Universiteit Utrecht

Master Thesis
in the
History and Philosophy of Science

Johannes Bosscha Jr. (1831-1911)

and the development of the field of physics in the Netherlands in the second half of the 19th century.

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Abstract

The aim of this research is to shed more light on the development of Dutch physics throughout the second half of the 19th century. As a representative of this generation of physicists I have investigated Johannes Bosscha Jr. *(1831–1911). At the end of the 19th century Dutch natural science flourished again, what by many historians is called the 'second golden age', after the first in the 17th century. Moreover, this period was formative for the field of physics as an emancipated discipline because of two aspects. Firstly, the law of conservation of energy was introduced in the 50s as an umbrella principle governing the field of physics. Secondly, quantitative precision measurements became the standard method in the field of physics.*

In this study it is shown that Bosscha Jr. *played a pivotal role in these developments.* Bosscha*, in his research, provided experimental proof of phenomena governed by energy principles, always with a strong emphasis on quantitative precision.* Bosscha *improved the general level of education in the natural sciences in the Netherlands by his role as first inspector of the newly founded HBS schools and from this position, he also helped the careers of young physicists by installing them as HBS teachers, by recommending them for academic positions or, indirectly, by his successful textbook on physics. Lastly,* Bosscha*'s influence can be held responsible for at least 4 'academic' physical laboratories in the Netherlands: Delft, Utrecht, Leiden and Groningen and their emphasis on precision physics.*

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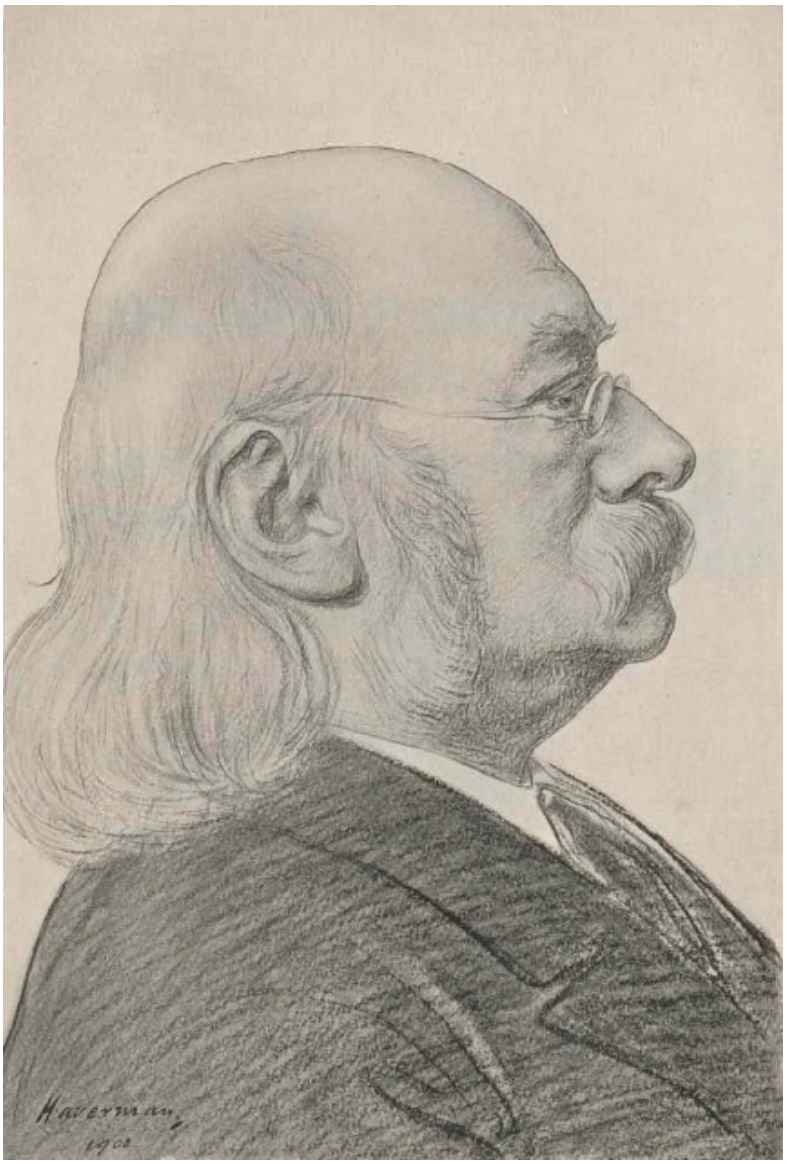


Figure 1: Sketch of Bosscha Jr. in 1900 by the Tachtiger painter Hendrik Johannes Haverman (1857–1928).

Acknowledgements

I would like, first and foremost to thank my supervisor Daan Wegener for having the patience to support me over the two years that I have toiled on this research. Due to my own wish to keep teaching during my research progress was sometimes so slow that it seemed unlikely that I would ever finish. Without the fruitful discussions and advice of Daan I could not have stayed on the right track. I am also indebted to Frans van Lunteren. Many papers I have read for this study are in some way connected to his scholarship, either directly as the author or through his supervision. Thirdly, I must thank Jacqueline Wooning for writing her thesis on Bosscha's experimental work and publications. I want to thank all of my proofreaders Hein Brookhuis, Rick Koekkoek, Mirjam Riedinger and Jelle Timmermans.

Lastly I would like to thank the hospitality of Noor and Ennius Bergsma-Bosscha Erdbrink, at whose house I have spent many days perusing letters from Bosscha and other archival material from the family archive.

Figure 2: Bosscha Jr. in his study at the *Hollandsche Maatschappij der Wetenschappen* (Holland Society of Sciences) in Haarlem

> Gebrek aan kennis is licht aan te vullen, gebrek aan vorming van de geest is dikwijls onherstelbaar.[1]
>
> Bosscha Jr.

[1] Translation: "Lack of knowledge is lightly supplemented, lack of development of the mind is usually unreparable." It is said that Bosscha used this expression in 1881, after which it became his *dictum*. Amerfoortsch Dagblad, 21-4-1908; Delftsche Courant, 19-09-1913.

Contents

Introduction

The Second 'Golden' Age

In the late 19th century, Dutch science flourished again, in particular in the field of physics, with names of later Nobel laurates such as Hendrik Antoon Lorentz (1853–1928), Heike Kamerlingh Onnes (1853–1926), Johannes Diderik van der Waals (1837–1923) and Pieter Zeeman (1865–1943). The period 1870-1930 is sometimes regarded by scholars as the 'second golden age' of natural science in the Netherlands[2] due to the success of, among others, these scientists and commonly 'starts' with Van der Waals internationally acclaimed dissertation: *Over de Continuiteit van den Gas- en Vloeistoftoestand* (On the continuity between the gaseous and liquid states of matter) in 1873,[3] but also with Lorentz's famous dissertation *Over de Theorie der Terugkaatsing en Breking van het Licht* (On the theory of reflection and refraction of light) in 1875.[4] The term the second golden age is also used for a wider cultural and economic revival in the Netherlands, including for instance the painter Vincent Van Gogh (1853–1890) and architect Hendrik Petrus Berlage (1856–1934).[5] Another aspect of this period is the awareness in a number of scientists of the great deeds of their countrymen in the first golden age (17th century) and beyond and an urge to establish a Dutch school of science, with scientific research on par with Germany, France and England.

We should be aware that the term 'golden age' originated in the period of the 'second golden age', where the first golden age means the period of wealth, power and culture just after the independence of the provinces of the Netherlands in the 17th century. In the words of Groninger law student Melchior Jan Bos (1856-1934):

> "We leven zelfs in een tijd die de oude overtreft en waarover men later ongetwijfeld zal spreken als over 'de tweede gouden eeuw', zo niet over de 'diamanten eeuw'."[6]

[2] K. van Berkel (1985), *In het voetspoor van Stevin*; K. van Berkel (1998), *Citaten uit het Boek der Natuur*; B. Willink (1998), *De Tweede Gouden Eeuw*.
[3] J. D. van der Waals (1873), *Over de Continuiteit van den Gas- en Vloeistoftoestand*.
[4] H. A. Lorentz (1875), *Over de Theorie der Terugkaatsing en Breking van het Licht*.
[5] R. Kistemaker, M. Bakker, and H. van Nierop (2000), *Amsterdam In De Tweede Gouden Eeuw*.
[6] Translation: "We even live in a time that surpasses the old one [the golden age] and about which people will

Bos was proven right, as many scholars now use the term 'second golden age', copying the usage of the term 'golden century' from those late 19th century scholars. Although we should be cautious with the terminology that scholars from that time chose to identify their age, science and society did indeed seem to flourish in the late 19th century. To be sure, the level of education and the level of research in the Netherlands were much higher in 1900 than after the French occupation in the first half of the 19th century. The natural sciences, and especially physics, by 1900, had emancipated themselves as respected, useful, and specialized professions.

19th Century Developments

The causes for this general revival are a complex matter. However, one can simplify by looking at developments in a small area of the cultural arena: the developments in natural science, or even more narrowed down, as I will do in this thesis, to the field of physics. Bastiaan Willink, in the book *De Tweede Gouden Eeuw* (The Second Golden Age), where he obviously follows the narrative of 'golden age', names two institutional changes as the causes for the success of natural science in the late 19th century. The first is the law on 'middle class education' of 1863 that formed the *Hoogere Burger School* (Higher Civilian School, abbreviated HBS henceforth) in which middle class students inadvertently received a better preparation than at the preexisting school systems for studying the natural sciences at university as well as severely increasing the amount of children receiving education between the age of 12 and 16.[7] The second cause is the law on higher education of 1876, which greatly improved the number and pay of university professors. This reformation itself was caused by a growing economy and the want for specialization in the sciences.[8] In combination with a decrease of students due to a saturated market for HBS teachers these developments created the perfect climate for doing specialized research, and thus, research in the Netherlands had to flourish, according to Willink.[9] Many of the successful scientists of this period were appointed shortly after 1876 and received their education from, or were in some way affiliated to the HBS.

Willink's analysis gives the means by which change was enacted, but does not tell us anything about the actors in this story. Who were involved in the formation of the HBS? What was their motivation to set it up the way they did? Who were the motors of setting up the laboratories in the 1880s and, more importantly, what was the motivation for Dutch scientists to become 'research'-oriented instead of 'education'-oriented? Ad Maas wrote in *Atomisme en Individualisme*

undoubtedly later write the 'second golden century', if not, about the 'diamant century'." Found in K. van Berkel (1998), *Citaten uit het Boek der Natuur*, p. 150. Note that the speech was originally published in French in the Nieuwe Groninger Courant, 30 juni 1914, which I have not consulted.

[7] In modern terminology the HBS was meant for the age group of 'high school' students, but from the middle class population.

[8] W. W. Mijnhardt (2004), "De Akademie in het Culturele Landschap rond 1900".

[9] B. Willink (1998), *De Tweede Gouden Eeuw*.

that the two laws did not 'cause' the second golden century by themselves. These laws were only concerned with education. The extra professors that were available after 1876 were necessary for the new ideal of specialization in education. To obtain a degree in only a single subject, as became the norm, required a specialized teacher. The law does not say anything about professors considering doing research as part of their obligations. The research-'ethos' is something the scientists made for themselves.[10]

The research-'ethos' of the late 19th century scientists can be better explained by another 19th century development. An important overarching aspect of Dutch science that has been noted by many historians was an emphasis for scientists to be useful to society, or in the more astute Dutch term "nuttig". As Theunissen has shown, a scientist had a moral responsibility to society to be useful. According to Theunissen, what it meant to be useful changed during the 19th century. Early 19th century scientists could be useful to society by education alone as more knowledge 'developed the mind' or 'civilized'. The importance of usefulness of scientists to society is displayed by the fact that scientists were sitting in numerous committees and advised on various topics, often taking up all their time for research. During the 19th century, however, science became more and more useful for and by itself, thus scientists could focus on research, without missing their usefulness to society.[11] A similar development was the professionalization of science. In the 18th century, 'scientists' could be learned amateurs and without university affiliation. Indeed the word scientist itself was coined in 1833 by William Whewell (1794–1866) to mean someone who did science professionally.[12] Research was primarily done within the scientific societies. During the 19th century the research shifted to the universities and the scientific societies even began to exclude amateurs, i.e. they began to professionalize.[13]

Another development of the 19th century involves disciplinary boundaries. Physics as an institutionalized discipline only developed and emancipated itself from chemistry, applied mathematics and their mother 'natural philosophy' during the 19th century. In the 18th century physicists would call themselves experimental natural philosophers or, depending on the topic, chemists. In the 19th century physics became a full-fledged discipline by taking over the methodology of quantitative precision from astronomy and defining its own field of knowledge: the field of force interactions or force conversions. This development was greatly accelerated by the introduction of the law of conservation of energy as an umbrella principle for physics. These developments originated mostly in Germany and England, but one might ask who introduced these developments in physics in the Netherlands?[14]

[10] A. J. P. Maas (2001), *Atomisme en Individualisme*, p. 14.
[11] B. Theunissen (2000), *Nut en nog eens Nut*.
[12] S. Ross (1962), "Scientist: The Story of a Word".
[13] W. W. Mijnhardt (2004), "De Akademie in het Culturele Landschap rond 1900".
[14] F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics"; F. van Lunteren (2013b), "Het Ontstaan van het Systeem van Bètadisciplines: de Natuurkunde"; D. Wegener (2011), "Wetenschapsgeschiedenis op Lange Termijn".

Johannes Bosscha Jr.

To answer some of these questions this thesis focuses on one of the main characters in the history of physics of the 19th century in the Netherlands: the physicist Johannes Bosscha Jr (1831–1911). Bosscha's influence on the field of physics in the Netherlands is large both directly and indirectly. He played a pivotal role in the introduction of the law of the conservation of energy in the Netherlands.[15] Bosscha contributed to standardization of units, such as the meter and kilogram, but also of the electrical units by being part of the respective international committees as the representative of the government and of the *Koninklijke Nederlandse Academie der Wetenschappen* (Royal Dutch Academy of Sciences, abbreviated KNAW henceforth) and by performing high-precision experiments establishing these units.[16] In fact, precise and thorough experiments were very important to Bosscha and this is where Bosscha's influence shows the most. In order to be able to do such experiments the laboratory equipment must be optimal, thus Bosscha strove on many occasions to increase the level of laboratory equipment.[17]

In 1863 Johan Rudolph Thorbecke (1798–1872) established the law on 'middelbaar onderwijs' (middle class education) that established the HBS. Bosscha was subsequently appointed to inspector of higher education, playing an indispensable role in the structure of and setting up the various HBS. Thanks to Bosscha, all the laboratories of the HBS were set up in a modern way, equipped to perform precision experiments. Bosscha also wrote an influential physics textbook with the law of conservation of energy as the foundation, to be used in the HBS and beyond. This textbook saw numerous editions published between 1865 and 1907. A first edition was written in a scientific collaboration with Dutch physicist Van der Waals.[18] Later, the laboratory of the Polytechnical School of Delft, where he became professor in 1873, was modernized under his supervision. He also instigated his assistants Kamerlingh Onnes to do the same some 10 to 20 years later at Leiden University, producing the cryogenic lab that became famous for the liquefaction of helium, and 'measuring physicist' and professor at Groningen University Herman Haga (1852–1936) to construct the Groningen magneto-physical laboratory, first of its kind. Bosscha also directly influenced some other successful Dutch physicists of a later generation, notably Van Der Waals, but many other links could be established.

Moreover, Bosscha was one of the first of the new kind of science popularizers in the Netherlands, inspired by his teacher Frederik Kaiser (1808–1872)'s popular science writing.[19] Science popularization helped to establish the professional status of the writer with respect to his audience and is in congruence with the development of professionalization of science. Later

[15] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland"; F. van Lunteren (2011b), "Johannes Bosscha Jr. en het Behoud van Arbeidsvermogen".
[16] F. van Lunteren (2004), "J.D. van der Waals en de Afdeling Natuurkunde".
[17] F. van Lunteren (1995), "Van Meten tot Weten".
[18] F. van Lunteren (2000), "Aantrekkende Krachten".
[19] F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie".

in life Bosscha strengthened the identity of 'Dutch' science by publishing letters of Martinus van Marum (1750–1837) and the *Oeuvres Complètes* of Christiaan Huygens (1629–1695). Slightly odd compared to the other two is Bosscha defending the image of German astronomer Simon Marius (1573–1625), against allegations that he took his results from Galileo Galilei (1564–1642) - a project Bosscha started at the very end of his life. This can be seen as a proxy war. Defending Marius brought down Galileo, who in turn defamed Huygens and Simon Stevin (1548–1620). Defaming Galileo, thus, indirectly meant defending the name of Dutch scientists Stevin and Huygens.[20]

All in all, it can be said that Bosscha is one of the key actors in the story of the revival of Dutch physics (education). This thesis will investigate these various aspects of Bosscha's life, one of the main actors of the changing scene of Dutch science. The goal of this study is to complement Willink's analysis with the story of one of the main actors in this history. The main research question is:

> How did Bosscha become influential to the field of physics in the second half of the 19th century and what was his influence?

Guided by developments described in the secondary literature, this study delves into all kinds of primary sources. Publications by Bosscha, reviews, journals, newspapers, letters, archival material. Many of these sources have not been studied before. The primary sources give a strong basis for the image that was already apparent from the secondary literature consulted. This biographical study can thus be seen as an in-depth case study investigating one of the more influential physicists of the mid-19th century. We will see how Bosscha fits in the general developments in the 19th century established by the secondary literature as well as how Bosscha influences these developments within the field of physics.

The reason why Bosscha has failed to attract the attention of scholars is probably because he is little remembered by current physicists. His work in the field of physics did much to establish experimentally the law of conservation of energy and introduce said law in the Netherlands, but others are lauded for its discovery. His high precision experiments, although pioneering and important at the time, are by now largely forgotten. No important theory or experiment is named after him. Electrical engineers of today might know about only through the largely forgotten 'Bosscha-method', a method to measure resistance similar to a Wheatstone Bridge.

So far, not much scholarly work has been written on Bosscha, though, there have been many short biographies on Bosscha, notably two by Kamerlingh Onnes and Lorentz. [21] Secondly,

[20] I thank Albert van Helden for this argument. See J. Bosscha Jr. and J. A. C. Oudemans (1903), "Galilée et Marius"; J. Bosscha Jr. (1907), "Simon Marius. Réhabilitation d'un astronome calomnié."

[21] "Johannes Bosscha" (1881), "Johannes Bosscha"; J. G. Frederiks and F. J. van den Branden (1888), "Johannes Bosscha Jr."; Unknown (1901), "Professor Bosscha"; H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, pp. 113-116;

there is one scholar known to me to write in more detail about aspects of Bosscha's life in a number of papers: Frans van Lunteren. Lastly, a master thesis supervised by Frans van Lunteren has already been written about Bosscha's research and written publications. For many of the things written in this study about Bosscha's research papers, I am indebted to this thesis.[22]

Structure of the thesis

This thesis is divided into 3 chronological parts, of which the first 2 form the heart of this study. The first part is about the period from Bosscha's birth until his appointment as inspector of middle class education (1831-1863). The second part continues until he resigns from his post as inspector (1863-1873). The third and last part will briefly discuss the later period of his life (1873-1911).

In chapter 1 I will recount Bosscha's early life and career. The main goal of this chapter is to establish who influenced Bosscha and what were Bosscha's interests. It will also show what career steps Bosscha made in order to obtain the distinguished position of inspector of middle class education. chapter 2 discusses Bosscha's research during the period of Part I and establishes Bosscha's research principles. In the 3rd chapter Bosscha's works in popular science are discussed: A semi-popular lecture on the law of conservation of energy, the popular journal *Blikken der Natuur* and popular book *Het Boek der Uitvindingen*. With these works, Bosscha establishes his position as a professional scientist and made the law of conservation of energy popular within the Dutch scientific community.

Part II shows Bosscha to be not only a man of science but also a man of education. The 4th chapter is on the formation of the HBS schools and Bosscha's role herein as inspector of 'middle' education (1863-1873). chapter 5 discusses Bosscha's widely used textbook on physics for the HBS: The law of conservation of energy ('arbeidsvermogen'), again, plays a major role. In this chapter Bosscha's research from this period is discussed, as his research on capillarity

J. Kraus (1911), "Notulen der Vergadering van Maandag den 26sten Juni 1911 te 11 uur"; H. Kamerlingh Onnes (1911b), "Prof. Johannes Bosscha"; H. Kamerlingh Onnes (1911a), "In Memoriam Prof. Dr. J. Bosscha"; H. G. van de Sande Bakhuyzen (1911), "J. Bosscha"; H. A. Lorentz (1911), *Rede gehouden door Prof. Dr. H.A.Lorentz gewijd aan de Herdenking van den Overleden Oud-secretaris der Maatschappij, Prof. Dr. J. Bosscha*; G. C. Gerrits (1948), "Johannes Bosscha (1831-1911)"; J. Charité (1979), "Bosscha, Johannes (1831-1911)"; L. Beek (1989), "Johannes Bosscha: veelzijdig maar bescheiden wetenschapsman"; K. van Berkel, A. van Helden, and L. Palm (1999), *A history of science in the Netherlands*, pp. 425–426.

[22] J. Wooning (2001), *Johannes Bosscha*. The other thesis written about Bosscha investigates in detail the experimental work and publications of Bosscha as well as investigates Bosscha's role in the meter committee and the subsequent 'meter incident' in the KNAW. For the last, see also F. van Lunteren (2004), "J.D. van der Waals en de Afdeling Natuurkunde". The emphasis of my thesis lies more in showing how Bosscha fits in 19th century developments and how he contributes to them. For instance, when Wooning discusses Bosscha's popular articles, Wooning describes the physical experiments in the contents of these articles, but does not point out that these articles were in fact written as popular science. In other words, my thesis contextualizes Bosscha's research where Wooning's thesis describes.

and thermometry at this time was always connected to the textbook. chapter 6 investigates the impact of the HBS in politics by discussing Bosscha's political and public career.

In the epilogue, I will shortly discuss the later period of Bosscha's life in which he was affiliated to the Polytechnical School in Delft, first as a professor and later as the director of the school. In this period it becomes evident that he had obtained a prominent position in the physics community in the Netherlands. Illustrative of his position in the community is his work for the various committees of the government and KNAW, and the subsequent appointment as secretary of the Hollandsche Maatschappij der Wetenschappen (Holland Society of Sciences), a position that held a lot of prestige in the 19th century.

A small note on citation style. Published materials of an identified author will always appear in the bibliography. Articles from newspapers or notes from archival material will only appear in the footnotes. One exceptional archive was the family archive in Baarn. This archive is denoted as Baarn-Archive throughout the thesis. Lastly, all of Bosscha's writings will appear in a separate bibliography. Dutch quotes are always translated into English in the footnotes. If a source is missing for any image, it means it is easily found on Wikipedia.org.

Part I

Early Life and Career (1831-1863): Precision Experiments, Introduction of the Law of Conservation of Energy and Popular Science

Chapter 1

Early Life and Career

In this chapter we will discuss Bosscha's early life, student life and career. Already from an early age Bosscha meddled in organizational affairs and sought material improvement for the rooms for the natural sciences at the University. Furthermore, the figures who influenced Bosscha are discussed. After his studies, Bosscha was appointed as assistant at the physical cabinet as the assistant of prof. Rijke in 1855, and in 1860 Bosscha became professor at the Royal Military Academy of Breda.

1.1 Early Life

Bosscha Jr. was born on the 18th of November 1831 as the son of Prof. Johannes Bosscha Sr. (1797–1874) and Henrietta Jacoba de Kruyff (1794–1837) in Breda,[23] where his father was professor in History and Dutch at the newly founded *Koninklijke Militaire Academie* (Royal Military Academy).[24] Prof. Bosscha Sr. too was at the time a school inspector of the ninth district of the province Brabant, just like Bosscha Jr. would be inspector of the Leiden district in 1860 and later inspector of middle school education for the south of the Netherlands in 1863.[25]

Bosscha Sr. was a member of parliament from 1853 to 1858 and minister of church-state relationships of the reformed church in two Dutch governments from 1858 to 1861.[26] That post was split since 1815 in a minister of the reformed church and catholic church ('Minister van Hervormde Eredienst' and 'Minister van der Rooms-Katholieke Eredienst'). The Bosscha family was openly protestant. It was in this function that Bosscha Sr. had a lasting, liberal influence

[23] Opregte Haarlemsche Courant, Haarlem, 24-11-1831.
[24] Bredasche Courant, Breda, 5-7-1828.
[25] Nederlandsche staatscourant, 23-1-1833. Note that it in the literature Bosscha Sr. and Bosscha Jr. are often confused. To avoid such confusion I will *always* include the affix Sr. to denote Bosscha Sr.
[26] Nederlandsche staatscourant, 2-6-1853.

on the reorganization of the educational system through the so-called Bosscha amendment on the law of 1857 and through his involvement with the law on middle school education of 1863. This will be discussed further in chapter 4. Bosscha Sr. also wrote a successful history textbook for the renewed lower education. As we can see, both father and son wrote an influential textbook and both were deeply involved in reforming education in the Netherlands. Moreover, Bosscha's father also wrote the book and weekly magazine *Neêrlands Heldendaden* that recounted 'great deeds' of the Dutch military, just like Bosscha Jr. will do later with the 'great' Dutch scientists Huygens and Van Marum.[27] In the latter part of his life, Bosscha Sr. wrote a couple of books that discussed political matters such as the new constitutional monarchy of the Netherlands and political relations with Germany.[28] These books were heavily discussed in society as well as by states' number one critic: Multatuli (pseudonym of Eduard Douwes Dekker (1820–1887)). It can be said that at least until shortly before Bosscha Sr.'s death in 1874, Bosscha Sr. was an important political figure in Dutch society, far outstripping the fame of his son.[29]

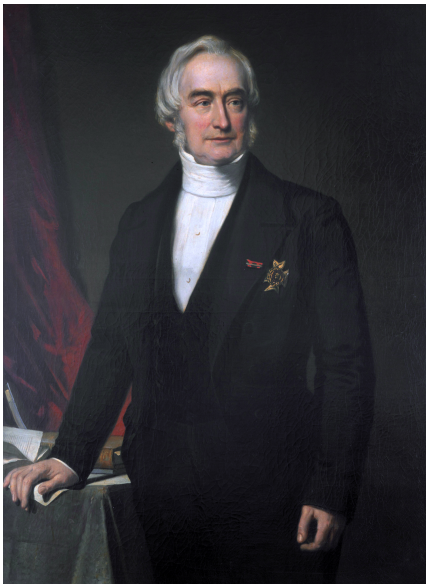


Figure 1.1: Bosscha Sr. painted by Nicolaas Pieneman (1809–1860), 1857.

Bosscha's father was not the only highly educated man in the family. Bosscha's grandfather Herman Bosscha (1755–1819) was a professor at the universities of Harderwijk and Groningen, and finally at the Athenaeum Illustre of Amsterdam. Herman's younger brother Johannes Bosscha (1767–1810) was rector at some gymnasia, lived in France during the French revolution and was from 1794 until his death in 1810 appointed to Secretary-General of Foreign affairs of the (several forms of) Dutch state, the so/called 'Bataafsche Republiek', under the French regime. Bosscha Jr. also had two uncles that were professors: Hendrik Bosscha (1791–1829), professor in anatomy and physiology at the Athenaeum Illustre Amsterdam, who died some years after he became professor, and Pieter Bosscha (1789–1871), professor in history and literature and rector of the Athenaeum Illustre Deventer.[30] As we can see the Bosscha family was an

[27] J. Bosscha Sr. (1838-1870), *Schets der Algemeene Geschiedenis en van die des Vaderlands*; J. Bosscha Sr. (1833-1875), *Neêrlands Heldendaden*; J. Bosscha Sr. (1852), *Het Leven van Willem II*.

[28] J. Bosscha Sr. (1863), *Kroon en Ministers*; J. Bosscha Sr. (1866), *Pruissen en Nederland*.

[29] Multatuli (1867), *Een en ander naar aanleiding van J. Bosscha's Pruisen en Nederland*; W. J. Knoop (1875), "Levensbericht J. Bosscha". Multatuli would also have a short personal encounter with Bosscha Jr., discussed in subsection 1.2.3.

[30] D. G. van Epen (1915), *Nederland's Patriciaat*; Algemene Konst- en Letterbode, 8-10-1810: Levensbericht Johannes Bosscha.

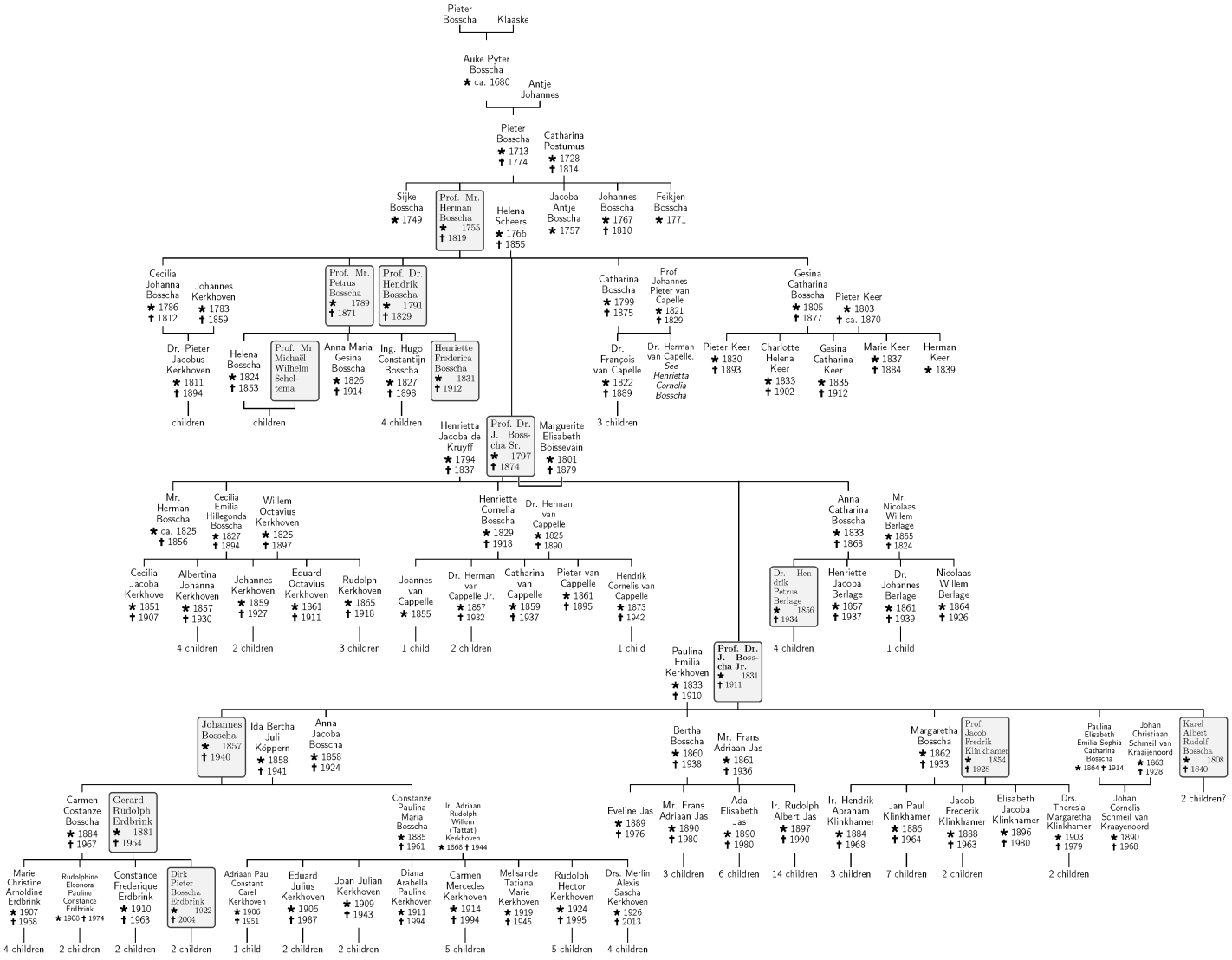


Figure 1.2: Bosscha's family tree. Note the many professors in the family. Noteworthy family members are indicated by boxes around their name.[32]

important Dutch family in the first half of the 19th century, indicated by its inclusion in the *Nederland's Patriciaat*. The Bosscha family was justifiably called a 'professorenfamilie'. Bosscha Jr. was, in fact, a third-generation professor.[31]

In 1839, when the young Johannes was 8 years old, the family moved to a house on the Leliegracht in Amsterdam.[33] In Amsterdam, his father would complement David Jacob van

[31] As is mentioned in a biography of architect Berlage, a direct nephew of Bosscha See J. H. von Santen (1979), "Berlage [sr.], Hendrik Petrus (1856-1934)" and Figure 1.1.

[32] I have constructed the family tree mostly from the data by Vincent Julian John Kerkhoven at gw.geneanet.org/vincentjjk, consulted in May 2017.

[33] Bosscha Sr. was one of the curators to the Latin school that Bosscha Jr. attended. Bosscha Sr. often

Lennep (1774–1853) as professor in History, Rhetoric and Greek and Latin literature at the Amsterdam Athenaeum Illustre.[34] Illustrious schools were, just like universities, a form of higher education with appointed professors ('Hoogleraren'), but unlike universities these schools could not award doctorates to their students.[35] For that, the students had to go to one of the universities. In the period after the 'Organiek Besluit' of 1815, which regulated the system of higher education in the Netherlands after the French occupation, there were five such athenaea: Amsterdam, Deventer, Maastricht, Harderwijk and Franeker and three universities: Leiden, Utrecht and Groningen. Illustrious schools also functioned as a transit between the Latin school and the university. When students graduated the Latin school at age 16 to 18 they were sometimes deemed not yet 'ripe' of mind, or, too young to start the notoriously extravagant student life.[36] We see a similar path for the young Bosscha.

Between 1839 and 1843 Bosscha was first taught by a governess and after received private tuition.[37] From 1843 to 1848[38] Bosscha attended the Latin school[39] - which became, in name, a gymnasium in 1848 - where he, briefly, followed mathematics from the physicist Volkert Simon Maarten van der Willigen (1822–1878), who temporarily taught at the Latin School from May 1847 to January 1848.[40] Van der Willigen took special interest in Bosscha and had him come to his house twice a week in the evenings for private lessons in mathematics.[41] There is some evidence that the young Bosscha excelled in mathematics, the field which at the time also comprised 'mixed' mathematics such as mechanics, astronomy and optics. In other words, the field contained much of what we would now call physics. Three times he was awarded first prize for a treatise on a physical subject of the learned society *Felix Meritis* in 1847 for which he was awarded the title 'jongeling van verdienste' (honorary youngster).[42] Felix Meritis was a learned society that promoted the arts and the sciences and was founded in 1777 by the Amsterdam

signed his letters from this period with Leliegracht.

[34] Algemeen Handelsblad, 15-4-1839; 7-5-1839.

[35] K. van Berkel (1985), *In het voetspoor van Stevin*, pp. 43–44.

[36] H. W. Blom, H. A. Krop, and M. R. Wielema (1993), *Deventer Denkers*.

[37] Bosscha was taught by the 'gouvernante' Miss Hopman and after by Master van Haeffen. Baarn-Archive: 'Stenographic' Autobiography. A small note on this source. Bosscha's son Karel Albert Rudolf Bosscha (1865–1928) gave his father a commemorative booklet in which important dates from Bosscha's life were written down. Bosscha himself wrote some details about these events in the booklet so that it became a sort of autobiography.

[38] Stadsarchief Amsterdam, Nr. 260 Scholarchen en Curatoren en Rector van de Latijnse School, Curatoren van de Openbare Gymnasia en van de Rector van het Stedelijk of Barlaeusgymnasium. 1.2.30 Album Discipulorum Register, bevattende opgave van de leerlingen in 1796 en van de daarna ingeschreven leerlingen, met opgave van leeftijd en klasse. At the entry 1843 is written: "Post Examen atumnale noviti sunt adscripti, Joan Bosscha fil." Another entry is in the 'Naamlijst der leerlingen van het Amsterdamsche Gymnasium geopend den 16 April 1847'. Here it is written: "Joannes Bosscha, Jr. geb. Breda, 18 november 1831, 6e klasse, eervol ontslagen 17 juli 1848 en in Augustus door de S.C. toegelaten. [Staats-Commissie aan de academische lessen toegelaten]"

[39] The Bosscha Family has ties with this school; Herman Bosscha, Bosscha's grandfather, was for some time rector of this school and as noted earlier, Bosscha Sr. was curator of the school in the time Bosscha Jr. attended the school.

[40] Ibid., 2.1.1.157 Copieboeken van uitgegane stukken 1847-1861, Notulen 18 juni 1847; Notulen 27 december 1847.

[41] Baarn-Archive: Autobiography.

[42] The three subjects are the electrifying machine, air pump and battery of two Grove elements. Baarn-archive: Autobiography; Algemeen Handelsblad, 3-4-1847.

Bourgeoisie. Bosscha attended their Saturday evening lectures on physics at this time. Also, Bosscha was, for two years in a row, top of his class in mathematics, for which he was awarded a prize by the director of the school.[43]

At 17 years of age, Bosscha followed Van der Willigen to Deventer in January 1849.[44] It is interesting to see that Bosscha actually changed from the Amsterdam Athenaeum to the Deventer Athenaeum,[45] as he was already registered at the Athenaeum of Amsterdam, while the former would have been the easier choice as his family lived in Amsterdam. Although, in Deventer, Bosscha also had an address to stay; his uncle Pieter was a professor at the Athenaeum.[46] Van der Willigen requested Bosscha Sr. to let Bosscha Jr. study under his auspices in Deventer.[47] It must have been Bosscha's wish to study under Van der Willigen that made him choose Deventer.[48] Van der Willigen became his mentor and he discussed many things with him.[49] They discussed about which university Bosscha would go to and which subject Bosscha should make into his specialization.[50] Bosscha should study not astronomy, but mathematical physics; not in Utrecht but in Leiden:

Figure 1.3: Volkert Simon Maarten van der Willigen (1822–1878)

> "Met prof. v.d. Willigen heb ik over den verderen loop mijner studien gesproken. Hij raadde mij af, om mij op Astronomie als hoofdvak toe te leggen, maar vond het

[43] Algemeen Handelsblad, 20-7-1847; 18-7-1848.

[44] Stadsarchief Deventer, ID0806, Rector Magnificus en Senaat van het Athenaeum Illustre, inv. no. 37 Album Studiosorum.

[45] Studenten-almanak voor het jaar 1849, J.H. Gebhard en Comp., Leiden.

[46] However, Bosscha did not live with his uncle at the Stroomarkt. Instead, he had rooms at a hospita. Baarn-archive: Autobiography; Stadsarchief Deventer, ID0806, Rector Magnificus en Senaat van het Athenaeum Illustre, inv. no. 41: Aankondiging van oraties te houden door nieuw benoemde hoogleraren en lectoren, gedrukte stukken, 1815.

[47] Baarn-Archive: Letters to his father, 7-9-1848.

[48] Another reason might have been the girl Pauline Emilia Kerkhoven (1833–1910), his future wife. He met her on a visit in September 1848 to the Kerkhoven family at Hunderen, close to Deventer. Bosscha recalls this meeting as: "Terstond bekoord" (immediately attracted). Indeed it was 'love at first sight' as they remained together for the rest of their lives. Her father Johannes Kerkhoven (1783–1859) was the widower of Cecilia Johanna Bosscha (1786–1812), the aunt of Bosscha Jr. From a different marriage with Anna Jacoba van der Hucht (1795–1856), Johannes Kerkhoven was the father of P.E. Kerkhoven. Baarn-Archive: Autobigraphy; A. E. M. C. Bergsma-Bosscha Erdbrink and J. Brewer (2012a), *Carmen, herinneringen 1894-1904*, p. 15.

[49] In a letter to his father Bosscha writes: "Prof. Van der Willigen is mijn raadsman en geeft zich de meeste moeite voor mij; ik heb veel aan hem te danken." Translation: "Prof. Van der Willigen is my mentor and puts a lot of effort into me; I have a lot to thank him for." Baarn-Archive: Letters to his father, 17-1-1849.

[50] Baarn-Archive: Letters to his father, 9-4-1850; 29-4-1850.

> beste, dat ik Mathematische Physica tot mijn hoofdstudie maakte. [...] Als studie plaats bleef hij bij Leiden. In Utrecht werd alles overschreeuwd door de Chemie en in Groningen was niet zooveel bijzonders om daar aan te denken." [51]

V.S.M. van der Willigen, a clergyman's son, wrote his dissertation on the aberration of light, a subject in between physics and astronomy under supervision of astronomy professor Kaiser in 1847.[52] Van der Willigen, 26 years old, was appointed professor in mathematics, the natural sciences and philosophy at the Athenaeum Illustre in Deventer in 1848.[53] According to van Lunteren, Van der Willigen's inaugural lecture clearly shows Kaiser's influence.[54] In this lecture he stated that astronomy was still superior to physics because of the greater precision of her methods and the method of statistical error analysis. Also, he echoed Kaiser in his research ethos: All teaching should be directed towards training for research. Later, in 1865, Van der Willigen became director of the physics cabinet of Teyler's Foundation in Haarlem, which allowed him to conduct various high precision experiments. According to Weiss and van Lunteren, in the 1870s Van der Willigen was the most prominent experimental physicist, seconded only by perhaps Bosscha himself.[55]

Bosscha joined the small student association ('studenten-corps') Iugantus Gaudia Musis, as was more or less socially obligatory at the time,[56] but he also became the rector of the corps in June 1849.[57] His rectorate of this student association shows Bosscha's early interest in organizational committees that remains apparent throughout his life; not a year in his life goes by without Bosscha sitting in one or more comittees.

1.2 Student at Leiden University

While Bosscha was already registered at the University of Leiden by 'honoris causa' in October 1848,[58] we may assume from the *Voluminem Inscriptionem* and the *Letters to his Father* that

[51] Translation: "With Prof. v.d. Willigen I have spoken about the future course of my studies. He discouraged me to choose Astronomy as my major, but thought it best if I made Mathematical Physics my major. [...] For the choice of city he advised Leiden. In Utrecht everything was overshadowed by Chemistry and in Groningen there was not much special to think about going there." Baarn-Archive: Letters to his father, 9-4-1850.

[52] V. S. M. van der Willigen (1847), *Dissertatio Inauguralis de Aberratione Lucis.*

[53] Leydse courant. 23-2-1848.

[54] V. S. M. van der Willigen (1848), *Over Natuur- en Sterrekundig Onderzoek.*

[55] F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics", p. 33; M. P. M. Weiss (2013), *The Masses and the Muses*, pp. 164–179.

[56] However, Bosscha did 'buy off' his, again, obligatory inauguration party as he preferred not to have to drink. Baarn-Archive: Letters to his father, 17-1-1849.

[57] Stadsarchief Deventer, ID0954 Studentencorps Iugantur Gaudia Musis en dispuutgezelschappen Daventria, Inv. no. 57a Register met de namen van de studenten die zich hebben aangemeld ter ontgroening, Inv. no. 55 Notulen 20 juni. Inv. no. 53 De notulen van de senaat. There are also a number of meetings presided by Bosscha between september 1849 and december 1850.

[58] Album studiosorum academiae lugduno batavae MDLXXVV - MDCCCLXXV [1575-1875], 's-Gravenhage, Martinus Nijhoff, 1875, p. 1346.

he only started his studies in Leiden in september 1850.[59] Leiden University was at this time the largest institution for higher education in the Netherlands, together with Utrecht University. In the academic year 1850-1851 there were a total of 1082 students studying in an institute of higher education throughout the Netherlands, of which 357 studied in Leiden and 381 in Utrecht. In order of the amount of students we can list the five faculties for Leiden: Law (177), Theology (86), Medicine (55), Arts (25) and the Natural Sciences (14). Utrecht had similar proportions between the faculties, although with a higher number of theology students (148).[60] Note that the classical system of the three faculties: theology, law and medicine together with the propedeutic philosophy faculty, - or artes faculty, - had been replaced by the French system in which the philosophical faculty has gained a slightly more independent role and is split into the arts and natural science faculties. Surprisingly, in this development philosophy itself was placed in the arts faculty. By the 1850s, the role of the science faculty was still very marginal and mainly consisted of teaching courses to medicine students; it had few students of its own.

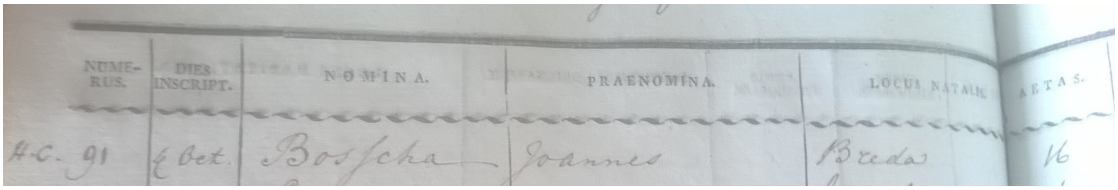


Figure 1.4: Bosscha's entry in the *Voluminem Inscriptionem*.

In the period that Bosscha was in Leiden the student number in the faculty of natural sciences remained around 10 to 15 students. Around one or two of those actually studied natural philosophy, or what we now would call physics. Among his fellow students in the faculty were Jacob Maarten van Bemmelen (1830–1911), professor of chemistry at Leiden University in 1874, Eduard Julius Kerkhoven (1834–1905), brother of Bosscha's future wife and who would become a famous 'Theeplanter' and business partners of Bosscha's sons, Antonie Kist (1834–1879), who actually studied physics and we will see that his thesis was directly influenced by Bosscha, Rudolf Sicco Tjaden Modderman (1831–1924), co-publisher, of *Blikken in het Leven der Natuur*, see section 3.2, Antoine Corneille Oudemans (1831–1895), professor of chemistry at the polytechnical school in Delft in 1864 and rector of that school as the successor of Bosscha in 1885, Jean Abraham Chrétien Oudemans (1827–1906), also influenced by Kaiser and appointed to professor of astronomy in Utrecht in 1856 and lifelong friend of Bosscha) and Willem Frederik Reinier Suringar (1832–1898), associate professor of botany in Leiden from 1857 and full professor from 1862, and also co-publisher of *Blikken in het Leven der Natuur*.

[59] From the academic year 1850-51 we see him registered as a student in Leiden in the *Voluminem Inscriptionem*. See also Studenten-almanak voor het jaar 1851, J.H. Gebhard en Comp., en Jacs. Hazenberg, Corns. zoon, Leiden.

[60] Verslag nopens den staat der hooge-, middelbare en lagere scholen in het Koningrijk der Nederlanden over 1850-1851, Bijlage I.

The two most influential professors to Bosscha were his physics professor Rijke and his astronomy professor Kaiser. The other professors in the faculty were the mathematics professor Gideon Jan Verdam (1801–1866), biology and geology professor Jan van der Hoeven (1802–1868), chemistry professor Anthony Hendrik van der Boon Mesch (1804–1874), and botany professor Willem Hendrik de Vriese (1806–1862).[61]

Figure 1.5: P.L. Rijke

His physics professor and supervisor in Leiden was P.L. Rijke. Rijke also studied in Leiden and wrote his doctoral thesis under the supervision of Pieter Johannes Uylenbroek (1797–1844) on the origin of voltaic electricity, a topic on the border of physics and chemistry.[62] In his time at the Athenaeum of Maastricht[63] his interest in chemistry was apparent as he gave lectures on chemistry at the Academy. In 1846 he was appointed professor in the faculty of science at Leiden University and lectured on experimental physics and mathematical physics. For the former he was lauded by the students, but students complained about the courses on mathematical physics.[64] Rijke's qualitative experimental physics was comparable to the German experimenters from the first half of the 19th century, such as Johann Christian Poggendorff (1796–1877) and Heinrich Gustav Magnus (1802–1870), or the Dutch experimenter Gerrit Moll (1785–1838), professor at the University of Utrecht. In Rijke's work, precision measurements did not play a significant role and theoretical considerations were missing completely. Bosscha did not inherit his style of research in physics, but Bosscha's topic of research as the assistant of Rijke was very close to Rijke's own topic. This shows that they must have worked together intricately.[65] Bosscha did not have a high esteem for

[61] Studenten-almanak voor het jaar 1851, J.H. Gebhard en Comp., en Jacs. Hazenberg, Corns. zoon, Leiden.

[62] P. L. Rijke (1836), *Specimen Physicum Inaugurale de Origine Electricitatis Voltaicae*.

[63] The Athanaeum was not the (protestant) Illustrious school, that did exist in the 18th century but never flourished, but the successor school of the French école secondaire. See P. J. H. Ubachs (1991), *Tweeduizend Jaar Maastricht*.

[64] It is possible that Rijke's courses on (mathematical) physics deteriorated as the discipline mathematized further. In W. Otterspeer (1986), "De Studententijd van Co Modderman", p. 122, Modderman still wrote: "Zeer degelijk waren de lessen over natuurkunde, gegeven door prof. Rijke, die hoewel geen vlotte spreker toch duidelijk sprak en zijn onderwerp helder uiteenzette." (Translation: "Very decent were the lectures on physics, given by Prof. Rijke. Although he was no smooth talker, he spoke clearly and explained his subject clearly."). However, already in 1864 the students complained in the *Studentenalmanak* about the quality of his mathematical physics lectures and in 1874 this was even more evident by the desire for a chair in mathematical physics. See F. van Lunteren (1995), "Van Meten tot Weten", pp. 115-116, 118.

[65] H. A. M. Snelders (1989), "Rijke, Petrus Leonardus (1812-1899)"; F. van Lunteren (1995), "Van Meten tot Weten", pp. 115-116; F. van Lunteren (2013b), "Het Ontstaan van het Systeem van Bètadisciplines: de Natuurkunde", pp. 31-32.

his professor's research capabilities. When Bosscha sent in a treatise on some experiments he performed in Deventer in the summer of 1851,[66] he comments that Rijke was unable to duplicate his measurements:

> "Van mijne prijsvraag heb ik nog niets vernomen, ik weet alleen dat Prof. Rijke, die geen groot waarnemer is, zich vruchteloos bemoeid heeft met de instrumenten van het Physisch Cabinet mijne waarnemingen te herhalen en nog niet geslaagd is in het doen van een wederstandsbepaling van een stuk koperdraad, een werk dat bij mijne arbeid slechts tot de voorloopige bepalingen behoorde." [67]

More influential to Bosscha was F. Kaiser. In some sense Bosscha's later influence is an extension of Kaiser's stimulating influence on the field of physics at the end of the 19th century in the Netherlands. In many aspects of the scientific enterprise Bosscha followed Kaiser's example. Illustrative of how high Bosscha held Kaiser was what he wrote near the end of his life to an anonymous friend:

> "Hij was mijn beste leermeester, die trots zijn kleine zwakke kanten, verbonden aan zijn zwak zenuwgestel, voor mij steeds gebleven is het ideaal van den oprechten, voor waarheid dweependen leeraar en vriend." [68]

Kaiser became the first 'observator' of the observatory of Leiden in 1826. Although he had no academic degree, he was put forward by a pupil of his uncle, none other than the Utrecht professor of physics Moll, who recognized his talents. In 1831 he obtained his bachelor's degree and in 1835 he obtained a honorary doctorate from Leiden University for his extraordinary work on Halley's comet (named after British astronomer Edmond Halley (1656–1742)). In this work, the precision with which Kaiser predicted the passing of the comet exceeded other astronomers. While most calculated the passing to occur within a time frame 2 to 9 days, Kaiser predicted, correctly, a window of only one and a half hours. As we can see here, but also in all of Kaiser's work, that precision was very important to Kaiser's astronomy. The reason Kaiser was interested in precision astronomy was because he was influenced by the 'statistical astronomy' of Johann Carl Friedrich Gauss (1777–1855) and Friedrich Wilhelm Bessel (1784–1846) among others. They adduced statistical error analysis with practical astronomy in

[66] Baarn-Archive: Letters to his father, 17-7-1851; 26-7-1851; 9-9-1851.

[67] Translation: "Of my prize-question I have not heard anything. I only know that prof. Rijke, who is no great observer, fruitlessly tried to repeat my observations with the instruments of the physical cabinet and has not succeeded in measuring the resistance of a piece of copper, a task that in my work belonged to the preliminary measurements." Baarn-Archive: Letters to his father, 22-12-1851. Note that Bosscha won the prize and continued this topic of research into his dissertation. See section 2.2.

[68] Translation: "He was my best teacher, who despite his minor weak sides linked to his weak nerves, to me, always was the ideal of sincerity and a devout to the truth as a teacher and friend." See H. G. van de Sande Bakhuyzen (1911), "J. Bosscha", p. 309.

Germany. Kaiser would follow their example and apply these methods to his own astronomical research. The new standard of precision needed new, more precise instruments. Therefore, from the very start of his career at Leiden University, Kaiser sought, with success, to improve the set of instruments at Leiden Observatory, culminating in the building of a new observatory in 1860 and the first sufficiently equipped astronomical observatory in the Netherlands.[69]

In Germany, Gauss would disseminate the new standard of astronomical precision in the field of physics with a grand European program of measuring terrestrial magnetism. Scientists that would copy Gauss's method in Germany include Alexander von Humboldt (1769–1859), Wilhelm Eduard Weber (1804–1891) and Gustav Robert Kirchhoff (1824–1887). Similarly, Bessel, from Königsberg introduced astronomical precision in German physics through geodetic research and the improvement of unit standards. Frans van Lunteren added that the switch to precision physics was not univocal:

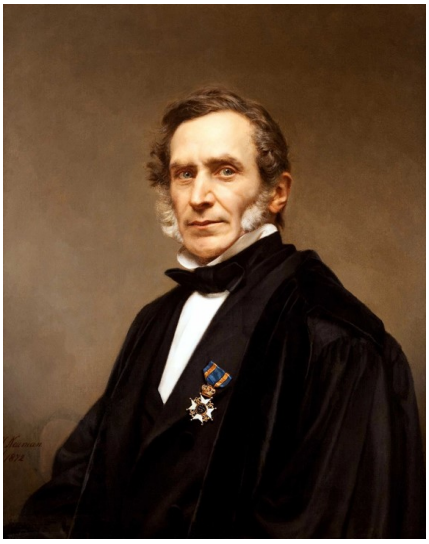


Figure 1.6: F. Kaiser

> "Around 1900, some German physicists distinguished between the 'measuring physicist' (with Kohlrausch as the prototype) and the 'experimental physicist', who – unlike the 'measurers' - often explored unknown territories."[70]

Likewise in the Netherlands, Kaiser became involved with geodesy and became the Dutch representative at the 'Europäische Gradmessung', on international conferences on weights and measures and he was appointed to the Dutch KNAW committee of the 'meter'. This position is one that Bosscha would inherit after Kaiser's death in 1872. Among Kaiser's students there were as many physicists as astronomers who were interested in the new standard of precision, which was strengthened by Kaiser's strong research-ethos and sheer enthusiasm. In this way the Gaussian precision physics became part of the Dutch scientific tradition. Of the astronomers, especially his pupils J.A.C. Oudemans, Hendricus Gerardus van de Sande Bakhuyzen (1838–1923) would carry on his tradition. Van der Willigen and Bosscha would be part of the first generation of physicists to have studied under Kaiser and to be influenced by him.

[69] H. Hooijmaijers (2011), "Frederik Kaiser en het Instrumentarium van de Leidse Sterrewacht"; H. Zuidervaart (2011), "Frederik Kaiser".
[70] F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics", p. 30.

Later, and mostly through the tutelage of Bosscha, Haga and Kamerlingh Onnes became the prime examples of the 'measuring' physicists.[71] Not only Kamerlingh Onnes shows Kaiser's precision science, but also Lorentz and Van der Waals were influenced by his methods and person.[72]

A last important aspect of Kaiser as a scientist that has not been mentioned yet is his popular writing. Bosscha also followed his example here. This will be discussed in chapter 3.

1.2.1 Kaiser's Observatory

Kaiser's influence is directly visible in Bosscha's actions to fund the new astronomy observatory and by his first choice of research. For his first research see section 2.1. From early on Kaiser strived to build a new astronomical observatory in Leiden. Due to his popular writing, there was enough public support available that a special fund was founded with the goal of constructing a new observatory. An anonymous 'worshiper', - this could be Bosscha, - called on the rich of Amsterdam, Rotterdam, Middelburg and elsewhere in the Algemeen Handelsblad of the 10th of February 1851[73] to donate money to the fund, starting a chain of such pleas. On the 1st of december 1853, Jhr. Daniël Théodore Gevers van Endegeest (1793–1873), member of parliament and curator of the Leiden University, held a speech in Parliament in favor of the Observatory. This plea to the government fell on deaf ears, especially since another new 'observatory' had just been funded by parliament: the *Koninklijk Nederlandsch Meteorologisch Instituut* (Royal Dutch Meteorological Institute), under the auspices of Buys Ballot in Utrecht. One new observatory in the Netherlands should be enough, they said. However, Gevers van Endegeest did not stand entirely alone in the parliament with his plea. The intellectuals surrounding Bosscha Sr., such as literator Jacob van Lennep (1802–1868), Justinus van der Brugghen (1804–1863) and the lawyer Johannes Servaas Lotsy (1808–1863) were also in favor.[74] It is plausible that Bosscha Jr. told about Kaiser's person at home and convinced his father to support the new observatory.

Shortly thereafter, a petition was handed in, first to Gevers van Endegeest directly on the 13th of December 1853,[76] and a year later to parliament on the 22th november of 1854[77] by

[71] Although we cannot exclude a more direct Gaussian influence on Kamerlingh Onnes because Kamerlingh Onnes also studied under Kirchhoff in Heidelberg. See D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 65-77.
[72] F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics", p. 15.
[73] Algemeen Handelsblad, 10-02-1851.
[74] H. Zuidervaart (2011), "Frederik Kaiser", pp. 19–24; Leydse Courant, 5-12-1853.
[75] H. Zuidervaart (2011), "Frederik Kaiser", p. 25.
[76] Erfgoed Leiden en Omstreken, Inventaris van de archieven van het Collegium Civitatis Academicae Lugdunum-Batavae Supremum, toegang 0260, inv. no. 155, Notulen van de gewone vergaderingen van het Collegium Civitatis, 7-12-1853; UB Leiden AC2 inv. no. 309, brief aan curatoren 13-12-1853.
[77] Erfgoed Leiden en Omstreken, Inventaris van de archieven van het Collegium Civitatis Academicae Lugdunum-Batavae Supremum, toegang 0260, inv. no. 1819, Verzoekschrift aan de leden van de Tweede Kamer, 22-11-1854.

Figure 1.7: The new observatory, photographed in 1870.[75]

the students represented by Bosscha, but, to no avail. After a request from the curators, the students decided to start a committee for collecting funds for the Observatory.[78]

Apart from becoming a member of the study group ('dispuut') *Naturae Studiis*, which was led by Van Bemmelen in 1850,[79] in 1852 Bosscha became an 'honorary member' and directly part of the board of the *Leidse Studentencorps* as the representative of the science faculty.[80] In the next year, he intensified his work for the *Studentencorps* by becoming ab-actis (secretary) - a function that includes not only the communication of the *Studentencorps* with the University, but also the function of editor of the important *Studentenalmanak*.[81] It is in this capacity that Bosscha was able to raise money for the new observatory.

Bosscha's requests for funding went far and wide. All over the country, in Amsterdam, The Hague, Delft, Rotterdam, Arnhem and Leeuwarden committees were founded to oversee the collection of funding for the observatory, as we can read in a letter by Bosscha to Kaiser on the 2d of March 1854. If the government does not do anything, Bosscha thought, then it is best

[78] L. D. Frank and H. B. Wiardi Beckman (1927), *Geschiedenis van het Leidsche Studentencorps*, pp. 61-62.

[79] Baarn-Archive: Diploma, 25-10-1850.

[80] Erfgoed Leiden en Omstreken, Inv. No. 0260: Inventaris van de archieven van het Collegium Civitatis Academicae Lugdunum-Batavae Supremum, 1839-1972, en zijn voorgangers, 1799-1839, en de commissie voor de Sociëteit Minerva, 1819-1972 (1982), Notulen van de gewone vergaderingen van het Collegium Civitatis, 22-9-1852; Studenten-almanak voor het jaar 1853, J.H. Gebhard en Comp., Leiden. Curiously, 'honorary member' means Bosscha never paid any membership fees to the association, see: Contributieboeken van de Sociëteit Minerva, 1850-1884.

[81] Ibid: Notulen van de gewone vergaderingen van het Collegium Civitatis, 17 februari 1853; Studenten-almanak voor het jaar 1854, J.H. Gebhard en Comp., Leiden.

to start a public funding:

> "Daardoor is bij mij het plan geboren geworden, om te trachten ten beschaafd en wetenschappelijk publiek voor het belang der zaak te winnen, of dieren, om de overal bestaande belangstelling te verzamelen, zoo zou het stichten van het gewenschte Observatorium mogelijk word uit de bijdragen der natie."[82]

The *Studentencorps* itself started the donation with f 500-, added with the donation of some of the professors at Leiden University of f 3600. Teyler's society, also donated a "considerable amount". In total, an amount of around f 21601.75 was collected at the original central fund in Amsterdam, directed by a friend of Kaiser, emeritus Prof. Jan Bake (1787–1864).[83] However, a true breakthrough came only when a new government was formed in 1856, with many ministers that were favorable to Kaiser. It would still take three years before, in 1860, the observatory was finally constructed.[84] Bosscha's meddling with the affairs of the observatory show that Bosscha held Kaiser in very high esteem and that Bosscha was always interested in improving the scientific rooms and instruments.

1.2.2 The Physical Laboratory

In fact, this was not the only material improvement that Bosscha sought to achieve for the University. Already in February 1851, half a year after Bosscha arrived in Leiden, he complained, together with A.C. Oudemans, Modderman, Van Bemmelen and some 30 other students, to the curators about the state of the laboratory. It was, according to them, completely unfit for practical exercises. They repeated the complaint in February 1852 and finally the curators agreed and sent plans for a new building to the government. In 1859 the new laboratory was built in the place of the 'small ruin', the site where in 1807 a ship loaded with gunpowder had exploded and had been a wasteland ever since. Maybe the building was finished just in time for Bosscha to have experienced working in the new building alongside Rijke as his assistant.[85]

However, the new laboratory did not lead to a change in the practices of the professors. They kept doing the same demonstrative experiments they were doing for years already, albeit in a somewhat more comfortable setting. Rijke even published less original research than before. There was still no room for high precision physics experiments for advanced students. Already

[82] Translation: "Because of which, the plan has come to me to try to win the civilized and scientific public for the case. To collect everywhere the existing interest. This way, the Observatory will become possible by contribution from within the nation." UB Leiden AFA FC FK 128, pp. 7-9, Letter of Bosscha Jr. to Kaiser, 2-3-1854.

[83] Letter of Bosscha Jr. to Kaiser, 2-3-1854, UB Leiden AFA FC FK 128, p. 7-9; Studenten-almanak voor het jaar 1856, J.H. Gebhard en Comp., Leiden, p. 105-108; Baarn-Archive: Letters to his father, 21-11-1853.

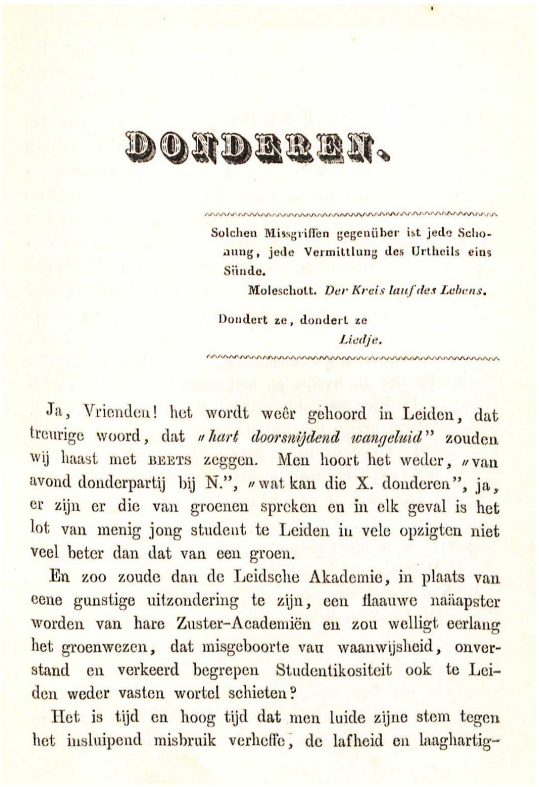
[84] Van der Brugghen, Lotsy and Gevers van Endegeest were part of this cabinet. H. Zuidervaart (2011), "Frederik Kaiser", pp. 20–21.

[85] W. Otterspeer (1992), *De Wiekslag van hun Geest*, pp. 121–122.

in the *Almanak* of 1861 the students wrote that the new laboratory did not at all improve the situation.[86] Reason for the students to complain again in the *Almanak* of 1875. Things would only improve with the vast changes in policy effected by RIJKE's successor and student of BOSSCHA, when KAMERLINGH ONNES became professor of experimental physics in 1882, and after whom the laboratory would be called later.[87]

1.2.3 Almanak and Student Life

As mentioned earlier, BOSSCHA was also in charge of the publication of the *Studentenalmanak* of the year 1853. The *Almanak* was published yearly and contained, basically, the annals of the student community in Leiden. The book had, traditionally, four major parts. The first part contained all the practical information; from the calender with the dates of the birthdays of the royal family to the exact schedule of the only three train lines in the Netherlands that existed back then and the schedules of the important traveling system of 'trekschuiten' (canal boats). The second part was a list of all the people affiliated to the University, from the rector magnificus to the students, including where everyone lived: whether at their parents or landladies, and in which street. Also, the *series lectionem* was published here, a list of all the courses and practicals of that year.



DONDEREN.

Solchen Missgriffen gegenüber ist jede Schonung, jede Vermittlung des Urtheils eine Sünde.
Moleschott. *Der Kreis lauf des Lebens.*

Dondert ze, dondert ze
Liedje.

Ja, Vrienden! het wordt weêr gehoord in Leiden, dat treurige woord, dat *„hart doorsnijdend wangeluid"* zouden wij haast met BEETS zeggen. Men hoort het weder, „van avond donderpartij bij N.", „wat kan die X. donderen", ja, er zijn er die van groenen spreken en in elk geval is het lot van menig jong student te Leiden in vele opzigten niet veel beter dan dat van een groen.

En zoo zoude dan de Leidsche Akademie, in plaats van eene gunstige uitzondering te zijn, een flaauwe naäapster worden van hare Zuster-Academiën en zou welligt eerlang het groenwezen, dat misgeboorte van waanwijsheid, onverstand en verkeerd begrepen Studentikositeit ook te Leiden weder vasten wortel schieten?

Het is tijd en hoog tijd dat men luide zijne stem tegen het insluipend misbruik verheffe, de lafheid en laaghartig-

Figure 1.8: The start of BOSSCHA's piece *Donderen*.

The third part was a report on the happenings within the student community for the last year, such as the yearly serenade, celebrated at the *dies natalis* of the University and the festivities at the third of October, which celebrates the liberation from the Spanish occupation in 1574, and are still celebrated today. This part of the *Almanak* is probably written by the ab-actis BOSSCHA, or maybe together one of the other editors. From 1858 or so, this part also reflected

[86] Interestingly, until 1860, while BOSSCHA was assistant at the laboratory the students did not complain. Studenten-almanak voor het jaar 1861, J.H. Gebhard en Comp., Leiden, p. 239.
[87] F. van Lunteren (1995), "Van Meten tot Weten", pp. 116–118.

on the state of the education at the University. Before, it was not appropriate to criticize the University or University policy in the *Almanak*.

The fourth part: *Mengelwerk*, contained poetry and prose from the students. The prose was by students and usually some idealistic idea or story. For the *Studentenalmanak* of the year 1853, Bosscha wrote one piece of prose where he turns against the practice of initiation ('ontgroenen'), which at the time was reduced to just one evening ('donderavond'). He calls it: "dat misgeboorte van waanwijsheid, onverstand en verkeerd begrepen Studentikositeit",[88] which clearly shows he is turned against such 'vile' and uncivilized activities. He wrote another piece of poetry that comically lauded the baker, who had a bakery on the Papengracht and fed the students with 'bolussen', a type of cake typical from Leiden, between lectures.[89]

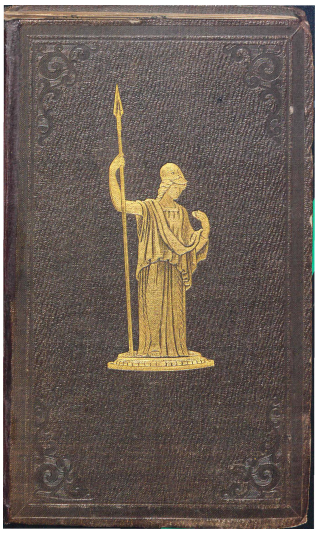


Figure 1.9: The cover of the *Studentenalmanak*, 1853.

Another task he had to fulfill as ab-actis was receiving guests from outside Leiden. For instance, for the serenade of 8th of February 1853 he received Eduard Douwes Dekker (1820–1887), more famous for his pen name Multatuli as one of the most severe critics of the state, with whom he celebrated the *Dies Natalis* of the University. Later, Multatuli would spend his last money inviting Bosscha's company to a hotel in Amsterdam for a supper.[90]

A most peculiar anecdote about Bosscha's student life, which contrasts much with his decent and professional style of his later career, is obtained from Modderman's account of the evening after Modderman's dissertation:

> "Toch kwamen mijn beste vrienden des avonds in de gemeenschappelijke zitkamer van S. en mij bijeen om onder een glas wijn die voormij heuchelijken dag te herdenken. Het was snikheet en het heugt mij dat Bosscha, die zich destijds met suggestie en spiritisme bezig hield zijn kunst op van der Ven en mijn broeder beproefde. Inderdaad lukte het hem de genoemden wijs te maken dat het winter was en het sneeuwde, ja

[88] Translation: "that miscarriage of delusion, foolishness and misunderstood student-ism". See J. Bosscha Jr. (1853b), "Donderen", p. 139.

[89] J. Bosscha Jr. (1853b), "Donderen"; J. Bosscha Jr. (1853a), "Bolus"; See also W. Otterspeer (1994), "HaverSchmidts eerste Almanak"; F. HaverSchmidt (1886), "De Muurtekeningen in het Leidsche Academiegebouw".

[90] C. E. du Perron (1956), *Verzameld Werk*, pp. 195-201; for the original Multatuli (1891), *Brieven. Deel 2. Vervolg eerste periode 1846-1859*. Bosscha liked Multatuli very much: "Het is iemand me wien ik zeer ingenomen ben, omdat hij bij een onbegrijpelijk vlug verstand een hart heeft, dat de belangen van anderen personen meer schijnt te raadplegen dan zijne eigene" Translation: "It is someone I like very much, because he, with a incomprehensible fast mind, has a heart that seems to consult the interests of others more those of himself". Baarn-Archive: Letters to his father, 20-2-1853. Note that the 'Souper' (supper) was served late in the evening, as dinnertime was around 4 pm.

> hij bracht hen er toe om te doen alsof ze sneeuwballen maakten en elkander daarmee gooiden. Tot slot liet een hunner (ik weet niet meer wie) den ander voor een meisje aanzien waarop hij verliefd was en knielend uitriep: "maak mij niet ongelukkig". Had ik het niet met mijn eigen oogen gezien dan zou ik zulkeen verregaande suggestie niet voor mogelijk hebben gehouden." [91]

This is one of the few personal anecdotes I have been able to find of Bosscha. However, the writers of his short biographies, Van de Sande Bakhuyzen, Kamerlingh Onnes and Lorentz are all unanimous in their opinion about Bosscha's 'warm' character, but leave out any personal anecdotes to elaborate upon their statements.[92]

At the time, a student of the philosophical faculty only had to do two exams. The 'candidaats'-exam (bachelor's exam) and the 'doctoraal'-exam (doctoral exam). To gain admission to the bachelor's exam one had to acquire testimonials in Greek, Latin and Logic. For the exams of Latin and Greek, lectured by Bake and Carel Gabriel Cobet (1813–1889) respectively, it sufficed to pay for and attend a couple of their lectures. For the testimonial of logic, taught by Jan Hendrik Stuffken (1801–1881), it was not so easy and one had to take a written exam. Subsequently, to obtain a bachelor's degree one had to do an oral exam in all subjects of the faculty. Preparation usually took two to three years,[94] however, it does not seem too difficult to obtain the bachelor's degree. The oral exam lasted for one hour in which all the professors would ask questions about their

Figure 1.10: Photo of Bosscha Jr. during his student life.[93]

[91] Translation: "Still, my best friends gathered in the evening in the common room of Suringar's house to remember that day drinking a glass of wine. It was blazing hot and I remember that Bosscha, who busied himself with suggestion [hypnotism] and spiritism at the time, tried his art on Van der Ven and my brother. Indeed, he managed to fool them to think it was winter and it was snowing. Yes, he was able to make them act as if they were making snowballs and throwing them to each other. Finally, one of them made the other seem like the girl which he had a crush on and he cried out on his knees: "Don't make me unhappy." If I had not seen this with my own eyes I would not think such thorough hypnotism was possible." W. Otterspeer (1986), "De Studententijd van Co Modderman", p. 127. We would not expect this most peculiar activity of hypnotism with such a scientific man as Bosscha. Bosscha explains in a letter to his father that he learned the art of hypnotism because he 'didn't believe it to be true from the start' and wanted to have a simple explanation for the wondrous phenomena. Baarn-Archive: Letters to his father, 15-6-1852.

[92] H. A. Lorentz (1911), *Rede gehouden door Prof. Dr. H.A.Lorentz gewijd aan de Herdenking van den Overleden Oud-secretaris der Maatschappij, Prof. Dr. J. Bosscha*; H. G. van de Sande Bakhuyzen (1911), "J. Bosscha"; H. Kamerlingh Onnes (1911a), "In Memoriam Prof. Dr. J. Bosscha".

[93] Photo reprinted from W. F. Hermans (1976), *De Raadselachtige Multatuli*.

[94] Bosscha obtained his bachelors degree on the 22th of May 1851, within a year of arrival at the University, but this does not seem unusual. As we know he already spent one year at the *Athenaeum* in Deventer. See Archieven van de Faculteiten - Universiteit Leiden, inv. no. 26: Album Promotiones 1835-1933.

field of expertise, subsequently one could 'ask for an exam', which usually was no more than a formality to sign the degree. In the case of Modderman, he was not examined in botany at all, just because he was such good friends with Suringar:

> "[...] maar toen ten slotte prof. de Vrieze aan de beurt zou komen was het uur verstreken. Hierdoor was ik in de plantkunde in 't geheel niet geexamineerd, want toen ik tentamen bij hem aanvroeg, zei hij het onnoodig te vinden. Ik was toch zulk een groote vriend van Suringar, dat hij vertrouwde dat ik in de botanie genoegzaam ervaren zou zijn." [95]

To indicate the level of trust the professors already had in Suringar: Suringar became associate professor of botany directly after his dissertation in 1857. For obtaining the doctoral degree, which usually took another two to three years, one had to write a dissertation on the specific field of choice. While one obtained the doctoral exam as 'doctor wis- en natuurkunde', i.e. in all subjects of the 'wis- en natuurkunde faculteit' (math and natural sciences faculty), one usually received dispensation for the other subjects besides the field of the dissertation. For example, Bosscha received dispensation in geology and technical chemistry.[96] In this part of the study, there were no more courses to be attended, nor was there any help available in the laboratory. The students had to fend for themselves at this stage.[97] For Bosscha's dissertation topic and research, see section 2.2.

This practice of dispensations also shows that the broad *Bildung* ideal of the 18th century and beginning of the 19th century was already largely let go in Leiden, although the regulations, which were still from 1815, were not fit to the new ideal of specialization. Thus, the professors resorted to dispensations structurally.

1.2.4 Scientific Journey

Directly after obtaining his doctorate, Bosscha went on a scientific trip through France and Germany, which was common at the time, together with his cousin Pieter Keer (1830–1893). On this trip he met with famous scientists such as Jean-Baptiste Biot (1774–1862), Hervé Faye (1814–1902), Henri Victor Regnault (1810–1878), Émile Verdet (1824–1866), Antoine Philibert Masson (1806–1860), Johannes Peter Müller (1801–1858), Ernst Haeckel (1834–1919). In Berlin he was introduced to Von Humboldt and by Emil Heinrich du

[95] Translation: "When finally prof. de Vrieze's turn came the hour was finished. Because of this, I wasn't examined in botany at all, because when I asked for an exam he deemed it unnecessary. I was such good friends with Suringar, that he trusted I had enough experience in botany." See W. Otterspeer (1986), "De Studententijd van Co Modderman", p. 119.

[96] UB Leiden, AC2, Archief van Curatoren, 1815-1877, Notulen 3-5-1853; 23-5-1853.

[97] W. Otterspeer (1986), "De Studententijd van Co Modderman".

Bois-Reymond (1818–1896) Bosscha was introduced to the German Academy where he met Magnus, Poggendorff, Georg Merz (1793–1867), and Rudolf Clausius (1822–1888). He also visited the famous laboratories of Regnault, Heinrich Daniel Rühmkorff (1803–1877), Joseph von Fraunhofer (1787–1826).[98]

Van Lunteren states that it is very likely that in Berlin Bosscha learned more about the new law of conservation of energy from an early proponent of the law. Du Bois-Reymond was always on the watch for new pupils who he could convince of the new law of his protégé Hermann von Helmholtz (1821–1894).[99] I, on the contrary, think that Bosscha already learned of the law of conservation of energy through Dutch publications and lectures, but it is plausible that Bosscha was encouraged to disseminate the law further by his Berlin contacts.[100] The law will become very important for physics and for Bosscha's further career; see also section 3.1.

In September 1855, after obtaining his new vocation with certainty, he married P.E. Kerkhoven,[101] a marriage from which the two sons Jan Bosscha (1857–1940) and Karel Albert Rudolf Bosscha (1865–1928) and four daughters would be born.

1.3 Early Career

1.3.1 Assistant at the Physical Institute

Already during his studies Bosscha was thinking about his further career. In 1853 he asked his father for advice on whether or not to apply for the vocation of gymnasium teacher. All of his professors: Kaiser, Verdam and Rijke discouraged him to do so as it would be bad for his career and bad for science. Bosscha would then be 'lost to science'.[102] Bosscha himself wants to remain a natural scientist. As he poetically writes it in a letter to his father, he wants to become one of that group of men that extends the knowledge of the laws of nature:

[98] Baarn-Archive: Autobiography; Letters to his father 8-6-1854; 26-6-1854; H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 113.

[99] D. Wegener (2009), *A True Proteus*, pp. 50–54; F. van Lunteren (2011b), "Johannes Bosscha Jr. en het Behoud van Arbeidsvermogen", p. 6

[100] In the sources of the previous footnote it is stated wrongly that Bosscha worked in the laboratory of Magnus at this time. Bosscha only visited his laboratory in a stay that lasted one month at maximum.

[101] Leydse Courant, 5-9-1855. The Kerkhoven family was intermarried with the Bosscha family. His aunt Cecilia Johanna Bosscha was married to Johannes Kerkhoven. His sister also married a Kerkhoven, and finally the family relations were also tied in Nederlands-Indië, where Bosscha's two sons would come to work with E.J. Kerkhoven and built a significant Tea-'empire'. Bosscha's granddaughter also married - in Nederlands-Indië with a Kerkhoven. Together with Johannes Kerkhoven, Bosscha Sr. planned and invested money in the polders of Anna Palowna and Johannes Kerkhovenpolder in Dollaard. See C. Frank (2012), "Drie Villa's aan de Nieuweweg in Lochem" and Nederlandsche staatscourant 21-07-1852. This all shows that the Bosscha family was a very rich family, which is not strange with the amount of professors and their status in society. Final evidence for the wealth of the Bosschas is that he, or his father, is in the list of people in the province of Zuid-Holland that had to pay the most taxes. See Dagblad van Zuidholland en 's Gravenhage, 7-5-1864.

[102] Baarn-Archive: Letters to his father, 4-4-1853; 13-9-1853; Letter of F. Kaiser to J. Bosscha Sr., 19-9-1853.

> "Het is aldus mijn ideaal geworden, daar aan mijn leven te besteden en mij te scharen onder het leger van diegene [...die] het hunne trachten bij te brengen, om de menschelijke kennis van de natuurwetten uit te breiden." [103]

In the same letter Bosscha adds that he will ask Rijke whether Rijke needs an assistant at the Physical Institute. A few days later he asks Rijke and Rijke replies that this would indeed be very helpful, although he thought that such a post would be beneath Bosscha. Rijke also replies to Bosscha Sr. that Bosscha Jr. should not apply for the gymnasium, as he would rather have Bosscha as his assistant.[104]

A new development at the universities, that speaks for the independence and specialization of physics as a discipline, was the expansion of the staff in form of the appointment of an assistant at the Physical Institute.[105] While astronomical observatories already had such an assistant to the professor with the title 'observator', and shortly before, in Groningen Petrus Johannes van Kerckhoff (1813–1876) and in Utrecht Gerardus Johannes Mulder (1802–1880) had appointed assistants for the chemical laboratory. The physical institutes at the universities in the Netherlands had no assistants yet, only a non-academic custos to help them with practicalities. This development of hiring scientific assistants had a parallel at the German universities, albeit some 20 years earlier in Germany.[106]

Prof. Rijke, who became director of the physical institute in 1846, asked the curators in 1854 for an assistant at the physical institute to lighten his burden of preparing the demonstrative experiments for his lectures. He wrote in a letter to the curators of the 14th of April 1854:

> "Het in elkander zetten der toestellen, het beproeven der werktuigen, het doen der experimenten vóór de les, 't geen alleen zekerheid geeft dat zij op de les zelve niet zullen mislukken, kost mij in den regel den geheelen ochtend. Tot het doen van eigene onderzoekingen schiet mij derhalve geen tijd over." [107]

Interestingly, