CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

(Appended after Page 442)

2c	The Children of Emile and Jeanette du Bois-Reymond with Iris Runge (Summer 1888)	[STB] 398
3	The Children of Aimée and Carl Runge	
3a	Iris, Ella, and Nina in the Winter	[STB] 519, p. 30
3b	Nerina (Nina), Ella, and Iris	[STB] 519 Enclosure, p. 4
3c	Aimée and Carl Runge with Iris, Ella, Nina, Wilhelm, Bernhard, and Aimée L. (1903)	[STB] 501, p. 10
4	Carl Runge at the University of Göttingen	
4a	Carl Runge and His Assistant Horst von Sanden	[STB] 501, p. 29
4b	Carl Runge in the Lecture Hall	Ibid.
5	Iris Runge	
5a	Childhood Portrait	[STB] 519, p. 28
5b	Teenage Portrait	[Private Estate]
5c	At Osram in 1929	[DTMB] Photo Album for Dr. Karl Mey
5d	Profile Portrait (ca. 1929)	[Private Estate]
5e	Passport Photograph (after 1945)	[STB] 755, p. 10
5f	Portrait as an Elderly Woman	[Private Estate]
5g	Portrait as an Elderly Woman	Ibid.
6	School and University Years	
6a	Iris Runge and Hedi Ehrenberg in Math Class	[STB] 754, 3v
6b	Iris Runge and Hedi Ehrenberg in Math Class	[STB] 754, 3r
6c	Elisabeth Klein	[STB] 754, p. 2r
6d	Erich Trefftz, Iris Runge, Anni Trefftz, Albrecht Renner, Richard Courant in Göttingen (1907)	[STB] 754, p. 5r
6e	A Theater Scene at the Göttingen Lyceum, Iris Runge First from Right (June 10, 1914)	[STB] 755, p. 3
7	The Circles of Sommerfeld and Tammann	
7a	Arnold Sommerfeld (ca. 1910)	Portrait Collection of the Deutsches Museum (Munich)
7b	Paul Ewald	[STB] 754, p. 4r
7c	Iris Runge with Tammann and Others	[STB] 754, p. 6v
8	Close Companions	
8a	Leonard Nelson	[UBG] Cod. Ms. Hilbert, Photo Album
8b	Wolfgang Kroug	[STB] 754, p. 5v
8c	Wolfgang Kroug	[STB] 754, p. 5v
9	Close Companions	
9a	The Wilmersdorf Samaritan Group (ca. 1931)	[STB] 754, p. 10r
9b	Dance Class in 1928. Iris, Wilhelm, and Maria Runge	[STB] 754, p. 8r
9c	The Wilmersdorf Samaritan Group	[STB] 754, p. 10v

10	The Electron Tube and Light Bulb Factory	Photographed by the author in September of 2009
11	Osram	
11a	Researchers at the Experimental Laboratory of Osram's Factory A (1924).	[STB] 754, p. 7v
11b	Richard Jacoby (1929)	[DTMB] Photo Album for Dr. Karl Mey
11c	Marcello Pirani (after 1945)	[Geiger Private Estate]
12	Osram	
12a	Magdalene Hüniger (1929)	[DTMB] Photo Album for Dr. Karl Mey
12b	Ilse Müller (1929)	Ibid.
12c	Otto Frenz (1929)	Ibid.
12d	Walter Heinze (1929)	Ibid.
12e	Erich Hoepner (1929)	Ibid.
13	Electron Tube Research at Osram	
13a	Adolf Güntherschulze (1929)	Ibid.
13b	Willy Statz (1929)	Ibid.
13c	Konrad Meyer as a Student in Munich	[HATUM] StudA., FotoB.Porträts, Meyer, K.
13d	Peter Kniepen (1929)	[DTMB] Photo Album for Dr. Karl Mey
14	Telefunken	
14a	Wilhelm Runge	[Private Estate]
14b	Wilhelm Runge, Conducting an Experiment at the Lighthouse in Friedrichsort (May 1937)	Ibid.
14c	Karl Steimel	[DTMB] PD 3483, p. 002
14d	Max Weth (1929)	[DTMB] Photo Album for Dr. Karl Mey
15	Telefunken	
	An Excerpt from a Post-War Document Describing Iris Runge's Expertise at Telefunken (July 4, 1947). Prepared by Dr. Zickermann of Telefunken's Electron Tube Factory and Addressed to: Military Government, British Troops Berlin, Disarmament Branch, Berlin-Charlottenburg.	[DTMB] 6734, p. 35
16	Iris Runge's Residence	
16a	The Apartment Building in which Iris Runge Resided from 1935 to 1966	Photographed by the author in September of 2009
16b	A View of from the Courtyard	Ibid.

AUTHOR’S PREFACE

> Regarding my work […] I can honestly say that it’s wonderful (as always!). Sometimes I feel that it was high time for Osram to hire someone with at least some background in mathematics, for there are employees here whose mathematical abilities are unbelievably primitive. Even Jacoby wouldn’t be able to capitalize on half of his countless ideas if he didn’t have me around to tell him right from wrong.[1]

Iris Runge wrote these words in June of 1923. By this time she had been working for just three months at the Osram Corporation in Berlin, specifically at a research laboratory directed by the inorganic chemist Richard Jacoby. The eldest daughter of Aimée (née Du Bois-Reymond)[2] and Carl Runge, who is remembered today for his part in developing the Runge-Kutta procedure of numerical analysis, she belonged to the first generation of academically trained women in Germany and was an intellectual product of the renowned center of science and mathematics at the University of Göttingen. Following in her father’s footsteps, Iris Runge was still a student when she wrote her first academic article, a study co-authored with the theoretical physicist Arnold Sommerfeld, whose integration of mathematics, physics, and engineering had set a new standard for research. She was held in high esteem, moreover, by the number theorist Edmund Landau and she was awarded a doctoral degree for a dissertation, written under the supervision of the physical chemist Gustav Tammann, in which she applied advanced mathematical methods.

The Osram Corporation, known chiefly for its production of light bulbs and electron tubes, was founded in 1919 and quickly developed into an international enterprise with ties to General Electric and other firms. Still in its infancy, and with its headquarters in Berlin, Osram hired Iris Runge and thus acquired the expertise of a researcher who would function as a bridge between mathematics and its applications. “Calculation instead of trial and error!” – on account of her influence – became a catchphrase in the company’s industrial laboratories.

This book arose from the uncommon circumstance of there being enough sources – from private letters to academic publications – to enable a reconstruction of a female mathematician’s path from her childhood throughout the length of her professional career. Although certain American companies, such as the Bell Telephone Laboratories, had established mathematical research departments relatively early on, the majority of firms in the electrical industry employed only a few individuals as mathematical consultants. Iris Runge worked as such a consultant at Osram from 1923 to 1939. When the Osram electron tube factory was acquired by

---

1 Iris Runge to her father, Carl Runge, in a letter dated June 6, 1923 [Private Estate].

2 Aimée Runge was the daughter of the physiologist Emile du Bois-Reymond and the niece of the mathematician Paul du Bois-Reymond, who developed the so-called Du Bois-Reymond lemma in 1879 and is known for his contributions to the calculus of variations.

Telefunken in July of 1939, she found herself among a group of similar researchers. The activities of these laboratory groups at Osram and Telefunken, whose research was devoted to incandescent bulbs and electron tubes, have never been examined before. This research activity will be treated here in light of its collaborative nature both within Germany and internationally.

Writing this book was an exercise in building bridges. First of all there is the bridge that connects mathematics to science, engineering, and business. It will be shown how the construction of this *mathematical bridge* was enabled by the formation of a center of science and mathematics at the University of Göttingen (Section 2.3), and it will be demonstrated in particular how industrial laboratories constructed mathematical bridges between statistics and the quality control of mass production; between the physical and chemical methods of materials research and the concrete problems of manufacturing conductors, filaments, bulbs, and electron tubes; and between the models of theoretical physics, and the design of scientific instruments. In other words, the book will describe the foundational approach to problem solving that is still characteristic of industrial mathematics. The origins of these methods, which were developed during the golden years of broadcasting and radio tubes (1920–1945), lie at the heart of this study, as do their causes and effects.

Second, this book hopes to build a bridge between the specialized fields of mathematics and engineering, and the general culture of a particular era. In the spirit of Theodore M. Porter, who has encouraged scientists to "put the category of the technical into historical perspective,"[3] industrial products and the methods of industrial mathematics will be examined in the context of the social, economic, and political developments that unfolded from the time of the German Empire until the end of the Second World War. The book will thus offer a number of fresh insights pertaining to cultural history. Included among its topics, for instance, are the representatives of the middle class who endured the catastrophe of the First World War and became increasingly active in the politics of the subsequent years. Also to be addressed is the role of certain outsiders in academia (women and Jews in particular) who had managed to secure insider positions during the Weimar Republic but soon found themselves threatened by the political pressures of the Nazi dictatorship.

Third, the book hopes to build a bridge between the history of science and industry, on the one hand, and the fields of Gender Studies and Women's Studies on the other. That its focus should be a woman scientist – and one with a broad interdisciplinary background – arose rather naturally from the fact that she was long employed as the sole mathematician at the Osram Corporation. While working there, Iris Runge was consulted as a mathematical authority by both scientists (physicists, chemists) and electrical engineers. By examining the life and work of such a researcher, insight was gained into the social and industrial conditions that

---

3 PORTER 2009, p. 297 (an original English quotation).

enabled a woman to achieve a prominent professional position, a position in an elite niche of industrial research that did not have to be abandoned despite the social upheavals of the time and the political opposition of the Nazi regime.

