, several scientists used this possibility as a "bait" for the authorities, to obtain means for continuing their scientific research. I assume this was also the case with the betatron.

3. What results did you personally expect?
Dr. Wideroe—First, a new, powerful means for physical research; second, a possible cancer treatment apparatus; third, a new apparatus for testing of materials. I am an engineer, not a physicist. My job is to construct apparatus for use by the physicists. However, I am interested in physics, and my opinion as an amateur is the following: Physics is just at the beginning of penetrating into a new field, nuclear physics, which is outside the field of present Quantum Mechanics (which fails at energies of about 70 MV). It started the discovery of pair formation of electrons, then came the mesotron, neutrino and the vague hypothesis about unknown elementary particles (Heisenberg, Møller, Rosenfeld, etc.). Most of this is still on the stage of "scientific poetry". The only experimental evidence comes from the greatly unknown cosmic radiation. In this field, the betatron is the ideal apparatus, and the only possibility for controlled experimentation. With a 200 MV betatron one would probably be in a position to create mesotrons and neutrinos at will. Such perspectives in themselves are according to my opinion sufficient to justify the expenditure of 1/2–1 million marks; which such an apparatus was estimated to cost.
Far more interesting results might be obtained with 2000 MV, at which energy one might expect to split (and possibly induce pair formations of) protons. However, it is doubtful whether such results can be achieved. The betatron gives us possibilities for studies of nuclear photo effects and beta- processes on a more detailed and accurate level that can be imagined today. The same applies to photo fission. However, I see no possibilities for starting chain reactions or in any way favour or induce the fission of uranium or similar nuclei by the betatron. It's use here is simply in helping increase our general knowledge of nuclear physics.
From what I have mentioned, I can very well understand the interest among German scientists for my work. I can also understand that many of them imagined for themselves possibilities that were not present.

4. <u>What anti-cathode was used?</u>
Dr. Wideroe—In the small transformer (15 MV betatron) we used a 1 mm thick tungsten sheet. For the big transformer (200 MV betatron) no definite plans existed. I was convinced that one could not dissipate the heat from an anti-cathode inside the tube, so I had thought out a method to get a great part of the electrons out of the tube as a ray. Outside the apparatus it would probably not be difficult to place a water-cooled Wolfram anti-cathode. According to Heitler (Qu. theory of Rad.) the range of 200 MV electrons in air should be about 400 m and we had planned to dig the big transformer into the ground and let the rays into a tunnel. Distant control to escape damage to operators was being talked about. All these questions were only loosely touched upon as yet.

5. <u>What connection has the betatron with nuclear physics?</u>
Dr. Wideroe–See 3. I had personally learned to know several scientists working in nuclear physics, among others:
Professor Jensen (Hannover), Professor Ott (Wirzburg), Professor
Bothe, Professor Dänzer,· Professor Hardeck, Professor Leuz, Dr. Süss (Hamburg), Dr. Gentner (Heidelberg), Professor Kuhlenkampp and Professor Räther (Jena).
It was, however, only incidental that we discussed the question of uranium fission (Professor Jensen, Hardeck and Dr. Süss).

6. <u>What demands did the Germans make regarding results?</u>
Dr. Wideroe - No special demands beyond making the transformer work, as well as possible and as fast as possible. I thought originally that it would be possible to make the small transformer work by the middle of 1944 (so that the experimental work· might begin). The big transformer I expected would need a year more to finish, if all demands concerning raw material and labour could be met. If the work could have proceeded unhindered in Hamburg, we would probably have been able to finish work and experiments with the small transformer during 1945. It was also planned to build a 30 MV transformer for the special purpose of investigating nuclear photo-effects. Whether actual building of the big transformer could be begun at all during this war was, according to my opinion, very doubtful.

7. <u>What is especially remarkable about your apparatus?</u>
Dr. Wideroe- The small transformer, built in Hamburg, was not much different from Kerst's apparatus of 1942. One difference was that we had introduced saturation in the guiding poles, which results in the electrons being forced outward after completed acceleration. This was done with a view to getting the electrons out eventually. The small transformer is relatively effective (judged by MV/kg), probably much more so than Kerst's transformer for 22 MV (19h2). It is interesting that our small transformer obtained such a good output at 50 periods. The output could probably be improved considerably (We experimented only for 2–3 months with this apparatus).

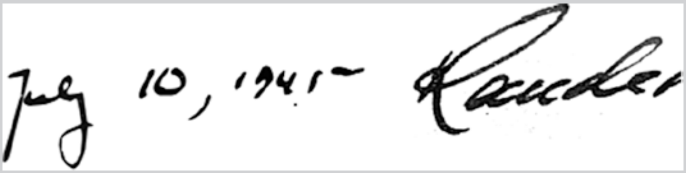
The circuit for obtaining electron emission of short duration was very successful.

The essential improvement. suggested by me in the later years is <u>the stabilizing of the electron current bv lenses</u>. This suggestion (which we unfortunately never got an opportunity to try) may be decisive for the building of large transformers.

In this connection I will also mention the suggestion to introduce the electrons by means of a magnetic "supplementary" field.

The last calculations have shown that it is probably impossible to introduce electrons into a lens field without such magnetic (or electrostatic) supplementary fields.

Essential for the building of large transformers is also the premagnetisation of the guiding field and counter-magnetisation of the induction flux. I am not in a position to know whether these things have been suggested by others. This goes also for my suggestion about changing the radius of the electron orbit by phase displacement between the guiding field and the induction field, as well as the idea to extract the electrons collected in a ray, a method to compensate for the radiation dampening in larger transformers.



The Rest of the Alsos Folder

But there was even more in the folder: the doctoral thesis; a smaller, technical document written by Rolf together with various sketches and an English translation probably done by Randers[148]; plus Rolf's own summary of his patent applications, in both language versions[149]; together with a number of other documents about the betatron and the work in Germany, mostly written by Rolf and all recorded in a separate list.[150] The most interesting of these is a 10 page note written by Rolf himself as early as 17th September 1943, in which he gives technical descriptions of the plans for both the 15 MeV and the 200 MeV betatron. This document is from early in the time of his work in Germany during the war, but was written while he was at home in Norway in a period of combined holiday and writing.[151]

The folder also contained various notes and reports written by Hollnack and Kollath, plus a list of 17 microfilmed documents. These included documents written by the renowned Professor Bothe, a report from Rolf to General Field Marshal Geist in the Air Ministry, a letter from Rolf to Professor Kuhlenkampff who torpedoed Schiebold's ray-gun, various notes from Rolf's assistant, Touschek and letters to Rolf from Heisenberg.[152]

In brief: The material that Alsos gathered was a combination of first hand information from either Rolf himself, Kollach his deputy or Hollnack his link with the Luftwaffe. To this was added the Alsos agent's own presentation and assessment of the matter. The documents from Hollnack and

Kollath were addressed to the British intelligence agency T-Force and then sent on to Alsos. How much Rolf knew about the American and British efforts to find out what he had been doing remains his own secret. However, in the light of what can now be found in the archives, there appear to be things Rolf knew about but didn't speak about publicly. We may ponder the chances and coincidences of life and wonder what would have happened if Randers had not come to question him. Would he have been held in detention longer? Would he have been released just the same because there was a maximum time limit on his detention order? Would he perhaps have suffered a more serious penalty? We shall never know.

Randers may in a sense have been his rescuer, even though as a member of the critically inclined expert committee he contributed to his fate. What is clear is that Rolf's betatron project was so important that Allied authorities had been watching him and that they eventually moved in on him. So what is missing from this already complicated picture for it to be complete?

Big business was undoubtedly a large part of the picture. Industrial companies with an interest in both short and long term business opportunities and sustainability nearly always play some part in a war. Here was revolutionary equipment with great market potential. The war would surely end sometime. A business that could survive in the short term and plan strategically for the long term might expect great rewards. Some were up to the challenge. The means and the motives could be more or less honourable and the boundaries difficult.

Did he know but not say

– ***that Brown Boveri was part of the picture all the time?***

Though Rolf never said so definitely, Brown Boveri was part of the jigsaw puzzle all the time. He did say clearly that he was an employee of Brown Boveri throughout the war, but he never said how much or how little the company was involved in what he was doing. He must have known, because Brown Boveri was included in his plans both during and after his time in Germany. Copies of notes of meetings, agreements and reports confirm that he was in communication with the head office in Switzerland, the company's factory in Germany and the Norwegian daughter company NEBB.

He mostly spoke clearly about Brown Boveri. He had worked for them even before he took on the assignment for the Luftwaffe, and the company remained an important part of his life, either in the background when he was working in Germany or in the foreground when he was working directly for them in Switzerland. However, he never gave a clear account of the important, almost leading role that Brown Boveri played in parts of the betatron project during the war or of the links from the director of NEBB in Norway via the director in Heidelberg to the head office in Switzerland. He did speak about their investment and sometimes about details, but some things he omitted to say. Maybe he thought 'What purpose can it serve?' or perhaps 'It's best that doesn't come out.' There was so much to consider in his complicated situation but whatever the motives, there were things he deliberately didn't say.

Hollnack tells us more, however. For as long as he had dealings with Rolf he also had connections with Brown Boveri, both in Oslo and in Switzerland. When he was informing T-Force about the contract he had agreed with Rolf, he explained clearly:

> At the same time, I gave the NEBBC, Oslo, definite written guarantees regarding Swiss claims.[153]

A Brown Boveri daughter company in a German-occupied country was working with the parent company head office in neutral Switzerland—with Hollnack as the middleman representing the German authorities. It was not just a two-way relationship between Germany and Norway, but a triangular relationship including the Swiss parent company. Hollnack's courier also came to understand that the brown folders he had delivered to various places contained technical information about the secret betatron in Hamburg and that some of them were destined for Brown Boveri in Switzerland.[154]

Rolf had already been in contact with the parent company before the war, and according to Tor Brustad he had already made arrangements with the Swiss in 1942 about working together to develop practical applications of various discoveries within the field of betatron technology. This was confirmed after the war in a letter from NEBB to Rolf's advocate on 12th June 1946.[155] The Germans, however, did not like Rolf being in touch with the office in Switzerland. The patents were an important consideration in this respect:

> As part of this collaboration the company requested and reminded Widerøe that he must have his inventions patented in Germany, and perhaps also in the USA and England. This was normal company policy. In this way, the company could secure both independent professional evaluation of the inventions and protection of their own interests and rights. (…)[156] In the spring and summer of 1943 Widerøe was negotiating with BBC about the sale of some of his patents and about registering patents in English-speaking countries.[157]

In his big comprehensive report[158] to T-Force, Hollnack explained the role of both Brown Boveri's head office and its subsidiary companies in greater detail. Among other things, he wrote:

– about when he made contact with Rolf in Oslo in 1943:

> Widerøe was and is employed by NEBB in Oslo, a subsidiary company of the head office in Switzerland.
>
> The formalities of his temporary absence on service were established with Director Solberg in NEBB, in an agreement that recognised the rights of the head office in Switzerland.

– about formal contracts that Hollnack had agreed in his capacity of "*Treuhänder*" for the Widerøe project:

> Agreement with Brown Boveri Switzerland through NEBB Oslo.
>
> Development agreement with Brown Boveri Heidelberg. The work on the patent rights was done by patent advocate Dr. Eng. Sommerfeld (…) Berlin. This was a personal friend of Dr. Widerøe; they worked very closely together.

– about the plans for the 200 MeV machine after the 15 MeV betatron had to be evacuated from Berlin towards the end of the war:

> Design work on the 200 MeV installation continued at Brown Boveri Heidelberg, under the direction of Dr. Meyer-Delius. Because of the circumstances of the war, an agreement on the available draft design and a confirmation by us for this construction were no longer possible.

A Status Project—The 200 Mega-Electronvolt Machine

While so much interest was being focussed on the 15 MeV betatron, when it could be ready and what it could be used for, Rolf was quietly and unobtrusively working on plans for another, much bigger machine. He didn't much want to speak about this after the war, dismissing it as almost uninteresting and something that didn't concern him. He even said that he didn't know whether Brown Boveri ever started work on building a 200 MeV betatron but that it was very unlikely. But he obviously must have known. This was a super-status project.

As soon as the first, small betatron was completed and ready for testing, the building of the bigger machine was the next project on the list, according with Rolf's plan. There was no doubt that this next step in the development process had political approval from above. It was no longer just an outline strategy drawn up at the start of the project and signed by Rolf Widerøe, Oslo, Norway. It was supported by the authority of Walther Gerlach himself, the new broom in the Physics Division of the National Research Council, appointed by Göring and a member of the Uranium Club, one of the men who after the war would be interned in England along with Heisenberg and others. There was significant interest in the project. Gerlach made a request for a 200 MeV machine, and Professor Bothe was very interested. In the meantime, the order for construction was given to Brown Boveri in Mannheim.[159]

Several researchers in Heidelberg were thinking about the questions involved with cyclotrons and betatrons, even though the boundaries between the various types of device overlapped and the nomenclature had still not crystallised. It is not always easy to say precisely which machine people were talking about. The fertile research environment that had developed in Heidelberg was the reason why the physicists wanted to locate the construction of Rolf's prestigious machine nearby, even though Ostgrossheim had originally been selected as the site. The respected Professor Bothe had already been working on a cyclotron in Heidelberg. Rolf would be in good company. Another expert, Wolfgang Gentner, was sent to Heidelberg towards the end of the war to assist Bothe with this cyclotron. Gentner was 'in secret a convinced anti-Nazi,' and he had worked for several years with Joliot in Paris and then with Lawrence at Berkeley.[160]

Rolf was also interested in what Bothe was working on. He wanted to be in contact with Bothe, and the interest was mutual. Before Christmas 1944 he sent Bothe an invitation to come to see the 15 MeV betatron. He also invited a professor from Frankfurt with whom Bothe worked on a 10 MeV betatron that they never managed to bring beyond the planning stage. On 23rd November 1944 Rolf received a polite reply from the Director, Prof. Dr. W. Bothe, *Kaiser Wilhelm-Institut für Medizinische Forschung, Institut für Physik.* Professor Bothe thanked Herr Professor Widerøe for his letter of the 13th with the invitation to him and his colleague to visit. They would be busy the next couple of weeks and so they asked to be able to return to the matter when Rolf had come back from his visit to Oslo. A friendly and encouraging letter from Bothe, who obviously knows of the plan to build the large radiation transformer and wants to collaborate. He expresses respect and admiration for what Rolf is doing, adding that he would like to share some of his own expertise and that it would be foolish for each of them to continue his own work independently of the other. He emphasises that it must all be on Widerøe's terms and that they would respect the requirements for secrecy, rights and so on, and that it was not a question of money.

There was obvious engagement in both political and academic circles. Bothe and Rolf then each received a letter from the authorities, dated 4th December 1944.[161] The letter starts with 'Highly respected colleagues' and ends with '*Heil Hitler!*' The letter-heading oozes Nazi formality: *Reichmarchall des Grossdeutschen Reiches/Präsident des Reichforschungsrat/der Bevollmächtige.* The next line is difficult to read, but it appears to be the name of Professor Walther Gerlach the Chief Scientist for nuclear physics, with responsibility for all German nuclear physics and for the secret Uranium Project. There was no higher physicist in Hitler's hierarchy. In addition to being one of the powerful political elite, however, Gerlach was the member of that group who best understood from a scientific perspective what Rolf was working on. Unfortunately most of the text of the letter, which is rather long, is faded and unreadable. From what can be made out, however, it refers to discussions at Erlangen and to meetings and contacts following that and it expresses a desire to follow up various topics. In other words, Rolf has the blessing and approval of the authorities. Just carry on!

Hush-Hush

The project to construct the large betatron was very prestigious, and Brown Boveri in Germany was very keen to get the contract. It was all very hush-hush and it involved meetings with the authorities and with Rolf. His unpublished article for the physics journal contained just the ideas needed for such a giant betatron. Rolf himself, who never concealed his membership of and loyalty to Brown Boveri, also wanted it to be built by them. In his biography he says that NEBB in Oslo 'was my employer throughout the war, and I was compelled to work in Germany.'[162] Just as he had said in the interview with the physicists ten years before being interviewed for the biography, he said in the same breath that his connection with Brown Boveri had not been of any help to him in getting out of prison, but he stressed that he had been on good terms with the chief himself, Sven Adolf Solberg, all the time.[163] The managing director had inherited the job from his father and grandfather and had studied civil engineering at the technical college in Zürich where Rolf later taught. Solberg jr. had worked for several years at the head office in Baden, but the German Nazi authorities didn't like dealing with the company's head office in Switzerland.

As early as 1942, Rolf had been in touch with Brown Boveri in Switzerland about industrial collaboration to develop practical applications for his various inventions. In the legal proceedings about patent rights after the war, this was an important point that was confirmed by Rolf's defence lawyer.[164]

During the preliminary hearing of his case, Rolf explained that throughout the whole spring and summer of 1943 he 'was engaged in negotiations with Brown Boveri in Switzerland about the sale of patent rights, so that the Swiss rights could be registered in English-speaking countries. This possibility was lost when the Germans confiscated the patents.'[165]

The director of NEBB in Oslo was one of the people Rolf kept informed about the police investigation after the war, and when Rolf was planning his first visit to Brown Boveri in Switzerland in spring 1946 he tried to arrange it so that they could both be there to take part in the meetings.[166]

Rolf wrote in an internal memo that in spring 1944 he was working on the plans for the 200 MeV machine, while the work on the 15 MeV machine was continuing at the C.H.F. Müller factory in Hamburg. Planning for the large betatron involved not only a big technical leap but also many conflicting interests and a difficulty in deciding where the work should be done. In February he had had thoughts of having the machine built in Oslo, but the original plan was to build it at Ostgrossheim:

> I have suggested that the machine should be built by BBC in Oslo. If this proposal is considered suitable both by the technical leadership and by other parties involved, its feasibility will be investigated in greater detail in Oslo in early March.[167]

But there were other possibilities. During a three day conference of the Brown Boveri management at the end of April, important discussions and site inspections took place in Weinheim and Heidelberg. On the morning of 29th April in the presence of all the people involved including the director himself, Meyer-Delius, a summary was drawn up. Details discussed in this document include a starting date and when people should be informed who would be taking part. Dr. Böcker, the high-tension expert who would have overall responsibility on behalf of Brown Boveri, said that he found the project very interesting and that he would see to it that the work at Brown Boveri was completed rapidly and effectively. The group agreed that the next round of technical discussions should take place four weeks later. Both parties wrote notes of the meeting, and on 1st May Rolf wrote a summary report in which he said among other things that he had had meetings with the director, with Dr. Böcker and with an engineer in Weinheim who would be responsible for the technical aspects. He wrote:

> I mentioned that in the meantime either Seifert or the gentlemen from the Air Ministry should handle the negotiations about to what extent the work should be transferred to Heidelberg. Quite independently of these negotiations, Meyer-Delius reported that he had heard from Bothe and Gentner that they were continuing their plans for a radiation transformer. They had also received information, through Sweden, about the big American transformer that was said to have succeeded in bringing the electrons out of the tubes and sending light rays several hundred metres. I consider Bothe and Gentner to be Germany's most experienced scientists in this area. They can probably give valuable advice which will be useful in the building of the apparatus and can also say something about practical use of the radiant energy.[168]

Rolf prepared a supplementary note the same day, and a further report the following day.[169] The director prepared his own report of the meeting on the first day, 'Secret report from BBC meeting in Heidelberg,' which reveals that the people who were present apart from himself were Widerøe, Seifert and three further named people who probably represented the company. Most important of all, he announces that Seifert had given BBC a preliminary order from the Air Ministry to start the research and development work for such a machine.[170]

The Internal Report

Important decisions were taken in a meeting on the second day. Dr. Böcker recorded these in a useful report that outlined the way forward.[171] Among those present were the Brown Boveri director, 'Hollnack on a special assignment from the Air Ministry' and Rolf. Hollnack started by informing the meeting that the contract to develop the radiation transformer had now been awarded to BBC Mannheim. The reason for this choice was that as Rolf was employed by Brown Boveri, the work should be done under the auspices of Brown Boveri. However, as the Germans could not use the services of the parent company in Switzerland it would need to be the subsidiary company in Germany. Several important points were dealt with:

Formalities

Hollnack pointed out that all development work in nuclear physics was under the leadership of Professor Gerlach. He assured them that everybody was endeavouring to achieve close co-operation among the research institutes and companies that were involved, and reminded them that when a project involved nuclear research, both the Air Ministry and the War Ministry were involved. Each of these ministries had an official with a remit for such research. In the Air Ministry this was Colonel Geist's area of responsibility, and in the War Ministry the official dealing with the Widerøe project was—interesting to note—Richard Seifert. Hollnack himself was the project's link person to both these ministries.

Staffing

The Brown Boveri director referred to the difficulties caused by the restricted availability of technical staff for the construction of transformers. They couldn't begin constructing the 200 MeV radiation transformer until they had the two technicians the company had been promised. Hollnack replied that they would have the first within 'a few days' and the second in the course of a fortnight.

Classification

According to the report, the project had a special status:

> On the question of classification of the work on the radiation transformer in the current programme, Hollnack said that MV programmes came under the category of very urgent measures that were given special priority by the Air Ministry and the War Ministry. Admittedly the work was not one of the immediate programmes, but its progress could nevertheless with special recognition by the relevant ministries always be accelerated.

The Forward Plan

The forward plan and the allocation of responsibilities were in place. The Air Ministry would within the next few days issue an official contract for the construction of radiation transformers. Hollnack would arrange finance. Brown Boveri would nominate someone to be responsible for the work on the radiation transformer. The person concerned would pay particular attention to ensuring progress and would be 'the link between relevant ministries and the Müller company (Dr. Widerøe) on the one side and Brown Boveri on the other.' In the course of the next few weeks Hollnack would put forward a proposal for a development contract with the Business and Industry Department, and he would prepare a note of the meeting and send it to those present.

Hollnack's Report

Hollnack's report, also marked 'Secret,' was more formally structured[172]:

> Present:
> Dir. Meyer-Delius, BBC
> Dr. Böcker, BBC
> Dr. Eng. Rolf Widerøe, *Fog* (*Forschungsstelle der Luftwaffe*—'Luftwaffe Research Establishment')
> Hollnack, *Fog*
>
> 1. BBC states that it is ready to start work immediately on the construction of a 200 MeV transformer in accordance with Widerøe's plans.
> 2. BBC Mannheim immediately accepts from the Luftwaffe's Research Establishment an urgent grade development contract DE 1382/XII L/44, with Arms Minister Speer's approval through Colonel Dipl. Eng. Friedrich Geist, head of technical research and development in Speer's ministry, and agrees that this programme shall be carried out within the framework of BBC's above-named programme with the same degree of urgency. (…)
> 3. With regard to the secrecy of the development work, Meyer-Delius will be informed of the negotiations with BBC Oslo in accordance with the protocol of 30.10.1943.This regulates the relationships between RLM on one side and BBC Oslo and Baden together with Dr. Widerøe on the other. (…)
> 4. BBC Heidelberg will give somebody within BBC the task of being responsible for the development work. The construction will follow BBC's guidelines under the leadership of and according to the construction ideas from rights protection through Dr. Eng. Rolf Widerøe.

5. After the award of the contract to BBC through Fog, there follows a draft of the detailed terms of the contract, through the Industry and Business Office under R&L (GL/F 1 IV B).
6. BBC receives through Hollnack knowledge of a prompt employment of a constructor from Telefunken. Because of the difficulty in obtaining constructor number 2 Hollnack shall try to find a replacement not later than 20.7.44.

Dillenburg, 3.7.44
Hollnack

Here, Hollnack uses the formal title of the organisation Rolf and he represent, *Forschungsstelle der Luftwaffe*, shortened to *Fog*, the Luftwaffe Research Establishment. When writing about more practical, operational matters he usually refers to the Müller factory where the work took place.

There is also a carefully composed distribution list of the people *outside* Brown Boveri who are to have copies, in addition to the named people within BBC.

Herr Seifert, Hamburg
Dr. Widerøe
Fog Group Administration
RLM Industriwirtschaftsamt (GL/F 1IV B)
RfRuk TAE Oberst Dipl.Ing. Geist
Dr. Spengler Forschungsführing des Rdl.

A few days later, the Brown Boveri director sent a confidential internal memo to a group of trusted colleagues, informing them that the firm had got the job.[173] The is simply headed *Strahlentransformator Wideröe* and it starts with an official announcement:

BBC has received a contract from *Forschungsstelle der Luftwaffe* Gross-Ostheim for the construction of a Widerøe radiation transformer.

The note goes on to specify who is responsible for what, and stresses that the technical direction 'shall be carried out in accordance with Dr. Widerøe's instructions.' It urges strict confidentiality and specifies procedures for dealing with this:

All personnel taking part in this project are committed to tight secrecy, in relation to other BBC employees as well as to third parties. All correspondence,

> whether in-house or external, shall be stamped 'Secret' and stored separate from other BBC documents.[174]

In autumn 1944 the discussions on how to build the 200 MeV machine turned to more practical details, and the reports became correspondingly more technical. In October, there was a further meeting in Heidelberg, where several possibilities were considered and detailed designs were presented. This meeting was attended by Meyer-Delius the Brown Boveri director and two of his employees, in addition to Rolf Widerøe and Rudolf Kollath.[175] The note of the meeting, which was written by Kollath, states explicitly that he and Rolf were representing the Widerøe project as workers for Brown Boveri. The meeting also discussed the progress being made by their competitor, Siemens.

On 6th December 1944 the Brown Boveri group visited Rolf at the Müller factory. Their purpose was to be shown the smaller machine, learn how a radiation transformer works and consider how to apply the experiences from the smaller installation to working together on a big, 200 MeV machine. Böcker, who was responsible for the project within Brown Boveri, had had a prior meeting the day before with Rolf, Kollath and selected other workers at Müller. Seifert was also there on the guided tour. There were intense discussions about the particular difficulties the development was facing at that time, and several technical points were discussed.[176]

By that time the Allied bombing, failure of the postal services and problems in moving around between German cities had become part of everyday life, or as Rolf expressed it diplomatically in a letter to the director on 20th December, 'For various reasons it is at present rather difficult for us to come to Heidelberg.' He added, 'Moreover, I hope that you by one means or another have survived the latest attacks and that things are going well for you and your family.' Then at the beginning of February Rolf at last received an important letter that had been written before New Year, from the director at Brown Boveri Mannheim. It was about calculations that were urgently required for the design of the 200 MeV transformer. In his response, Rolf enclosed diagrams and asked for a quick reply, preferably by telephone. He also suggested a meeting in Hamburg to discuss the design calculations in greater detail, because it was obviously easier to travel from Heidelberg to Hamburg than the other way round.[177]

The plans materialised, and on 3rd March there was a very up-beat technical article in Brown Boveri's in-house magazine about a new type of large transformer.[178] People in the USA also learned somehow that something was under way and that a contract had been placed with BBC Heidelberg to build a 200 MeV betatron.[179] That seems strange when seen from the other side, as Rolf says in his biography that Brown Boveri was not represented in Heidelberg at that time. One of the directors lived there and some meetings had been held there, but that was all.[180] It was war.

But then …

In the midst of all this enthusiasm and intense activity, the plans suddenly came to a stop. It was all over before it had begun. Strangely, Rolf says very little about this when he discusses the 200 MeV machine in his biography. The project is only mentioned briefly, just before we are informed that he returned home for good in April 1945. He says very little, considering the dramatic turn of events, but just summarises the story in few words:

> I discussed the building of a 200 MeV betatron several times with the directors and the construction staff in Brown Boveri. Dr. Seifert had given the preliminary order for the construction works to the company Brown Boveri, as a commission from the Air Ministry. Several technical solutions were worked on, to the stage of producing detailed designs. (…) But at the end of the war all these plans were unrealisable. The BBC factory in Mannheim had been almost destroyed. When Germany was overrun by the Allies there was no more talk of the plans.[181]

Here too he says no more than he has to. He doesn't mention the enthusiasm from Brown Boveri, the interest shown by German experts or the impetus from the authorities, and in the end he almost trivialises the plans. For there had been active planning, and Rolf had been involved in it in 1943, 1944 and 1945.

Pedro Waloschek told me that during the many discussions he and Rolf had in connection with the biography, Rolf had only reluctantly talked about the 200 MeV machine. When Waloschek reminded him what he himself had written in a summary report about the betatron plans,[182] Rolf agreed to include it. But the fact was, thought Waloschek, that Rolf and his team of Kollath, Schumann and Touschek must have invested a lot of time in planning for this machine. He stated that apart from that one occasion Rolf told him nothing more either about this large machine or about anything else that was supposed to happen at Grossostheim. Waloschek wondered about this, because he thought that Rolf had seen it as prestigious. Perhaps the explanation of Rolf's reticence on the subject is no more mysterious than frustration at having to give up after such intensive planning.

Waloschek considered it unlikely that the Luftwaffe had much interest at that time in far-sighted basic research into nuclear physics or improvements to medical apparatus for X-ray imaging or cancer treatment. So there must have been some special reasons for supporting the time-consuming and complicated construction of such a big radiation transformer.

Another consideration is that Rolf later realised that a 200 MeV machine was not the most suitable for medical use. Machines less than 50 MeV were sufficient and actually the best, and moreover were smaller and cheaper. The purpose in building a big machine was to promote research in atomic and nuclear physics, but other types of accelerators such as cyclotrons and synchrotrons were more successful in this application.

This tallies with what an American expert later wrote in an official report about the development of accelerators in Europe. Waloschek said that Rolf knew about this report and referred to it in their conversations on this topic. The author was a physicist in the U.S. Naval Research Laboratory in Washington DC and the report, which was released in January 1947, showed that he had remarkably good knowledge of the German work on betatrons. He called the 200 MeV machine the most important betatron project in Europe and thought that the Widerøe group was evidence of the high level in this field in Germany. He also wrote quite plainly that 'The construction plans for this apparatus were drawn up by Brown Boveri in Mannheim under the leadership of Rolf Widerøe and on instruction from the Luftwaffe.' He compared it with the 100 MeV machine that Kerst had made at General Electric, and went on to say that Rolf's machine had 'even more very interesting technical details' and that he saw traces of Rolf's experience as an electrical engineer.[183]

Why did it stop so suddenly? What became of the plans? Could the answer be that they were suddenly caught in the act when British troops moved into Heidelberg in spring 1944? The university town was seen by the Allies as a key location for nuclear physics and accelerator technology. It was here, for example, that they found Professor Bothe, who was interested in betatrons and wanted to be in touch with Rolf and who had considered similar plans but who during the war had continued working on a cyclotron, with encouragement from the authorities. This was the man whom Goudsmit the scientific head of Alsos found difficult to interview because they were former colleagues. Heidelberg was also one of the places Albert Speer named later when he was being interviewed, saying that he had given high priority to the building of cyclotrons.

Here it was that in April 1944, 6th Army Group's T-Section found both documents and personnel from Brown Boveri and I.G. Farben, both important intelligence targets. T-Section set up a special document centre in the university library to sort through all the material, which was then copied and sent on to various intelligence organisations, including those dealing with war crimes. When the centre was shut down, much of the confiscated material was sent to the USA where it was dealt with by a special section in the Pentagon. The original documents were later sent to the National Archives in England.[184]

Nor would it be unreasonable to suppose that the course of the war itself was the reason for abandoning the 200 MeV betatron. That was what Rolf said. He might also have spoken so little about it because he had lost faith in it himself, having far-sighted goals and not allowing himself to be distracted by short-term distractions and adversities. Whatever he may have thought then, after the war he opted for a medium sized machine of 31 MeV, a size that he found optimal for cancer treatment. This was the machine with which he was successful, 'the first betatron for medical research,' as it was described in Brown Boveri's in-house magazine.[185] The only scepticism about this claim was from the competing firm, Siemens.

Professor Tor Brustad at the Radium Hospital said that subsequent experience had shown that for radiotherapy for cancer patients there was little benefit to be gained from betatrons with a higher energy level than about 30 MeV. Also, radiation technology had advanced enormously, especially in England, and it was now possible to make small, compact linear accelerators that made it easier to direct the radiation to a particular site in a patient. Nuclear research, on the other hand, required particle radiation of much higher energy than had at that time been achieved with betatrons. In other words the classical, medium-sized betatron—both in radiotherapy and in nuclear physics—had a limited historical lifetime.

Cyclotrons and Betatrons

This is a good time to pause to look at the bigger picture of how this politically influenced and sometimes spy-ridden field of research developed. The 'Atomic Age' can be said to have started with Rutherford's work in the early 1900s. Then Niels Bohr from Denmark presented his theory of the structure of the atom. It was found that under very special conditions, electrons could be sent round and round in a tube and generate high energy, for example in a cyclotron. During the 1930s many researchers experimented with this, including Bohr in Copenhagen, Joliot in Paris and Scherrer in Zurich. Bothe continued the work in Germany during the war.

The main difference between a betatron and a cyclotron is in the method used to accelerate and steer the electrons. It is worth repeating that though the first working betatron was built by Donald Kerst at the University of Illinois in 1940, the concept stemmed from Rolf Widerøe's work in the 1920s. When it became known that Kerst had built a functioning betatron in America, interest rapidly spread to Europe. In Norway, Rolf took up the development of betatrons again, 13–14 years after he had launched the theory of how it could be done. Max Steenbeck in Germany had already been working on a machine of this type in the 1930s, without ultimate success. Now all the leading nuclear physicists in Germany joined the wave of interest in this form of high energy: Heisenberg; Bothe; Kopfermann; Kulenkampff; Kollath; Schmellenmeier.[186] The topic was also followed up in Japan, especially in Osaka and Tokyo.[187]

Rolf was not alone in building betatrons, but the aim in this competition was always to be the first and the best. Before the war there were about twenty betatrons in the USA. In Europe, none.[188] By the time the war was over, two projects in Europe had succeeded: Steenbeck and Gund with their 6 Mev betatron for Siemens and Rolf with his 15 MeV machine. Some people would claim that it was really only Rolf who had succeeded, as only his betatron was completely ready.

Betatrons and cyclotrons are both types of accelerator in which electrons are propelled round and round on a circular course as in a carousel. The nomenclature for the different types of particle accelerator had not become fixed when the war started, and there was overlap in the designs of the different machines that were being developed. This made it difficult to categorise them. Here is a chronological overview of the most important descriptive labels used (in German and in English) for the machines by their respective inventors:

Gund/Steenbeck	*Elektronenschleuder*	Electron-centrifuge
Widerøe	*Strahlentransformator*	Radiation transformer
Gans/Schmellenmeier	*Rheotron*	Rheotron
Slepian	*Röntgenröhr*	X-ray tube
Kerst and Serber	*Induktionsbeschleuniger*	Induction-accelerator
Kerst	Betatron	which eventually became the usual name for all the types of apparatus listed above.

Betatrons Become Political

Building apparatus to accelerate electrons became prestigious both for nuclear physicists and for big industrial companies that wanted to demonstrate how technically advanced they were. There were also strong political overtones to this activity, which towards the end of the war made it easier to obtain funding.[189] In Germany, it became clear at a conference convened by Arms Minister Speer to review the status of research, that this applied even if a particular project was not of 'decisive importance for the war effort.'[190] A Siemens worker who was present later summarised the situation: Developing a cyclotron was now so important for Germany's technological reputation that even in a time of war it was necessary to press ahead with all available means.[191]

The whole sequence of developments had been initiated by the great scientists who in the early 1900s had started to understand the structure of the atom. Rutherford, Einstein and Bohr, standing on the shoulders of all who had preceded them in wondering about the inmost secrets of matter, had given laboratories throughout the world a big new field of research to explore. Some scientists then began to perceive the consequences of what was under way. But not the politicians and the military.[192] A month before the war started in September 1939, Einstein had already written his now famous letter to President Roosevelt, warning him of German advances in nuclear physics and what they could lead to. Six months before that the German War Ministry had been informed of the possibility of building a weapon of mass destruction.[193] Physicists visited the National Research Council to discuss whether one could build a 'uranium machine,' a reactor for military use. The Uranium Club was set up, Heisenberg was given 'call-up papers' to take part (though not as leader) and the German atomic project was under way.

The first job facing the researchers was to work out how they would fulfil the task they had been given, which was no small enterprise. It later became known that the Americans had spent almost six years on the building of their bomb, and they were significantly more in number, much better organised and backed by enormous financial investment. New results from atomic research stimulated not only a scientific race, but also a military one. Previously unimagined levels of energy could be released by splitting the atom. The country that could utilise this would be overwhelmingly powerful, and just days after this had been recognised the Germans' Uranium

Club was in existence.[194] The leading figure in atomic research was Werner Heisenberg, and speculations about his role still continue. To some, he was the Nazis' man, to others he was the one who probably scuppered the atom bomb project. But after two or three years German researchers and industry were complaining that investment in physics had *declined* rather than increased and were asking for measures to be taken to reverse this decline.

The war minister had indeed instructed the National Research Council that more money should be made available for nuclear physics and that the research should be more effective. The first leader of the council had tried to sort things out by rather simply saying that new projects must not be started until the previous ones had been completed.[195] However, he had had little influence on the development of new cyclotrons or of the betatron.[196] Under the leadership of his significantly more powerful successor, Gerlach, a giant betatron was to be built in Heidelberg under the auspices of *Heereswaffenamt (HWA)* ('The Army Weapons Agency'), *Kaiser-Wilhelm-Gesellschaft* ('The Kaiser Wilhelm Institute') and AEG. Key people in the council generally included several current or previous Nobel prize-winners, including Otto Hahn in Berlin, Walther Bothe in Heidelberg and Werner Heisenberg in Leipzig.

In May 1945 Gerlach was interned in France and Belgium by the British and American forces as part of Operation Alsos. From July until the end of the year he was at Farm Hall in England along with Heisenberg and others, under Operation Epsilon. In the 1950s he helped to draft and signed the Göttingen Manifesto against atomic weapons, a declaration initiated by 18 leading West German nuclear physicists opposing tactical atomic weapons. This was during an early phase of the Cold War, and it was the first time German researchers collectively demonstrated responsibility for political decisions and their consequences.

Bombs and Rockets

When looking at the history of these developments, we should note the distinction between 'nuclear research' and 'accelerator research.' At the end of the 1930s Germany was best at the former and the USA at the latter, but during the course of the war this situation was reversed. Non-physicists can easily confuse these two fields of science. So here is a short course on the difference between them:

Nuclear Research

The fact is that just before the war Germany was closer than anyone else to making an atomic bomb. The key factor in this was research on uranium. In 1938 the chemist Otto Hahn and physicists Lise Meitner and Otto Robert Frisch discovered atomic fission.[197] When uranium is bombarded with neutrons, uranium atoms split in two and energy is released. This discovery led directly to the work to create a nuclear weapon, also referred to as an atomic weapon.

Germany started the Second World War the following year and won initial victories with its superiority in military technology and resources. The Germans became over-confident, omitted to follow up the research on atomic fission and let their opportunity slip away. The USA, on the contrary, diligently followed up the German research group's discovery and eventually developed the atomic bomb. Rolf had no part in nuclear research.

Accelerator Research

Before the war, the USA was ahead of Germany in accelerator research, with a working cyclotron in 1933 (Lawrence) and a betatron in 1941 (Kerst). Then in 1944–1945 Rolf succeeded in building a working betatron in Germany. He had a major part in accelerator research.

Hitler Despised Physics

Hitler himself seldom mentioned physics. He had nothing but disdain for a science in which so many Jews were prominent. He was also accused of basing his opinion about nuclear research on popular fiction rather than professional expertise. Industry on the other hand, particularly Siemens, AEG and I.G. Farben, knew how to make money from physics by opening new markets and new possibilities. Not without commercial hostilities, though. They fought patent wars with each other, and the cleverest ones recruited the A-team. Rolf was involved in these hostilities and had a part in the drama that was being played out in politics, in industry and in research laboratories. Within his first year in Germany during the war he registered ten patents for Brown Boveri, and many more followed. The hot topic now was accelerators of all types including betatrons, cyclotrons and everything between. This research needed industrial backing, the industry needed innovative researchers and the Nazi authorities found funding. It is not our present purpose to analyse this complicated situation and scrutinise motives, as many people have attempted that already. The point is that Rolf benefitted from the situation.

Pedro Waloschek said that the details surrounding the patents that were granted to Rolf during the war are unclear. According to him, the patents were officially registered for Brown Boveri. They were certainly confiscated by the Allies and later given back, but they were only released to public knowledge in the 1950s. The formal documents are now archived in *Deutsches Museum* in Munich among the papers bequeathed by Rolf's patent expert, Ernst Sommerfeld. The question is whether Rolf originally registered them for the company, or whether he first registered them in his own name and then transferred them to Brown Boveri. It is also conceivable that a transfer such as this could have happened *after* the war. However that may be, said Waloschek, they were applied for at the request of Brown Boveri. However you look at the picture, Brown Boveri is part of it. The former curator of the archive, Norbert Lang, says that all Rolf's patents were taken over by the company and are now listed in Brown Boveri's patent catalogue.[198]

The research race was also hard at a human level. One of those who fell by the wayside was Rolf's competitor, Konrad Gund, the engineer who was hired by Siemens to make betatrons. His first one was successful, and in 1946 another machine was put into therapeutic use in Göttingen. Konrad Gund got his Nobel Prize and was promoted. The machine was displayed at the International Exhibition in London in 1950 and was shown to the Queen Mother.

However he struggled with the next one, a 15 MeV machine intended to treat even deeper cancer tumours, the same strength as the machine Rolf had already made during the war. Early performance was promising, but then repeated problems arose with the ceramic vacuum tube. The technology could not keep pace with Gund's designs, and he wouldn't compromise in his attempt to meet the great expectations. He went back and forth, day and night, to the hospital where the machine was being installed. Then, one day in May 1953 when he was on his way to a conference in Amsterdam, he broke off his journey and turned back to the laboratory. The next morning he was found dead beside his betatron. He had taken a sleeping medicine and turned on the gas. Not only that, the following morning his wife was found dead in the kitchen with the gas turned on. She had followed her husband. The problem with the betatron was solved only a few weeks later, but Gund's fate made an impression on Rolf.

Scherrer the Spy

Even though Switzerland had remained neutral during the war, factories with German ownership connections were thoroughly investigated by Allied intelligence services once the war was over. Only a month before Rolf travelled to Switzerland in March 1946 for his first meeting with the Brown Boveri management, two British technicians visited the site in Baden and sent a report to The British Intelligence Objectives Sub-Committee ('BIOS').[199]

During the war the Swiss scientist Paul Scherrer, known for his cyclotron, had teamed up with the Americans and with Alsos. He had an enormous network of contacts, and from 1944 onwards he leaked information to the Americans about German research and German attempts to develop a nuclear weapon.[200] He was the initiator, for example, of a plot to lure Heisenberg to a conference in Zurich to meet Goudsmit, the head of Alsos. Heisenberg, whom OSS had given the code-name 'Christopher,' was on his guard and agreed to come only if it was guaranteed that they would not talk politics and that it would only be a small gathering. He did come. Among those sitting in the conference room was a man called Morris 'Moe' Berg, who was armed with a pistol and had orders to kill Heisenberg if necessary. Berg had been drilled in the theme of the conference and knew what Heisenberg might say in his lecture that would be the cue for him to shoot. It didn't happen. Perhaps Scherrer saved the life of his former colleague by managing to convince the Americans that Heisenberg didn't represent any threat, that he would not create any bomb and that he was in no way a Nazi as he had first thought.

Scherrer must have known about Rolf, for when the war was over he advised the management of Brown Boveri that they should get hold of the Norwegian. The Brown Boveri directors had agreed a policy statement in 1942, asserting that the most important thing the company could do to improve its prospects after the war was to maintain the technical status of its products. Their recruitment of Rolf is an example of this policy, which they also applied in their daughter companies in Germany. These had quite a free relationship with their parent company in Switzerland, and several of them had their own daughter companies. The factory in Mannheim had over 15,000 employees and only three of the nine directors of BBC Mannheim were Nazis, according to the independent Swiss report.

The role of neutral Switzerland during the war is a big topic that is still being explored. An independent expert commission prepared a report in

2002 on Switzerland and National Socialism. The report concluded that the war was still a sore point for Switzerland. A major part of the report is about Swiss industry's attitude to the Nazis and how the leaders of industry navigated between the shoals and skerries of keeping in with the Nazis, hiding away all political involvement, using forced labour, employing Jews and reacting to the Holocaust.[201]

In brief: The Swiss company Brown Boveri had a hand in all the exciting events in Rolf's field of work—before, during and after the war. He was employed by the Norwegian daughter company from June 1940. He continued to be formally employed by them while he was working for the Luftwaffe during the war, and he worked at the head office in Switzerland from 1946 until he retired with a pension. During the war, the Brown Boveri daughter company in the German town of Mannheim played an active and more or less independent role in betatron research. The mother company in Switzerland could be seen in the backdrop of this, though the Germans wanted to have as little to do with them as possible. Likewise, the Norwegian daughter company was in the wings. Brown Boveri was centre stage, but the company was not the sole player building betatrons in Europe during the war. There was strong competition, and Siemens and AEG were also important actors. The European companies were in competition both with each other and with American companies such as General Electric and Westinghouse.

Did he know but not say

– ***that there was a whole spider's web?***

As Rolf pursued his research, protected for better or worse by both Brown Boveri and the German authorities, there were many competing interests swarming around him. The industry had its own agenda, the scientists had theirs and the order of the day was determined by the course of the war. Everybody tried to juggle the various demands as best they could, in a confused buzz of genuine scientific interest, competing industrial giants and high-level technological competition between Germany and America, all with jangling undertones of fanaticism, naiveté, sheer nonsense, propaganda, idealism and global political strategy.

Rolf was caught in a spider's web spun by researchers, governments, high-ranking Nazis, intelligence agents, small private companies and major industries, each with its own network of real Nazis, Nazi sympathisers, agents, allies and sole players either pursuing self-interest or trying to remain neutral.

There is no lack of reasons for this situation: international politics; big science; war; political conflict; research competition; academic envy; industrial and military espionage. It was an extreme situation both for individuals and for society as a whole. Vengeance, frustration, naiveté, denunciation, despair; all shaken by the course of events. Two or three generations later we can claim that detachment helps us to see the main themes more clearly, but we face further difficulties because the people it relates to were reluctant to talk about it and are now gone.

It is difficult to decide who was using others and who was being used, but fortunately that is not the purpose of this book. Our interest is in whatever to a greater or lesser degree concerned Rolf. That is complicated enough. Not everyone had cloaks that were black or white, or even grey. Some people had several, or stopped wearing the one they had. Amidst this confusion, one thing that is certain is that research labelled 'important for the war effort' got funding. Rolf found himself among people with the authority to make that happen, but he didn't particularly make an issue of it.

Today we can look at the situation from outside. We have access to many people's accounts of events and to documents that have finally become available. Secrecy clauses have expired, the Iron Curtain has been raised and participants have at last told their stories. This reveals a complex, multi-dimensional network.

The list on the next few pages is intended to give an overall impression of the extent of the gallery of people involved. Each word-picture contains two points. The first briefly summarises the person's official position, and the second indicates his connection to Rolf.

Top Nazi Officials Involved with Research and Physics

Göring

- Hermann Göring was *Reichsmarschall* and head of the Luftwaffe. He was second only to Hitler.
- Göring became President of the National Research Council when it was reorganised in 1942 on the initiative of Albert Speer. The intention was for Göring to lead the research council with the same discipline and effectiveness as he led the air force. Research needed to be accelerated, especially in arms development and nuclear physics. The label 'important for the war effort' released funds. The best scientists in Europe were needed, and Rolf was one of them.

Milch

- Erhard Milch was General Field Marshall and Inspector-General of the Air Force and one of the most trusted and influential men under Göring. He was of Jewish origin.

- Schiebold's 'death-ray project' that later morphed into Rolf's betatron project was set in motion by Milch, who knew Schiebold personally.

Speer

- Albert Speer was Arms Minister from 1942, with almost unlimited powers and resources within his remit.
- When T-Force interrogated him after the war, he said that they had done quite a lot of atomic research but that nothing really practical had come out of it. 'They needed another ten years.' He referred to the research that had been led by Heisenberg and Bothe[202] and confirmed that he had given high priority to the building of two cyclotrons in Heidelberg.[203] Heisenberg had recommended Rolf, and Bothe had expressed interest in Rolf's betatron and a desire to work with him.

Geist

- Friedrich Geist was head of technical research and development in Speer's Ministry of Munitions and War Production and Speer's right hand man, according to Heisenberg.
- Rolf considered Geist to be the person officially responsible for his work. Geist was a member of the management committee of Schiebold's research station at Grossostheim where Rolf's project influenced and later replaced Schiebold's work.

Good Scientific Contacts

Gerlach

- Walther Gerlach was Professor of Physics at Munich and along with Heisenberg was one of the most influential scientists in the Uranium Club. He was arrested by the Allies and among those interned and secretly recorded at Farm Hall in England after the war.
- Gerlach was Head of Political Policy in the Physics Section of the National Research Council, with responsibility for everything to do with nuclear research and for Rolf's betatron project. He was also Chairman of the Management Committee of the Luftwaffe Research Station at Grossostheim where it had originally been intended that Rolf's 200 MeV betatron would be built.

Schiebold

- Ernst Schiebold was Professor of Physical-Chemical Mineralogy in Leipzig. He introduced a method of using X-rays to investigate metals. He built up an institute for this type of materials testing. After this was bombed during the war he set up a research station at Grossostheim with what was left of the instruments.
- In 1943, he obtained funds from the Luftwaffe through Milch to develop his idea of an X-ray cannon that would take out enemy planes and crew. Rolf was employed as part of this death-ray project. Rolf said that he met

Schiebold once, at Hollnack's house. When the wonder-weapon turned out to be completely unrealistic and its construction was stopped the following year, the project was continued in the form of Rolf's work on the betatron.

Georgii

- Walter Georgii was Professor of Meteorology and Head of Department in the elaborately titled *Forschungsführung des Reichsministers der Luftfahrt und Oberbefehlshaber der Luftwaffe*.
- The Luftwaffe research station at Grossostheim was part of his remit, and it was he who sent the letter to Schiebold saying that the death-ray project must be abandoned but that Rolf's part of it, the betatron project, should continue. He was also a member of the management committee of the research station at Grossostheim where Rolf's project started.

Fennel

- Kurt Fennel was an engineer who was at the meeting where Schiebold's death-ray project was established on 17th April 1943. He was one of the trusted people who signed the foundation document and one of the four whom General Field Marshall Milch had personally authorised to act on behalf of the project. The other three were Hollnack, Seifert and Schiebold.
- Fennel was a member of the management committee of Schiebold's research station at Grossostheim where Rolf's project started. He was probably the formal recipient of the letter from the Air Ministry on 15th February 1944, intimating that the death-ray project at Grossostheim must be stopped. He was the authorities' representative in the project, but it is difficult to be specific about his role.[204]

Egerer

- Karl A. Egerer was a physicist who was Chief Editor of the scientific journal *Archiv für Elektrotechnik*, published by Springer in Berlin. He was a member of the scientific steering committee of the Luftwaffe research station at Grossostheim and an advisor to General Field Marshall Milch.
- Egerer's journal published Rolf's doctoral thesis and later published several other of his articles. The article Rolf submitted in spring 1943 was not printed, but the people who came to Norway to fetch Rolf knew about it.

Hollnack

- Theodor Hollnack had studied both scientific and social subjects and also specialised in organisation and marketing. He had close connections with the Nazi authorities and a large network of contacts within both business and academia.
- Through his semi-official company he was administratively responsible for Rolf's betatron project in Germany and was the link between Rolf and the Air Ministry. Hollnack attended to the practicalities of the Luftwaffe's

payments to Rolf. Rolf considered Hollnack to be a Nazi, but at the end of the war he revealed to Rolf that he had contacts among the British. He was a member of the management committee of the research station at Grossostheim where Rolf's project started.

Seifert

- Richard Seifert jr. had a doctorate in physics and managed the company Rich. Seifert & Co. that manufactured equipment for the X-ray industry.
- Seifert was a personal friend of Rolf, and their families continued in touch after the war. Seifert was technical advisor on X-rays in Hollnack's company. He was also a friend of Schiebold and technical manager first for the death-ray project and then for the betatron project, where he had full authority to act on behalf of the Air Ministry.

Kratzenstein

- Kratzenstein had a doctorate in physics. His forename was probably Hermann, but it may have been Marius.
- Hollnack described him as the 'instigator' of Rolf's Luftwaffe project. It was Kratzenstein who put Hollnack in contact with Egerer, who knew about Rolf's research through his work as an editor. Krtatzenstein was probably one of the people who came to Oslo to bring Rolf to Germany. He appears to have been of Jewish origin and he is mentioned in a book published in 2004 about Germans who opposed the Nazis.

Three Key People in the Widerøe Group

Kollath

- Rudolf Kollath had a doctorate in physics and had worked at the aluminium smelter in Sauda in Norway and at AEG's research laboratory in Berlin. He faced problems in Nazi Germany because his wife was of Jewish origin. So he could not be appointed to a university or to public office but had to either work in industry or do compulsory labour for the war effort.
- Kollath was one of the key members of Rolf's team in Hamburg and he served as Rolf's deputy. Rolf described him as 'a good fellow-worker and colleague.' He moved to Kellinghausen/Wrist when the betatron was evacuated there in spring 1945. He wrote several detailed technical reports about the betatron immediately after the war ended. These ended up in the hands of the Allies, and when the betatron was removed to England as war booty Kollath was also there for a while. He and Rolf maintained personal contact after the war.

Schumann

- Gerhard Schumann had a doctorate in physics.
- He was a core member of Rolf's team, along with Kollath and Touschek. He moved to Kellinghausen/Wrist when the betatron was evacuated there in spring 1945.

Touschek

- Bruno Touschek was a gifted mathematician and physics student from Austria. Because his mother was Jewish he had been expelled from schools and universities.
- At the age of 22 he became Rolf's assistant, having been recruited by Egerer who had previously given him a job first in the company he worked for himself and then with the journal where he was editor. Touschek lodged at home with Professor Lenz, where Rolf met him for the first time in August 1943. He was allowed to attend Professor Jensen's lectures even though he could not be registered as a student. During his time working for Rolf, Touschek was arrested both by the Gestapo and by the British. When he came out of prison in May-June 1945 he lay in hiding with the Seifert family in Kellinghausen. He later became a greatly respected accelerator physicist in Italy. He said he owed some of the credit for his success to Rolf, as likewise Rolf acknowledged his indebtedness to Touschek.

German Physicists with Various Connections to the Uranium Club and to Rolf's Project

Heisenberg

- Werner Heisenberg was one of the great physicists of the twentieth century, a Nobel prize-winner at the age of 31 and a key member of the German Uranium Club. He was a professor in Munich and a member of the National Research Council. He was arrested by the Allies and was one of the people interned and secretly monitored in England after the war. There is still much speculation about Heisenberg, particularly about what he really thought of Hitler.
- Heisenberg is said to have been the person who advised that Rolf should be brought to Germany. He was also a member of the committee of Schiebold's research station at Grossostheim where Rolf's project started.

Bothe

- Walther Bothe was a professor in Heidelberg, an important member of the Uranium Club and a member of the National Research Council. Along with his assistant, Gentner, in 1941 he was given the job of building a cyclotron for Brown Boveri. He told Speer that the machine would only be for medical and biological use. Bothe was opposed to the Nazis. He was later awarded the Nobel Prize for Physics.
- Bothe was one of the nuclear researchers whom Rolf knew personally. They both worked on the development of betatrons. He tried to make contact with Rolf to develop ideas about a 200 MeV betatron. He himself worked on a 200 MeV cyclotron. Together with his colleague Dänzer, Bothe had plans for a 10 MeV betatron.

Gentner

- Wolfgang Gentner was a professor in Heidelberg and a member of the Uranium Club.

- Gentner was one of the German nuclear researchers Rolf knew personally during the war. He was Bothe's assistant in the work on a cyclotron for Brown Boveri. He had previously worked with Joliot in Paris and Lawrence at Berkeley. Gentner was a friend of the spy Paul Rosbaud ('The Griffin') and in secret he was a convinced anti-Nazi.[205]

Kulenkampff

- Helmuth Kulenkampff had a doctorate in physics and was recognised for his work on X-rays and on betatrons.
- Kulenkampff and Rolf both had the right to attend and speak at meetings of the steering committee of the Luftwaffe research station at Grossostheim. After a conversation with the committee chairman, Kulenkampff warned the person in highest authority in relation to the death-ray project, General Field Marshall Milch, that Schiebold's X-ray cannon was totally unrealistic. Indirectly, he prepared the way for Rolf's project proceeding independently.

Lenz

- Wilhelm Lenz was Professor of Physics and Director of the Institute of Theoretical Physics at the University of Hamburg. Together with Otto Stern and others he built the institute up to become a centre of nuclear research.
- Rolf knew Lenz personally, and Rolf's assistant, Touschek, lodged with him.

Jensen

- Hans Johannes Daniel Jensen was a professor in Hamburg and received a Nobel Prize. He described himself as a socialist, but was said to have really been a communist. After the war he moved to the USA.
- Jensen was one of the nuclear researchers Rolf knew personally during the war. They met each other at Lenz's house. Jensen and Lenz both allowed Rolf's assistant Touschek—who was banned from university because he was Jewish—to attend their lectures without being a registered student.

Suess

- Hans Edvard Suess was a chemist and nuclear physicist. He was employed at the Institute for Physical Chemistry at the University of Hamburg, where he worked with Jensen and others. During the war he was at Vemork in Norway as the German advisor on the production of heavy water. After the war he moved to the USA, where he became a professor at the University of California.
- Rolf first met Suess at Lenz's house. According to Rolf, Suess was one of those who said openly that he opposed Hitler.[206]

Sommerfeld snr.

- Arnold Sommerfeld was Professor of Theoretical Physics in Munich and was considered one of the most important physicists of his time. Along with

Heisenberg he was one of the first to realise that Schiebold's death-ray cannon was a flight of fantasy.
- He was dismissed from his position because of his opposition to the Nazis. He was in the USA during the war and supplied Rolf with information about the research being done there.

Sommerfeld jnr.

- Ernst Sommerfeld was an engineer specialising in patent registration. He was a respected patent advisor in Berlin, and son of the famous physicist Arnold Sommerfeld.
- Sommerfeld jnr. and Rolf were close friends. He dealt with all the legal and formal aspects of Rolf's patents. He was very probably subject to surveillance by the Nazi authorities, who thereby would get insight into Rolf's work.

Gund

- Konrad Gund was an engineer and X-ray specialist. He worked for Siemens on both a 6 MeV betatron and a 25 MeV one, based on Steenbeck's ideas and designs.
- Gund and Rolf were 'colleagues' and competitors. They both received official support from Nazi Germany for their betatron projects.

Steenbeck

- Max Steenbeck was a professor of physics who had written his doctoral thesis while he was in the research department at Siemens. At the end of the war he was arrested by the Russians and sent to Moscow, where he worked on the Russian atomic bomb project and became a declared communist. He later became a professor in the German Democratic Republic and expressed criticism of his previous time at Siemens.
- At the time when Rolf was working on his doctoral thesis about betatrons, Steenbeck had already developed his ground-breaking ideas about a cyclotron—and also a first sketch of a synchro-cyclotron. Rolf knew Steenbeck slightly because of his experimental work on betatrons at Siemens, initially with Gund and later also with Kopfermann and Paul.

Kopfermann

- Hans Kopfermann was a professor of nuclear physics and a member of the Uranium Club. In 1941 he was appointed Dean of the University in Kiel where he was employed. In this position, he was required to join the Nazi party.
- He and Paul worked for a long time trying to develop their own betatron in Göttingen, but when they heard of Gund and Steenbeck's project for Siemens they offered their assistance there instead. The researchers at Siemens were Rolf's only real competitors.

Paul

- Professor Wolfgang Paul in Berlin worked for a long time together with his teacher, Kopfermann, to develop their own betatron, but eventually they both joined Gund and Steenbeck's project at Siemens. Paul later shared a Nobel Prize.
- Paul and Rolf were 'colleagues' in betatron research. Paul wrote a historical review of developments in accelerator research, in which he described two researchers as prominent, namely Rolf and also Steenbeck, with whom he later worked himself.

Nuclear Physicists Abroad Whose Work Influenced the German Physicists

Lawrence, USA

- Ernest O. Lawrence invented the cyclotron in 1930.
- He got the idea from studying the sketches and equations in Rolf's doctoral thesis from 1927.

Kerst, USA

- In 1941, Donald Kerst was the first person in the world to succeed in constructing a betatron that worked.
- This was based on the principles set out in Rolf's 1927 doctoral thesis. When Rolf heard of it, he resumed the research on betatrons that he had set aside for several years while he was working on electrical relays and power distribution networks.

Bohr, Denmark

- Niels Bohr was one of the most famous physicists of the twentieth century and known as the founder of quantum mechanics. He was awarded the Nobel Prize in 1922 for his study of the structure of the atom and of atomic radiation. Heisenberg was one of his students. Bohr had Jewish ancestry, and during the war he fled to the USA where he took part in the Manhattan Project.
- Bohr had been a pupil of Rutherford in England. Rutherford, who was also a great inspiration to Rolf, had started the atomic age by managing to split an atomic nucleus. Bohr followed this up in theory and Rolf in practical application.

Scherrer, Switzerland

- Paul Scherrer was a nuclear physicist and Professor of Experimental Physics at the college in Zürich where he taught for 40 years. In 1940 he built the first Swiss cyclotron. He was also involved in setting up the CERN laboratory. From 1944 onwards he leaked information to the USA about German research and the attempt by German scientists to develop atomic weapons. He was also responsible for the plot to lure Heisenberg to Zürich as part of *Operation Alsos.*[207]

- It was Scherrer who advised the owner of Brown Boveri in Switzerland to recruit Rolf. The three of them met in Baden shortly before Easter 1946 to discuss Rolf's appointment to the head office. About the same time as Scherrer retired from his teaching post at the college in Zürich, Rolf started lecturing there. Scherrer has an internationally recognised research institute named after him, the Paul Scherrer Institute, PSI, which is situated close to Nussbaumen where Rolf lived during most of his time in Switzerland.

Major, research-intensive international industries were also racing to build accelerators:

Brown Boveri

Brown Boveri played a very particular role, in that Rolf was employed there before, during and after the war. The company was a party to Rolf's contract to do research for the Luftwaffe during the war. Brown Boveri had its head office in Switzerland and subsidiary companies in both Germany and Norway. The German company was closely involved in the second phase of Rolf's project, the design of the 200 MeV betatron to be built at their factory in Mannheim. Rolf developed almost a hundred betatrons for them after the war, contributing to the company's great international success.

Philips–Müller

C.H.F. Müller in Hamburg belonged to the Philips Group. The company designed and manufactured X-ray tubes and other X-ray equipment. During the war they also produced sonic apparatus for underwater use. When the war started the company had 500 employees. 20 of these were in the high-voltage department, whose activities included the work on the betatron. 160 worked purely with X-ray equipment and the others were engaged in various related technologies. The factory narrowly avoided being damaged by the bombing raids on Hamburg, and when the Allied investigators arrived in spring 1945 they found the equipment mostly intact.[208]

Under the heading 'Ultra high voltage equipment,' the CIOS investigators wrote in their summary report: 'C.H.F. Müller who are working in Wrist in collaboration with and under the leadership of "*MV Forschungs-Verein*/MV Research Association" completed the construction of a 15 MeV betatron.'[209]

The report goes on to say that in December 1944 the M.V. Research Association completed the calculations and designs for a 200 MeV betatron with an estimated weight of 30 tonnes, to be built at Brown Boveri in Mannheim.[210]

A chapter about the medical use of the betatron describes the remarkable procedures hospitals could now use. It explains how X-rays can be used in cancer treatment, killing cancer cells without overdosing the surrounding healthy cells. It refers to how this technology was 'invented' at the end of the 1920s but not 'proven' until 1941, when the American, Kerst, managed to get Rolf's betatron theory to work. There is no doubt, therefore, that what the investigating officers had discovered was Rolf's betatron project. Nor is there any doubt that they understood that it was of great medical significance.

Hans Ritz, the manager of the Müller factory, was an electrical engineer though X-ray tubes were not really his area of special expertise. He was one of the inner circle round Schiebold, the man with the idea of the death-ray weapon. Ritz had previously been employed at AEG, until he was appointed manager of C.H.F. Müller for political reasons. As a foreign-owned enterprise, part of the Philips Group, the factory was subject to obligatory control under *Zwangs- und Fremdvervaltung* and could be compelled to do particular jobs with the help of specified people. A few weeks after the end of the war, Ritz and two others were dismissed by the management of Philips, because they had been active members of the Nazi party.

Albert Kuntke was a completely different type, and was more important for the practical work on the betatron. He was head of the high-voltage laboratory and did important precision work. Rolf described him as very capable, gave him credit for his contribution to the success of the 15 MeV betatron and visited him at home several times. Kuntke took part in meetings and visits when representatives from Brown Boveri came to plan the development of the 200 MeV betatron. He had been an apprentice at Seifert and when he started at Müller he was given help to train further and qualify as an engineer. Kuntke was among those who were questioned thoroughly by the scientific intelligence agents in the spring and summer of 1945. A summary report from the British Intelligence Objectives Sub-Committee, BIOS, says that 'Müller, working with a Norwegian, had built a 15 MeV betatron' and adds that 'It has been moved to Wrist.'

Dr. Werner Fehr, an X-ray specialist, was deputy manager at Müller and another person with whom Rolf worked closely. When he was questioned by the British while they were investigating the site, he told them that the betatron 'was something the Luftwaffe had been experimenting with in the hope of being able to generate a death-ray for use in an anti-aircraft gun.' For reasons unknown, there is a question-mark in brackets after the word 'hope.'[211]

Rolf later met Fehr again several times and he particularly mentioned that Fehr several years later sent him a photo of the Hamburg betatron, and that he had written an interesting little leaflet on the history of the C.H.F. Müller factory.[212]

Fehr and a couple of other employees at the Müller factory later claimed that they had realised right from the start that Schiebold's X-ray cannons were not a realistic prospect.[213]

In their eyes, Schiebold was just a pompous eccentric whose ideas were wide of the mark. The only reason his project was interesting to them was that it gave the factory work with high war priority. Müller was well in on the act, and even though their work with Rolf went well most of the time, Schiebold's project eventually failed.

General Electric

The American physicist, Donald Kerst, had connections with General Electric. GE had custom-built the doughnut-shaped glass tube he used in his first betatron. Together with General Electric he then set about developing his design further to 20 and 100 MeV machines. He succeeded in making his second machine, 20 MeV, in 1942 and GE completed a 100 MeV machine in 1945. In the meantime Kerst had been called back to the University of Illinois where he built an 80 MeV prototype betatron and a gigantic 300 MeV version which was and remains the biggest machine of this type ever made and is considered the final step in betatron development.

Westinghouse

In the USA, Westinghouse with physicist *Joseph Slepian* were also in the race. Slepian modestly described his 1922 apparatus as an X-ray tube. Westinghouse's daughter company, National Industry, had head-hunted Rolf to their branch in Oslo in 1937.

AEG

AEG, Allgemeine Elektricitäts-Gesellschaft, was a prominent company in the electrical industry, with traditions just as long as Brown Boveri. They played a major role in the development of cyclotrons. The company was ambitious and was awarded contracts from the highest authorities. AEG together with the Kaiser-Wilhelm Company undertook for the army munitions office the building of a 'giant cyclotron' for the Uranium Club.

Among other things, AEG supplied equipment to Schiebold's death-ray project. Seifert as technical director of the Widerøe project switched over to ordering glass tubes from AEG, after originally buying them from the Müller factory. Work was also done on plans for a 20 MeV betatron from AEG but that came to nothing.[214] AEG collaborated with General Electric in the USA for as long as that was possible. Many of the people who later became important in betatron research, both in Siemens and in Brown Boveri, had come from AEG. Rolf himself had worked there when newly qualified, before he moved back to Norway. Rolf's deputy, Kollath, was recruited from AEG's research division, though the two of them were not there at the same time. Gans was in the same department before Siemens engaged him and the manager of the Müller factory, Hans Ritz, was also from AEG.

Siemens

Siemens was already a big company and was Brown Boveri's main challenger in betatron technology. The principal researchers in this field at Siemens were *Konrad Gund* and *Max Steenbeck*, later joined by *Wolfgang Paul* and *Hans Kopfermann*.

For Siemens as for AEG and Brown Boveri, the interest in high voltage equipment was very timely. This was the newest thing in their field, and they needed to be assertive. It was obviously important that research on electron accelerators was classified as important for the war effort, as there had been a lack of research during the first phase of the war and both physicists and industry had started looking around for money. Walther Gerlach, the man who took over as the national head of physics research towards the end o the war, had for example given Siemens three betatron contracts.[215, 216]

When the Americans arrived to investigate Siemens, they confirmed there had been work on two small betatrons and that there were plans for a slightly bigger one, similar to Rolf's first one rated at 15 MeV. Siemens told the investigators that their interest in betatrons was directed purely at cancer therapy.[217] The Americans confiscated a small, 6 MeV machine. Orders were given for it to be destroyed, but Paul and Kopfermann managed to prevent that through their contacts in the British military regime.[218]

The theoretician behind the Siemens project, Max Steenbeck, later said that 'The betatron was certainly not important for the war effort,' and that the investment was directed by business interests. He maintained that as the Americans were working on betatrons, the Germans had no choice but to press on with a view to entering the market as soon as possible after the war.[219]

Rich. Seifert & Co

During the war, Rich. Seifert & Co. were the biggest producers of industrial X-ray equipment in Germany, and they also made apparatus for medical use. Seifert bought components from their competitors Siemens, Müller and AEG. The company had about 350 employees when the American intelligence services investigated the factory and they interviewed the owner Richard Seifert and several of his staff.[220] The company still exists. It was bought by Agfa in 2001 and is now part of the GE group.

Seifert's firm merits special mention. At the same time as they were supplying equipment, the owner was employed by the Luftwaffe as technical director first in Schiebold's death-ray project and then in Rolf's betatron project. He was a qualified physicist and had inherited the well-run company from his father. He had previously been advisor in X-ray technology for Hollnack's company and Rolf thought that it was Hollnack who had brought Rolf and Seifert together, though he couldn't exactly remember how they first met.[221] Seifert was also a friend of Schiebold, and when Schiebold first told the authorities about his secret death-ray project he was given special permission to tell Seifert about it. Seifert was then brought into the project management team. Not only that, Seifert had a foot in the Air Ministry. He represented the ministry when the contract for the 200 MeV betatron was being awarded to Brown Boveri. He was also an important part of the Hollnack-Schiebold-Seifert triumvirate who ensured contact high in the Nazi hierarchy and secured mandates and means for Rolf's work on betatrons. As Rolf himself said:

> My first and by far the most important contact in Hamburg was Dr. Richard Seifert, a very sound and able person whom I greatly respected. He actively helped and supported me in my special situation.[222]

Seifert was thought to be a Nazi,[223] but Rolf's mind was obviously on other things and he either didn't see or he deliberately ignored the political manoeuvring. Seifert was a necessary contributor to the job in hand, both because of his professional ability as a physicist and as a supplier of equipment to Luftwaffe projects. His key role and his many connections provide a good example of how difficult it was at that time to specify and label people's positions on the network, when many people held several posts and some didn't quite seem to fit in anywhere. Even from today's perspective it is difficult to trace the strands in the complex, multi-dimensional network. Although Rolf spoke familiarly with the Nazi opponent Hans Suess during the war, he also remained a personal friend of Seifert for the rest of his life. Such apparent contradictions don't make the unravelling any easier.

What Became of Them

After the war, Rolf often expressed concern about the people who had worked with him in Germany. He wondered what had become of them, and he kept in touch with many, including employees at the Müller factory who had become involved in the situation not on their own choice but who had nevertheless worked loyally with him. Hollnack's organisation vanished from sight. Schiebold, who had started the whole thing with his ideas about death-rays, moved to the GDR where he was dismissed from his first post because of his political history but finally got a professorial appointment elsewhere. Gerlach, the very influential research politician, signed the Göttingen Manifesto along with other leading German physicists. Steenbeck, the researcher at Siemens, became a communist and settled first in the Soviet Union and then in the GDR. Rolf's two closest colleagues, Kollath and Schumann, continued their research careers in West Germany and maintained contact with Rolf, as did his business contact and friend, Seifert.

Then there was his assistant, Touschek, the student with a Jewish background who had benefitted from the professional opportunity and had survived under Rolf's nurturing and protection. Whenever Rolf later spoke about the people he had worked with and had contact with at that time, he always made special mention of Touschek.

This was the gifted youth, born in Vienna in 1921, who had to come out of further education because his mother was Jewish. He was offered a post in England after the war, but he chose to work in Göttingen where he installed the Siemens betatron that somebody had managed to rescue. Then he was in Glasgow, and in the 1950s he came to Rome where he established his reputation as a theoretical physicist. Ten of his colleagues composed a tribute in the form of an article entitled 'A Stolen Nobel Prize,' where they asserted that Touschek had obviously deserved a Nobel Prize.[224] After his death a colleague at The Frascati National Laboratory accorded him the epitaph 'Strong professionally, undoubtedly talented and very entertaining.'

Touschek had a tragic end, however. He became alcoholic and died at the age of 57, three or four months after being appointed as a professor. Rolf met Touschek several times after the war, the latest occasion being in 1975. The difference in age was such that Rolf could have been his father. They had a close relationship, and the time they had spent working together was important to both of them.

Since the time Touschek and Rolf had discussed Rolf's vision of the clouds colliding, Touschek had continued working on the problem of how to steer particles against each other, and he succeeded as the first person in the world to build an effective storage chamber. There was still a little friendly rivalry between Rolf and his former assistant. When Touschek made his break-through in 1960, the master congratulated his pupil but couldn't quite restrain himself from mentioning his own contribution:

> This working storage ring was the first in the world, and so that was the first time my patented ideas from 1943 had been applied in practice.[225]

Research based on Rolf's ideas is still being pressed forward. All over the world, lectures are being published on the internet about the importance of Rolf's work and the betatron's place in the history of science. Each new batch of physicists who need to grasp accelerator technology studies the line of development from when Rolf formulated his first theses, through the successors who built on his theories, and on to today. As recently as 2011 two Italian physicists brought to light new details about Rolf's work and his collaboration with his assistant, based among other things on the recent discovery of letters that Touschek had sent to his parents during and shortly after the war.[226]

In 2015 the Norwegian journal 'Technical Weekly' published an article saying that the University in Oslo was planning to build up expertise in particle acceleration based on recently developed technology. The article also pointed out the paradox of Norway's lack of expertise in this field:

> Norway has areas of strength in particle physics that have grown up around the activity at CERN, but we are weak in one field. In contrast with most European countries, we do not have much expertise in accelerators. Rather strange, perhaps, as from a historical point of view we have strong traditions of building them.
>
> The technology was first developed by the Norwegian Rolf Widerøe who published his ground-breaking results as long ago as 1928. We now find them in all particle accelerators throughout the world, irrespective of whether the radiation travels in a circle or in a straight line.[227]

Not just physicists, but also scientific historians, local historians and amateur researchers together with some charlatans and fantasists continue the story in various ways, expanding this web of people interested and involved. Some find previously unknown threads, others spin new ones. South-East of Frankfurt, around Grossostheim, the wildest rumours circulated about the mystique of what was supposed to have happened during the war at the abandoned airbase. There was a bunker that nobody was allowed to approach. Some people suggested that it was intended as a concentration camp. Others thought that sinister research went on behind its metre-thick walls.

After the war the curiosity just continued to grow. The myth-enshrouded bunker where radiation was to be generated and which nobody was allowed to approach drew the interest of experts and amateur historians to this little village. They unravelled the stories both of the X-ray-cannon-professor Schiebold who wanted to build a laboratory on their airbase and of the Norwegian who had a brother in a German prison and who was to build a giant betatron there. In spring 1944 Schiebold's machine hall had stood ready to receive a betatron, due to arrive from the Müller factory in Hamburg in the summer—they thought. But then the barrier came down on Schiebold's activity. Rolf, on the other hand, was allowed to continue his project in Hamburg where he had started.

The plans for Grossostheim had been grandiose, but nothing came of them. What happened there has now become the theme for a museum. The people of the town have been able to fill their local gap in the history of the war with documented facts, imaginatively put together with fragments of archive material, reminiscences and not least, Pedro Waloschek's book about the death-rays.[228]

But not all the interest leads to such useful outcomes. Themes such as forces that are unseen but we know are there, set people thinking far beyond the technological milieu. When a topic is speculative and is in the borderland of comprehension for ordinary people, and especially when it involves documents marked *Geheim* and 'Secret' and *Heil Hitler*, all in an obscure context, it invites us to create narratives within the realm of science fiction. There is a whole industry of conspiracy-theory writings making a business out of people's interest in this 'something more' between heaven and earth. Even when the authors pile on names and facts that in some instances are correct, or at least look plausible, the information is not always what it appears to be. Schiebold's 'death-rays' have obviously found a place here. What is worse is that Rolf and his betatron have also been drawn into tales of Nazi occultism, possible UFOs and levitation.

The Spider

What was happening round about Rolf didn't need such over-dramatization, however. What he was working on was exciting enough in itself. As was the race against other researchers, cheered on by industries trying to survive and earn money and a government and military powers trying to win the war. Then the drama increased further as people added further threads to the web. A Hollnack; an Egerer; and others with their own agendas. It has been difficult to know what descriptive label to apply to many of the people in the list of *dramatis personae*.

Hollnack told the British his version. It may not necessarily be accurate, but it is difficult to doubt the essence of the information he provided. Rolf told his version to the Americans. Nor is this necessarily a correct objective account. But that was what he said, and that was also what he wrote. His second-in-command, Kollath, wrote detailed reports for the British. The newly appointed head of intelligence services did the same when peace came. From meetings between Brown Boveri, German authorities and the Widerøe project there are minutes and personal summaries. The Allied scientific intelligence officers sent their reports and documents back and forward across the Atlantic.

Although Hollnack claimed a principal role for himself, he was not necessarily the one at the centre of the web. The real spider could be someone else. Egerer, the journal editor who took possession of Rolf's latest article, has a key role irrespective of whether he was directing or being directed. The most speculative scenario would be that the spider managed to remain in hiding. Perhaps a Seifert, who is consistently omnipresent. Or Kratzenstein, whom Hollnack hardly names in his report. Perhaps a Fennel, who at the start always had to be at the meetings with officials but who then disappeared into the wings, only to reappear at the end.

But do we really need to know who the spider was, in order to understand Rolf's situation? The point is that it was a web.

In brief: It is difficult to disentangle what were the various motives of the people in this network. This part of the story cannot be summarised in one or two excerpts. The answer may be the unexciting one that most of them were just trying to get by and cope as best they could in a difficult situation. But there were principles to be considered too. What is expected of you when your country is at war? Rolf hardly knew himself how many different interests were involved in his project. He was focussed on the research. He could see that he was held in a network, but he had no way of seeing the whole pattern. And if he did know anything, he didn't care to talk about it. Or he couldn't. Always uncertainty. War is war.

He could obviously feel honoured that it was Heisenberg who had recommended him—if he knew. The people who brought him to Germany had contacts right at the top of the hierarchy. This too was an honour, in a sense. But it is not at all certain that he knew. How could he? His job description came from the Luftwaffe, as did the money. The person who negotiated the job and acted as paymaster was called Hollnack. That much he knew. But there was more, much more, that he didn't say.

The whole history of nuclear research in Germany during the war is enveloped in mystery, propaganda, faith and doubt. A good illustration that where facts are lacking, fears and rumours arise. There was a belief that whoever made an atom bomb first, would win the war. Quite early on, the Allies knew more than the Germans—that there really wasn't so much to know about on the German side. But the Germans didn't know that the Allies knew this. So they put in support, step by step, to find their ultimate weapon, the wonder-weapon, a *Wunderwaffe* that had to be found if the atom bomb was not ready in time. But there was also an economic war, an industrial war—about rights, patents, licences, about the bottom line after the war; and for that they needed the best.

It was inevitable that Rolf would have a part on the wartime world stage, because he happened to have had an idea about one of the main themes of the plot; because he sketched it in a thin, square-lined notebook as early as 1922, while he was student; and because he continued to work on his idea. Continued on and on. Looked neither to right or left. Kept his eyes on the target, that was both so simple and so complex—like Rolf's own story.

Following on from his idea, physicists will continue to explore the potential of atomic power. Accelerator technologists throughout the world will go on crossing boundaries of knowledge. Scientific historians, politicians and most people will look for connections past and future. But life is lived forwards and must be handled from day to day without being able to see connections in all directions. And the higher the stake, the greater the possible gains or losses. In Rolf's case, he had to live with the consequences of his choice. So we may all ponder what he said or didn't say about what he lived through, for example why he never said:

– that he was nearly arrested both by the British and by the Russians;
– that his project continued, away from he hands of the Nazi authorities, after he went home;
– that he knew his assistant would soon be released from prison;

– that he must have known the identity of the SS officers who visited him in Oslo;
– that the physicist who interviewed him in prison represented high level American intelligence services;
– that Brown Boveri was part of the picture all the time;
– that there was a web of Nazis, Nazi sympathisers, anti-Nazis, secret agents and Allies behind his project.

He *must* have known some of this. How much, will remain his secret. It was his decision that it should be thus, and we just have to live with that. His posthumous reputation has had to endure censure and speculation, misinterpretation and defence. Nor has the history of atomic bomb research in Nazi Germany reached its final conclusion, despite continuing input—and there is little likelihood that it ever will. Experts advise healthy scepticism and an open mind about both the accelerator programme and Germany's weapons programme during the Second World War.[229]

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Rolf's decision to go to Germany had its price, and he accepted the consequences. With straight arm and back, stiff lip and head held high. With his gaze fixed high in the distance. Right through the treason proceedings, imprisonment, a fine and harmful rumours. He stood by his decisions, whatever happened. He also had to live with the uncertainty about what more there was to know, the responsibility for not telling everything that he did know and the result that people therefore just thought whatever they wanted.

But what did *he* think about why he had submitted himself to all that? … Oh, if only we could know.

Notes

1. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum Vitae' (English translation) sent to T-Force 1st February 1946.
2. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum Vitae' (English translation) sent to T-Force 1st February 1946.
3. The biography.
4. Alsos, 'Visit to Widerøe in Oslo. July 1945. Capt. G. Randers,' the document. '*Bericht über die historisch-organisetorische Entwicklung*' ('Report of the historical and organisational development') written by Theodor Hollnach,

pkt. 'Vorgeschichte,' 9th June 1945, Niels Bohr Archives, American Institute of Physics.

5. Alsos, 'Visit to Widerøe in Oslo. July 1945. Capt. G. Randers,' the document '*Bericht über die historisch-organisetorische Entwicklung*' ('Report of the historical and organisational development') written by Theodor Hollnach, pkt. 'Vorgeschichte,' 9th June 1945, Niels Bohr Archives, American Institute of Physics.
6. David Irving: 'The Rise and Fall of the Luftwaffe. The Life of Field Marshal Erhard Milch,' Focal point, 14 Total War, February-March 1943, pp. 226–227.
7. Waloschek: Schiebold, E.: *Niederschrift über die Besprechung Seifert-Fennel-Schiebold vom 17. April 1943* ('Transcript of the Seifert-Fennel-Schiebold discussion on 17th April 1943') in Hamburg, NES ♯75 to 77.
8. Waloschek: '*Todesstrahlen*'.
9. Waloschek: '*Todesstrahlen*'.
10. '*Schiebold's braune Sciencefiction',* 2004 Leipziger Volkzeitung 16th/17th April 2004, review of Pedro Waloschek's book '*Todesstrahlen als Lebenretter*' ('Death-rays as Lifesavers'), 2004.
11. Waloschek: *Todesstrahlen.*
12. Waloschek: *Todesstrahlen.*
13. Luisa Bonolis and Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Frascati, Italy. 'Bruno Touschek: Particle Physicist and Father of the $e^{+}e^{\div}$ Collider', 14th March 2011. Letter from Bruno Touschek to his parents 17th November 1945. The letter was translated into English by Giulia Pancheri.
14. Waloschek: *Todesstrahlen.*
15. Pedro Waloschek, who had met several former employees when he was writing the book about Schiebold's death-ray project, in conversation with me in connection with my book.
16. Luisa Bonolis and Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Frascati, Italy. 'Bruno Touschek: Particle Physicist and Father of the $e^{+}e^{\div}$ Collider', 14th March 2011. Letter from Bruno Touschek to his parents 17th November 1945. The letter was translated into English by Giulia Pancheri.
17. ETH Library Zurich HS 903:203, Letter from Touschek to Widerøe 29th March 1946.
18. ETH Library Zurich HS 903: 28, Kollath: '*Bericht über die Arbeiten am Betatron in Wrist für die Zeit vom Mitte November bis Mitte Dezember 1945',* ('Report of the work on the betatron at Wrist for the period from mid November to mid December 1945') *'MV-Forschungs-Vereinigung',* Wrist, 11.12.1945.
19. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum Vitae' (English translation) sent to T-Force 1st February 1946.

20. AB 12/4 ACAE Nuclear Physics Sub-Committee Accelerating Systems Panel: minutes 1945–1946.
21. British Army of the Rhine (BAOR) was the new name for what was originally called Supreme Headquarters Allied Expeditionary Force (SHAEF), led by Field Marshal Montgomery and established in London in July 1943. SHAEF had consisted mainly of British and Canadian troops and had been responsible for Operation Overlord, the codename for the overall plan for the liberation of North-West Europe that started with D-Day and the invasion of Normandy. From June 1944 until the end of the war the group was called the 21st Army Group and operated in Northern France, Luxembourg, Belgium, the Netherlands and Germany. After the war, the name of the force changed to BAOR and it continued to be called by this name throughout the Cold War. (In some countries a Field Marshal is the highest military rank, above a general. In Germany and some other countries the equivalent rank is called General Field Marshal.)
22. National Archives FO 1032/230. Subject: Hollnack. 7A: 20th Feb. 1946. To Brigadier C.F.C. Spedding. Written by Colonel F. Read, Mil. Gov. Econ 4 (Research), Block L., Mudra Barracks, Minden, B.A.O.R.
23. All documents in the National Archives have a reference number with three parts: a departmental code, for example WO for War Office; a category code which usually has three digits; and an individual number that usually has four or five digits. Older documents can differ in the number of digits.
24. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum Vitae' (English translation) sent to T-Force 1st February 1946. 2A: Translation 6th February 1946 Sign. Econ. 5A: Translations. 7th February 1946. Chief Interpreter. 5B: Covering sheet 7th February 1946.
25. Luisa Bonolis and Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Frascati, Italy. 'Bruno Touschek: Particle Physicist and Father of the $e^+e^{\div}$ Collider', 14th March 2011. Letter from Bruno Touschek to his parents 17th November 1945. The letter was translated into English by Giulia Pancheri.
26. National Archives FO 1032/230 Hollnack: 7A: 20th Feb. 1946. To: Brigadier C.F.C. Spedding. Written by Colonel F. Read, Mil. Gov. Econ 4 (Research), Block L., Mudra Barracks, Minden, B.A.O.R. Report of visits to Hamburg 28th Jan and 4th Feb 46.
27. National Archives FO 1032/230 Hollnack. 6A: Letter to Read. Subject: Mr. Hollnack. 25.2 1946. From Major Coleman, ASO, Hamburg. FO 1032/230 Hollnack. 6B German (English without a number). To Read. Letter. Written in Kellinghausen 18 Feb. 46 From Hollnack.
28. National Archives FO 1032/230 Hollnack. 8A: To Coleman. From Read. 20.3 1946. For the attention of Major Coleman. Written by F. Read, controller, Research Branch.

29. Letters from Touschek to Widerøe 29th March 1946, ETH Library Zurich Hs 903: 203; 20th May 1946 Hs 903: 205; 28th September 1946 Hs 903: 212; 19th November 1946 Hs 903: 207; 6th April 1957 Hs 903: 215.
    Letters from Kollath in Wrist/Kellinghausen/Hamburg to Widerøe 30th March 1946 ETH Library Zurich Hs 903: 119; 30th May 1946 Hs 903: 120; 14th July 1946 Hs 903: 124; 20th July 1946 Hs 903:126; 21st July 1946 Hs 903; 127; 29th August 1946 Hs 903: 130; 4th September 1946 Hs 903: 129.
    Letter from Widerøe to Kollath 16th September 1946 ETH Library Zurich Hs 903: 131.
    Letter from Meyer-Delius in BBC to Widerøe 7th August 1947 ETH Library Zurich Hs 903: 234.
    Letters from Kollath in London to Widerøe 1947–1948 ETH Library Zurich Hs 903: 138–160.
    Letters from Kollath in Hamburg to Widerøe 1951–1953 ETH Library Zurich Hs 903: 408–432.
    Letter from Widerøe to Sommerfeldt 14th June 1952 ETH Library Zurich Hs 903: 508.
    Letter from Sommerfeldt to Widerøe 17th June 1952 ETH Library Zurich Hs 903: 509.
    Letters from Seifert to Widerøe 1951–1953 ETH Library Zurich Hs 903: 486–504.
    Letters from Wolfgang Gentner to Widerøe 1950–1953 ETH Library Zurich Hs 903: 346–352.
30. In the biography it is said that Kollath followed the betatron to London around the turn of the year 1945/46. However, this does not tally with the information in Kollath's letters to Widerøe in the period 1946-1948.
31. National Archives FO 1032/230 Hollnack. 9C: Attachment 1: 3rd July 46. written by Major A. Battegal for Lt. Col. 16 (Hamburg) Int. Office: Thedor Hollnack—to whom it may concern.
32. National Archives FO 1032/230 Hollnack. 9C: Attachment 2: 25th July letter from Major Wallis to Dr. Eng. R. Kollath, Hamburg-Fuhlssbüttel, Erdkampsweg 16.
33. National Archives FO 1032/230 Hollnack. 9B: To Read from Hollnack, German version, 20.10.1946 on Hollnack's own writing paper.
    FO 1032/230 Hollnack. 9A To Read from Hollnack, English version 22.10.1946, also on Hollnack's own writing paper. (Does this mean that he had written the English version himself?) On the English version the name 'Groves' is hand-written at the top of the sheet. This might be a coincidence, but Leslie Groves was the name of the leader of the American Manhattan Project that developed the first atom bomb.
34. National Archives FO 1032/230 Hollnack. To Hollnack. Subject: Graded Scientists. 12th April 1948. Signed by Barnes.

35. National Archives FO 171/5211: 'T-Force intelligence summary for period 2nd May to 10th May 1945'.
36. Letter 22nd June 1945.
37. ETH Library Zurich HS 903:203 Touschek in letters to Widerøe 29.03.46 and 20.05.46.
38. Folder marked 'Alsos' (material gathered by Captain Gunnar Randers), in Niels Bohr Archives, American Institute of Physics. 'Visit to Widerøe in Olso. July 1945. Capt. G. Randers'.
39. The letter was dated Kellinghausen 9th June 1945 and was formally addressed to 'T-Force, 2. Britische Armee, Hamburg.'
40. Niels Bohr Archives, American Institute of Physics: 'Protokoll *MV-Forschungs-Vereinigung*/MV Research Association.' Alsos/Capt. G. Randers: Re: Betatron (for further evaluation).
41. The following are named in addition to Rolf's close co-workers: Schulz (workshop foreman); Flegel (laboratory engineer); fru Gärtke (office worker), frk. Goos (laboratory assistant); Rümling (mechanic); Luhn (mechanic); and frk. Lindemann and Walter (instrument makers). The last four of these are listed as Seifert's co-workers. The day to day manager is dipl.eng. Wernwer Bartelt. The following are listed in the administrative management: Januszak; Köchig, frk. Borchedt; frk. Lochmann; frk. Lucas and Klyne (?) (indistinctly). In addition, Hollnack has his own secretariat consisting of frk. Blome; Kirchner; frk. Bernhardt; Overbeek and Helffenbein/Meier/Vrana.
42. Niels Bohr Archives, American Institute of Physics, Attachment I-1-2, Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
43. Niels Bohr Archives, American Institute of Physics, 'No. 1. Report," Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
44. Niels Bohr Archives, American Institute of Physics: '*Bericht über die historisch-organisatorische Entwicklung des Entwicklungsvorhaben Dr. Widerøe, Oslo, in Deutschland*' ('Report on the historical and organisational development in Germany of the development project led by Dr. Widerøe of Oslo.')

    'Protocol' (Foundation document with 13 appendices).

    '*Tätigheitsbericht und Programm für die Weiterarbeit der MV-Forschungs-Vereinigung/MV Research Organisation. Bericht über den Strahlentransformator nach Dr Widerøe.*' ('Activity report and programme for the further work of the MV-Forschungs-Vereinigung/MV Research Organisation. Report on the radiation transformer after Dr. Widerøe.')

    '*Für die in der MV-Forschungs-Vereinigung betriebene Entwicklung sind und waren folgende Mitarbeiter Tätig*' (List of workers).

    All the documents are in the Alsos folder, Capt. G. Randers: Re: Betatron for further evaluation.

45. Niels Bohr Archives, American Institute of Physics: '*Beschlussfassung*' ('Decision') Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
46. Similar letters to Prof. Dr. Heisenberg and Prof. Dr. Bothe, Niels Bohr Archives, American Institute of Physics, Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
47. Letter with invitation sent to 10 professors, Niels Bohr Archives, American Institute of Physics, Alsos/Capt. G. Randers: Re: Betatron for further evaluation. Thomas Powers: Heisenberg's War, 1993.
48. Niels Bohr Archives, American Institute of Physics, Attachments II-1-11 and II-1-12, Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
49. Niels Bohr Archives, American Institute of Physics: '*Einladung eines Englischen Wissenschaftlers des einschlägigen Gebietes zur Mitarbeit*' ('Invitation to an English scientist in the relevant field to work together') (Prof. Dr. Bragg), Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation'.
50. ETH Library Zurich HS 903:203 Touschek in letters to Widerøe 29.03.46 and 20.05.46. Letter from Touschek to his father 17.11.45, Louisa Bonolis and Dr. Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Italy. 'Bruno Touschek: Particle Physicist and Father of the $e^{+}e^{\div}$ Collider,' 14th March 2011. Letter from Bruno Touschek to his parents 17th November 1945. The letter was translated into English by the Italian Professor Dr. Giulia Pancheri.
51. 'Moonraker,' 1955.
52. Sean Longdens T-Force: 'The Race for Nazi War Secrets,' 1945. Constable. London. 2009. 'How T-Force Abducted Germany's Best Brains for Britain.' By Ian Cobain. The Guardian, 29th August 2007. How Britain Put Nazi's Top Men To Work. By Stewart Payne. The Telegraph, 30th August 2007. Tom Bower: 'The Paperclip Conspiracy: The Hunt for the Nazi Scientists,' Little, Brown, 1987.
53. T-Force units were linked to three army groups on the Western Front: Sixth United States Army Group, 21st Army Group and 12th Army Group.
54. The 6860th Headquarters Detachment Intelligence Assault Force (from the Internet).
55. Tom Bower; 'The Paperclip Conspiracy: The Hunt for the Nazi Scientists,' Little, Brown, 1987.
56. Ian Cobain, The Guardian 29th August 2007.
57. Bruno Touschek in a letter to *Geheimrat* Professor Dr. A. Sommerfeld 28th September 1945. The letter was translated into English by the Italian Professor Giulia Pancheri.
58. Luisa Bonolis and Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Frascati, Italy.'Bruno Touschek:

Particle Physicist and Father of the $e^{+}e^{\div}$ Collider', 14th March 2011. Letter from Bruno Touschek to his parents 17th November 1945. The letter was translated into English by Giulia Pancheri.

59. The National Archives: WO 171/5211: 'T-Force Intelligence Summary for period 2nd May—10th May 1945.' Closed until 2046. Cancelled. 620/1. 5th British Kings Regt. Pkt. 1.
60. The people who *had* been interviewed were Otto Gundermann (administrator/manager?) and Dr. Ritz (research director). The people who *should* be interviewed were Deert Jacobs (research director), Alfred Kun(t)ke (high voltage physicist) and Dr. Müller (electron optics).
61. 6th May 1945: Radio tube experts F/Lt. F.R. Holt M.A.P. and Captain W.H. Horner R.A., and 7th May: Major J.H. Arthur, U.S. Signal Corps; Lt/Com De Baun U.S.N.; F/Lt. E.R. Holt M.A.P., Lt L. Strauss U.S.N.R.
62. Eval. Report 534 (b): 18th June 1945. Interrogation of Albert Speer. Target No 28/5.01. 3rd Session—11.00 to 12.30, Tuesday 29th May 1945. Sign Hausell, Slatery, Sanabria. 'Bode' is named, but perhaps that should be 'Bothe.' There was a Volkhard Bode who together with Gerhard Kaiser wrote *Raketenspure: Peenemunde 1936–1944*, ('Missile Tracks: Peenemunde 1936–1944') Berlin 1995.
63. WW2 European Theater Army Records, Historical Division: Records, 1941–1946, p. 53, NARA, Record Group 498, 2011.
    Cyclotron Investigation Heidelberg, Item no. 21&24, file no. XXIX-47, Combined Intelligences Operatives Sub-Committee (CIOS).
64. National Archives WO 232/92: Subject: BIOS and FIST field team reports. Jan–Jul 1946. (With the date 3.3.1978 handwritten on the cover.) Summary no. 7 of reports from BIOS Field Teams 6th February 1946. Group 2 Metallurgy: 'Visit to "C.H.F. Müller," reported by C.G. Lloyd 8 Oct 1945. Group 1': Ultra-sonic research and development in x-ray equipment Siemens-Reiniger Werke A.G. Erlangen. Reported by G.J. Thiesen. A visit to I.G. Farben is also mentioned.
65. Written by the German atomic physicist Wolfgang Paul, later Nobel Prize winner, and Hans Kopfermann, who both were connected with the early years of CERN.
66. National Archives FO 1032/230 Hollnack 2a and 3a pkt. 10.
67. Niels Bohr Archives, American Institute of Physics, Alsos/Capt. G. Randers:
    Re: Betatron for further evaluation, Progress Report. Attachment II-2. *Tätigkeitsbericht und Programm für die Weiterarbeit der 'MV-Forschungs-Vereinigung.'* ('Progress Report and Programme for the Further Work of the 'Megavolt Research Organisation') Kollath 6.6.45.
68. According to Dr. Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Italy.

69. *Archiv für Elektrotechnik. Der Strahlentransformator (1. Teil)* ('The Radiation Transformer, Part 1'), submitted 15.09.42 marked *Geheime Reichssache!* ('State Secret') *Der Strahlentransformator II* ('Radiation Transformer II'), submitted 12.07.43.
70. *Zur Theorie des Strahlentransformators* ('On the Theory of Radiation Transformers'), Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
71. Letters from Touschek to Widerøe 29th March 1946, ETH Library Zurich HS 903:203; 20th May 1946 Hs 903:205; 28th September 1946 Hs 903:212; 19th November 1946 Hs 903:207.
    Letters from Kollath to Widerøe 30th March 1946 ETH Library Zurich Hs 903:119; 30th May 1946 Hs 903:120; 14th July 1946 Hs 903:124; 20th July 1946 Hs 903:126; 21st July 1946 Hs 903:127; 29th August 1946 Hs 903:130; 4th September 1946 Hs 903:129.
72. It says in the biography that Rolf returned home to Norway in March but this can't be right, because he was still in Hamburg on 11th April. The quotation from Touschek is taken from his letter to his father on 17th November 1945.
73. Touschek in a letter to his father 17th November 1945.
74. Touschek in a letter to his parents 22nd June 1945.
75. Touschek in a letter to his parents 22nd June 1945.
76. Hollnack: *Bericht über die historisch-organisatorische Entwicklung* ('Report of the historical and organisational development') Written for T-Force 9.6.45. Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
77. The report says 5 MeV, but it is probably meant to be 15.
78. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum vitae' (English translation) sent to T-Force 1st February 1946, Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
79. Samuel Goudsmit: Alsos, p. 240.
80. Hollnack: *Bericht über die historisch-organisatorische Entwicklung* ('Report of the historical and organisational development') Written for T-Force 9.6.45. Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
81. The biography.
82. Rudolf Kollath's obituary, Phys. Today 31 (12), 73 (1978); https://doi.org/10.1063/1.2994891. Widerøe in the interview with the physicists.
83. The interview with the physicists.
84. Jomar Brun: *Brennpunkt Vemork 1940–1945* ('Focal Point Vemork'), p. 31, *Universitetsforlaget* 1985.
85. Jomar Brun: *Brennpunkt Vemork 1940–1945* ('Focal Point Vemork'), pp. 28–31, *Universitetsforlaget* 1985.

86. Waloschek: *Todesstrahlen.*
87. Waloschek: *Todesstrahlen.*
88. Waloschek: *Todesstrahlen.*
89. Hollnack: *Bericht über die historisch-organisatorische Entwicklung* ('Report of the historical and organisational development') Written for T-Force 9.6.45. Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
90. National Archives FO 1032/230, Hollnack, 2A and 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum vitae' (English translation) sent to T-Force 1st February 1946.
91. National Archives FO 1032/230. 3A: '*Daten und Tätigheit*' ('Dates and Activity') and 4A 'Curriculum vitae' (English translation) sent to T-Force 1st February 1946. pkt 9.
92. The biography.
93. *Kratzenstein, H.: PB1755is21* (V-200) *Praxis zerstörungsfreier Werkstoff Prüfung* ('The practice of non-destructive examination of materials'). Text in German 1941. FIAT FR536, Supp.21. IP $.25. PB81500. Department of Commerce. W. Averell Harriman, Secretary: 'Classified List of OTS Printed Reports.' A List of Reports on German and Japanese Technology Prepared by American Investigators Which Are Available in Printed Form From the Office of Technical Services. Property of Technical Reports Section. Science and Technology Division. Library of Congress. Office of Technical Services. John C. Green, Director. Compiled by O. Willard Holloway and Oliver B. Isaac. Reports Division. October 1947.
94. Egerer and others. PB 17551-S12 (V-200) Rb'ntgenraumsicht (Stereoscopic X-rays). Aug 1914. FIAT FR 5345, Supp. 12. 2p $.25. [That is how it is written.]
95. '*Widerstand in Berlin gegen das NS-Regime 1933 bis 1945*'—A biographical dictionary in 12 volumes, *ISBN 3-89626-350-1, Trafo Verlag* 2002–2006. Kratzenstein, Hermann; 21.1.1893 -? is listed in Volume 4.
    http://www.trafoberlin.de/widerstand_in_berlin/Widerstand_startseite.htm Editor Dr. Hans-Joachim Fieber. Publisher: *Geschichtswerkstatt der Berliner Vereinigung ehemaliger Teilnehmer am antifaschistischen Widerstand, Verfolgter des Naziregimes und Hinterbliebener (BV VdN) e.V.* In the foreword it says:
    'The biographical dictionary "*Widerstand in Berlingegen das NS-Regime 1933 bis 1945"* was published between June 2002 and June 2006. This biographical dictionary is so far unique among publications about resistance to the Nazi regime in Berlin, and indeed among publications about resistance to the Nazi regime in general. For the first time—so far as is known till now—over 13,000 people were named who had shown opposition to Hitler's regime in Nazi Germany's capital city between 30th January 1933 and 8th May 1945, with whatever political intention and in

whatever way, in whatever circumstances and irrespective of whether they had been born in Berlin or elsewhere.'
Kratzenstein is named in volume 4. Egerer is named in volume 4, p. 157. (I assume that H. Kratzenstein is identical with Hermann Kratzenstein.)
There is also a Marius Kratzenstein in Hamburg, who wrote about similar themes, including an article in *Zeitschrift für Physik,* Volume 93, Number 5, 6th May, 1935. As Kratzenstein's forename is not given, it could alternatively be him.

96. Arnold Kramish: 'The Griffin. The Greatest Untold Espionage Story of World War II,' Houghton Mifflin Company, Boston, 1986.
97. The Security Service in Britain, known as MI5 (Military Intelligence, Sect. 5), looks after inland counterespionage and security. The Secret Intelligence Service (SIS or MI6) deals with threats from abroad.
98. In e-mail from Arnold Kramish 16th October 2009. In an e-mail on 11th September that year he also asked me to pass greetings on to Olav Riste, historian and expert on Norwegian secret services, with whom he had been in contact while working on his book about the spy Paul Rosbaud.
99. Svein Sæter: *Spion I Hitlers rike. Student og agent Sverre Berghs dramatiske dobbeltliv* ('A Spy in Hitler's State. The Dramatic Double Life of Student and Agent Sverre Bergh.'), Damm, Oslo 2006.
100. Theo Finndahl.
101. Victor Goldschmidt.
102. Edgeir Benum: *En forskerskole bygges. Odd Hassel og strukturkjemien 1925–1943* ('Building a Research School. Odd Hassel and Sructural Chemistry 1925–1943') *Historisk tidskrift* vol. 88, pp. 639–670*, Universitetsforlaget 2009.* Kramish 1986 (Norwegian edition): 42–43, 64, 69, 79–80, 83–85, 110, 133, 157, 178–180, 197, 224.
103. Jomar Brun: *Brennpunkt Vemork 1940–1945* ('Focal Point Vemork'), p. 31, *Universitetsforlaget* 1985.
104. R.V. Jones: 'Most Secret War. British Scientific Intelligence 1939–1945,' Hamish Hamilton, London 1978.
105. Arvid Broderson: *Siemens direktøren—Oslo-rapporten* ('The Siemens Director—The Oslo Report'), *Forskningspolitikk* ('Research Policy') 2/1994. Broderson was professor at the New School of Social Research in New York.
106. R.V. Jones: 'Most Secret War. British Scientific Intelligence 1939–1945,' (1978) and 'Reflections on Intelligence' (1989).
107. 'Die deutsche Regierung hat den Führingsanspruch auf Europa proklamiert. Ich habe es im Rahmen der mir selbst gezogenen Grenzen führenden Männern Deutschland klargemacht und werde es weiterhin tun, dass ein Anspruch auf eine solche Führung sich nicht ständig auf Bajonette stützen kann, sondern dass wir der Weilt zuerst unseren Geist entgegenzusetzen haben.'

('The German Government have proclaimed their right to the leadership of Europe. I have explained to leading personalities in Germany, within my own self-delineated limits, and will continue to do so, that a claim to such leadership cannot base itself permanently upon bayonets, but that we have first to impose our spirit upon the world.') [Official translation, in archive material].

108. Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
109. Letter to T-Force from Hollnack 9th June 1945, Alsos/Capt. G. Randers: 'Re: Betatron for further evaluation,' Niels Bohr Archives, American Institute of Physics.
110. ETH Library Zurich HS 903:203, Letters from Touschek to Widerøe 29.3.46 and 20.5. 46.
111. The Swiss editor Karl Meyer.
112. Jacov Lind, *Selbstporträt* ('Self-portrait'). S. Fischer, London, 1970, p. 147.
113. Touschek's autobiography, p. 158.
114. Touschek's autobiography, p. 160.
115. ETH Library Zurich HS 903:203, Letters from Touschek to Widerøe 29.3.46 and 20.5. 46.
116. Question from Jan Vaagen, transcript of interview.
117. Randers: *Lysår* ('Light Years'), Gyldendal, 1975, p. 75.
118. Samuel A. Goudsmit: Alsos (Samuel A. Goudsmit American institute of Physics Woodbury, New York Library of Congress Cataloging-in-Publication Data ISBN 1-56396-415-5).
119. Goudsmit, pp. 77–80 and Thomas Powers: 'Heisenberg's War,' pp. 411–412.
120. Goudsmit, pp. 112–113.
121. Goudsmit, pp. 120–121.
122. Randers: *Lysår* ('Light Years'), p. 76.
123. Randers: *Lysår* ('Light Years'), p. 86.
124. Hans Skoie: *Norge—en atommakt?* ('Norway—an Atomic Power?') Forskningepolitikk 2/2006. Olav Njølstad: *Jens Chr. Hauge—Fullt og helt,* Aschehoug, 2008.
125. Olav Njølstad: *Jens Chr. Hauge—Fullt og helt,* Aschehoug, 2008.
126. Olav Njølstad: *Jens Chr. Hauge—Fullt og helt,* Aschehoug, 2008.
127. Roland Wittje (Dr. philos.—history of science and technology) History of Science Unit, University of Regensburg, Germany: 'Nuclear Physics in Norway, 1933-1955,' *Physis in Perspektive* ('Physics in Perspective'), Birkhäuser Verlag, Basel, 2007, pp. 406–433.
128. Olav Wicken to the newspaper *Forskning* ('Research'), no. 6, 1997. Olav Wicken and Olav Njølstad: *Kunnskap som våpen. Forsvarets forskningsinstitutt 1946–1975* ('Knowledge as a Weapon. The Defence Research Institute 1946–1975'), Tano Aschehoug, 1996.

129. Asbjørn Barlaup (ed.): *Norges Teknisk-Naturvitenskapelige Forskningsråd 1946–1956* ('The Norwegian Technical and Scientific Research Council 1946–1956').
130. David Cassidy in the foreword to the 1996 edition of Goudsmit's book, 'Alsos'.
131. David Bodanis: *En biografi om verdens mest berømte ligning*, Gyldendal, 2001. Original title: $E = mc^2$ A Biography of the World's Most Famous Equation, Walker Publishing Company, Inc., USA, 2000.
132. Goudsmit, p. 123.
133. Goudsmit, p. 125.
134. Erik Bagge, Kurt Diebner, Walther Gerlach, Otto Hahn, Paul Harteck, Werner Heisenberg, Horst Korsching, Max von Laue, Carl Friedrich von Weizsäcker, Karl Wirtz.
135. Otto Hahn.
136. Bernstein, Jeremy (2001). Hitler's Uranium Club: the secret recordings at Farm Hall. New York: Copernicus. p. 281. ISBN 0-387-95089-3.
137. BBC Radio 4, 15th June 2010 in 'Nuclear Reactions,' written by Adam Ganz.
138. Thomas Powers: Heisenberg's War. The secret story of the German bomb, 1993. Samuel Goudsmit: Alsos.
139. Eric Tunstad, 12th September 2002, http://www.forskning.no/Artikler/2002/september/1031815152.4.
140. Goudsmit pp. 138–139.
141. Randers, p. 79.
142. Randers, p. 77.
143. Goudsmit, p. 140.
144. Goudsmit, p. 147.
145. Goudsmit, p. 154.
146. 'Report of the visit to Widerøe in Oslo, July 45. By Capt. G. Randers R.N.A. of ALSOS,' Niels Bohr Archives, American Institute of Physics.
147. 'Interview with Dr. Widerøe in Oslo, July 1945,' Niels Bohr Archives, American Institute of Physics. The questions and answers in this document appear again later in the form of Documents 14 and 15 in the case folder in the Norwegian National Archives Treason Section.
148. 'Arrangement for Introducing Electrons into a Radiation Transformer (Betatron)'.
149. Patent Claims. Originally written by Rolf and translated from Norwegian into English, probably by Randers. Dated Oslo, 11th July 1945, a rough page, in 10 points.
150. Copies of papers:
    (1) *Bericht über die Entwickelung von Strahletransformatoren* ('Report of the development of the radiation transformer') by Widerøe 27/2/44.

(2) *Angaben* ('Information') *for Dr. Boersch* (who was the electron optics man in Vienna) 13/3/44.
(3) *Bericht über den Besuch bei B.B.C. vom 27 bis 29 April 1944* (Report of the visit to Brown Boveri Company from 27th to 29th April 1944), by Widerøe.
(4) Comparative figures from Kerst's 20 and Widerøe's 15 MV apparatus, 9/6/1944.
(5) *Theoretischee Untersuchungen für das MV-Verfahren in Hamburg während der Zeit May bis September 1944* ('Theoretical examination of the MV Process in Hamburg during the period May to September 1944'). A summary by Widerøe and Touschek.
(6) *Über die Erzeugung von Röntgenstrahlen* ('About the generation of X-rays'), by Widerøe 8/2/44, Niels Bohr Archives, American Institute of Physics.

151. Rolf Widerøe: *Denkschrift über die Weiterentwicklung des Strahletransformators* ('Thoughts about the further development of radiation transformers'). A 10 page technical description of the15 MV and 200 MV betatrons, Oslo, 17.9.43, Niels Bohr Archives, American Institute of Physics.
152. List of contents of microfilms:
(1) Complete summary and description in detail of Widerøe's radiation transformer (betatron) written by Widerøe during his stay in Ilebu concentration camp near Oslo during May, June and July 1945. (Both the theoretical and the practical questions of construction are included. The paper was not considered by Widerøe as completed yet. This probably means mainly that his new ideas have not been worked out. Also figures are missing; these may be obtained, if wanted, from Widerøe in a month or so, according to his own estimate.)
(2) Document written by Professor Bothe.
(3) Letter dated 12/12/1944 from Widerøe to Prof. Kuhlenkamp.
(4) Letter dated 19/10/1944 from Heisenberg to Widerøe (suggesting 150MV as target for the big betatron).
(5) Report up to 15/9/44 on the progress of the betatron work.
(6) Letter report Widerøe to Col. Geist 15/12/44.
(7) Report from meeting in Erlangen 31/10/44 by Widerøe.
(8) Report on conference at B.B.C Heidelberg 2/11/44.
(9) *Der Ablenktheorie der Schleuderelektronen* ('The theory of electron beam deflection') by Dänzer 19/1/1945.
(10) *Bemerkungen zur Vorstehenden Arbeit* ('Comments on the above-named work') by Bothe.
(11) *Die elektrostatische Stabilusierung*), *Die Lisenstrasse* ('Electrostatic stabilisation, The road to patenting') by Dr. Müller 29/11/43.
(12) *Führungsproblem der Elektronen* ('The problem of steering electrons') by Touschek.

(13) *Die magnetische Fokusierung* ('Magnetic focussing') by Touschek.
(14) *Die Maximalverteilung* ('Maximum distribution') 8/1/44, by Touschek.
(15) *Zur Theorie der Wideröeschen Strahlungstransformator* ('On the theory of Widerøe's radiation transformer') by Touschek.
(16) *Theorie des ebenen Einschiessens* ('The theory of destroying planes from the ground') and *Wahrscheinlichkeitsbetrachtungen zum vorgang des Einschiessens* ('Probability considerations in relation to shooting.') by Touschek 5/12/1944.
(17) *Theorie des Einschiessvorganges* ('Theory of shooting') and *Wachtstumseffekte* ('The growth effect') probably by Touschek, Niels Bohr Archives, American Institute of Physics.

153. National Archives FO 1032/30. 3A *Daten und Tätigheit* ('Dates and activity') and 4A Curriculum Vitae (English translation) sent to T-Force 1st February 1946, pkt. 9.
154. Jacov Lind: *Selbsporträt* (Self-portrtait).
155. Tor Brustad; Why is the Originator of the Science of Particle Accelerators so Neglected, Particularly in his Home Country? Extended version. Scandinavian University Press 1998. ISSN 0284-186X footnote 24. (An abridged version of this paper, without inter alia, is in press in *Acta Oncologica* 1998, 37.)
156. Why is the Originator … Footnote 25.
157. Why is the Originator … Footnote 26: An interrogation carried out by advocate G.B. Dreyer on 4th July 1946 revealed the following: 'During the whole of spring and summer 1943, the interviewee explained that in negotiations with BB&C in Switzerland he had agreed to sell the company patents, so that via Switzerland these could be patented in English-speaking countries. This opportunity disappeared when the German countries confiscated the patents (…).'
158. Hollnack: *Bericht über die historisch-organisatorische Entwicklung* ('Report on the historical and organisational development') written for T-Force. 9.6.45.
159. National Archives FO 1032/30. 3A *Daten und Tätigheit* ('Dates and activity') and 4A Curriculum Vitae (English translation) sent to T-Force 1st February 1946, 8, Niels Bohr Archives, American Institute of Physics: Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
160. Kramish p. 148.
161. *Reichmarchall des Grossdeutschen Reiches/Präsident des Reichforschungsrat/der Bevollmächtige* (The rest of the letter-heading is illegible): Letter to Bothe and Widerøe 4th December 1944. Niels Bohr Archives, American Institute of Physics: Alsos/Capt. G. Randers: Re: Betatron for further evaluation.
162. Kramish p. 148.
163. The interview with the physicists.

164. Letter from NEBB to High Court Advocate Oscar de Besche 12th June 1946.
165. Note of the interview of Rolf Widerøe by Junior Police Prosecutor G.B. Dreyer 4th July 1946.
166. Letter from Rolf Widerøe to S.A. Solberg 22nd January 1946, ETH Library Zürich, HS 903:79–80.
167. Rolf Widerøe: *Bericht über die Entwicklung von Strahlentransformatoren* ('Report on the development of the radiation transformer'), 27th February 1944. ETH Library Zürich, Hs 903:49.
168. Rolf Widerøe: *Berichte über Besuche bei BBC in Weinheim vom 27. bis 29. April 1944* (Report of the visit to BBC in Weinheim from 27th to 29th April 1944), written on 1.5.44, ETH Library Zürich, Hs 903: 62 and 63.
169. Rolf Widerøe: *Niederschrift* ('Notes'), Heidelberg 29th April, dated 2nd May 1944.
170. In conversation with Pedro Waloschek. The thee others were Kade, Weiss and Kneller.
171. BBC note: *Grosser Strahlentransformator Wideröe, Besprechung in Heidelberg am 30.6.44* ('Widerøe's larger radiation transformer, discussions in Heidelberg on 30.6.44'). BBC-note *EB-Bericht nr 71—'Geheim'.* ('EB-report no. 71 - Secret'). Written by *Böcker,* who was responsible for the project in BBC. Dated 3rd July 1944. The note states that the relevant department will write a separate report of the technical discussions with Widerøe on 1st July. Niels Bohr Archives, American Institute of Physics.
172. Theodor Hollnack: Über Besprechung am 30.6.44 bei BBC Heidelberg. Geheim ('Regarding discussions on 30.6.44 at BBC Heidelberg. Secret'). Dated 3rd July 1944, Niels Bohr Archives, American Institute of Physics.
173. The people who received the note were Director Deichmann and Dr. Kade, and also the departments Gr v/Martens, Hfk v/Weiss and EB v/Dr. Böcker.
174. BBC note: Concerning: *Strahlentransformator Wideröe. Geheim* ('Widerøe's radiation transformer. Secret'). Written by Meyer-Delius. Dated 7th July 1944, Niels Bohr Archives, American Institute of Physics, Alsos/Capt. G. Randers: Re 'Betatron for further evaluation.'
175. Otto Weiss and Helmut Böcker.
176. BBC note. *EB-Bericht nr. 71/1* ('E.B. Report no. 71/1'). Böcker. Mannheim, 20th December 1955.
    Concerning: Radiation transformer 15 MeV. Discussions at C.H.F. Müller, Hamburg-Fuhlsbüttel, Niels Bohr Archives, American Institute of Physics.
177. Letter from Rolf Widerøe to BBC Director Meyer-Delius, Heidelberg, Hamburg, 12th February 1945, Alsos/Capt. G. Randers: Re: Betatron for further evaluation, Niels Bohr Archives, American Institute of Physics.
178. The Brown Boveri Review: 'New designs of transformers and choke coils,' no. 3, March 1945.

179. Kaiser, H.F. (U.S. Naval Research Lab., Washington, D.C.): 'European Electron Induction Accelerators,' Journal of Applied Physics. 18, 1-17 (1947).
180. According to RW there was no BBC representation in Heidelberg at that time. One of the directors lived there, and a few meetings were held in Heidelberg. (Pedro Waloschek).
181. The biography.
182. This refers to the plan Rolf wrote on 6th November 1943.
183. Kaiser, H.F. (U.S. Naval Research Lab., Washington, D.C.): 'European Electron Induction Accelerators,' Journal of Applied Physics. 18, 1–17 (1947).
184. The 6860th Headquarters Detachment Intelligence Assault Force (T-Force).

    Les Hughes. 1997. Hochwald, Jack, 'The U.S. Army T-Forces: Documenting the Holocaust,' American Jewish History, Vol. LXX, No. 3, March 1981.
185. *Brown Boveri Hauszeitung* 1972, No. 2.
186. *Sonderdruck Technikgeschichte,* Band 55 (1988) *Hft 1, VDI Verlag, Anmerkung* 15.
187. Gordon Fraser (author), Egil Lillestol (author), Inge Sellevag (author), Stephen Hawking (introduction): *Auf der Suche nach dem Unendlichen* ('The Search for Infinity: Solving the Mysteries of the Universe') Among others, the Japanese Hideki Yukawa developed Heisenberg's theories further.
188. Goudsmit p. 254.
189. *Sonderdruck Technikgeschichte,* Band 55 (1988) *Hft 1, VDI Verlag, Anmerkung 87.*
190. Speer: *Erinnerungen* ('Memories'). Frankfurt/M 1969, p. 240. *Zur Politik des HWA genüber dem Uranverein vgl.* Walker, M: p. 67ff. (*Sonderdruck Technikgeschichte,* Band 55 (1988) *Hft 1,VDI Verlag, Anmerkung* 88).
191. *Sonderdruck Technikgeschichte,* Band 55 (1988) *Hft 1, VDI Verlag, Anmerkung 89.*
192. Operation Epsilon: *Jakten på Tredje Rikets atomhemligheter* ('The Hunt for the Third Reich's Atomic Secrets'), tomaslindblad.se (Swedish freelance science journalist).
193. The advice came from Paul Harteck at the University of Hamburg, one of the researchers Rolf later came to know.
194. Rainer Karlsch: 'Hitler's Bomb.' *Die geheime Geschichte der deutschen Kernwaffenversuche Deutsche Nuklearwaffenforschung.* ('The Secret History of the German search for a nuclear weapon; German Nuclear Weapon Research'). DVA, 2005. 416 pages. ISBN 3-421-05809-1. (http://sandammeer.at/rezensionen/hitlersbombe.htm).
195. Esau, A: *Ergebnisbericht der Arbeitsgemeinschaft Nutzbarmachung der Atomkernenergie vom 24.11.1942* ('Report of the results from the working

party on atomic energy from 24.11.1942'). Esau, A: *Bericht über den Stand der Arbeiten auf dem Gebiet der Kernphysik vom 1.6.43* ('Report on the state of the work in the field of nuclear physics from 1.6.43'), Irving Papers, *Sondersammlungen des Deutschen Museums* ('German Museum Collections').

196. *Sonderdruck Technikgeschichte,* Band 55 (1988) *Hft 1, VDI Verlag, Anmerkung 93: Bothe baute in seinem Institut an einem Betatron, das vom Oberkommando der Wehrmacht gefördert wurde. Vgl. Bothe Nachlass 62, Bothe an Vogler am 20.1.1943. Die von Wideröe 1941* (Editorial correction: 1943) *bei der Hamburger firma C.H.F. Müller begonnene Entwicklung eines 15 MeV Betatron, das noch vor Kriegsende fertiggestellt wurde und die Planung einer 100 MeV bzw. 200 MeV Maschine wurde von der Luftwaffe unterstützt. Vgl. SAA La/84.* ('…') Report no. 148: German Betatrons. British Intelligence Objectives Sub-Committee.
197. Otto Hahn worked with Lise Meitner and Fritz Strassmann. Hahn and Strassmann were awarded the Nobel Prize in Chemistry in 1944 for the discovery of fission, and many people think that Meitner should have shared the prize too. In 1966 all three of them were awarded the American Atomic Energy Commission's prize, the Enrico Ferni Prize, for the same discovery.
198. In 1986 BBC/ABB's particle accelerator division was sold to the American company, Medical Systems. Conversation during preparation of the book 29th August 2011.
199. National Archives BT 211/15: 'Visits to Switzerland by British technicians to investigate German owned plants etc. SC/ZH.' BIOS Investigations—Switzerland. 9th February 1946. Wood. Maunsell. Preserve permanently. Closed until 1977. Registered 15.2.46.
200. *Weltwoche* no. 32/2011 and 33/2011. *Der Spiegel* no. 23, 24, 25, 26, 27 and 28, 1967. Thomas Powers. 'Heisenberg's War,' Goudsmit: 'Alsos'.
201. Switzerland—National Socialism and the Second World War, Final Report of the Independent Commission of Experts Switzerland—Second World War/*Schlussbericht der Unabhängingen Expertenkommission Schweiz—Zweiter Weltkreig/Rapport final de la Commission Indépendente d'Experts Suisse—Seconde Guerre Mondiale—Rapporto finale della Commissione Indipendente d'Esperti Svizzera—Seconda Guerra Mondiale*.
    Unabhängingen Expertenkommission Schweiz—Zweiter Weltkreig, Jean-François Bergier (Chairman), Editorial Team/Co-ordination: Mario König, Bettina Zeugin, Pendo Verlag GmbH, Zürich 2002 ISBN 3-85842-603-2.
202. It reads Bode, but it is possible it should be Bothe. There was a Volkhard Bode who together with Gerhard Kaiser wrote: *Raketenspure: Peenemunde 1936-1944*, Berlin 1995.
203. National Archives, Eval. Report 53 (b): 18th June 1945. Interrogation of Albert Speer. Target No. 28/5.01. 3rd Session—11.00 to 12.30, Tuesday 29th May 1945. Sign Hausell, Slattery, Sanabria.

204. Waloschek: *Todesstrahlen.*
205. Arnold Kramish, p. 148.
206. The interview with the physicists.
207. *Weltwoche* nos. 32/2011 and 33/2011. *Der Spiegel* nos. 23, 24, 25, 26, 27 and 28, 1967. Thomas Powers: 'Heisenberg's War.' Goudsmit: 'Alsos.'.
208. 'The X-ray Industry in Germany,' Combined Intelligence Objectives Sub-Committee, Item nos. 1, 9 & 21, file no. XXVIII-31, reported by: Caperton B. Horsley, U.S. Civilian on behalf of the U.S. Technical Industrial Intelligence Committee, CIOS Target nos. 1/32e, 1/144, 1/246, 9/37, 9/147, 21/180 Radar, Physical and Optical Instruments & Devices, Metallurgy, August 1945.
209. 'The X-ray Industry in Germany'.
210. Waloschek: *Todesstrahlen.*
211. National Archives, BIOS, Final report no. 210, item no. 1, 7, 21, Visit to C.H.F. Müller A .G., Reported by: C.G. Lloyd—Canadian G.E., G.J. Thiesen—N.R.C., BIOS Target Numbers 1/32e, C7/193, C21/744.
212. Fehr, Werner: 'C.H.F. Müller … *Mit Röntgen begann die Zukunft: Überliefertes und Erlebtes,'* ('The future began with Røntgen: Tradition and Experience.'), Hamburg 1981.
213. The two others were Bergmüller and Reineger, according to the interview with Pedro Waloschek.
214. Professor Ludwig Biermann, AEG. 'The X-ray industry in Germany, Combined Intelligence Objectives Sub-committee, Item no. 1, 9 & 21, file no. XXVI-II-31, Reported by: Caperton B. Horsley, U.S. Civilian on behalf of the U.S. Technical Industrial Intelligence Committee, CIOS Target nos. 1/32e, 1/144, 1/246, 9/37, 9/147, 21/180 Radar, Physical and Optical Instruments & Devices, Metallurgy, August 1945.
215. To build a small 5 MeV apparatus, start research and development work for a medium-sized electron accelerator of 20-25 MeV and prepare plans for a large 100 MeV apparatus.
216. Sonderdruck *Technikgeschichte, Band 55 (1988) Heft 1, VDI Verlag: Kernphysikalische Grossgeräte zwischen naturwissenschaftlicher Forschung, Industrie und Politik. Zur Entwicklung der ersten deutschen Teilchenbeschleuniger bei Siemens 1935-45 von Maria Osietzki. (Dieser Aufsatz entstand in einem von der Stiftung Volkswagenwerk finanzierten Forschungsprojekt.) note 96:SAA 35 Lg/84, Durschriften der Aufträge Walter Gerlachs, September 1944.*
217. 'The X-ray Industry in Germany'.
218. Paul, Wikipaedia.
219. Max Steenbeck, p. 124 (footnote 97 in VDI-pamphlet).
220. 'The X-ray Industry in Germany'.
221. The biography.
222. The interview with the physicists. The biography.

223. Pedro Waloschek told me in a conversation that he thought Seifert really was a Nazi.
224. Giovanni Maria Piacentino wrote the tribute.
225. The biography.
226. Luisa Bonolis and Dr. Giulia Pancheri, Theory Group—Research Division, INFN Frascati National Laboratories, Italy: 'Bruno Touschek: Particle physicist and father of the electron positron collider.' The article was marked 'To be published in EGJH' and was dated 14th March 2011, draft ('Bruno Touschek: Particle physicist and father of the $e^+e^\div$ collider.') Letter from Bruno Touschek to his parents. Translated to English by Giulia Pancheri.
227. *Teknisk Ukeblad* 19th January 2015, article by Odd Richard Valmot who interviewed Assistant Professor Erik Adli at the University of Oslo: http://www.tu.no/industri/2015/021/19/ny-teknologi-gir-elektroner-enorm-energ.
228. The secret projects in the research bunker in the former airfield at Grossostheim are discussed in in the book '*Grossostheim in den Kriegsjahren 1939-1945,*' chapter *Fliegerhorst* 207X11, p. 94 ff. They are also discussed by Peter Hepp and Klaus Sauerwein in '*Die Geheimprojekte des Fliegerhorstes Grossostheim.* The airbase at Grossostheim (now known as Ringheim) is also described in '*Fliegerhorst in Grossostheim-Ringheim: Hiere wollte Hitler seine irre Geheimwaffe bauen!'* by Bernd Hilla, co-editors Klaus Sauerwein, Peter Hepp.
www.primavera24.de/lokalnachrichten/aschaffenburg/10850 *27 Mai 2011.* Rolf's biographer was Professor Pedro Waloschek, who later wrote the book '*Todesstrahlen als Lebensretter,'* German edition 2004 and updated, English edition 2012.
229. David Porter: World War II Data Book. Hitler's Secret Weapons 1922–1945. The essential facts and figures for Germany's secret weapons programme, Amber Books, 2010.

6

Why?

There is no doubt that Rolf paid dearly for his dealings with Germany during the war. A fine of 5,000 kroner—now equivalent to about 100,000 kroner or 11,500 U.S. dollars—was what stung him least. The loss of income from patent rights was considerably more. Then add the unquantifiable loss and distress of a stay in prison before the law decided that he shouldn't have been imprisoned at all. If you are reported for allegedly having taken part in the building of the enemy's most dangerous weapon and suddenly find yourself facing a fine along with a document stating in black and white that you have *not* done anything important for the enemy's war effort, then the fine begins to appear almost insignificant. Almost an acquittal, as Rolf saw it.

Rolf would live for another fifty years exactly. Significant burdens had to be borne for the next half-century, however rough the road. The people around him would expect explanations: family members, professional connections, research colleagues. It was a delicate matter. There was a whole scale of reactions, from people who feared the worst imaginable to those who refused to see any problem at all. The biggest group, though, was in the middle, all those who either didn't want or didn't dare to enquire, but took it for granted that he must have been a Nazi sympathiser.

When the contents of the legal documents finally came to be known within medical circles in Norway in the 1990s, it came as a shock to some and for others the pieces fell into place. Waloschek's biography a few years before had described some of what had happened, but the book had had a very small distribution in Norway, confined to family members and a small

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_6

number of other interested people. Rolf himself sent two copies home, one to his brother Viggo and the other to his sister Else.

One of the theories about why Rolf went to Germany during the war was that he was drawn there by the possibilities available. Many of the people who knew him considered that to be the most likely explanation. He was able to continue his life-long research project. He was able to attract resources to it and the milieu was scientifically stimulating, though he was politically naïve.

Perhaps he had no real choice. Perhaps he understood clearly beforehand that all the other options were worse.

Did an appealing inner voice say 'Opportunity knocks,' or did a more cautious voice emphasise the risk, saying 'Take a chance.' The opportunity appears to have knocked loudly.

But the price was higher than he could have foreseen. Maybe it was worth it; maybe not.

How?

How could Rolf travel backwards and forwards so freely during the war?

Travel was restricted in Norway. Electricity, oil and coal all had to be used sparingly, so that the Germans could use them for their own transport. If travel were unrestricted, somebody would use it to flee by train to Sweden or by boat to England. Rationing affected everything. Coupons were needed to buy milk and sugar, clothes and shoes. If you didn't have any, you had to turn to barter. 'I can get by without paraffin if you can give me your coupons for knitting wool.' Black markets, black-out curtains and ersatz coffee were the order of the day. Air-raid alarms, air-raid shelters, German soldiers in the streets, mass arrests. Can we really trust the neighbour?

That was the situation in occupied Norway, including the family in Røa with three small children. In the midst of all this, Rolf's position as a highly respected researcher in Germany appears anomalous and absurd.

There is only one reason why Rolf could travel as widely as he did. The Germans allowed him to do it. They used him. They needed him. So they looked after him, hoping that he would appreciate his good fortune. I think they feared that he might come under the control of others, that he might turn to the Allies or flirt with the Swiss. If they had threatened him with reprisals, they might have lost his help. Instead, their technique was to offer interesting technological bait that he would turn to willingly, without offending his patriotism more than he would tolerate.

In extraordinary times, people do extraordinary things. We all do. It becomes usual not to say everything, or to say one thing and do something else. These were extraordinary times. There was always something to be hidden. People who were doing illegal work mustn't know whom they were working for or the real names of those involved. Some people didn't even know which underground organisation they had been part of before they fled the country and were in safety. In the home front and intelligence activity, silence was part of the job. It was also part of daily life. People kept quiet not necessarily for fear that what they said might go further, but from an understanding that it was often best for people not to know.

Even simple small talk was dangerous. An 11 year old delivered food to Jews and to refugees and later delivered weapons to a local resistance group. He didn't say anything to anybody. He was just helping an older brother and two uncles who were couriers and who needed a helper who wouldn't arouse suspicion. Nobody talked about it. After the war, the vow of silence was lifted. They still remained silent. They were silent for 15–20 years. The uncles died. The older brother said a little about it shortly before he died, so that the youngest man at least could receive his Resistance Medal for his patriotic acts during the occupation.[1]

There are many such stories. Everybody was cautious about everybody else. Two brothers regularly left the house at about the same time each evening. After the war it turned out that each of them had been listening to forbidden radio broadcasts from London without the other knowing.[2] It was better to be on the safe side. Nobody made an issue of it. That was just how things were. It was war.

When the war was over, it was time to move on. Peacetime. Why talk about the past? Everybody had his own opinions. People had opinions about Rolf, too. They did talk about this. Neighbours and colleagues gave opinions. 'You obviously don't do that sort of thing.' Even members of the scientific community jumped to more or less the same conclusions.

But eventually people laid the questions aside. It was safest that way, for just think about it.

Nazi or Not?

The first thought that people had about anyone who had been in Germany during the war was that he must have been a Nazi—unless of course he was a prisoner. Though what do we mean by prisoner? It is war. When the person in question had moreover been working on something that nobody understood, something obscure to do with atoms and research and radiation, then surely he *must* have been a Nazi. The label was often applied for much less.

In parallel with his activities in Hamburg, though, Rolf had a family life in Oslo. Few people growing up at that time had their childhoods recorded photographically on 16 mm. film as extensively as his children. We can watch his youngsters in late autumn 1943, playing with a new sledge on the slope outside the house, surrounded by other adults and a swarm of children on toboggans and kick-sleds. We can see him in January 1944 with a good grip on little Rolf who is standing on his first skis, between his father's legs. He is teaching his children to ski, as Norwegian fathers have always done. Arild, who is big enough to use ski poles, is on one side and Unn, who can now manage by herself, is on the other. In the wartime summer of 1944 they are bathing in Bogstad Lake and in the sea, wading and splashing and building sandcastles. Then in autumn he is splitting wood and letting the children help to stack it. Then he goes back to Germany, as always.

Christmases come, first one and then another. Everybody is looking forward to father coming home. Just as in a normal Norwegian family, except that it isn't. How strange it must have been that when father was not there with them playing with Peter Rabbit and the kittens *Nøste* and *Trulte*, in the garden or at the beach or at the cabin, he was in the enemy's country. Working on a top-secret project, employed by the enemy himself. It's scary.

Like every other Norwegian family, the Widerøes were living in a society that divided people into those who were 'one of us' and those who were not. It was in everyday life during the war that the morale and character of the Norwegian people was tested. The historian Guri Hjeltnes has described it thus:

> Did he or she choose the right side? Could people keep their mouths shut? Were we trustworthy? Did people resist temptations such as the benefits to be gained from joining the Nazi Party or collaborating with the Germans? Opportunism flourished. Attitudes hardened. Some people never took a clear position. Labels and descriptions of people multiplied. We got patriots, Quislings and traitors, Nazi sympathisers, deserters, German tarts, barracks building barons, profiteers, good Norwegians and bad Norwegians, woodsmen, sympathisers. These terms were a sign of sharp social divisions between individuals and between groups – and of some of the changes that were taking place in Norwegian society during the occupation.[3]

Rolf and Ragnhild Widerøe in Nussbaumen, October 1992. (*Photo* Pedro Waloschek)

So it was in tune with the times for somebody to ask—or just to wonder—'What side is Rolf on?' When everybody was watching everybody else, it would have been strange for people not to ask. But if the answer could be dangerous, it might be safer not to ask the question. These attitudes continued for one or two generations after the war. But which label suited a man such as Rolf? Oh, if only I could have asked him myself. I'm just not sure if he would have answered, though. But I can still formulate the questions. I don't want to make him either greater or lesser than he was. So, looking at it objectively, what information do we have about him?

Oh yes, his wife Ragnhild, née Christiansen, had a father who was a Nazi. We can document that, but what then? The National Socialists are said to have held meetings in the basement of Rolf's house in Oslo. That might be true, or it might be a rumour. Rolf did work for the Luftwaffe during the last year and a half of the war. Yes, on a secret radiation project. We have evidence for that, but do we know why he did it? He was arrested after the war. Got a fine. Do we need to know any more?

Anyway, we can ask the family and others who knew him. Surely they will know where he really stood. Was Rolf a Nazi? A direct question, with direct answers:

Else Widerøe (sister):

No, he was not a Nazi, he was just fully absorbed in his research.

Louise Reksten (wife's sister):

Nazi? No, not at all.

Egil Reksten: (husband of wife's sister Louise):

A Nazi? No, I have a distinct impression that he was not a Nazi.

Did he do anything to defend himself, fight back, squash the rumours that he was a Nazi?

I don't know.

Did he rise above it perhaps?

I don't think it bothered him much.

Wanda Widerøe (Viggo's youngest daughter):

I don't know. It was never an issue when I was growing up.

Turi Widerøe (Viggo's eldest daughter):

I don't know about that, but I do know he worked with them.

Per Trifunovic (grandson and adopted son):

I've not really thought about that. But I could never imagine him as a Nazi. So that wasn't a big issue for me. I only know what I have heard, that he collaborated to help his brother.

Have you met his brother, Viggo?

Yes. We were always in touch with Viggo. They always had a good relationship.

Pedro Waloschek (formerly Head of Information and Professor at DESY, Germany):

He was not a Nazi. He was fascinated by German technology, but not German politics.

Tor Brustad (formerly Professor at the Radium Hospital and at The Norwegian University of Science and Technology in Trondheim):

He was certainly not a Nazi. He was absorbed in his research.

Egil Lillestøl (Professor at Bergen University and a researcher at CERN):

I reckon he was perfectly sound. An idealist.

Finn Aaserud (Director of the Niels Bohr Archive in Copenhagen)

No, he was no Nazi.

Søren Bentzen (Professor at the University of Michigan, USA):

No, he wasn't a Nazi. He was a genuine and ambitious research type, an internationalist and no Nazi.

Olav Aspelund (physicist and holder of a state bursary):

No, he wasn't a Nazi.

Jan Sigurd Vaagen (Professor at Bergen University and Nordic Countries Director in The European Academy):

He was naïve, but he wasn't a Nazi.

So the conclusion is that I haven't met anybody who thought that he supported Hitler. I haven't heard a single person who knew him personally say that he was a Nazi. People have described him as having all sorts of other attitudes and characteristics, but not as a Nazi. However, I have come across people who have scarcely heard of the man but who don't want to approach the problem, in the same way as the CERN research laboratory couldn't find anybody to review Rolf's biography—even though it was written by a determined anti-Nazi with a Jewish background.

Pedro Waloschek told me that he too had thought at first that Rolf must be a Nazi, but that he had quickly changed his mind. Having grown up in Norway in the 1950s, I myself confess that I was concerned lest I might discover that he was a Nazi. One doesn't emerge unaffected from growing up in such times. Good Norwegians didn't flirt with the Germans. Good Norwegians resisted, demonstrated their loyalty.

Enough said. The only strong argument for him having been a Nazi is his stay in Germany during the war. Nothing else that he did or said indicates that he was a Nazi supporter. Neither before, during or after the war.

But why on Earth did he go to Germany? If only we knew *that*.

Nevertheless?

Why didn't he explain himself afterwards? Why didn't he fight back when he was handled unfairly? 'Hallo, I'm the boss. You mustn't say this and that.' Was he embarrassed? Or did he think it wasn't worth talking about it? He had his own opinion and that was enough for him. There can be many reasons for not saying anything. Was he one of those who had vowed to remain silent? Had he been in one of the Home Front's intelligence organisations? The scientific community in Oslo recruited many to XU for example. But accusations circulated that he had been on the other side. The questions grind round and round. I want to call out:

> Did you have something to hide nevertheless? So you were a Nazi too?! A German spy. Or were you on the Allies' side? Or was it not dramatic at all? Just driven by events. Until it was over. Nothing to write home about. You were just naïve. Absorbed in your own research. You were blinkered. A blindfold and your head in the sand. You were stupid, irresponsible. No, no … thoughtless anyway … thoughtless at best.

I get entangled in my own virtual dialogue and try to provide the answers too:

Didn't you think about what your children would say?
I thought about them all the time.
You liar, all you thought about was yourself and your research.
They were very young.'
Unn was seven when you left. What do you think she said when her little brothers asked about Dad? They weren't stupid. They had neighbours. Aunts and uncles. I've spoken with your oldest son, Arild. *He seemed totally honest with me, didn't try to embellish the facts, and answered my questions helpfully. He gave me permission to quote him. He was only five when you started your long-distance commuting to Hamburg. He was told some things and more to follow, but not everything. And how could he know that what he did hear was the right version? First was the child's version. "Pappa had to go away for a while because there was something he had to do in a town far away." As he grew older, Arild got the official version, the version designed to be safe for public consumption and tolerable to his employers if it reached them on the jungle telegraph. Or was it a case of "I must spare you the truth, my boy," or mother's frightened and frustrated version? What did the boy work out for himself? At his grandparents at Vinderen and Ullern? A little of everything, probably, to build up his own picture which sometimes collided with awkward questions. Such as later when he wanted to join the military. But he is grown up now, over seventy, and he has told me how he sees it. I don't know if it tallies with your version, but here is his – and this conversation has taken place.*'

Arild, Oldest Son

I've wondered why your father is so little known in Norway.
Yes, there are many reasons for that. He worked in Hamburg—or, should we say, he *had to* work in Hamburg. I don't know how much you have heard abut that.

Yes, I know that he worked in Germany during the war.

He didn't work in Germany of his own free will, but he thought that well, there's no benefit in me being sent to prison too, just because I don't want this job in Germany. But if I take this job in Germany I'll be able to carry on my research. The Germans certainly knew about him. They knew exactly what he was working on, and so they understood what a potential asset he could be to them. I can't remember when it was, whether it was in 1942 or 1943 when the Germans came and gave him the offer, saying "Just listen, either you come to work for us in Germany or you end up in a concentration camp in Germany like your brother." Then my father thought that—yes, he certainly thought about it for quite a long time—and he replied that he thought it was better that he took the job. And so he also was able to help Viggo a little. He could visit him from time to time.

He visited him once, that I know of. Were there other times?

We never really talked much about that. He came back to Norway in 1945. Then soon after the liberation he was arrested. Somebody lodged an accusation against him, understandably.

He was held in custody in prison for 47 days.

Yes, it was something like that. Wasn't it a whole two months? At that time he had a job in Brown Boveri, and their director advised him to move to Switzerland.'

This was the established story, the short, authorised version of his father's 'Dark Chapter,' as repeated by a loyal, grown-up son who was trying to remember correctly and report correctly. But I wanted to know more:

What do you feel about what your father did during the war?

There hasn't been any talk about that aspect. The only thing I personally heard about it was when I wanted to be a pilot and joined the Norwegian Air Force in summer 1959, because I was a Norwegian citizen. I was asked about various things and when they actually asked me—and I was a little, what shall I say, I was a little …

… surprised?'

Yes, not just surprised, I was shocked, for I had never thought about it—we didn't think about it at that time.

What did they say to you then?

Yes, they wanted to know what I thought about my father's doings during the war and so on. And I, well all I knew was that he had been in Germany then, for we had never spoken about it. And after that I was told by an uncle, my father's sister Grethe's husband, that the situation had been such and such. But I never spoke about it with Uncle Viggo, for example, even though we were quite close because I always went to him when I wanted advice on anything to do with flying.

Did your father tell you anything about his work in Germany?

No. No. But. I really don't know. I could have asked him, I suppose. For example when I came back from Norway after I had been 'briefed' by my uncle. But I didn't really feel the need to ask him. I didn't think there was anything particularly interesting to know. Perhaps I preferred not to know. Because I knew that Uncle Viggo had had a really hard time.

Overheated

So has Rolf himself either said or written anything that could throw light on the situation? Or will the dark chapter remain obscure? Yes, Rolf has both written and given interviews about this. Soberly and concisely, as always. 'I worked in Germany from then till then.' 'I met this person and that person.' He characterises some people as Nazis, with whom he had to be careful what he said, and others as non-Nazis, with whom he could talk openly. A colleague who was arrested by the Gestapo was half Jewish and "We visited him in the prison and helped him as well as we could.' He could say of a meeting in Berlin that 'The the Gestapo were not there, so we could talk freely.' After being given quite a powerful account of people's emotional reactions he just asserts 'The mood after the war was overheated. Things didn't always go smoothly. I'm not complaining and I don't bear any grudges. But it was good to arrive in Switzerland and start work again.[4]

An undramatic account, we might say. But shedding light on the situation? No, he just continues in the same way:

> Despite everything, the suspicion against me after the war left a slight aftertaste in certain circles, and I'm glad that everything now seems to be fully explained. Anyway, the big bouquets of flowers I received from Norwegian embassy people in 1992 in connection with the bestowal of various honours convinced me that nobody in Norway had anything against me.

Yes, that was how he allowed Pedro Waloschek to write it in the biography. Quite simply! Did he believe it himself? A psychologist would call it rationalisation. This is clearly a spruced up version for official use, a Sunday version. He just had to say something, without having to explain too much. A formal statement for people who asked—or didn't ask. For overseas research colleagues at CERN. For the directors in Siemens and Philips and Brown Boveri. For when he was delivering a lecture in Australia or visiting a cancer hospital in the USA. For journalists, for members of the family and—who knows—perhaps even for himself. The reflections, the understanding of what really happened, the explanations and explaining away, all gradually grew and developed during the exactly fifty subsequent years of a long life, between 1946 and 1996. They matured into a standard version, a shaping of the history that he could live with, an authorised account of his life that he repeated for everybody who wanted to listen, until he came to believe it himself.

Tried to Understand

Nobody can see the world through someone else's eyes, or feel the pinch of someone else's shoes. There are many words of wisdom along these lines. To see something from exactly the same position as somebody else is physically impossible, but it can be fun to try. Such an approach can throw light on the problem and accentuate the shading. A useful way to look at a picture that has long been black and white. One of the people who has made a determined attempt to understand Rolf is the Dane, Søren Bentzen, a true admirer who says right out that he is sceptical about the opinion that Rolf went to Germany to help his brother. Bentzen is an expert on the ethics of research and is a professor at the University of Maryland School of Medicine in the USA. At the presentation ceremony when he was awarded the Widerøe Prize in 2006, he surprised the audience with his acceptance speech:

> In his autobiography, Rolf Widerøe maintains that he did it to help his brother, Viggo. (…) This sounds a very understandable and honourable motive – my problem is that I'm not sure I believe him. It obviously must have been a difficult and very emotional decision, but the explanation is simply not very convincing, at any rate for me. It seems like an expedient explanation, a version of the truth that he and others could live with after the war. I think he was driven by his scientific ambition; this was an opportunity to do what he was good at and what he wanted to do. To take the job in Hamburg was the only opportunity he saw. It was "the only show in town."[5]

Exciting Conflict

While researching for this book I asked Søren Bentzen to expand his view. At that time he had been working abroad for twenty years[6]:

I think he is an exciting person. If Rolf Widerøe had 'just' been a Nazi, we would soon have been finished with him, for there would have been nothing special in the human aspect of his story. But there are good grounds to believe that he was absolutely not pro-Nazi. So as I see his story, Rolf Widerøe is a man who is a victim not of his own political convictions but of his scientific ambition.

How did you become interested in him?

I heard Tor Brustad's lecture about him in the 90s. I'm interested in the history of science, and there was something about this person that caught my interest. The conflict between pursuing one's scientific goal on the one hand, and doing what at the time was considered right and proper on the other. In the biography he mentions being able to help his brother as a motive for taking the job in Hamburg in 1943. The problem is that this sounds like a slightly too easy explanation, an explanation that both he and others could accept. I think that what drove him was scientific interest. Working in Germany was an opportunity to do what he was clever at and wanted to achieve. I think that blinkered him. He said himself that he was politically rather naïve, as indeed he may have been.

But what makes his story relevant for people today is that we have such conflicts all the time. There are numerous examples in connection for example with genetic manipulation and prenatal diagnosis, where we have the same dilemma between research and the ethical or social attitude to what is right. Widerøe made a great contribution to the physics of accelerators, and most of the treatment technology that we see today in radiotherapy is more or less directly based on his inventions. So here we have a very talented man who works hard and pays a personal price for advancing his science. When he had to make a choice during the occupation of Norway, he made the wrong choice from a political point of view.

Bentzen is also interested in why, towards the end of his life, Rolf had a change of career when he became interested in new questions. He wanted to understand the biological action of the radiation.

Does that bring us closer to your own area of study?

Widerøe's contribution in that field was very relevant to what people were working on at that time. It is interesting to take principles and methods from one subject area and see to what extent they can be applied in another area. Just as physics had a golden age before and during the Second World War, now it was the turn of a golden age in biology. Even if one's own background is in physics, it is professionally attractive to try to understand some of the new developments in biology. Widerøe also took part in this. He actually ended up working on biology and on models of how ionising radiation affects cells, and some of his principles still apply. We can say that he was a sort of pioneer of what we call biological field models. But his contribution would have been even greater if he had published his theories in English language journals. Instead, his articles from that period are mostly published in German, and that tends to restrict his contribution.

A partly shared experience

Does it help us to understand why he decided to move to Switzerland after the war if we take into account the particular mood in Norway at that time?

I think that to some extent I see my own experience mirrored in Widerøe's story. When you leave the land where you grew up, leave your family and leave your friends, there is a price to pay. Widerøe was willing to pay it, but I think he may have under-estimated the political element. Maybe he was politically blinkered. He might have done differently if he had known, but I'm not sure about that. I think that he saw it as an opportunity to work on what interested him. He paid the price professionally with the loss of his reputation. It's difficult to know what really influenced him, but I think I recognise from my own experience some of the pressures working on him. I have come to the conclusion that he was so dominated by his scientific ambition that that was the driving force. He later tried to explain this himself. It is possible that what he did would have been reasonably uncontroversial if it had not been for the particular social climate that the occupation had created in Norway. You do need to take the mood in the country into account in order to understand him. People found it difficult to forgive him, and they found it difficult to distinguish between German nationality and Nazism.

Professor Bentzen categorically dismisses the idea that Rolf might have been a Nazi. He was fascinated by things German, but not by Nazism or by Hitler's Germany:

What is your assessment of his political point of view?

There isn't much to suggest that he was politically attracted by Nazism. But I'm fairly sure that he was attracted by German nationalism and German nationality, and that he was inspired by his stay in Germany. That was obviously influential in his decision to move to Switzerland and spend most of his career within the Germanic cultural zone. Even though he always said that he was proud to be Norwegian, there is no doubt that he liked Germany and German culture. He had studied there and lived there most of his early adult years. He was ahead of his time in this way too. He was an internationalist at a time when nationalism was still very prominent in Europe and had been strengthened by the Second World War. I'm surer that his conscience was clear during and after the war, but because of the attitudes in Norway at that time his decision was perhaps unwise. He didn't in any way help the Germans to fight the war, but there has been great antagonism to recognising him in Norway. From abroad, on the other hand, people see it differently. The irony that hit him was that he was mainly recognised within the German sphere of influence, while the post-war world was dominated by England and America. Perhaps we could say that if he had stayed on in Norway for another few years and turned down the position in Germany – and then come to the USA immediately after the war – his contribution would have been even greater.

It's paradoxical. Germany was the locomotive of Europe before the war.

Yes, Germany was a leading nation culturally and intellectually before the war, not just in science but also in literature and art. But the German influence diminished after the war and many people left.

Bentzen though that like Werner Heisenberg, Rolf faced the problem of how to explain himself. For Heisenberg it was a question of explaining why he didn't leave Germany in the 30s. He was working in Göttingen with many of the other leading physicists of the day when the law was made that people with Jewish ancestry could not work in the service of the state and many people left Germany. Nearly all his colleagues in Göttingen either were Jewish themselves or resigned from the university in sympathy with their Jewish colleagues. Heisenberg was one of the few important physicists who chose to remain in Germany.

Heisenberg probably wasn't a Nazi either, as I see it; he was a German nationalist who saw it as his duty, and perhaps his fate, to stay in Germany. We can see from his autobiography how he seems to wander round the topic. He obviously had a problem explaining himself.

Bentzen refers to a play he had seen in London:

When I lived in London I saw Michael Frayn's play about Heisenberg. It tells the story of Heisenberg travelling to Copenhagen during the German occupation of Denmark, to visit his old friend and mentor, Niels Bohr. They had a close relationship, they had gone on holidays together and Heisenberg knew Bohr's close family. There is a famous description of them going for an evening walk during the war-time visit. Bohr came from a Jewish family, and he obviously found it very disturbing to welcome a scientist from Germany when Denmark was occupied. We don't know exactly what they talked about during the visit, but we do know that when they parted again they were no longer friends and they never again would be. A *Guardian* journalist, Michael Frayn, wrote the play *Copenhagen* which was seen in many places throughout the world and has also been made into a book and a TV programme. He presents three different scenarios of what might have happened during the meeting. An interesting play, even for non-physicists.

The dramatization of the fateful meeting between these two has also been performed at the National Theatre in Oslo, with the famous actors Svein

Tindberg as Heisenberg and Sverre Anker Ousdal as Bohr. It starts with the words 'Now we are all dead …' Only then could one speak about it. One of the people who saw the play was the physicist, former Industry Minister and head of the Defence Research Institute, Finn Lied. He discussed it in an article, where he particularly describes the episode where Heisenberg had received an invitation to dinner with Bohr and had reacted with hesitation:

> Before, when Heisenberg had been a research student with Bohr, they had often gone for a walk. Now, they went for a walk partly to avoid being overheard. What happened? What did the two physicist-philosophers talk about? The meeting is said to have been very difficult and to have ended in a psychological catastrophe with Bohr very angry. It is no surprise that this material has now been given a dramatic interpretation.[7]

Finn Lied described the performance as presenting 'a rather dreamy and philosophical Bohr' and 'the younger and more precise Heisenberg.' There are only three *dramatis personae*, namely the two physicists and Bohr's wife Margrethe who 'is doubtful about Heisenberg and is the commentator within the plot.' The play was performed first at The Royal National Theatre in London and later in Copenhagen and Stockholm. Lied asserted that it offered the public an extraordinary cultural experience:

> The whole spectrum of problems surrounding nuclear fission is explored in the conversations: the effect of fast and slow neutrons; the problems surrounding the manufacture of U^{235} and plutonium; the difference between a reactor and a bomb, etc. (…) And the whole play is set in occupied Denmark with Heisenberg representing the occupying power. We can safely say that it is an unusual drama. The audience can decide from themselves whether Frayn has solved the riddle of Heisenberg's visit. I am still in doubt!

Finn Lied abstains from firm conclusions. In the play itself, the main characters also express themselves in uncertain terms: 'If people are to be measured only according to what can be measured ….,' says Bohr, and Heisenberg finishes the sentence for him: ' … then we need a whole new quantum-ethic.'

'The Mad Scientist'

Søren Bentzen says that he doesn't think Rolf worried very much about what other people thought and felt about what he did, but he does think that it must have been a personal dilemma.

He must have known that at that time it would be difficult to defend his decision to go to Germany. Yet he did go. There are parallels with researchers today who work with technology that could be misused. The urge to explore deeper and deeper into an area of research can create a fundamental conflict. This arises in discussions about stem-cell research, whether or not the researchers should try to clone a human being. There is a sense of "the mad scientist" who will follow a line of research as far as it leads, whatever the price.

I think I understand Widerøe somehow or other. If he had been a Nazi, what he had done would have been equally striking, but I think there would not have been the same fascination with the man himself. What makes him interesting to me is that he did what he did despite the political situation. If he had been pro-Nazi he would just have been doing what he thought was right according to his ideology, and that would have been the end of the dilemma. I think that he himself felt a sort of ethical conflict and that after the war he needed to justify himself. So he produces these more or less convenient explanations about his brother. That is when it starts to become interesting, because he has really been working towards his scientific objective not because of Nazism, but despite it.

Does that make him more human in your eyes?

Yes, absolutely. He was also confident and charismatic. I've seen a picture of him delivering a lecture at The American Institute of Physics. You can see from his body-language that he was a formidable character.

But what sort of a person was he? Did you get an idea of his personality?

There are glimpses that begin to give us clues what sort of a person he was. I think he really lived and breathed for his research. In his biography, he tells us how he continued his work on accelerator physics while he was in prison, how he was almost using his imprisonment to lock the world out. He said "It was hard for my wife, because we didn't have much money," and things like that. "But I was fine because I could sit there in prison working on the things that interested me and make progress in this and that." He had quite a different agenda, and the conflict involved in his choice here is what makes him interesting to people today. The fact that he chose as he did is what makes those who are interested in him try to understand his real motivation. The moment when he was offered the post in Germany characterises him as a person. He could have chosen to stay in Norway and said "No, thank you. In present circumstances I don't want to take a job in Hamburg." At that time nearly everybody realised that Germany would lose the war, and if he had been more politically astute he could have sat on his hands and said "No, no. Be patient, friends. I'll wait till after the war." The choice that he made was more interesting because he was not a Nazi. If he had been a Nazi he would just have followed his instincts.

You're referring to the public conflict again?

That's the heart of the matter: what one *should* do, as compared with whatever benefits one might gain from doing something else instead. I'm sure that many people at the time considered him a Nazi, but I think that to give him that label is a logical short-circuit. They labelled him as a Nazi because he took the job in Germany. It then becomes a circular logic: "He took the job in Germany because he was a Nazi." I think that as the years passed the story involving his brother was brought in as a convenient explanation. That is something we can all identify with, but he tells the story in a basically unemotional form, almost as a marginal comment, that that was the deciding factor for him. If he had really had qualms of conscience about accepting the offer of the job in Hamburg, he would have devoted more time to explaining himself and describing how he had faced a personal conflict.

If we take a cynical point of view, can we ask who was trying to use whom?

That's an interesting question, whether he was using his brother or genuinely trying to help him.

Theoretically, Viggo could also have used him to obtain benefits for himself and thought that Rolf was a traitor.

Whatever the case, the story about his brother was a simple, practical explanation. But as in Frayn's play, we shall never know the truth of the matter. We can't necessarily even trust those who were right in the middle of events, for each of them needs to find his own version of the truth that he can live with. This applies to both Viggo and Rolf. As with Bohr and Heisenberg, we know both of their versions of the story but neither of the two versions appears fully accurate. I think they have both subsequently re-written the story a little.

But as we are now speculating, what would the consequences have been if he had been a Nazi?

In Scandinavia we have the discussion about Hamsun, for example. Thorkild Hansen's book "The case against Hamsun" in the 1970s. I think that is an illuminating attempt to understand Hamsun and his motivation.

Hamsun received a Nobel Prize and is recognised as a great author. Nevertheless the Norwegian people struggle to accept him. Such things are obviously not simple.

No, and there was an attempt to declare Hamsun insane. In England there was what was called "Social Darwinism," an attempt to rationalise a sort of super-race theory where one obviously thought that the English were on the highest imaginable level of development. Nazism was also in many ways a romantic and an anti-modern movement. It was an attempt to turn back to nature and the original values and so on. Much of this appealed to people at the time even if they were not necessarily in agreement with the persecution of the Jews and the extermination camps. That is where

Thorkild Hansen does a wonderful job in making it seem more understandable how a person like Hamsun could have a certain sympathy for some of these ideas. Obviously people didn't see it like that during the war.

No, and it is a more tabloid point of view.

But it was difficult. In Denmark we had the Gymnastics Movement, and many of the leaders there flirted with Nazism and were invited to some of the big assemblies in Germany. After the war it became taboo. It was associated with all the dark aspects of Nazism, and the idea of "a healthy body and a healthy mind" became almost illegal. Much of this has acquired an odious sound because of the link with Nazism. Like Wagner's operas. But one can still listen to Wagner. I have a friend in the USA who will not drive Japanese cars, because of the Second World War. But doesn't it have to stop somewhere or other?

At the Right Time

Professor Bentzen thinks that Rolf's contribution to science was significant. In answer to the question whether he was ahead of his time in that his ideas outstripped the available technology, he answers as follows:

No, he wasn't ahead of his time. He was exactly on time. He was the right man at the right time, but not necessarily always in the right place. Some of the opposition to him was professional opposition; people just doubted whether his theories would work. Even in modern times I have heard people say it was really amazing that they worked. But Rolf Widerøe was persistent. He eventually found a university that would allow him to work with his ideas, and he persevered with them. His difficulties started with the choice he made during the war. And it was that rather than any professional considerations that damaged his reputation. From a purely professional point of view he had the right ideas, at a time when they were within the scope of the available technology.

Even though it was several years before the Americans took up his ideas, you suggest that it didn't take an unusually long time before they were put into practical use.

In the history of science there are other examples of somebody having an idea that was never followed up, because it was beyond what was practically feasible. In a historical perspective, there wasn't really a long time between Widerøe's ground-breaking ideas and their application to the treatment of patients with cancer. In this sense, Widerøe's story is almost a model of how science often progresses. Here we have a talented youngster who sets himself up against the authorities in the field but is later seen to have really understood something. Modern radiotherapy couldn't exist without Widerøe's ideas.

The Scene Is Set

Søren Bentzen wonders why Rolf's personal fate continues to engage people. He thinks it is because of the conflict of interest, with patriotism and politics on one side of the balance and science on the other.

In this case, Widerøe the scientist chose to come down on the side of science. I think there is something noble about that.

But aren't there many people throughout history who have done that?

The Widerøe case is so extreme because he wasn't German and he wasn't a Nazi, yet he still decided to go to Germany. At a time when one could say that sound common sense and political awareness – and perhaps even professional opportunism – would have argued against going. These considerations would have favoured lying low and waiting in Oslo for the Germans to lose the war. I think that the offer made to him was very tempting. It was the opportunity to build his machine.

He understood that there was a very particular mood in Norway after the war. How significant is that?

There was a particular mood that we must take into account when we try to understand the rough treatment he experienced. There was also the commercial and industrial influence, which was not really welcomed by physicists at that time. That is controversial too. I think that especially in the European academic tradition people saw it as almost improper to try to commercialise and earn money from ones scientific ideas. In addition, around the time of the Second World War the professional milieu was much more elitist and self-centred than the same milieu would be in our day. So he was probably treated badly both because of the unique circumstances following the German occupation of Norway and because of intolerance among fellow-scientists.

So do you think that a younger generation of physicists will see things differently? That it will be easier for them to acknowledge his contribution when they are clear about it?

I really do believe that, because physics has changed too. Not many people nowadays believe that physics is truth with a capital T, that to study physics is to read The Word of God or Nature's Great Book. The postmodern way of thinking about it is more that every physical theory has a restricted area of application and that we can always uncover new layers. It's a more open way to think about physics, that systems are useful in so far as they are able to provide the right answer in one context or another.

And I think that physics is really much less orthodox than many other sciences. The physicists in those days may have been more purist and therefore more judgemental when it came to seeing Widerøe's contribution in perspective. I think it is true to say that a modern physicist will find it easier to recognise a contribution that is more in the category of applied physics. We need to declare that Widerøe did a very important piece of work in physics. We can see the pure physics at the heart of it, but we can also say that it is practical, applied physics because the machines he built can be used to treat cancer.

Bentzen says we cannot ignore the fact that Rolf was controversial both in his day and since.

When Tor Brustad had the idea of restoring his reputation in Norway, even fairly close colleagues were strongly opposed to the plan. Nevertheless, Rolf's history continues to fascinate not only scientists but all of us, because inwardly we can see ourselves in his shoes. What has fascinated me is the choice that Rolf faced, rather than trying to understand him in detail. The scene is set, we might say. An extreme decision has to be made, in a hostile setting that sharpens the choice. The drama is intensified as in an opera or a play.

Maybe this could provide good material for a play like the one about Bohr and Heisenberg?

Yes, indeed. Just as Michael Frayn did with the meeting between these two in Copenhagen, one can imagine a scenography of what drove Widerøe. It is a drama of conflicts that humanity has faced for millennia.

Voluntarily or 'voluntarily'

Søren Bentzen's starting point is that Rolf had a dilemma, a real choice, and chose to go. His brother's situation was a substitute justification. Tor Brustad at the Norwegian Radium Hospital was also fascinated by the dilemma, but for him the voluntary choice was more a euphemism for 'voluntary compulsion.' Rolf *had to* go. The question was what he could negotiate in return, how he could use the situation to his advantage. Professor Brustad put it thus:

Rolf Widerøe understood clearly how problematic it was in 1943 to take a job in Germany when all links between Norwegians and Germans were looked at askance. But his brother was sitting in a concentration camp, with his health deteriorating. On the other hand, there were strong reasons not to go, as Norwegian opinion would not understand collaboration with the Germans. So this was another part of his dilemma.[8]

Thinking aloud about how Rolf might have reasoned, he formulated it thus and thereby demonstrated his goodwill towards him:

> He knew that developing such a betatron with this energy level could not enhance the war effort. Time has proved him right. On the other hand, general opinion was strongly opposed and the question was how his move would be understood. 1943 was a catastrophic year for the German war machine. They had capitulated at Stalingrad on 2nd February and when the German officers came to Oslo to talk to Rolf later that year Hitler was in retreat on all fronts, including Africa and Italy. In England, the Allies were building up the world's biggest store of munitions in preparation for an invasion of Europe and a death-blow to Germany. He knew all this when he met the German officers. Germany was beyond rescue. There was no longer any doubt who would emerge with the victory; it was just a question of time.
>
> Rolf realised that there would hardly be enough time to develop a betatron. They would be lucky to achieve it. The work could have no effect on the outcome of the war, but with contacts in neutral Switzerland he could later develop a betatron for cancer treatment and the testing of metal welds, of which ruined Europe would have great need. Nevertheless there were such strong arguments against going that he must have considered that he couldn't let himself into this situation and the answer would have to be 'No.' But then he wanted to help his brother. Going to Germany could give him an opportunity to do this. So he took up with the German delegation the question of whether by agreeing to their research project he could reckon on receiving support from them for an application for clemency for his brother.

Such were Professor Brustad's reflections.

As Waloschek Saw It

The third person who took up the story of Rolf's life was Pedro Waloschek, the German physicist who wrote Rolf's biography. Pedro passed on Rolf's version of the reason for the decision and more or less satisfied himself with that. From his conversations with me, he originally believed Rolf's explanation that the prospect of helping his brother was decisive, although at the same time he clearly saw the Germans' technological interests in having him in Germany. In the foreword to the biography, where Waloschek is speaking with his own voice, he presents Rolf's stay in Germany during the war simply and unequivocally:

> In the hope of being able to help his brother out of prison in Germany, Rolf Widerøe agreed in 1943 to go to Hamburg to build his youthful dream, a 'radiation transformer' or 'betatron' that could produce very strong X-rays. His brother Viggo was one of the pioneers of aviation in Norway and had taken part in the Resistance. Some experts in the German Air Force believed at that time that one could use X-rays to shoot down planes. But Widerøe didn't believe this, and serious physicists also considered it impossible.[9]

But after Waloschek had finished writing the book, he started on a project about arms research in general during the war. During this he came across Rolf's betatron again, and he now suggests explanations other than Viggo's plight as the reason for Rolf's decision:

> His Norwegian employer NEBB was in agreement with the decision, or must have been involved in it. But judging from what happened later, NEBB and the Swiss parent company BBC were also interested in building this type of accelerator themselves. We can also assume that while Widerøe was in Oslo working on ideas for his two radiation transformers in 1942 and 1943 he had support from NEBB, as this must surely have taken up a lot of his time. (…) Obviously the German authorities at that time had no objections to his continuing good relationships with NEBB and BBC.[10]

In a later conversation I had with Waloschek, he said right out that he had come to the conclusion that the brother could not be the only reason for Rolf going to Germany during the war.[11]

As the Family Saw It

The family has never made any public comment on Rolf's stay in Germany during the war, but in conversation with me during the preparation of this book his sister Else summarised the situation:

– We said 'Don't you realise that it will be seen in a bad light?' But Rolf wasn't interested in politics, he was absorbed in his life's work. There was no use in talking with him. And you can't talk *down* to a grown man.[12]

What did he say himself about why he went? I have listened repeatedly to the tape-recording of the interview with the physicists in Oslo when he was over 80. I've read the transcript from that time and his own later translation of it into German. Tried to find out what he said, both on and between the lines. In the interview he was asked directly how the project in Germany came into being. He referred then to the fact that he had tried to find out more before he moved and had said that 'I obviously can't do this without further discussion. I'll need to hear a little more about it all.' They had replied to him, 'We can talk about that in Berlin.' He said that they had then mentioned his brother:

> They also implied that it could make a big difference for my brother. My brother, Viggo Widerøe, was the Director of Widerøe Airlines, which was dormant, naturally, but had helped several chaps travel from Norway to England and that had naturally been discovered and he was arrested and condemned to ten years corrective detention in Germany, severe detention. And then they implied the possibility that he could be set free. So then I went down to Berlin, and we talked a lot about it there. They had thought of building a small betatron in Hamburg, and they said that if I went along with that and helped them there, they would set him free. So they would do what they could to have him set free. Then I said yes, I'll do it. I didn't know anything then about all the business with Schiebold and that there was the anti-aircraft weapon and all that behind it, I didn't know anything about that because it was all so strictly secret, I wasn't allowed to hear anything about that.

'Transported There'

In a whole page featured interview in a Saturday issue of *Aftenposten*, Rolf uses the phrase 'transported there by the Germans' when talking about his stay in Germany during the war. This was the only comprehensive interview with Rolf that ever appeared in a Norwegian newspaper. Rolf was 69 then, and the interviewer was an experienced journalist who in the course of his career interviewed major figures such as Sartre, Adenauer and Golda Meir. He had been the foreign correspondent connected to The International Press Institute in Zurich when the betatron was being installed in the Radium Hospital in Oslo.

This obviously tells us a lot about the media, who at that time were considerably less critical and less probing than they are today, but it also says something about how totally unknown Rolf must have been in Norway when a heavyweight press reporter can let him off so lightly when he talks about his time in Germany, without suggesting that there might be other points of view:

– The first betatron to be built here in Europe was the one I built in Hamburg during the war. I was transported there by the Germans to build such a machine for them.[13]
– *Was it of military importance?*

– Absolutely not! It was a pure experiment. They thought that something might come out of it for medical use, or in other fields. That worked out, but the machine in Hamburg was too small for subsequent needs.

Earlier in the same interview Rolf had said two other things about his time in Germany:

that in 1943 he had taken out a German patent on 'collision between high-energy particles'—his pride;

and that the patent 'proposed collecting protons in two rings where they move in opposite directions and using special arrangements to steer them onto colliding paths.'

He adds:

'So the idea is originally Norwegian.'

That is literally all that is said about the war years in the featured interview. As a journalist one generation later, I am burning to ask follow-up questions. The interviewee must surely have more to say about this. Why did the Germans want him to work for them? And why was he willing to do it? Whether I would have got any reply is another question.

Interpreting the Biography

Rolf himself translated the transcript of the interview with the physicists from Norwegian into German. Pedro Waloschek used Rolf's translation as the basis for this section of the biography, which was read through and approved by Rolf:

> Whatever the Luftwaffe had thought to do with the betatron, they didn't tell me. I only got to know about that later. At any rate, I didn't know then – nor did I have any idea that the betatron could or would be put into use as a weapon. Nor did I think that it was technically possible. There must have been a strong motivation to regain the lead the Americans had in this field – in other words what betatrons could later be used for.
>
> Officially it was always about the development of unique, high-quality X-ray equipment for use in medicine and non-destructive material testing. In connection with the betatron it was about small, relatively convenient apparatus to take the place of normal high-tension installations.

> So I agreed to go to Hamburg later or to be more precise, with my own more or less voluntary consent (and obviously with consent from NEBB), I was set to compulsory work.[14]

In a video recording Waloschek made with him in autumn 1992, Rolf repeats more or less the same account, with a few minor additions including an introductory comment that we must remember that the situation in Norway in spring 1945 was not normal. People were hunting for traitors. This interview is mainly variations on the same theme, and repetition doesn't make us any wiser. But this is also connected to the fact that the text has been translated back and forwards and that the written sources are partly based on the transcript of a tape-recording.[15]

The interview with the physicists in Oslo was in Norwegian. The transcript was then translated into German and quoted in Waloschek's book, which was later translated into English and Russian. In the biography Rolf uses the phrase that we have quoted above as 'my own more or less voluntary consent.' This concept is open to various translations and interpretations of the nature and degree of 'voluntary consent.'

Freely and voluntarily? What does that mean when the enemy is asking the question? And anyway, what is the alternative? Was there really any choice? It is war.

Perhaps Rolf's conclusion about this was just as uncertain as mine. Perhaps it was his best understanding forty or fifty years after the event. But to admit that he had been in doubt whether to go or not would have been conciliatory towards his critics. Tor Brustad thinks that he was in doubt. If he was not, that in itself would be enough to provoke people to judge him with moral indignation.

Bitter?

I approach the question of freedom of choice from another angle and try to find out whether Rolf felt bitter about what had happened. The answer will be interesting from a human aspect but will also throw light on the reasons for going to Hamburg. In the absence of answers from himself, his family are the most likely to know. First, someone from his wife's family:

Jørgen Holmboe (son of his wife's sister Anna Margarete, interviewed in 2006):
Did you have the impression that he was bitter about his arrest and the fine and the way he was treated after the war?

I don't know anything about that. It was never a topic of conversation and this is all so new to me; I never knew anything about it before. But I now know – I've spoken with my parents more recently – and I have heard that it could be a rather, shall we say, difficult family relationship about this, not in the Widerøe family but in my mother's family, where people had slightly different judgements and slightly different experiences in connection with the war. Another uncle, Egil Reksten, who was married to Ragnhild's sister Louise, was a prisoner in Germany. There was certainly something or other there, but it was never a topic. But my father said relatively recently that there could be some very difficult Sunday lunches at Ragnhild's parents' house right after the war.

What about the lack of professional respect in Norway. Did that upset Rolf?

I really wouldn't have noticed that. No, I think he joked about that, with all his honorary doctorates from various medical faculties. I once heard him say 'Now I've received all the possible prizes except the Nobel Prize, and it's too late for that.' And that was probably when he was 75 or 80. The fact that he was with Brown Boveri, an industrial firm, whether that had anything to do with it, well – it is the case that research carried out in industry is not always accepted with equal status in academic circles. I don't know how much we should read into that, but the fact that research also happens in industry is much more widely recognised abroad.

Do you mean by that, that it was the professional environment and resources that lured him to Hamburg in 1943?

Yes, the most likely explanation may well be that since that was where the resources and the milieu were – and being the slightly blinkered scientist that he was – so he decided to go. But that is guesswork on my part. It's not entirely unusual to be in a research environment that is financed by industry and at the same time has academic connections, but it is more usual in countries other than Norway.

Is it problematic for Norwegians to give an engineer with commercial connections academic status? That they take out patents instead of publishing academic papers?

Yes, in a way. But the possibilities of making progress may be better if you have strong industrial backing. So it can work both ways.

Rolf Widerøe jnr. (*youngest son, five years old when they moved to Switzerland)*:

Could you in the family see whether your father was sad that he couldn't stay in Norway?

No, we didn't notice any signs of that. We knew that Father had worked in Germany for a year or two during the war. There were people in Switzerland who said that he had worked on the development of the V2 rockets. But it isn't the case that I then went straight to Father and asked him if that was true. I didn't go into that. I thought that if there was something of the sort, my parents would sooner or later get round to telling me about it. But he did once hear that within the family his mother was referred to as "poor soul."

Then he goes on to talk about the professor at the Radium Hospital who went through the case documents from that time and rehabilitated his father's reputation with an article and a meeting at Hardanger.

We were all there, Mother, Per, Arild and myself. I got to hear what had happened. In addition there was Waloschek's book, published a few years earlier, that had also told us a little. As regards what you asked about, whether father regretted not being able to work in Norway, we didn't get that impression at all. We always went on holiday to Norway. He said once or twice that when he retired he would return to Norway to die. That was the only sign we saw that he longed for Norway, when he was able to say that. How seriously he meant it, well, but he was rather – with all the business during the war and all that – he was rather more concerned that he basically in a way was forced to move out of Norway. I think he felt that a little more than Mother. That's what I think.

That they had to leave the country because of public opinion after the war?

Yes, I do think so. But it's not as if he was really bothered by it. Not at all, for he was really – for the most part – very positive and happy, and satisfied with everything as it was. But it isn't the same thing whether one moves willingly or not, you understand.

How willingly do you think it was?

Hm…

Really? Do you think that he went to Germany willingly?

That's possible, for when he had the idea of the betatron and this task he had set himself, fifteen or twenty years before, and now he sees that the possibility was there to carry it out… And he knew that there were others who would be trying themselves. In England and the USA there were people who had also started developing this sort of apparatus. I think that may be possible.

It fits the picture you have of your father, that he could be so absorbed?

Yes. Yes, perhaps that, yes. He was never really interested in politics. And going to China to deliver a lecture during the Cultural Revolution, that was no problem for him. On the contrary, he thought that what they were doing in China was really fine. He was uncritical in that way.

And then Rolf jnr. pauses to think a little before he continues. Reminds himself of the question:

Whether Father went willingly or not, that is difficult to say. I really can't think anything definite about that. But you should speak with Per, who lived with my parents from when he was 7 until he was 24, and with my brother Arild, he may have a slightly different impression.

So I still haven' t had any unambiguous answer to take me forward in my search. I don't think that is just because the people I ask are being diplomatic. I think they genuinely don't know. They respectfully refrain from expressing confident opinions when they are unsure. Each person who replies reminds me to ask somebody else. They refuse to claim a monopoly on the truth.

Then I go to somebody with a prison number tattooed on his arm, a man who has married into the family. Maybe he will have a sharper point of view.

Egil Reksten (*married to Rolf's wife's sister Louise*):

I've been wondering why your brother-in-law went to Germany in the midst of the war. Why do you think he did it?

I think he didn't really think it through. He was so buried in his own thoughts that he didn't think there would be anything wrong. That was where he had the chance to make progress with his project, anyway that's how I have understood the situation. It fits with how I saw him afterwards too. He was so obsessed by thinking about technical and scientific matters that he just had to follow them through. I'm convinced he was so deeply immersed in his own ideas and work that he didn't have space in his brain for other things.

If you had had a brilliant idea, what would you have done? Would you have followed up your idea in Germany if you got the chance or would you have followed the flow, postponed the research until later and been a good Norwegian?

Yes, what would I have done in such circumstances? I would have gone to England and developed it from there. But I don't have the basis to assess how a researcher such as Rolf would see it.

But is it conceivable that Rolf could have moved to England? Was it a practical possibility? Moreover, he had spent several years studying and working in Germany; that's where his contacts were.

Yes, I wouldn't exclude the possibility. If he had really wanted to he could well have gone to England. Some people travelled round the whole World to get there. But I don't think that really occurred to him.

Name and Shame

Some people didn't ask openly why Rolf worked for the Germans, but nevertheless had opinions about it and spoke about it among themselves. To them, Widerøe's name became shameful. 'Remember what he did!' End of discussion. Many of the Oslo University physicists in the Norwegian Academy of Science and Letters were opposed to Rolf being given any honours. One person who has observed this is his nephew, Aasmund Berner, formerly Professor of Pathology. When I interviewed Professor Berner in his office at the Radium Hospital, he had a copy of his uncle's biography on the desk and his doctoral thesis on the bookshelf. He told me about the reaction when his colleague Tor Brustad suggested as part of a lecture that Widerøe should be given some honorary recognition:

Aasmund Berner (*son of Rolf's sister Grethe*):

Uncle Rolf was still alive at that time, but he was ill and was not expected to live very long. Brustad wanted to arrange some sort of recognition while he was still alive, but it didn't come to anything. Remember that nobody understood very much about Rolf's research. That was one thing. The other thing is that the research environment in Norway at the time of Rolf's imprisonment wasn't ready for his ideas. They hadn't reached that level. The professors in the expert committee during the legal case labelled them as just nonsense; he wasn't a real researcher.

How could they say that?

I don't know them, so this will just be speculation. But we can think that – well, people in prominent positions often have self-important traits. And if you think that you know best and then somebody comes in from outside, and especially somebody who is thought to have acted suspiciously, then … For example, there was a bust of Uncle Rolf sculpted for the Radium Hospital and when the Physics Department at the university was asked if they wanted a copy they said 'No, thank you.' I know this only at second hand, I know a little at first hand. But it is striking – even though we have a small presentation about radiation in the foyer here at the Radium Hospital - it is striking that when I mention Rolf's contribution it seems to me to be undervalued. I've tried to say something to the management, both past and present, but I feel I'm talking to deaf ears. Professor Brustad is an exception. He has done a lot for Rolf's reputation.[16]

The lecture that Professor Berner referred to was organised by the Norwegian Academy of Science and Letters, of which Brustad was a member. The meeting was arranged in connection with the anniversary of the discovery of X-rays, on the theme of researchers who had made advances in this field.[17] Brustad said that he thought Widerøe had been overlooked, and he proposed that a committee be set up to consider whether the Academy should take the initiative to honour him in an appropriate way. He based his proposal both with a view to the Academy's own reputation and on 'what we as its members owe to this pioneering scientist.' According to Brustad himself, he contacted the leadership of the Academy several times both verbally and in writing to remind them of his proposal. Eventually he was informed that it would be sent to senior academic members to be dealt with, one of whom confirmed to him that his proposal had been rejected. Rolf died three or four months later.

> 'The proposal came to nothing, and I'm not surprised if the reason was that powerful men were opposed to commemorating him,' Brustad commented.

Membership or not

There had been similar controversy 25 years before, about whether Rolf could become a member of the Academy. Powerful forces were opposed to him. Other members said yes, that it was high time and that it was a shame he had been neglected for so long. Then as now, The Norwegian Academy of Science and Letters was a venerable institution for leading scientists, not a club that just anybody could join. One was invited. Although the constitution of the 150 year old academy has been adapted over the years, it still states that 'Admission of Norwegian and foreign members happens after an evaluation of the significance the proposed candidate's scientific contribution has had in the relevant subject area.' The fact that Rolf was ageing didn't make the proceedings any less dramatic. It also says in the constitution that 'New members shall normally not be older than 65 years. Specified reasons are required when the nominee is older than 65 years.'

Tor Brustad said that finally in 1973 the time was ripe for Rolf Widerøe to be voted into membership of the Scientific Academy. It was then seven years since the death of the powerful chairman of the expert committee in connection with the legal case.[18] As a newly appointed member Rolf delivered a lecture in the mathematical-scientific section entitled 'Radiobiology and Radiotherapy,' his new subject area. It was an important victory for him and for those who had argued his case, but it didn't really change very much either in scientific circles or beyond. He delivered a variant of the same lecture at The Radium Hospital. This was printed as an article in *Fra Fysikkens Verden* ('From the World of Physics')[19] with a whole series of scientific degrees and honorary titles piled beside his name—'Dr. Ing.; Dr. Ing. e.h.; Dr. med. h.c. R,'—and with the additional information that 'Widerøe is Professor Emeritus at E.T.H. Zürich.' Whether this was him now getting his own back or whether it was the editor who had wanted it thus, the message was clearly that he was an academic and not an engineer from industry.

Professor Berner said that as there was no doubt about Rolf's contribution to science it was amazing that he hadn't also been recognised at home in Norway. He wondered how much politics was behind that.

Looking at it in isolation, it's difficult to understand that we can't recognise somebody who continues his professional work even during a war.

Yes, I don't know what it is.

Really?

No, I don't understand it at all.

We need to be able to disperse the fog of war and see more clearly. Is that what you mean?

Many weren't up to that. They were so obsessed by past events. I think many people are wrongly condemned. Even today, people still have strong feelings about the war.[20]

Viggo was the Hero

The public mood in Norway after the war honoured Viggo as strongly as it rejected Rolf. Viggo had distinguished himself as a resistance fighter and had acquired heroic status. Gunnar 'Kjakan' Sønsteby, the highest decorated of Norway's resistance workers, said that Viggo Widerøe was among those who laid the foundations of the resistance organisation, *Milorg*:

> I got to hear about him right away. We were already beginning to think on 9th April, and he was among the very first pioneers who brought Milorg into being. I didn't meet him personally then, as that would have been too risky. The more you knew, the greater the danger. He didn't know my name either, just my codename "24."[21]

In a document presented to the Norwegian Parliament in 1948—'The Government and the Home Front During the War'—Viggo Widerøe the aviator is among those named as having taken part in the historic meeting where the decision was made to set up a military council.[22]

> 'But it was because of the traffic of escapees that he was caught,' Sønsteby said. 'And he was caught early on. Somebody had been a little sloppy. He was helping people to escape to Great Britain. That was one of the most important things people could do, to get people out who had to leave, over to England or to Sweden'.

Viggo had been doing one of the things the Germans cracked down upon hardest. He was arrested and condemned to death but had the sentence commuted to ten years corrective detention. He survived. After the war he and Sønsteby became close friends. And to complete the picture, we should add that Viggo's wife Solveig was also active in the Home Front. She was one of the women who worked in immediate contact with central parts of the resistance movement, in the circle around Gunnar Sønsteby. With two young children in the house, she sheltered British officers on missions in Norway. When Birger Rasmussen, a member of *Kompani Linge* and of The Oslo Group, was shot and wounded she hid and looked after him before he escaped to Sweden. Sønsteby wrote in her obituary that she was 'an important person in the resistance movement from December 1942,' in other words nearly all the time her husband was in prison.[23]

A Handful of Norwegian Physicists

In fairness, it should be put on record that if we look carefully we can find contemporary Norwegian physicists who recognised Rolf's contribution. Particularly deserving of mention are the two scholars who arranged and took part in the interview with Rolf when he was in Norway on summer holiday in 1983. Jan Sigurd Vaagen has since lectured about Rolf's betatrons to his students in Bergen, and he has also spoken about Rolf's contribution in a lecture at an *Academia Europea* seminar about accelerators. Finn Aaserud in his role as Manager of the Niels Bohr Archive has been interested in Rolf as part of the big picture of the history of science.

Another professor from Bergen who has since expressed great respect for Rolf's contribution is Egil Lillestøl, who worked at the CERN Research Centre in Geneva. He has held regular courses for physics teachers and written popular scientific articles, and Rolf is included all the way. Lillestøl's explanation of why Rolf did what he did during the war sums up the thoughts of many:

– He knew within himself that he hadn't done anything wrong. What other people thought was not important to him. I think that Rolf saw his great research opportunity, followed his chosen path and decided to ignore everything to do with the war.[24]

Odd Dahl, also from Bergen, is another who has taken an interest in what happened to Rolf. He and Rolf had worked closely together in the starting phase of CERN. This was Dahl's judgement:

> When the war came, he went back to Germany to continue his work – not from ideological convictions but rather because he was totally absorbed in his research. That made things difficult for him in Norway after the war. He was arrested, but some of us who knew him quietly managed to get arrangements made for him to be allowed to leave the country. He did well in Switzerland as Director of Research at Brown Boveri, and I have worked with him on several occasions.[25]

There were some others. One of them was Gunnar Randers, the colourful astrophysicist and Alsos Captain whom Rolf though had been instrumental along with Dahl in getting him out of prison. This is the same Randers who was a member of the expert committee set up by Oslo Police Department during the legal proceedings, and who wrote in *Dagbladet* that Rolf should be treated as a traitor. And—he is the same Randers whom Rolf communicated with after the war, about establishing a research institute to help rebuild the country. But despite his professional curiosity, Randers never took upon himself the role of rehabilitating Rolf. It can be claimed with some justification that Randers pumped Rolf for his knowledge and then stabbed him in the back in connection with the legal case.

So some did see and recognise his genius. But the Norwegians who over the years have advocated Rolf's case loud and clear in his homeland can be counted on the fingers of two hands. What they all have in common is that they have spent a lot of time abroad. Randers and Dahl in the USA and Geneva. Lillestøl also in Geneva. Brustad in the USA. And the colleagues Aaserud and Vaagen with experiences from USA, England, Denmark and Russia. In leading position are the two foreigners who have taken a special interest in Rolf. One is Søren Bentzen, the Dane with special expertise in ethics who has lived for long periods both in England and in the USA. The other is Rolf's biographer, physicist Professor Waloschek—born in Vienna, grew up in Argentina, long resident in England and finally many years in Germany.

The entry about Rolf in The Norwegian Biographical On-Line Dictionary states simply and uncontroversially that 'After the Second World War Widerøe moved to Switzerland.' It says nothing about where he was during the war. Skilfully omitted. But it does say that the reason he moved back to Norway *before* the war, after several years with AEG in Berlin, was among other things because 'the new political circumstances were not to Widerøe's taste.' A sort of indirect answer to our question. Several other articles in works of reference say much the same.

A Nobel Prize, Him?

Even several decades after the war it was suspect to be too positive about Rolf, lest there was anything in the rumours that he had been a Nazi. In the 1980s, when he was over 80 years old, there was a move to have him nominated for a Nobel Prize. This was initiated by people from what is now The Norwegian University of Science and Technology, in Trondheim. Two who disregarded the fear of being associated with Nazism were the Professor of Technical Physics, Sverre Westin, and the holder of a government scholarship, Olav Aspelund. They both gathered documentary evidence and mobilised their contacts. But they didn't win support among Norwegian physicists, especially in Oslo.

Aspelund had written an article in *Morgenbladet* for Rolf's eightieth birthday in 1982, and had arranged for Rolf to deliver a lecture both in Geilo and in Oslo the following year. A problem with Aspelund's involvement in Rolf's rehabilitation was that he was not always taken seriously by colleagues who thought that he was too submissive and uncritical in his admiration for Rolf. To some people, his enthusiasm to support Rolf seemed self-defeating. Aspelund was a nuclear physicist who was living in Germany in 1971 when he read the featured interview with Rolf in *Aftenposten*. Until then he had only associated the name 'Widerøe' with the airline, but now he immediately got in touch with Rolf, as he told me in an interview during the preparation of this book.

> I think it was scandalous how he had been treated. I think the verdict should have been nullified.[26]

He told me that he then wrote a recommendation to The Royal Swedish Academy of Sciences, recommending Rolf for a Nobel Prize in Physics.

> That is to say, *I* wrote it and then I got Sven Oluf Sørensen at the Physics Institute at Oslo Unversity to send it, for he was a professor and I was not. I also tried to get several other people to nominate him, but my impression was that Rolf was regarded as a non-person.

But other, more powerful voices were calling for a Nobel Prize for Rolf. Parallel with the Norwegian initiative, things were also happening during the 1980s in the USA.[27] Professor Robert Hofstadter at Stanford University, himself a Nobel Prize-winner, nominated Rolf for the Physics Prize before the 31st January nomination deadline in 1985. He proposed a treble-shared prize with the Americans Kerst and O'Neill. Hofstadter's nomination proposal was based both on Rolf's pioneering studies of the principles of particle accelerators and on the use of the technology in cancer treatment, 'to the benefit of humanity.'[28] But the proposal didn't succeed.

In 1992 the Director of the DESY Laboratory in Hamburg took a new initiative with a view to nomination.[29] Sverre Westin was involved in this attempt too. He wrote to the director, saying that from a purely objective point of view:

> …there can be no doubt that Widerøe is worthy of nomination for either a whole or a shared Nobel Prize on the basis of his unique contribution to accelerator technology. He has surely made a contribution on a global level, even though so far as I know he has not personally made any discoveries in nuclear and particle physics.

This was an objection many people raised, that Rolf had not made a discovery in physics itself, but in the *application* of the laws of physics. Sverre Westin thought that the same could be said of Lawrence, who had found Rolf's betatron sketches in the library and got the idea of building the cyclotron that had won him the Nobel Prize. He commented:

> So far as I know, no nuclear physics results were put forward in that instance as a basis for the Nobel Prize.[30]

Sverre Westin took up the case with the President of The International Union of Pure and Applied Physics,[31] who was a former Chairman of the Swedish Nobel Committee, but he thought it was now too late. It was now many decades since Rolf had launched his theories and built his betatrons. Westin considered that this need not be a hindrance, as Lars Onsaker had received the chemistry prize almost thirty years after presenting his theory. Nor should Rolf's own age be any obstacle, even though he was now 90, as the Norwegian Trygve Haavelmo had received the prize in economics when he was almost 80. But anyway, and despite the fact that he was looking for good arguments, he was cautious enough to write to the DESY Director:

> I really fear that there is not much hope of achieving a break-through with a proposal for a Nobel Prize for Widerøe when not even Hofstadter's proposal won support.

And that was presumably their conclusion, for there is no knowledge of any nomination being submitted.[32]

In Switzerland, the thought had already been aired in the 1970s, when a physicist at a meeting arranged by the Technical College in Zurich said 'I wonder why my colleague, Professor Widerøe, has not received the Nobel Prize for his works.'[33]

The Danish physicist and medical doctor, Søren Bentzen, is in no doubt, however, and he says plainly:

> He was cheated out of a Nobel Prize. Because Widerøe should quite certainly have shared the Nobel Prize that was given to Lawrence. There can't be much doubt about that. If what Nobel Prizes do is to reward original and ground-breaking ideas, Widerøe should certainly have had his share of it. Lawrence did the right thing afterwards in always recognising him. He has said on many occasions that he read Widerøe's dissertation and that he understood the idea immediately and went ahead with it. But Widerøe was the trail-blazer. He met strong opposition and had many doubters, even among well positioned people who thought that it would never work. But he won the battle. Modern accelerator technology stands in great debt to Widerøe. And to Widerøe's discoveries. His professional reputation is undisputable. He is a major figure in the history of radiotherapy and radiation physics.

The former director of IBM's research centre in Switzerland, Karsten Drangeid, says the same:

> Widerøe should have had the Nobel Prize for Physics.

Sharing the prize with one or more of the three Americans Lawrence, Kerst and O'Neill is what was most often suggested when people discussed the possibility of a Nobel Prize for Rolf. Lawrence invented the cyclotron, on the basis of Rolf's doctoral thesis. Kerst built the world's first betatron, on the basis of Rolf's doctoral thesis. O'Neill, who developed storage ring technology, did so independently at the same time as Rolf was taking out a patent on the idea in 1943. Rolf was proud of this idea but kept it secret for many years because of the war, and machines using this technology were not built until the 1950s, at CERN and elsewhere. O'Neill and Rolf understood that they had been working in parallel on the same topic. They admired each other's work and they later met several times.

After several years Rolf received a letter from one of the key people in the Accelerator Department at The Brookhaven Laboratory in the USA. The author of the letter was concerned on Rolf's behalf. He had noticed that people referred to Kerst and O'Neill, but not to Rolf, when they discussed colliding beams. He said that he had checked the documentation the Americans had presented at a conference at CERN in 1956 and had not found any reference to Rolf. He had now written an article to rectify this omission, but he wanted to show it to Rolf before it went to print.

In the article he wrote that 'It has recently become clear to us that this was suggested much earlier by the multi-talented inventor Rolf Widerøe.' He described Widerøe as the man who had founded accelerator technology with his doctoral thesis in the 1920s and who had made an important discovery while on holiday in Telemark in 1943. And then follows the now legendary story that begins with the words 'One fine summer day as I lay on the grass, watching the clouds roll by…'

He went on to write that Rolf had immediately tried to register a patent, but that it had not been granted until many years later. In the meantime Rolf had developed the idea further and drawn up several proposals for the construction of a machine with 'colliding beams.' The article concluded with references to publications that confirmed the truth of this and stated that 'It is our impression that Dr. Widerøe deserves a large share of the credit for CERN's success with the ISR machine.'[34]

Behind the Scenes

The close relationship between Lawrence's research and Widerøe's research is mentioned in a book published in the USA about what goes on behind the scenes in the selection of Nobel prize winners.[35] The book is written by a scientific historian, and it is generally critical of how individual people or groups have tried to use the prize to advance their own scientific, cultural or personal agenda. The book claims that in Lawrence's case the committee awarded him the prize for his promising work on the cyclotron—rather than to somebody who really had made a discovery—because they wanted to help him to obtain the vast sums of money he needed for the work.

A chapter entitled 'Cyclotronists of the World Unite,' tells of the discussion prior to the award to Lawrence in 1939. One of the objections was that he was part of a team with many assistants and therefore could not be given sole credit for the achievement. There is mention here of Rolf as one of the people who inspired him and of how this happened, but without suggesting Rolf as a candidate. The book describes the 1930s as a hectic time scientifically, with an active climate that made it difficult to promote candidates. There were few nominations in the time before the outbreak of the Second World War and Hitler's ban meant for example that Germans were excluded. The growth of a new international way of doing physics, Big Science, was also a weighty consideration. Some people thought that the Europeans, Cockcroft and Walton, deserved the prize before the American, Lawrence, though they too finally got it.

The book starts with the words 'The Nobel medallion is etched with human frailties. Both those who select winners and those who receive the Nobel Prizes are, well, mortal.' A warning that both to receive and not to receive the Nobel Prize can be the result of error. A Nobel Prize is not a last judgement of ones contribution to research.

One person who cannot professionally assess Rolf's eligibility for a Nobel Prize but who has a purely personal view of it, is his grandson and adopted son, Per Trifunovic. He sums up soberly:

> He could perhaps have got it if the war had not been an issue, if he had just worked in Norway.

If I had not been for the war … well, perhaps. But the war was real, and so this was just speculation. And even if the war had not happened, the 'perhaps' would still have been there.

In the Wrong Place

In later times, Rolf had support from unexpected directions. Finn Lied, an electrical engineer by profession, was admitted to the Science Academy in the 1970s. He had been critical of Rolf's stay in Germany during the war, but he was not dismissive of the suggestion of a Nobel Prize for Rolf.

> It wasn't so unnatural to think of him. He was very early with linear accelerators, which have later proved to be a very important tool. But there was something or other that prevented him from being embraced by the Norwegian people.

Lied couldn't remember whether there had been talk of setting up a bust of Rolf at the university:

> I don't remember, I can well imagine – that if somebody asked me today whether he should have a statue at Blindern – then I would say no. Simply because we don't set up statues like that. It would be inappropriate. No; no statue for Widerøe. No, I must admit that after four years at war I have become less sympathetic, no. But I can't remember being opposed to the proposal. But I have opposed so many things, so it may well be that my memory fails me.
>
> *I've been told that when this was under discussion, either you or Jens Chr. Hauge said that he shouldn't be remembered, and shouldn't have a statue.*
>
> I can't remember that. Myself, I haven't been interested in him or his subject area, which was particle accelerators, that has never interested me. But he was an important man. There's no doubt about that; very important.

In what way?

He was ahead of this time. The accelerator he was working on for his doctoral thesis, it was not achievable with the electronic technology of that time. But he later became a consultant at CERN and these other Norwegian physicists of the time, such as Tangen and others, they were just children in comparison with Widerøe.

Hylleraas too?

No, Hylleraas was really a theoretician. But Odd Dahl, he was a pioneer. He had a real understanding of exactly what Widerøe was working on. But there is a danger there, I would advise against making Widerøe into some great hero. He wasn't. He was a very clever engineer. But there was something about Widerøe I haven't managed to grasp. I've never really understood his stay in Germany during the war. There may be some unsolved puzzles there. But if his conscience was clear, he behaved stupidly. The public impression was that he was in the wrong place at the wrong time. But that he hadn't done anything particularly wrong; he just worked in Germany during the war. Many Norwegians did that, he wasn't the only one. It's different now, we are more relaxed. We don't have the concern we had at that time in relation to those who had not been in the right places. But when I try to put myself back to that time, then it couldn't be accepted.[36]

… And in the Right Place

A parallel—and contrasting—case to Rolf is the four years older chemist Odd Hassel, who did the 'right' things. Grew up in Oslo, student in Germany, doctorate in Germany, wrote his scientific articles in German. And then—when the war came—he began to write in *Norwegian*. In Norwegian journals. And after the war—then he published in English, not German. He got a bust in the science library at Oslo University. And he got a Nobel Prize, shared with a Brit.

This is the man whom 'The Griffin,' the German Paul Rosbaud, probably used as a courier to British intelligence services and whom the Americans are said to have tried to recruit as an agent. In 1943—about the time Rolf went to Germany—he was arrested and sent to Grini where he gave lectures for his fellow-prisoners. His publishing in Norwegian may have provoked the occupying power.[37]

Most Norwegians say that they don't know enough either to condone or to condemn Rolf's stay in Germany during the war. This applies both to scientists and to others. One person who said that he felt the lack of information about Rolf was Haakon Sandvold, former Director-General in Årdal and Sunndal Verk, himself a civil engineer in a related field and an important figure in the politics of research for many decades:

> I have never been totally clear about what Rolf's contribution was. I have heard a lot of opinion that he was a Nazi, but I don't know enough to assess that. But he must certainly have been so committed to work through his ideas that he looked for German contact.[38]

Among other things, it was this lack of factual information that Tor Brustad at the Radium Hospital wanted to put right. He thought there was a responsibility to ensure that the public got to know about Rolf's contribution to science, so that he didn't remain the 'footnote' in the history of physics in Norway that Brustad thought he had become.

But documentation and facts are not always enough. Feelings don't follow factual answers. It doesn't necessarily help if the formulae and formalities are correct. Everybody who lived then, knows that. You just don't go to Germany in 1943. Not unpunished. And Rolf *had* worked there during the war. On a project under the wing of the Luftwaffe, even. How could he? Be so stupid? Much of the scepticism was because of lack of information. But some people didn't want to know. Or they didn't want to let other people know what they knew. And where information is lacking, rumours flourish.

Nothing is just black or white. In the interview with the physicists, Rolf said that he had been described in an article as an 'obscure' person, and that he wasn't sure himself what the author meant by that. One possible interpretation is 'morally doubtful.' Many people thought that was hardly an exaggeration. Even after Tor Brustad's input at the X-ray conference in 1997 and his article in *Acta Oncologica* a year later, the physics community in Norway hesitated to be persuaded. Nor did the institution of a special prize in his name help very much. There was no big recognition. All the demonstrations of respect abroad—the prizes, the talks, the honorary professorships—counted for little. Brustad had washed his name by digging out the case papers, and his little group of Norwegian followers arranged for some articles in strategic places. In *Morgenbladet* for his eightieth birthday, in *Bergens Tidende* and *Aftenposten* for his ninetieth birthday. That didn't make him a hero. But more recently he has appeared on the website *forsking.no* and in the on-line lexicon. Little by little, as the wartime generation dies out, he is finding his place in the history of science even in Norway. Not as big a place as he could have had if the circumstances had been different, but a place. At last, people will ask not 'What was that business with him during the war?' but 'What was his contribution to science?'

'Something'

Karsten Drangeid, one of the people who worked with Rolf in Switzerland in the 1950s, said he had the feeling that his boss didn't want to speak about the war.

> I think he had a difficult time afterwards, but he never said anything about that. There were some things I didn't know until I read Waloschek's biography – that he had been in Germany during the war, and that he had done what he did in order to help his brother. The fact that something is legally permissible is not the same as that it is morally acceptable, and if he believed that his brother's life depended on him going, I can understand from my own experiences during the war that it must have been difficult for him.

It is difficult to say how many people were fully informed about Rolf's situation right after the war. Maybe no-one. There is much to indicate that even those closest to him didn't have the full picture. Neither his siblings nor his parents. His wife, possibly. Yes, his wife, according to Vaagen. But the children were too small when things were at their worst and the day never seemed to come when the grown-ups would sit down and say 'Now we'll tell you the truth about Daddy's stay in prison.'

Those whom it most affected found ways to live with what they knew—and with what they didn't know. They heard a little here and understood a little there. People didn't speak about details from the war; neither those most affected nor those round about them. With children around and people needing to be rehabilitated, consoled, helped to find their feet again—that is not the time to bring out painful and difficult topics. Not then, and not since. It is done thus with best intentions, not to hold things back but to be done with it, put it behind. Sometimes deliberately. Move on. The war is over.

The fretful, anxious confusion that must have lain over people because they didn't know, or knew something but not everything, is long gone. Children and grandchildren, brothers-in-law and sisters-in-law and their children have picked up the pieces, carried them onward and thought their own thoughts. Each generation has understood it in its own way. Everybody knows that there is 'something,' as Rolf's adopted son expresses it. But nobody knows entirely what that 'something' is. Interviews with close family members tell us mostly how little they have been informed, and how late they were in getting to know what they do know—often only after Waloschek and Brustad looked into it in the 1990s:

Per Trifunovic (*grandson and adopted son*):

We didn't talk about that. I never discussed it with Father. And when I heard about it, heard that there had been a "dark chapter," then I got a sort of explanation – what the official version was – and then nothing more was said about it.

Did you get it from him?

No, from Mother.

So it was your grandmother and adoptive mother, Ragnhild , who had to tell you about "the dark chapter?"

Yes. I had heard that there was something about the war. I don't know how I got to hear about it. I haven't thought so tremendously much about it, but I could never imagine that he was a Nazi. And therefore it wasn't so important for me either.

How did she explain it then?

What I learned, was that Viggo was in the resistance movement in Norway and ended up in a concentration camp in Germany, and that Father had agreed to work for the Germans so that Viggo would get better conditions in prison. Father apparently had no real problems with this afterwards. He was a short time in prison, and then there was an investigation, and then he was free again. And then they went to Switzerland. To develop the betatron, but otherwise I don't think this was any hindrance.

But there is a legal document saying that he worked for the Germans during the war. He had written a pro-German article and he had given money to a pro-German organisation. And these two things, the article and the donation…

as if that was the main evidence?

The time and the mood in Norway at that time were such that if you had spoken with a German, then you were a Nazi. And if you had been in Germany you must surely have been a Nazi.

Yes, he did work for the Germans, but I don't know what impact that had on the war. But he worked contrary to his fellow-countrymen's feelings of loyalty. We just have to accept that's how it was.

Other people might have thought that if they felt themselves unjustly treated they must fight back.

Yes, the question is how unjust it was – that's the other side. I don't know. I only know what I have heard – and that he collaborated in order to help his brother.

Do you know if it bothered him that his reputation wasn't restored in Norway while he was alive?

I don't think he was concerned about that. I don't think he was really so excited about getting honours and honorary doctorates here and there.

He was given many honours internationally.

He was indeed. But I don't think he worked to get them. They just came. And if they came, that was fine. He was pleased about them. But if they didn't come, that was OK too. The honours weren't what motivated his research.

Has it ever occurred to you that he might have been a double-agent?

No, never.

The person who was his administrative manager when he worked in Germany during the war, and whom everybody believed was a Nazi, was really a British spy.

Ah, yes, that was interesting. No, I've never thought about that. It could be, but I don't know. Do the official investigations say that he was a Nazi, either?

No, they don't say anything about that.

Now young people hear about war every day and are doubtful about national boundaries—he was ahead of his time there.

Yes, the world just didn't think like that. But I believe he thought like that. I think he went because the work was interesting. And the whole political business interested him so little that he didn't foresee the consequences. And if he could also help his brother, then it's understandable.

Have you met his brother, Viggo?

Yes. We were always in touch with Viggo. The two brothers always had a good relationship. And what I heard was that Viggo was in a concentration camp in Germany and that Father had agreed to work for the Germans so that he got better conditions. In the family – even in the Widerøe family in Norway – none of the brothers and sisters was basically very concerned about the war. What I believe – if you think it's alright to write this – was that he was politically very naïve. It's quite possible that there was more than just wanting to help. A bit of naivety. He did travel a lot, and lectured all over the world. In China he was very impressed by Mao. And when he was working in the garden, he always wore a blue Mao tunic. He didn't see anything wrong with that. He thought Mao had achieved a lot. What definitely impressed him was how they planned and were focussed on science. But the fact that he could be fascinated by Mao, who was so extreme, shows that he basically wasn't really interested in politics.

Per Trifunovic also refers me to the others and doesn't want to claim a monopoly of the truth. When I thank him for our conversation, he says:

It's exciting for us too, that we need to think a little. You've also given me lots of information I didn't know about.

It is symptomatic that when the members of the Widerøe family are interviewed, the situation is often a little inverted, not quite upside-down but to the extent that the questioning turns into a dialogue. Everybody wants to know more and to share what they do know. The pictures should be completed. The nuances should be explored. Speak to this person and this person. Maybe they have a different understanding.

What does this tell us about Rolf? That he was a man of many facets, and that people saw different aspects.

The Sons and the War

It is interesting to fill in the picture by asking the generation between Rolf and his grandson, i.e. his own two sons, what lasting impressions they have of what happened during the war. Arild, the elder, was four when his father went to Germany during the war and eight when they moved to Switzerland. He answered thus:

Did your father tell you anything about his work in Germany?

No. No. But, I don't know, I suppose I could have asked him. I didn't think it was anything particularly interesting to know about. Perhaps I preferred not to know. Because I knew that Viggo had had a very bad time during the war.

The younger son didn't ask either.

Rolf Widerøe jnr. (*younger son*):

All of that business about the war – I really didn't know all that until Waloschek's book came out in 1993. I had no idea about it. Only heard about it later. But I knew that he had been in Germany. And when we came here to Switzerland, some people said that he had worked on these V1 and V2 rockets. But it wasn't as if I went straight to Father and asked him if that was true. I just let it be. And then it became apparent that there had been nothing to do with the V2 or the V1. People here knew that the Germans had used these rockets. I may have heard about it from some of my classmates at school, and they may have heard their parents talking about it, who may have known about Father and his job during the war.

And with the mood in Norway as it was then, can you understand the reaction?

Absolutely, yes. Yes, I'm saying nothing about that. Oh no.

When you as a family were in Norway, did you notice any suspicion towards you?

No. No.

Or antagonism?

No. Never. Never.

Was there any sign that the other parts of the family didn't want you to visit them during the war because your father was in Germany?

No, no.

Have you yourself subsequently experienced any consequences of your father's stay in Germany during the war?

Some years ago, here in Switzerland there was a lot of concern that people were being subjected to secret surveillance, and the authorities had to allow anyone who wanted to do so, to ask for copies of the contents of the folder. I asked for that, and do you know what was in it? Everything possible about my father having been in China and so on.

Rolf jnr. referred to his grandmother's German ancestry. He pointed out that his father spoke German well, studied in Germany and then worked there for several years. So he probably did not see Germany as the great enemy in the way that people did who had never had anything to do with the country. He had many friends and acquaintances there.

The last member of the family to whom I asked the question was Egil Reksten:

Egil Reksten (*brother-in-law, married to Ragnhild's sister Louise*)[39]:

What is your view of your brother-in-law's activity during the war and his arrest when he came home? You were in a concentration camp.

We can say that what ought to have been done was for example to find out whether he had done anything directly wrong. That was what I think nobody tried to find out. Was that so?

Now afterwards Professor Tor Brustad has been in the National Archives and read the case documents, which state that there was no basis for the accusation.

I have never in any way thought of him as a traitor, I've not done that. I couldn't see him that way.

According to Brustad he shouldn't have been imprisoned.

No, I really don't think so either. On the other hand, feelings were running very high, weren't they?

Yes, but how much is one allowed to ascribe to that?

No, I really don't know what I should say about that. In a situation like that, things are done that are later found out to be unjust. And it can be that there is a sort of necessity in that, yes, that there is a sort of psychological need – people are much stricter and less reflective than they should be.

Why, Why?

Yet again. The big question remains. Even after speaking with those who were close to him. What made him travel to Germany in 1943? There are several explanations.

One is that he was absorbed in his research and looked neither to right nor to left. That is the simplest explanation, and many members of the family incline towards it. But some qualify it by questioning whether he went voluntarily. They say 'more or less voluntarily.' Or even that it was forced labour, something he was called up to, *dienstverpflichtet.*

Others, such as Tor Brustad at the Radium Hospital, maintain that he went to help his brother and add that he was politically naïve. But he also puts weight on Rolf being attracted by the professional opportunities.

All this may be so, but then along comes Søren Bentzen who reads the scales a little differently. Just as much in Rolf's favour, but casting doubt on the explanation involving the brother and advancing instead the possibility that had arisen for Rolf to realise his dream.

Perhaps the thought occurred to Rolf that there were not many people who were capable of understanding this, appreciating the professional and scientific implication. It was better to keep it simple for them with the explanation that he went to help his brother, and that the Germans got his work on the betatron in exchange. For he held consistently to the explanation that he went with a view to helping his brother.

Perhaps he thought quite objectively that what he was doing was not significant for the war effort. What other people thought was not so important, as they didn't have the technical knowledge. So he chose to rise above public opinion and rumour. Did what *he* thought was right. His conclusion was that the development of a betatron with the energy level that was being spoken about could have no possible importance for the conduct of the war. History has proved him right.

It is not easy to pass judgement on this. When everything has been relived and turned over and weighed—and come to a distance—only then can we possibly see and say what was really going on. Or perhaps not even then. Life moves on, even in time of war. We must also take into account that not everything was spoken about. Neither then, nor since. That was part of the package and of the pact. There were obvious security reasons for this, but also some personal reasons that should not be discounted. This, combined with the fact that after the war it was disruptive to talk about things that might have a Nazi element, has led to there being things for which it is difficult to find a good explanation retrospectively.

Tor Bustad called it the 'tragedy' in Rolf's life, the contrast between on the one hand his success and everything that went so well for him in the wider world, and on the other hand that he didn't receive recognition in Norway—all because of the treason case. Rolf's grandson, Per Trifunovic, called it 'The Dark Chapter.' But Rolf should not be seen as an unfortunate victim because of this. He used the opportunity, even if he was forced to it. Either way, he rose above the public rumour and he was not concerned to do anything about the judgement. That wasn't important. At any rate other things were more important, according to Brustad:

> I think he knew that many people didn't like that he had been in Germany during the war, obviously he knew that. But his fanaticism for utilising his talents at whatever cost, plus his brother's position, led him to go. He would become famous for bringing his idea to reality. And then the matter of his brother crops up, which leads to the Germans serving the opportunity to him on a tray. The fact that he kept in not only with Brown Boveri but also with both Siemens and Philips, also shows his capability and his will to go to where there was something to be had. This 'cynicism' was part of his character.

We can continue asking: What was going on in his head in 1943 when representatives from the Luftwaffe met him outside his office and in best spy style invited him to accompany them to a meeting at the Grand Hotel? Why did he go with them to negotiations in Berlin? Why did he settle in Hamburg? Did he have no choice? Was he tricking the Germans or were they tricking him? Was he naïve? Blind? Cynically calculating? Who was using whom? Who was a liability or an asset to whom? Was Rolf using Viggo rather than trying to help him—as a pretext, a cover for something else? Was the story about helping his brother just an excuse? What did he really do for Brown Boveri during the war? What was really going on?

We cannot know. The answer becomes a repetition of what people thought then, what they have thought since and what they think now when they are asked about things that happened so long ago. It becomes digging for source material, investigations and analyses. The more we learn, the more questions still face us. Sometimes an interview inverts to the interviewee asking the interviewer. And the more objective facts emerge, the more curious I become about what I don't know. Not about what he did, not even who he did it for. But why. That is what I wonder about. The human factor. Call it the psychological, philosophical, existential side if you wish.

Going to Germany in the middle of the war? He must have been mad.

But then this business about his brother sneaks back into the story. The factor that some say is the main driver and others just call a vicarious argument. His brother, who had been so close to him as they grew up, when they were students, while the family was founding the airline. The pair who had walked to Sognsvann after school, drunk beer in the student flat in Karlsruhe, gone on ski holidays in the Alps, been surrounded by their loved ones on Easter holiday in the Norwegian mountain home, watched their children bathing together in their grandparents' summer paradise on the Oslo Fjord. And who long, long after, when they were pensioners, still holidayed together every year at Viggo's country house in Spain.

Is the answer to the big 'Why?' a combination of reasons? Is it so human? That he is absorbed in his project, suddenly gets the chance of his lifetime and wants to arrange it so that he combine it with a possibility of doing something for his brother? Or is he so cunning and cynical that he uses the latter to justify the former? The thought is painful.

There are many unanswered questions. But I think there are enough answers to give us reasonable grounds to know that he was not in league with the enemy. I haven't found any documentation directly to the contrary, to show that he was working with the Allies, but I have wondered about it. The Allies did however want to get a hold of him as the war was drawing to a close. This is shown by study of the British and American intelligence archives. And in the Norwegian National Archives the monstrous accusation of being involved with the V2 bombs is boiled down to three small points that resulted in a fine. But nowhere have I found anything to indicate that he was a double agent, even though his contact Hollnack was. Or is working for the enemy sufficient evidence of being in league with them? Many people think that, but fewer think he was a double agent. A Nazi in the sense of a member of the National Socialists he was not. Nor was he a Nazi ideologically. Quite the contrary. He came home from Germany at New Year 1932–1933 in protest against the situation in Hitler's Germany.

If he had refused when they wanted to take him to Germany in 1943, in the same way as his brother refused to allow the Germans to control his activities, what would have happened? Rolf chose the opposite, to comply with them. Seen in that way, the question of how freely he went becomes a philosophical and existential question more than a practical and political one. There are other solutions than the one we reach by logic and judgement, supported by all we have heard and read and allowing a little for contingencies. As one event follows another in most people's everyday lives. As we all navigate as best we can through whatever happens, with some grounded values as anchor-points.

I haven't found any master plan behind Rolf's engagement in Germany during the war. It is always possible in retrospect to analyse and try to see a pattern. Whether it was a temptation or a threat that directed him. Simply laying bare the facts is not sufficient to judge that. Nor is intuition. How much can we really know about somebody else? We know Rolf's official version and response, but nobody can read another's innermost thoughts.

If I could only have reached behind the façade, understood even more of his personality and what moved him. For there is something alluringly attractive in being able just to 'forget' the war and realise the dream. And then, in addition, perhaps being able to help a brother in need. Yes, when opportunity knocks, grasp it with both hands.

But what if he had afterwards done what another famous person did who had made a politically controversial journey and had the world against him? Paul Simon went to South Africa, played with African musicians and recorded his big Graceland album when the country was boycotted because of apartheid. What rescued him from judgement was that he bowed his head and said that he had been naïve. Paul Simon had understood that. The world forgave him. The record became a major hit and Simon became heroically famous.

But Rolf bow his head? Far from it. Not him, no. In his own eyes he had nothing to ask forgiveness for.

The Dream

He had his dream, a dream of a distant goal with many names. He had the results, and even more results. Responsibility. Self-denial. 'Now I must see to completing it soon.' 'It is expected of me.' 'I expect that.' He had a vision of great things that would happen one day. Now all the lines join up. Now all the formulae are found. Lucky are those who have a dream. He would have been in agreement with the founder of 'Apple' who said that the only way for people with such an obsession to be completely satisfied is to carry on with what they consider their great work, the task they dream of completing. Steve Jobs, ill with cancer at the time, must have known what he was talking about when he told graduating students at Stanford 'How to Live Before you Die,'.[40]

Dreams and visions don't operate by closed thinking, but they are more than loose flights of fancy. They say something about what kind of life we want to lead, and they can be realised.

For some people the dream is to create. Make something. Get something to work. Design something beautiful. Find connections. Do something nobody else has done, something that is just mine, that has my maker's mark. Make a table. Write a novel. Plant a garden. Have a child. Arrange a festival.

For others, the dream is exactly the opposite—just absorb the experiences, sense the surroundings, let things happen and don't fret about the everyday things of life.

The dream is your own. It shapes you. It characterises you, but it doesn't excuse you.

Rolf followed the dream, *his* dream, mingled with the events and circumstances of his life. That is why his life was as it was.

***

The people around only saw it from the outside.

Notes

1. *Fredrikstad Blad* 4th April 2008.
2. Their sister, Maalfried Sørheim, in conversation during preparation of the book.
3. Guri Hjeltnes: *Hverdagsliv* ('Daily life'), *Norge i krig* ('Norway at war'), vol. 5, Asschehoug 1987, p. 27, separate edition, new edition 1990.
4. The biography.
5. The talk was given in English.
6. Interview with Søren M. Bentzen 22.11.06.
7. Finn Lied: *Dramaet Copenhagen* ('The Copenhagen drama'), *Forskningspolitikk* no. 1, 2000, published by The Nordic Institute for Studies of Innovation, Research and Education (known at that time as *Norsk Institutt for studier av Forskning og Utdanning, NIFU*).
8. In conversation during preparation of the book.
9. Waloschek's biography, foreword, pp. 5–6 (The prison stay was detention in custody, and strictly speaking 47 days.)
10. Waloschek: *Todesstrahlen* ('Death Rays').
11. 15th November 2010.
12. In conversation with me, 30th November 2006.
13. *Aftenposten* 17th July 1971 morning edition, p. 11, whole page 'Saturday Portrtait:' *Mange Columbi egg I hans kurv* ('Many dove's eggs in his basket'), written by Henning Sinding-Larsen.
14. The biography.
15. Video-interview recorded over two days, 22nd–23rd October 1992.
16. Interview in connection with the book 6th November 2006.
17. *Det Norske Videnskaps-Akademi Årbok* ('The Norwegian Academy of Science and Letters Yearbook') 1996. Meeting 11th January.
18. The initiative was dated 10th January 1973 and signed by Professors Aadne Ore, Alexis C. Pappas, Nico Norman, Per Finholt and Arnold Nordal.

19. 73, no. 2 pp. 39–47.
20. In conversation 6th November 2006.
21. Interview in connection with the book 5th January 2011.
22. London 28th October 1941, Jacob Schive to General Fleischer, *Regjering og Hjemmefronten under krigen. Aktstykker utgitt til Stortinget* ('The Government and the Home Front during the war. Documents published for the Parliament'), 1948.
23. Birger Rasmussen and Gunnar Sønsteby: Solveig Widerøe's obituary, *Aftenposten*, 25th September 1989.
24. In conversation in connection with the book.
25. Odd Dahl: *Trollmann og rundbrenner* ('Wizard and Maverick'), Gyldendal 1981.
26. Interview with me on 15th October 2009. (Aspelund used the word *dommen* [here translated as 'verdict'] in the sense that a *forelegg* that has been accepted and signed is equivalent to a formal judgement.)
27. Letter from Robert Hofstadter to Sverre Westin 23rd January 1985. Letters from Sverre Westin to Robert Hofstadter 8th January and 14th January 1985.
28. The proposal read: 'Rolf Wideröe—Nobel Prize for Physics 1984, for pioneering studies of particle acceleration principles, for fundamental and practical discoveries and inventions in the field of particle acceleration technology (a discipline founded by Rolf Wideröe), and for outstanding lifelong work concerned with adaptation of particle acceleration technology to the requirements of industrial radiography, of nuclear and elementary particle physics, of radio-biology, and of high-energy photon, electron and pion cancer therapy, and all efforts purposely dedicated to the benefit and to the welfare of mankind.'
29. Letter from Sverre Westin to Bjørn Wiik 15th January 1992.
30. Letter from Sverre Westin to Bjørn Wiik 22nd January 1992.
31. Kai Siegbahn.
32. Letter from Sverre Westin to Bjørn Wiik 20th January 1992.
33. *Gespräch über Elektronenoptik* ('A discussion about electron optics')/ Participants: Rolf Wideroe, Enis B. Bas, Giovanni Induni, Lieni Wegmann, Herbert Sprenger, Walter Willy Zürich: ETH-Library [Prod.], 1974, 2 digital audio tapes (total 169 min) + supplement (typescript, 91 pages, various publications and photos) *Aufzeichnung der Gesprächsrunde in der Phonothek der ETH-Bibliothek, 29*th *August 1974/Wideroe, Rolf 1902–1996 Elektroingenieur Norwegen/Schweitz* ('Recoding of the discussion in the acoustic laboratory of the ETH Library, 29th August 1974/Widerøe, Rolf 1902–1996 Electrical Engineer Norway/Switzerland')//BGWFTS/Tape D 237:1–2.

    The physicist who spoke about the Nobel Prize was Enis B. Bas.

34. John Blewett: 'The First Proposal for Colliding Beams,' News and Views, Particle Accelerators, April 1972.
35. Robert Marc Friedman: 'The Politics of Excellence. Behind the Nobel Prize in Science,' A W. H, Freeman Book, Times Books, Henry Holt and Company, New York, 2001.
36. Conversation in connection with the book 15th October 2009.
37. Edgeir Benum: *En forskerskole bygges. Odd Hassel og strukturkjemien 1925–1943,* ('Building a research school. Odd Hassel and structural chemistry 1925–1943') *Historisk tidsskrift bd. 88, s. 639–670, Universitetsforlaget 2009.* ('Historical Journal vol. 88. p. 639–670, University Press 2009') Vivi Ringnes, viten.no.
38. In conversation in connection with the book 14th September 2009. Sandvold died in 2010. He was born in 1921.
39. In conversation 21st December 2006. Reksten died in 2009. He was born in 1917. (He knew Odd Dahl well, among other things from his time at the Chr. Michelsen Institute and in 'The Royal Norwegian Council for Scientific and Industrial Research (NTNF.)
40. 'How to live before you die.' Graduation address by Steve Jobs the founder of Apple, at Stanford University June 2005, You Tube Video.

7

Postscript: The Letter from His Brother

One day when I was well into the process of writing this book a long, white envelope arrived on my desk. The letter was addressed to 'Rolf Widerøe, 5415 Nussbaumen, Schweiz.' Postmarked in Alicante, Spain, 1994. Sender: Viggo Widerøe. Inside the envelope were two sheets closely written by a shaky, elderly hand. The first page had been annotated on a top corner: 'Very important letter from Viggo.' Rolf's eldest son, Arild, had found the letter among his late father's papers and thought that I should see it.

The content of the letter was remarkable, but what was more remarkable was that it was new to Arild and that nobody else in the family knew about it either. The letter was about something they had hardly ever discussed but that they knew a little about nevertheless: the relationship between the brothers Rolf and Viggo during the war.

Arild had read in Waloschek's book about his father that the Germans had used Viggo as a bargaining chip to persuade Rolf to go to Germany, saying that they would try to have Viggo's prison conditions improved. There were just a few lines about this on pages 5 and 63 in Rolf's autobiography, written for him by a German professor of physics. That was all the information the family had to go on. When Tor Brustad researched in the Norwegian National Archives some years later, he found further evidence that Rolf had hoped to help his brother. The book didn't say to what extent he had succeeded, but he had tried. His brother survived. That was briefly what the family had known since Waloschek's book was published in 1993, and they had not even known that in the fifty years prior to 1993.

A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
https://doi.org/10.1007/978-3-030-26338-6_7

Then the letter came to light in summer 2007, the letter from brother to brother, explaining so much but nevertheless saying so little:

> Now I realise for the first time how hard you tried to help me during the war. Considering what happened, it is pretty certain that your efforts were successful.

And slightly further on:

> I was moved to the garden, where I was the only gardener. With nobody supervising me.

No warm words, no grand gestures, no easy embrace. Just sober language. After so many years of silence, that is drama enough.

So it has last been revealed in black and white: Rolf really did help him during the war. Viggo has learned that now, in his ninetieth year, not because Rolf had told him directly but because it has been published in a book. In the letter, Viggo tells Rolf that he now knows. The brothers are now about 90. When all this happened, they were about 40. Since then they have been silent, thought their own thoughts, stayed silent.

Meantime they have visited each other on holiday, laughed together and enjoyed each other's company along with their children and grandchildren … put the war behind them. It's best that way. They have come to terms with life in the present, with each other and perhaps with themselves. So many strange things happened at that time. Let's draw a line under it and go forward. There's nothing to be gained by digging up old ashes. Anyway, nobody would understand. And then one February day in 1994 while Norway and the world was following the Winter Olympics at Lillehammer, evidence appears that even the brothers themselves had not been clear about everything.

'Now I realise for the first time,' Viggo writes, 'that it was you, Rolf, who managed to arrange things so that I survived in the prison.' An elderly man living in a hilly suburb of Oslo can now put the bits of his life's jigsaw puzzle in place. An older brother sitting in his armchair in Switzerland can be confident that his brother now knows. Neither of them needs to wonder any longer.

Thank God that the tabloid press wasn't there. A few simple sentences among apologies for not having sent thanks for the Christmas present before now, talk of almond trees in bloom and 'You'll surely be coming to visit us in Spain this year too.' The question is solved.

It may seem strange, but that is how it was. Here is the letter—which was Viggo's thank you letter for the recently published book that Rolf had sent to his brother and sister in Oslo for Christmas:

> 8/2–94
> Dear Rolf,
> Thank you very much for your long Christmas letter. Best wishes to you and all the family in this new year. You complain of poor memory, but there is no sign of that in your letter! I hope I have thanked you for the two books about your life. Else got one of them. I've only now had time to read the whole book. I haven't been able to thank Pedro W., I don't have his address, but you can convey my appreciation. Greetings from Egil Amundsen, who was very impressed by your work. He liked the book because it was so honest and so well written.
>
> Now I realise for the first time how hard you tried to help me during the war. Considering what happened, it is pretty certain that your efforts were successful. First I was sent from the North-East right to the South of Darmstadt, Dreibergen. People serving a ten year sentence were obviously considered dangerous and not allowed to work outside.
>
> On the day I arrived at the prison there I was called up to see the boss, a major of the old school.
>
> We had a friendly chat about Norway and our culture. (He obviously hated Hitler.) After I had been working in the fields for a couple of months he came on an inspection of the camp. I was called in from work and again had an amiable conversation with him—He was called Mohr, by the way.
>
> Soon after that I was moved from agricultural toil to the garden, where I was the only gardener. With nobody supervising me. Among other things, grew tobacco that close friends got a little of. The last winter there was work in the woods, but the guards realised the way things were heading and paid hardly any attention to the work or to us.
>
> The Americans came in March and some of us took over the running of the camp (2,200 men) and evacuated it in a week. After that I became an interpreter and secretary in General Patton's military government and had many unusual duties round about Hessen. Closed banks, dismissed the management and opened them again with new management and masses of money, apparently provided from the USA.
>
> Have had sun and summer weather almost all the time since 14/11. Now the almond trees are in blossom. Are you coming to visit in 'winter?'
>
> Love to all the family,
>
> Viggo
>
> P.S. It was the 60 years jubilee of the airline in Bodø recently. There was a pamphlet made up about the history of the company, that I have asked them to send to you.

After four short pieces about his time in prison there was a sentence saying that he had been freed by the Americans. All equally undramatic. Was this really all news to Rolf? Didn't he know which German camps his brother had been in? Didn't he know that Viggo had served under one of the leading American generals of the Second World War, tank-general Patton himself? For he too had come home at the end of May 1945. Some of this information must have been new to him. Otherwise Viggo would not have included it in such a brief letter—even though it is clearly an attempt to sum things up for himself also.

We may wonder.

The Family Knew Nothing

The family knew nothing about these events until they came to light one day in the letter. Was that how things were? So had Rolf succeeded in having his brother's condition in captivity improved?

All that they had been able to learn previously was from two short mentions in Waloschek's book:

> In the hope of freeing his brother Viggo – the Norwegian aviation pioneer who had taken part in the resistance against the Germans – from imprisonment in Germany, Rolf agreed in 1943 to come to Hamburg and build his youthful dream, a 'radiation transformer' or 'betatron' that could be used to generate powerful X-rays.[1]

Slightly further on there is a description of how this came about:

> When we came to the Grand Hotel, they asked me if I would go with them to Berlin. They thought it could be helpful to my brother. (…) The German officers implied that my brother could possibly be released if I helped them. That was decisive for me, and I said I would be willing to go to Berlin.[2]

There was nothing in the book about what any input towards Viggo's welfare had consisted of, or whether it had succeeded. But it did say that Rolf had visited him in prison. Viggo's daughter Turi expands on that[3]:

> I know that Uncle Rolf visited Dad in several prisons in Germany, and that he tried to help to have him released. Nothing concrete ever came out of this.

Several weeks after the publication of the book, Viggo wrote the letter saying that he had read the book and had been able to see with his own eyes that his brother really had helped him. This was the confirmation of what he basically thought. However, it was only when the letter was found among Rolf's papers that the wider family learned about it. Reconciled at last. They hadn't needed to know everything. What one or the other had said and done and thought and known wasn't important. They just wanted to look to the future and live in peace with each other. Be friends. The letter confirmed that had been right. Then it was laid aside, annotated 'Very important letter from Viggo' and rediscovered in 2007.

Nowadays it is difficult to understand that close family members—even the two most directly involved—were unaware of the facts for a long time. However, considering the circumstances during the war and trying to imagine oneself in that unusual situation with all aspects of daily life affected by military rule, it may not appear so remarkable. When families were meeting for birthday celebrations after the war, it is perhaps understandable that they didn't want to accompany their coffee and cream cake with conversation about gruesome events and prison camps. Then as time passes, one would not want to open up grim memories. Some people try to forget. There is a communal erasure of recollection. It has something to do with respect, possibly mixed with an element of pride in a respectable family. And maybe a little fear.

That is one explanation. The other is that you just didn't talk about what you had done during the war. End of story. You just did things because they had to be done … and learned not to ask questions.

Another reason for not being surprised that the Widerøe family didn't know, is so obvious that it is nearly always overlooked. People are different. Families are different. It is commonly thought that an extreme situation accentuates individual characteristics. If one doesn't want to intrude on others' feelings, if respecting each other's integrity and boundaries is a family virtue, if tolerance and good manners are important, secrets will be buried without any deliberate intention to conceal them.

In All Directions

In time of war, the undercurrents in large extended families with many children often run in many directions. Such was the situation in the Widerøe family, even though they were relatively prosperous. The waters could be choppy, and family celebrations had to be arranged with a careful weather eye. Also, some family members were abroad or elsewhere, or busy with other and 'more important' activities. This did not stop the different currents but it made them less obvious. Arild recalls that during the war they obviously continued to visit Grandmother and Grandfather at their house in Vinderen on important occasions and at other times.

> But so far as I can remember there wasn't much contact between the adults in the family during the war. After the war, things returned to normal quite quickly. My grandparents on my father's side, Carla and Theodor, had this fine big country place on Skjæløy near Fredrikstad. We were always welcome to go there. Skjæløy was always open.

All ages went to the country retreat; it was a 'sanctuary.' Uncles and aunts and cousins came. Then the next generation and their partners. As the years passed, they discovered things that they had not known about before, either because they had been children at the time or because these things just weren't spoken about. Practical common sense, respectful good manners, a long tradition of solidarity and a large measure of love all worked their healing powers, helped as always by the passage of time. The family is unanimous that they have now left the stormy waters far behind. Nobody denies that it was difficult; but it is over.

> Thor Spandow, son of Rolf's sister Else, says that relationships within the family have always been good, across all generations. 'My uncle Viggo used to visit his parents at Vinderen after work several times a week.'

Then he goes on to tell me about the summers on Skjæløy with his cousins Kari and Turi (Viggo's daughters) and Unn and her brothers who came from Switzerland, and all the others. He tells of grandmother's matriarchal role and grandfather sun-bathing and sea-bathing, Aunt Grethe who built a house on the adjacent land and his mother Else who took over her parents' country home.

> They were strong people,' he says, 'but I never heard of any hostility. True, there was some tension between Rolf and Viggo after the war, but they chose to look beyond that. Time passed, and the family relationships were restored. I've heard the story of why Rolf went to Germany, told to me afterwards in the way the family wants to interpret it. But what my mother told me was that he went to Germany to help his brother who was in prison. I've formed my own ideas about it on the basis that he was scientifically talented but politically illiterate. There was no opportunity for him to develop his project in Norway. His in-laws had a certain admiration for Germany, in their own way. Sunday

lunches were an institution in the Widerøe family,' he continues 'and that must have been difficult sometimes. For a while Aunt Solveig, Viggo's wife, was not often there, and the same was true of Aunt Ragnhild. But that's all history now. Everybody chose to look to the future.[4]

Difficult?

With Viggo and his wife and several others having been so involved in the resistance, we would think that it must have been difficult for Rolf to find his way back to a normal situation in the wider family. Viggo, the resistance worker, would remember that Rolf was married into a family with Nazi sympathies.[5] Then when his brother suddenly started working for the enemy while Viggo himself sat in prison, we cannot avoid the question of how this would affect the subsequent relationships between the two of them and within the whole family. It was obviously an unusual and a dangerous situation. However, when we ask family members about it now they all reply that this did not pull the family apart as might have been feared. Family life gradually returned to normal. Rolf's nephew Aasmund Berner describes it thus in a conversation with me:

Rolf and Viggo fumbled to re-establish their relationship. So we just didn't talk about it. There was nothing to be said. But it was there in the background nevertheless.

But surely Rolf had been trying to get his brother's prison conditions improved?

Yes, I have heard that, but some people think it could be seen differently. Other members of the family know more about this than I do and not everybody interpreted the situation in the same way, but afterwards there was reconciliation all round.[6]

So what did Rolf's brother-in-law Egil Reksten think abut the relationship between the two brothers?

I remember - I think it was on his ninetieth birthday – that Viggo wondered if he had been too angry with his big brother.

How was that?

He wondered, when he though about it later, whether he had not been as considerate as he should have been.

Was he thinking about anything in particular?

> No, I don't think so. He had certainly criticised Rolf, said something or other in conversation, I believe, that he was worried could have been understood as criticism. I don't remember what it was.

Then I asked about the story of Rolf's visit to Viggo in prison in Germany.

> Really? I didn't know about that. I don't even know which prison Viggo was in.

I go on to point out that conditions improved towards the end of Viggo's time in prison. I ask if he knows whether Rolf was responsible for that.

> No, I know nothing about that. Nothing at all.[7]

So none of this had been a topic of conversation. Nor was there much evidence of bad blood between the brothers, at any rate not so far as their brother-in-law knew.

Two Daughters' Accounts of Their Father and Their Uncle

Viggo's daughter Turi Widerøe also emphasises the reconciliation, saying quite plainly:

> Nowadays the family has got over the wartime difficulties, put them behind, been reconciled.[8]

She was three or four years old when her father was arrested and says she cannot remember her father and her uncle Rolf having a difficult relationship. If they had problems, they kept them to themselves.

Her sister, Wanda Widerøe, who was born seven years after the end of the war, describes her father as a man of peace.

> Father was tolerant. He just let people get on with their own lives. Setbacks and difficulties didn't seem to bother him. He always chose to look at the good side of other people.[9]

Their opinion is supported by the senior member of the family, Rolf and Viggo's sister Else. It is no longer 'dangerous' for people to ask questions; and they get answers. Rolf's father-in-law was a Nazi. Rolf was not. Nor was

Ragnhild. Rolf did work in Germany towards the end of the war. Yes, he was politically naïve. Yes, he had to take the consequences of that. Yes it was a difficult time, but we have held together and got over it.

Two Sons' Accounts of Their Father and Their Uncle

I need to ask Rolf's sons about this too. First, Arild the elder of the two:

How was the relationship between your father and Viggo?

All I know is that when my father died in 1996, Viggo wrote to my mother that "Rolf was a very good friend. He was my best friend" And he didn't just write that to be polite. Viggo wasn't like that.

Viggo wrote that "Rolf was my best friend"?

Yes.

I've heard that when they retired they often visited each other at Viggo's place in Spain.

Yes, they holidayed down there regularly during the years when Viggo lived in Spain in winter.

But he didn't come to Rolf's funeral?

No, but they hadn't expected him to come to Switzerland then. He was 92 at the time. And he wasn't the type who goes to funerals. So I fully understand. He didn't even want any funeral for himself. He didn't think anything of the church and the priests; it was all just hypocrisy.

But your father had a slightly different view, hadn't he?

Yes, my father was religious, not in the sense that he went to church regularly, absolutely not. But he would go to the Christmas service. At first we went to Germany. Here in Switzerland they are reformed and we were Lutherans, so we travelled right over the border to Waldshut and went to church there. He liked that best. At first we always went there. But later it was Zürich. For there was a Norwegian, yes we can call it a congregation, there. And my brother and I still go there on Christmas Eve, together with other Norwegians and half-Norwegians. We don't meet at other times, but we greet each other and wish each other Merry Christmas. It's the same every year. The whole service is in Norwegian. A real Christmas feeling. Some people come in national costume, and it's a proper Norwegian celebration. We're trying to hold on a little to our traditions.

Then I ask Arild's younger brother, Rolf jnr., for his assessment of the relationship between his father and Viggo.

> I can't really tell you very much about that. I think it was alright. But I don't know if there was something to do with Uncle Viggo having been a prisoner in Germany. I don't know, I'm not sure about that connection. But what I do know is that even though Viggo said he would never set foot in Germany again, he would just fly over it, he was very, very welcoming to all the visitors we had on summer holidays, irrespective of whether they were German or they were Swiss. He spoke fluent German with them and was careful not to show that he didn't want to have anything to do with anything German.

He adds that many people who had experienced the same conditions as most of the population during the occupation often complained and felt sorry for themselves, but that those who had been in prison and experienced greater hardships didn't talk about it afterwards.

> Wasn't Uncle Egil also in a concentration camp?
>
> *Yes, he was in German captivity for almost four years. He disappeared as a Nacht und Nebel prisoner.*
>
> He has never said a word about that. Never. I think it's something you just don't talk about. Perhaps Father realised that this silence was connected with something unpleasant and so he didn't want to talk about it either. I don't know…
>
> *But your father visited Viggo in the prison in Germany. Once, anyway. I've heard that from several people. Did you ever talk about that with your father?*
>
> No, not at all. I've never spoken with him about that. The first time I heard about it was when Waloschek started writing the book.
>
> *Some people firmly maintain that your father was trying to have his brother's prison conditions improved.*
>
> I've read about that. And do you know what I thought?
>
> *No.*
>
> I really wasn't sure.

Advocate de Besche

Another person whose opinion should be heard is Rolf's defence counsel, Oscar de Besche. As a defence counsel's job is to defend, it is no surprise that de Besche made Rolf's situation the main thrust of his presentation of the case to the authorities, describing it as a choice between agreeing to work in Germany or ending up in a concentration camp, and that in the middle of this dilemma it was revealed that 'if he worked, his brother would be allowed concessions and possibly released.'[10]

The defence counsel based his case on what Rolf had written to him during the legal process, in a situation where he was under pressure and where he revealed more than he did later in interviews when everything was more remote. Here, he also told about colleagues in NEBB whom he had tried to have released:

> 'The deciding factor for me in the question of whether to work for the Germans or to refuse was that they promised to release my brother. If my only brother, who had been sentenced to ten years corrective detention were to die down there (he had already been very ill in the prison), I would always feel myself partly responsible for his death. Nor do I think that my father, who was very frail, would have been able to survive such a loss. As I also knew that the requested work was not important for the German war effort, I can't see that I really had any choice. Finally, I will just add that the Germans also promised to release 13 men from (…) and (…) who were in prison. I worked a lot on this case and finally succeeded in having two men set free, (…) and (…)'[11]

After quoting from Rolf's note, de Besche adds 'I think we can agree that there was no real choice here,' and also 'It should be noted that although Viggo Widerøe was not released, he did in fact subsequently receive several reductions in the severity of his conditions in corrective detention and he survived the war.'

Tor Brustad asked Viggo about the relationship with his brother when he was studying the legal case. He summarises his impression for me thus:

> 'It was obvious throughout that they were close. But I got the impression that Viggo was disappointed that Rolf had married into a Nazi family. He thought that was going too far, but brotherly loyalty is what features most and I think he also really admired his older brother for all he had achieved. I really think that he thought inwardly that the relationship with Rolf during and just after the war had been problematic, especially because of Rolf's work in Germany. It must have been tense between them at times, really tough, but they chose to look beyond that. They wanted to be at peace, they wanted a good relationship, and I think they achieved that. Viggo appeared very fond of his brother.'

After hearing in this conversation with Brustad that the brothers had had their difficulties, I thought: 'If the two main characters decided to live in peace with each other, should I respectfully leave it at that and not dig any deeper into the matter?' At that point I had not yet read the 'important letter from Viggo.' I just knew that the brothers regularly visited each other during their years of retirement, that their children remembered the summers together in the 1940s and 50s as an important part of their growing up—and that they have maintained these close relationships as adults. Curiosity about the reconciliation that must have taken place, and indeed about whether there *was* anything that needed to be reconciled, had led me to ask questions to all of them, for surely it couldn't be hurtful to have the matter elucidated from several angles. If everything was as it should be, truth would not harm the relationships. Nevertheless, I hesitated to write about it; something about respect for other peoples' private lives held me back.

But then I received the letter and changed course, out of respect. That needed to be included. The fact that the brothers had had difficulties during the war and for a while afterwards tallied with the letter and did not need to be hidden. They had been reconciled for a long time; before the biography, before the letter and before they knew all that was to be known. If they had not had difficulties relating to each other from their contrasting situations, I couldn't have taken them seriously. And I realised—as if it was a surprise—that it hadn't always been so easy for them either. No, obviously. How did they manage to do it?

My conclusion was: The two brothers had been through a lot during the war, both separately and together. Their relationship had been put to a hard test, the task of leaving the pain behind and going forward as friends. That was what the letter was really about. Their reconciliation was obviously not cheaply bought. *They* didn't need to know about what was in the letter, but the content confirmed that their choice to be reconciled was the right choice, and posterity understands a little more about what unconditional reconciliation is and the good it can bring.

With Inhibitions Down

So many years with such good friendship but so little said. These were men who lived as they had learned, thinking well of each other.

The fact that Rolf didn't come home from Switzerland for his father's funeral in 1947 might be thought to fit in with this pattern of silence and stiff upper lip, but it did surprise me. Was he so inconsiderate, so lacking in compassion for his mother as not to come home for the funeral? Was he so lacking in respect for his father, who had been his skiing companion over countless miles? His father, with whom he had gone on walking expeditions and motoring tours. This too appears inconsistent, but the hard fact is that he did not travel home to his father's funeral in January 1947, a few months after he had moved to Switzerland. A member of a good family whose members had a lot of contact with each other did not attend his father's funeral.

We are tempted to wonder: Was he frozen out? Was he embarrassed? Was he worried he might arouse rumours? Concerned about what the family would say? Or was he so tired and disillusioned with Norway that he couldn't face the thought of going there? Did he lack a sense of his proper duty as the eldest son? It was his father who had given him the means to study overseas. Or could Rolf not afford to travel back to Norway? That would not be surprising after two years without a salary. Did he just not go to funerals? His brother Viggo was said to be the type of person who doesn't go to funerals. Was that how Rolf thought too? Did he not care, did he just go his own way without thinking of others?

That is how the simple fact might be interpreted, but like the Widerøe family we should not jump to negative conclusions too soon. There may be things we don't know. Once again, help arrives on my desk in the shape of letters; two almost 70 year old letters from son to mother. The first was written by Rolf on 23rd January 1947, the very day his father died, when his inhibitions were down.

Dear Mum!
We just received the telegram telling us of Dad's death. It's strange to think that he is gone, almost impossible to believe. Yes, we shall miss him a lot, most of all yourself. It's so sad to have father's last letter with your note added; it was obviously like a last greeting from him, but I really didn't think at that time that everything would happen so quickly. – It must have been a hard week for all you at home. Down here we have been able to keep going and wait and hope. Today we received Else's letter explaining how everything had gone, and we did have a slight hope that it would pass over. But then when the doorbell rang at 9 o'clock this evening we both understood what it was.

It's strange to think back now to the last time I was at home with Dad. He was sitting at his desk sorting his stamp collection while I sat working. Then he told me about little bits and pieces from his youth: about the first time he came to Kristiania; his work in Eide; walking tours in Nordmarken and from home. I had never really come so close to him before that time, he spoke so openly and friendly and I am really thankful for that last time when I was at home.

You'll all have a lot to cope with now until everything is sorted out, but I hope that Viggo as he wrote in his letter to me can deal with Dad's business affairs and you'll also have help from Edel, Else and Grethe. You can write at once if you want me to come home for the funeral. If it is possible at all (flights are not easy to find), as it is not an easy matter. If so, one of you will need to buy a return flight for me and telegraph the confirmation. (I will sort out the payment when I come home.)

It's very difficult for me to come away from here just now when we are busy with some very definitive trials.

Please give my love to all the others and thank Else and Viggo for the letter.

> I daren't write much more, for there is so much I need to think about and think back on.
> Much love, Rolf.

In the top margin there are two added notes:

> There is no telephone connection with Norway, though there is a connection with Sweden. My no. is 335232 but I assume that Viggo is now with you.
> The letter Dad was expecting was about the tax return. I expect that it has arrived and Viggo can deal with it.

I think his mother understood. He can no longer be labelled as cynical and unfeeling. If his old mother had ever been in doubt about her son's disposition, and if the letter didn't demonstrate clearly enough his compassion and feelings, she would have been emphatically convinced when the next letter arrived, written nine days later and after he had received an account of the funeral from his sister.

The Children Are in Bed

This letter is longer than the previous one. Rolf must have had a lot of emotions to cope with—her own little boy, her clever, grown-up son far away there in Switzerland:

> Giesshübelstr. 114, Zürich 1/2-47
> Dear Mum!
> Now the hustle and bustle of the week is over, the children are in bed and I would like to have a chat with you. I've just taken the recent letters out to look over. (We keep them all.) Else's letter which we got on Monday, your letter which you wrote on Monday and a long letter from Uncle Marius that we got today, where he tells us about the funeral. It's a strange feeling to be so far away in quite different surroundings and experience the whole funeral and the whole mood at the funeral meal. I think I can see the whole table and all the guests talking, there's just one thing I cannot imagine and that is that Dad is not there at the departure feast. He seemed so surely there in the picture that I almost think I can see him at the head of the table nodding and smiling and doing everything to ensure the guests are happy. Yes I can't believe that he is gone and that I shan't see him any more and get his letters. I did think when I last saw him and said goodbye to him that the future was uncertain but as you know we hesitate to think the worst and of course I didn't say anything about that to him
> Uncle Marius tells me that you have had good help with everything at this time but of course I realise that it has not been easy for you. After all, you were the person who knew Dad best and it must have been almost like losing a part

of yourself. However I think it must be a comfort to you that he had such a gentle and beautiful death. It was almost as if he had completed what he had to do here on Earth and was now drawing back so as not to be a burden for you others, indeed it would hardly surprise me if that was how he had been thinking—he always thought of other people before himself.

Now I hope that you are taking it all calmly. There's no benefit in losing heart and as I have said to you once before I think that the departed would rather see it that way. There is indeed a lot you will have to see to now and I can imagine that needs a calm head and a clear vision. I'm glad that Viggo is coming to town in March, I wrote to him and urged him to continue Dad's businesses and not squander the good will that Dad had built up throughout his long working life.

Uncle Marius said in his letter that he would visit you more often and I think you will be very glad of that for I think he is easy and friendly—Yes, I think I like him best of all the brothers.

As you can well imagine, the work down here needs my full attention. When I got the first telegram about the heart attack I wondered right away whether I should try to get a flight home, but I decided that it was better to wait for further details. Viggo's telegram reassured me somewhat and suddenly it was too late.

I'm glad you didn't feel that I as the eldest son should necessarily be at the funeral. What would have meant more for me would have been to say good-bye to him while he was alive—to bid my farewell to his coffin is not the same. Also, as I wrote already I'm now working fully on my transformer, we hope to have it ready by 1st June but if the calibrations I am now working on are not properly done (and they are not at all easy) I run the risk of a year's work being wasted and needing to be repeated. So I have been so exhausted in the evenings that I simply haven't been able to gather my thoughts to write a sensible letter home to you and that is why I have not written sooner.

All is well with us here. We are all healthy and that's really quite surprising because it has been frightfully cold here now for a week or more. The temperature has been as low as 17 °C below zero and we had only 12–13 °C in the living room at home. It generally started with 8–9° in the morning and then rose slowly throughout the day to about 11° at 3 o'clock and 12–13° when I came home about half past six. It has been a hard time for Ragnhild who is at home most of the day. It's nice and warm in the office but it's only 10–11° in the laboratory, where I go around in a winter coat most of the time. Happily, it now looks as if the worst of the cold has passed and today it was quite spring-like with sunshine and only a few degrees of frost. – We use the car only on Sundays, but we have been away skiing almost every Sunday since the snow came. Last Sunday there was not much snow where we went, and it was mainly Rolf and I who practised—he has become very good on the slopes this winter.

Otherwise, the children are working hard at school. They have long hours and not much free time, but apart from the fact that they are not much out in the open air I don't think it's doing them any harm. I've just started teaching Arild to read, but we've not yet come far enough for there to be anything to boast about. Unn, on the other hand, is struggling with unbelievably difficult assignments and she keeps at it from morning till evening with school, sewing and gymnastics (to get herself in shape and look fashionable). Best wishes to everyone and love both to you and to Else, from Rolf.

PS:
I would be very grateful if you could keep some little personal thing from Dad for me so that I can have a particular little memento of him.

This letter to a grieving widow is not from the brilliant high voltage engineer with a doctorate and a top position in European business life. Nor is it from a man with a history of a mysterious stay in Germany during the war who has paid a fine for treason. It is from her boy, her eldest child—now 44 years old and father of three children, in mid-life and chasing time, who is sitting in a draughty three-room flat in Zurich, writing thoughtfully and intimately. A son who writes freely about stress at work and stress at home, now able after the demands of the week to sit down, gather his thoughts and write a letter home. A man who is concerned about the people back home and about his own family with him in a foreign land. He keeps the letters from Norway and brings joy to a grandmother by telling her about her grandchildren; how far Arild has progressed in learning to read and little Rolf in learning to ski. He tries to be sensible and sensitive, finding points of light amid the grief to comfort both his mother and himself. He writes about big and little things, what has been and what is to come. This letter embraces a whole life and a whole clan. Written in a moment of disinhibition, in a language so different from the terse, clipped sentences of his biography which might give the impression that he was emotionally shallow.

And the old lady who has recently been widowed, sitting in the family house at Vinderen and reading the letter—as a mother she must have thought after all, her fledgling had not really flown so very far from the nest. It was a letter that her Theodor could have written. And then she thinks about all the times he had been out with the boys in the countryside, or all the occasions sitting by the stove in the cabin when visiting friends with children of the same age. As if it was yesterday. Life is so short.

High Expectations

Since settling in Switzerland in the autumn, Rolf had rapidly been caught up in the demands of his position. His first task at Brown Boveri, the betatron for the hospital in Zurich, was at its most definitive phase that spring, and a lot was at stake. He had much to protect and much to prove, for the directors at Brown Boveri who had confidence in him and had given him the opportunity to start a new life in Switzerland and for the family who must have had diverse thoughts about him, not least his brother Viggo. Also scientifically; now was when he was expected to demonstrate that he really could build the machine for which he had worked out the principles in theory.

There were also economic pressures. He was responsible for a wife and three children who had been pulled up by the roots and replanted in a new land. Their finances had been uncertain since they moved. He had had to sell thirty patent rights to meet the cost of his fine to the Norwegian state. Some people thought that his wife's father might have provided financial support. Others thought not, as he had enough problems of his own. Or his own father might have contributed.

That was exactly what Rolf's father had done before, Rolf later repaying the loan with interest. After several years buying a house and establishing a family, Rolf had repaid the debt to his father in three instalments during the last stages of the war: 1,500 kroner in June 1943, 2,500 kroner in April 1944 and the rest, 15,000 kroner in March 1945, when he received his final payment from Theodor Hollnack.

His father's death came suddenly on top of all this. Just ten days before his death he had written to Rolf about a 'real predicament' he had come into, as 'the calculation is so excessive, they want to tax me for ten years for the 19,000 kroner plus 2,900 kroner in interest that you have paid me for outlays I had in connection with your education.' He 'had based it correctly in relation to my other children who have not had such expensive education, that you paid back the expenses your education had cost.' But he hadn't wanted to declare the asset as income until it was received, and he had declared everything as paid in 1945, but 'the interest has been accumulating ever since 1920 when the loans started.'

Rolf replied to his father on 17th January with details of loan payments and other payments, paid and unpaid, and with figures from tax returns over the years. Just as embarrassed as his father was at having to take up this topic, Rolf accounted in much more detail than he needed to; that he had paid off the mortgage on the house and still owed his mother 10,000 kroner and had paid his father 625 kroner in April 1945 as interest on the debt that had been paid off.

It is not certain whether the letter reached his father before he died. None of them realised how ill the old man was, and Rolf concluded his letter by saying that it was sad to hear that father had had to take to bed again and had not recovered from the bronchitis, and recommending him to 'go to a specialist with that cough of yours.'[12]

They got legal help to sort this out, and at his father's request Rolf added a declaration confirming their agreement:

> 'I hereby declare that later when my income and financial circumstances permit I shall according to my means pay back to Theodor Widerøe the expenses that are due in relation to my studies in Germany'.

Yes, it had to be sorted out. But it wasn't simple. Economically, the next two years were characterised by tax problems and paying off the fine to the retributions directorate. Sales of shares, inheritances and advances on inheritances eventually cleared everything up. Rolf used his former defence lawyer, Advocate de Besche in Oslo to deal with it, including giving him full authority to sell shares. Rolf would also have liked to make use of the 3,500 kroner he had lent to Widerøe Airlines and 1,500 kroner to his brother Viggo, he wrote to his lawyer, but 'If that is not suitable I would rather not cause Viggo or the business unnecessary difficulties but would rather wait for this payment until it is needed.' His father-in-law had offered earlier to lend him money, but Rolf didn't know if he had the means to do that now and he didn't think it would be necessary.[13]

But finance was now only one of the things he had to cope with.

The most important thing he had to prove was about himself. The radiotherapy machine he was working on should justify his going to Germany in 1943. Perhaps his father, when it came to the crunch, had also wanted him to attend to his project instead of coming to the funeral? Perhaps what needed to be taken care of was the opportunity his father had given him by sending him to a good technical college? Perhaps that was how to show respect, fulfil his obligations, do his duty.

– And a Dream

In thoughtful moments, Rolf reflected on how to keep everything that was important in his life in balance—including his dream. 'Balancing' and 'dreaming' are not obviously compatible, but Rolf shared a family trait that was both a strength and a weakness—a slightly proud sense of confidence. This was a characteristics maintained over several generations of strong personalities and sometimes stubborn individualists. The strength and perseverance had worked out well for many of them, but could be a challenge for the people round about them, as he said himself. At the same time, he reminded himself that one mustn't forget ones dream.

Many years later, addressing Ragnhild in his speech at their golden wedding celebration in 1984, he spoke of life as 'an oscillation between extremes' and admitted that he sometimes lost the balance. He referred to the American comic strip 'Bringing Up Father,' about an oddly matched couple called 'Jiggs and Maggie,' that he had happened to read once before they met, and he pointed to a picture from the play 'The House Tyrant' on the wall behind him. He commented that living together for fifty years entails many challenges and pointed out that 'Mankind is the great unknown.' He had already wondered about this as a 15 year old and committed his thoughts to his diary, and in his golden wedding speech he added that among the guests were two psychiatrists who surely understood this better than he did himself. He then launched into a dissertation on the phenomenon of 'men:'

> 'Men come in many different shapes and sizes. There are the prophets totally absorbed in a fixed idea; people who try to scrape together as much money as possible; those whose greatest interest is in football and sport; and then thousands of other variations – artists, gardeners and industrious ants who wear out office desks. (…) And women have to sort all these variants out and get them into shape! (…) Think for example of being married to a prophet, such as Mohammed. That must have been dreadful. One day he was flying to Jerusalem on a winged horse and the next he was sallying out with sword in hand to slaughter his neighbours. You can be glad, Ragnhild, that you didn't marry such as that. But we men do have a touch of the prophet and the fixed idea as part of our nature; I will make no excuses on that score. There have been times when I have been rather monomaniac and my thoughts and vision were very restricted. But apart from tennis I have never been interested in sport, at least that is one redeeming feature.'

Then he takes up the topic of women and the discourse becomes even more subtle, for he doesn't claim to know very much about women, who 'are much more unknown and unresearched than the relatively simple menfolk' and who have 'many difficult duties in a marriage.' They need to control the 'prehistoric' creatures known as men 'with the help of little words, hints and suggestions—a type of soft power.'

> 'We can think of man as an old locomotive spitting steam and smoke and constantly needing to be controlled, working under high pressure, huffing and puffing, swaying and jerking, with thousands of wheels and controls needing to be greased regularly, requiring patient handling because it is unpredictable and can easily go off the rails – and the woman, she is the engine driver who tries to control the monster. In addition to this demanding job she has to cope with countless other difficulties. She needs to bring up the offspring – that is far beyond the man's capabilities; she needs to go to the hairdresser every second week to have

her hair washed; and sometimes, as for example here in our house, she needs to control the purse-strings and see to it that I get my monthly pocket-money.'

He concludes in the same half-humorous, semi-serious style:

> 'As you will understand, Ragnhild , from these rambling thoughts, I value your work in 'bringing up father' very highly. And when I grumble and complain because half of life is spent tidying up all the disorder or when I bristle like a hedgehog at the thought of buying new clothes or when I totally refuse to eat chicken, all this is just an indication that we value things a little differently. What seems to me highly unimportant and unnecessary is very important and significant for you. Of course you are usually right and I am profoundly grateful to you for keeping such a dumb, prehistoric creature under control.'[14]

Inside and Outside His Bubble

Nowadays we might call it tunnel vision. When Rolf goes into his own world, the world of the betatron, and shuts the door behind him he is in his bubble. Unlike many, he is aware of this. And he stays there. At a celebration with damask cloths and wine glasses on the table, his speech to his wife and to their guests reveals that he is not totally insensitive of how it must affect those around him when the urge to research takes control of him.

A person who has his ideas and will follow them to their conclusion; that was how Professor Tor Brustad characterised him. A bit of a boffin, as Brustad adds tactfully.

> 'My impression is that Rolf had one great interest in life, namely technology and the development of accelerators. We could simply say that he was a bit of a boffin as his interest in this was so absorbing. That might be over-stating the point and it is not unkindly meant, but there is an element of truth in it. He was a person who formed his own opinions, and when he had made a decision it was very difficult to get him to change his mind.'

'A bit of a boffin?' Yes, but not entirely, even though Brustad is not alone in describing him this way. Obsessed by his research, thinking of nothing else? His children don't talk of him thus. Absorbed in it, dedicated—yes. A working life driven by creativity and curiosity, without ready-made answers, draws one in. I think he understood that. It is hardly by chance that when important occasions called for reflection and appropriate words, he spoke of balance, oscillation between outer points, seeing things differently, personal boundaries, mutual understanding, patience, tolerance and kindness.

Just science, no sentiment? Once again, no. If the idea that he was entirely absorbed in his work had ever crossed my mind, it became unthinkable after reading some of his private letters. Is it possible both to be super-engaged in ones work and to have warm feelings? Of course it is. Why not? Both require the same talent for understanding and involvement that calls for your full commitment and over-rules norms and circumstances. The diary he wrote in his youth; his conversations; talks I have had with his children and grand-children, sister, brothers-in-law, sisters-in-law, nephews and nieces—These all declare that it is possible. 'An uncle whom it was fun to visit,' says a nephew. 'We were always welcome,' says a brother-in-law. 'Father "celebrated" Sundays,' says his youngest son, Rolf:

> 'Early every Sunday morning he would sing and whistle and relax and fool around and be in a good mood. That affected the whole family. In those days people worked on Saturdays, but Father took Sunday off. We all went out on a trip. Every Sunday. We were the only people there who had a car, we drove for a bit and then we walked, or we skied, absolutely every Sunday. We children liked to have friends with us. Seven people in the car. He was good at holding the family together. We had friends with us when we went to Norway, too. Then when we grew a little older we no longer took part in the Sunday outings. But Mother and Father were often with friends then and went with them. But they always went on Sunday outings. As long as I can remember. Every Sunday at nine o'clock, they were off!'

Then he tells me about his father's interest in mushrooms and all the foreign trips he had made with friends in his student days:

> He picked mushrooms, I remember, and knew many different types. If he wasn't sure, he tried them, took a chance with a tiny little bite. As a student he always had friends from Norway staying with him, Kaare Backer and his brother Viggo and others, and then they went to Paris and Spain and Venice and they were on mountain-tops here in Engadine at Pontresina and they must have had a great time.

Like his older brother, he denies that his father thought only about his job:

> 'I don't think it's true that he thought only about his job. He certainly *enjoyed* his work a lot and was greatly interested in everything to do with it. He was interested in so many things. Right until the last two years of his life, when he must have had a stroke. But right up until then he was interested in everything possible. I remember his ninetieth birthday, which we celebrated in Oslo, in a hotel at Holmenkollen – and his friend Kaare Backer was also there and he

> was even a year older. And Backer didn't *say* very much and he didn't *hear* very well, but they had a splendid time together. They looked like two young boys. So I really do think that he enjoyed life.'

Just science, no sentiment? No again. People aren't as simple as that. Rolf wasn't as simple as that. It would be unfair to portray him like that. He who confided in his diary that he felt tough and confident when he wasn't near the girl he was in love with, but that when he was in her presence 'a single glance from Elsie was enough to make me crazy.' He who at the age of 44 gently asked his mother to 'keep some little personal thing from Dad for me so that I can have a particular little memento of him.' He who wanted to come back to Norway 'when he grew old, really old' as his grandson Per expressed it. 'But he never seemed to realise that he was old.' He continued following his dream.

Youthful Enthusiasm

'Rolf was young all his life,' said the physicist Jan Sigurd Vaagen. Nobody is so confident as a 22 year old of being able to solve a problem. There is a solution. No shadow of doubt. I've got the right idea. I'll do it. I'll build a machine of which nobody has seen the like. I'll show the world. Faith moves mountains. Opposition is the trigger.

That was Rolf, all his long life. He kept his pioneering spirit, enthusiasm, curiosity and enterprising attitude alive for almost a century. If an exciting new development cropped up he grasped it, but he always had his fundamental idea in mind and he would take this up and look at it in a new light. Practical difficulties—minor problems such as a machine not working, a technology that failed or people not understanding—these were just obstacles which were there to be overcome. His faith didn't falter. His view of the goal didn't flicker. Young eyes see clearly.

At college in Karlsruhe, Rolf thought out the big idea for which he later became famous. The design idea was correct. He didn't manage to prove that his theory was right, because he couldn't get it to work in practice. But the theory and the principle *were* correct nevertheless. Others later got it to work. Lawrence in the USA took hold of the idea and built a similar machine. When he was awarded a Nobel Prize for that he was generous and gave Rolf credit where it was due. Rolf said 'Hurray, I was right,' drew back his shoulders and also developed a machine. A more powerful one, the first of its kind in Europe. Then there were more, many more. Slightly different, according to the need and the technology available at the time. They were installed in China, Australia, Russia, the USA and throughout Europe.

That was his career in a nutshell.

The whole world wanted his betatrons. He could have retired then, around 1970, at the height of his career; retired honourably, received prizes, delivered a few lectures, acted as a consultant. He had done a lifetime's work. Museums wanted his machines. He was required reading in physics texts throughout the world. He had a broad experience and had been in industry in fields as diverse as power distribution and cancer treatment. He could have continued travelling as long as he was willing and able, enjoyed the fruits of his labour.

But not Rolf. He moved to pastures new. He spent the last twenty years of his working life researching how the radiation produced by the betatrons affected living tissue. What did it do to patients with cancer? Having already spent a working lifetime producing radiation, he now turned his attention to studying how it worked. He continued this until he was well into his eighties.

His vital, stubborn, persistent, open attitude to life included a slightly 'alternative' approach. He took his daily dose of dietary supplements, anointed his skin with various creams, thumped himself according to a fixed ritual and treated himself with acupuncture needles. With aristocratic tendencies and pleasure in company, he was a sort of *pater familias* for his extended family in Norway. They counted on him and he counted on them, even after fifty years in Switzerland. He attended all major family gatherings. The whole world was his arena.

His independent spirit was boundless. As a young technology student he sent an article on the analysis of monetary inflation to an economics journal, and he declined an offer to study for a doctorate at his old college because they wouldn't listen to him and let him continue his chosen line of research. He travelled throughout Europe selling his own designed relays to the electrical power industry. He led the Widerøe Group in Hitler's Germany, surrounded by Nazis, fantasists, allies, double agents and Nobel prize-winners. At the height of his career in radiation physics he changed over to a new subject area, biophysics. When he was already a pensioner, he adopted his orphaned grandson. On the evening of 21st July 1989, at the age of 87, after his obligatory trip to Norway he wrote in his travel diary, 'drove 2810 km.' and nobody was surprised. Six years after that, one of the head scientists at the DESY laboratory in Hamburg said that Rolf 'is still full of ideas that he tests out on me.'[15]

Solar Energy and Acupuncture

Nor is it surprising that he threw himself into the public debates about solar energy and the disposal of nuclear waste. His brother-in-law Egil Reksten is keen to bring out this side of him too:

> There are two things more that you must hear about, a couple of ideas he had. One was to do with nuclear waste. He said that there had been an attempt to store it under the Greenland inland glaciers, but that they hadn't bored deep enough down. At a depth of 200 metres it would just slowly melt into a lake lying under the ice. It could lie there for so many thousand years without harming people or animals, but Greenland had protested strongly.
>
> Then there was another thing, an appealing idea of sending energy without wires, and that is something that is still a little in the future. He thought one could place a solar energy station out in space, where the solar energy could then be converted into short-wave radiation or electromagnetic radiation that would be directed in towards a receiver in an array of antennae on Earth, and so one would put solar cells out in space, a big station that would have much better performance than what we have down here. It would be unaffected by weather and such things. I think he said that for safety's sake we should have a receiver aerial of 30 square kilometres or something like that, which would take in this electromagnetic radiation, short-wave radiation, yes, and then it would be transformed into electricity.
>
> *When was it that he talked about that? It sounds a very youthful idea.*
>
> No, no, it was in his later years.

I asked his grandson, Per, who lived with him at that time, about other 'trendy' ideas Rolf had as a pensioner in the 1970s:

> *Is it true that he had slightly unconventional views about medicine and the like?*
>
> Oh yes, he came back from China with a whole set of acupuncture needles and he had a doll showing where they should be inserted, and then he treated himself. People said afterwards that he was mad to have done that, as you need to be trained to do such things. But he thought it had helped him.
>
> What was he trying to cure?
>
> It was something to do with his back, sciatica, I think. He read what to do in the instructions and then did it himself. I think he only tried once. He realised that it really wasn't such a good idea. But he was basically always very fit. He swam every day.
>
> *Did he? Yes, you had your own swimming pool.*
>
> Yes, even in winter.
>
> *Cut a hole in the ice and …?*

Yes, I remember helping him to remove the ice. And once he got a really bad back after that. But he wouldn't accept that it was the swimming. He maintained it was because we had eaten chicken! And so he never ate chicken again as long as he lived. After that it was always called turkey, not chicken, and then it was alright.

But surely there's no connection between a sore back and eating chicken?

No, obviously not, but he maintained it for twenty years. He didn't smile when he said it, so it seemed as if he believed it. But otherwise, alternative medicine, he didn't really believe in it. Homoeopathy and the like, no. He didn't go in for that sort of thing.

Always 22 Years Old

In many ways he stayed 22 years old his whole life. Roamed free, loved challenges, welcomed novelties. And it was very exciting. We can see this by trying to apply a label to every decade of his life. As he was born in 1902 and died in 1996, his own decades more or less match those of the century:

00: Child	Don't stand on the cables, Viggo!
10: Youth	Come on a ski tour.
20: Student	I have a dream.
30: Power industry	I'm going to build the world's best relay.
40: The betatron	I'm going to build the world's best betatron.
50: Social	Welcome, I hope we'll all have a lovely evening.
60: Biomedicine	But what does this radiation do to the patient?
70: Adopted son	Come and sit down, my boy.
80: Travel	See you at Skjæløy in the summer.
90: More honours	Now the only thing I lack is the Nobel Prize.

When the appetite for life is so great and the work so absorbing and when one is still 22 and a young, hungry, curious pioneer, new avenues open up all the time. One line of activity merges towards another and runs parallel. Such as starting to lecture in a technical college while still working in a major industry. Later, when research on betatrons had passed its peak, out went radiation physics and in came biophysics.

The fixed points in Rolf's life were his wife and children and the visits to Norway every summer with a stop in Hamburg to visit friends. In his later years they were the family gatherings on Saturdays when children and grandchildren came to lunch. There were also the visits to his brother in Spain each spring, plus lecture tours all over the world.

Despite all this, people say that his view was blinkered. I can see their point. They talk of a one-track mind. Why? Rolf, whose activities were so wide: major industry and research; skiing and tennis; dancing; social gatherings; teaching; lecturing. A large circle of friends and acquaintances, colleagues he kept in contact with all his life, visits abroad right until his final years. And a big extended family in Norway who still had a good relationship with his sons when they were both over 70. Rolf, who went his own way and opened up new trails.

The family members themselves cannot quite agree whether he was single-minded or not. I ask Egil and Louise Reksten to assess their brother-in-law. Perhaps we might be coming towards the core of this complicated and controversial person:

Egil: He did have a rather one-track mind.

Louise: … No, not really …

Egil: But yes, he is, he was like that. Yes, possibly, rather one-track, there weren't many side-tracks. Anyway that's my impression. But he was enthusiastic. And at the same time … He was an optimist. I don't think he worried much about the end of the world. If he got a pain in his shoulder, he just went into the laboratory and gave himself a dose of X-rays.

Did he really treat himself like that?

Egil: He had developed a pain in his shoulder. Yes, he had this idea that …

Then Egil the chemical engineer picked up a paper and pencil and began to draw. 'The x-axis equals intensity; the y-axis equals damage. Those who were more mainstream at that time had already suggested that the relationship is like this' He continues to draw. 'The more radiation, the more damage. So the greater the risk. Others had said no, that it wasn't quite like that, and that a little radiation wasn't so dangerous.' Then he points at the diagram and explains:

Rolf thought that the radiation risk was probably like this.

Really?

That you would probably get benefit rather than harm from a little extra radiation. And there were even doctors in Germany who treated patients by taking them down into old mines where there was a particular combination of temperature and radiation. These were qualified doctors, not untrained quacks. Rolf said that nuclear researchers are among the people who take in a lot of radiation, and they live several years longer than the average in the population as a whole. That's misleading.

> *It's not politically correct to say that. And it's not scientifically correct either.*
> No, it's not, but it could be that he was right. I thought it was interesting.
> *Was he a follower of what we would now call alternative medicine? I've heard that he had a ritual every morning.*
> Yes, I can well believe that.
> *Was he unconventional about energy technology too? I'm thinking of nuclear power.*
> Oh yes, very much so. He thought firmly that we must embrace nuclear power. I think he saw it as a sort of intermediate stage until we could set up another, for example space-based, energy source.

The brother-in-law, chemical engineer and former concentration camp prisoner then launches into an enthusiastic account of all the radiotherapy machines Rolf made; the patents; and the CERN laboratory crammed full of strong electromagnets and particles colliding at high speed under the ground, that Rolf had taken part in establishing at Geneva. And after that he had been involved in a similar centre, DESY in Hamburg; and then PSI, the *Paul Scherrer Institut* outside Zürich; and after that GSI, the *Gesellschaft für Schwerionenforschung* in Darmstadt. All of that.

When the last of these institutes was ready, Rolf was 67 and well under way with his research career number two, about the biological effects of radiation—alongside his continuing management position at Brown Boveri and the lectures at the college in the evenings. That was the year when he was awarded the Röntgen Medal and the scientific community began to understand that Rolf could have got the betatron to work while he was still a doctorate student if suitable equipment had been available at that time.

With all this behind him and going on round about him, three years later Rolf adopted a seven year old into his house. Throughout the boy's whole upbringing Rolf continued to receive medals and honours, and the child had grown up and left home by the time Rolf's career was finally crowned with international recognition as the founder of the science of particle accelerators. It is 1992. Rolf is 90. Several people have tried to get him to step down. His sons say that even when Brown Boveri finally deprived him of his office, that didn't help; he went on working at home.

So we have come to the beginning of 1994. Christmas is over, and Rolf receives the letter from his brother, thanking him for the book. Another part of the equation is in place. We are approaching the position of being able to draw a line under the answer. But there are still several unknowns. The calculation isn't complete. For on closer reflection: How could the content of this letter make such an impact? The brothers had been reconciled long before the letter. That is what was important. They had wanted reconciliation despite the wounds they didn't understand; not because of knowledge that gave grounds for it.

In his old age, Rolf Widerøe enjoyed going for walks in the local neighbourhood, always with his dog. (*Photo* Pedro Waloschek)

Perhaps the equation is solved nevertheless, for Rolf. The solution may be that there should always be something left over, something to wonder about. Perhaps life's calculations should not work out. Life should be lived continuously, in a dynamic process where one is always in movement and taking the set-backs and the victories as they come, with whatever strength and endurance one has at the time. Perhaps that is the key; that a proper life is a dynamic life where the possibilities are numerous and overwhelming and never end—until life itself ends. Maybe that was his understanding. Perhaps.

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During the last two years when his health began to fail, especially his hearing, Rolf sat a lot in the rocking chair by the big window in the living room. Read, as he had always done. Sitting there in the comfortable chair, with a wide view over the valley and up towards the hillsides overlooking the little village, not unlike a Norwegian landscape, he once again found something to take an interest in; the bird-life outside. He became absorbed in it. He observed. He wondered. He needed to know, and to know more. On the window sill there was an illustrated bird book.

Notes

1. The biography, Waloschek's foreword.
2. The biography.
3. In conversation during the preparation of the book.
4. In conversation during the preparation of the book, 10th June 2010.
5. Tor Brustad refers to this in connection with the book, from an interview with Viggo Widerøe in the 1990s.
6. The conversations took place before the letter was known.
7. In conversation on 21st December 2006.
8. In conversation during the preparation of the book.
9. In conversation during the preparation of the book.
10. Document 25 to Oslo and Aker Police Office, Treason Department, Viktoria Terrasse 5/7, from high court advocate Oscasr de Besche, dated 11th March 1946.
11. This is also dealt with in an interview with Widerøe on 4th July 1945, conduced by Junior Police Prosecutor Gustav B. Dreyer, where the report reads: 'The interviewee wishes to add that during the negotiations in Berlin in October 1943 the Germans also promised to release some of the employees of NEBB who had been arrested.'
12. Letter from Theodor Widerøe to Rolf Widerøe 13th January 1947, ETH Library Zürich Hs 903: 239. Letter from Rolf Widerøe to Theodor Widerøe 17th January 1947, ETH Library Zürich Hs 903: 239.
13. Letter from Oscar de Besche to Widerøe 25th February 1948, ETH Library Zürich Hs 903: 209. Letter from Widerøe to Oscar de Besche 22nd March 1948, ETH Library Zürich Hs 903: 239.
14. They celebrated their golden wedding on 23rd September 1984, but the actual wedding day was 14th November.
15. Gustav-Adolf Voss, head of the Accelerator Division at the DESY Laboratory: 'A Personal Perspective on High Energy Accelerators,' 1996 IEEE.

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A. Sørheim, *Obsessed by a Dream*, Springer Biographies,
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