Chapter 1 presents an overview of the theoretical approaches that are adopted throughout the book. The second chapter examines why Iris Runge, a representative of the first generation of academically trained women, chose to forsake a traditional career as a schoolteacher for a position in the field of industrial research. Her roots in a large Huguenot family will be explored, as will her involvement in various extracurricular groups at an elite preparatory school, her academic training in applied mathematics and other disciplines at the Universities of Göttingen and Munich, her participation in the activities of reform-oriented secondary schools, and her engagement with certain scientific and political societies (*thought collectives*). Chapter 3 is concerned with the role of mathematics in industrial laboratories, particularly with graphical and numerical methods, statistics, and the problems that such approaches were used to solve. The structure of research laboratories and the place of mathematicians within these settings will also be discussed. Chapter 4 analyzes how social and political upheavals influenced Iris Runge's behavior and disrupted national and international cooperation among industrial researchers. Her interaction with George Sarton will also be related, as will the emergence of the history of science as a viable academic discipline. Chapter 5 summarizes the major themes of the book and casts a glance at the years after 1945. The Appendix contains a timeline of Iris Runge's life, lists of the articles and reports that she produced during her industrial career, and reproductions of other valuable source material.

The original German edition of this book was published in 2010 by the Franz Steiner publishing house in Stuttgart, and its positive reception by mathematicians, scientists, engineers, and historians of science motivated the production of the present translation.

Acknowledgments

I would like to thank the Society of Friends of the History of Radio Technology (*Gesellschaft der Freunde der Geschichte des Funkwesens*) for awarding the German edition of this work its honorary book prize in 2010. Thanks are also due to many mathematicians in Germany, Austria, and France for their helpful discussions and for their generous invitations to present my research at professional conferences. I am grateful for having had the opportunity to discuss my findings before the Society for the Didactics of Mathematics (*Gesellschaft für Didaktik der Mathematik*), before the German Mathematical Society (*Deutsche Mathematiker-Vereinigung*), and at the International Congress of the History of Science and Technology in Budapest. This book has benefited considerably from my close collaboration with French historians of mathematics – among whom Denis Bayart, Marie-José Durand-Richard, and Dominique Tournès deserve special mention –

and with Reinhard Siegmund-Schultze (Kristiansand, Norway). A pivotal aspect of the book, namely its concern with the application of graphical and numerical methods in industrial contexts, could not have been treated in such depth without the insights that I gained at a workshop, led by Dominique Tournès and myself, which was hosted by the Mathematical Research Institute in Oberwolfach.

I owe special thanks to Helmut Neunzert, the founder of the degree program in techno-mathematics in Germany and the inspiration behind the Fraunhofer Institute for Industrial Mathematics, for furnishing the book with a thoughtful foreword. Initial funding for this project was made available by the German Research Foundation, to which I remain grateful, and I could not have completed the book without the generous accommodations provided by Herbert Mehrtens and the Department of History at the Technical University in Braunschweig. Access to the library at the Max Planck Institute for the History of Science in Berlin significantly facilitated my research, and for this I am especially grateful to Hans-Jörg Rheinberger, Jürgen Renn, and Dieter Hoffmann. I would like to express my cordial thanks to John Broadhurst and Hans W. Courant (University of Minnesota) for helpful information and to Ms. Anna Maria Elstner (née Runge) for the permission to read and quote from the papers left to her by her aunt, Iris Runge. For references, cooperation, discussion, advice, and support, I am indebted to numerous colleagues and to the directors and staff members at several archives, each of whom is acknowledged by name in the German edition.

Regarding the present translation, Roger Stuewer (University of Minnesota), Karl Stephan (Texas State University), Brenda Winnewisser (The Ohio State University), Reinhard Siegmund-Schultze (Agder University of Kristiansand), Günter Dörfel (Leibniz Institute for Solid State and Materials Research in Dresden), Hans-Joachim Girlich (University of Leipzig), David J. Green and Martin Hermann (University of Jena), and Ulrich Krengel (University of Göttingen) deserve warm thanks for their helpful advice and support. Furthermore, my gratitude extends to the Friedrich Schiller University in Jena for employing me as a visiting professor and for welcoming interdisciplinary research across a broad range of fields. It remains for me to acknowledge the Birkhäuser Verlag and its dedicated editors – most notably Karin Neidhart, Anna Mätzener, Thomas Hempfling, Erhard Scholz, Helge Kragh, and Eberhard Knobloch – for accepting this volume for publication, and to thank the translator, Valentine A. Pakis, for his good work and his steady commitment to the project. For their invaluable suggestions, the translator is pleased to thank Jeremy Bergerson, Carrie Collenberg, Ariane Fischer, Jay Gopalakrishnan, Michael Jerman, Martin Muldoon, James Pasternak, Kurt Scholz, Karl Stephan, and Roger Stuewer. He is quick to note, however, that this list of generous consultants does not absolve him from any remaining inaccuracies.

Renate Tobies
Jena – September 2011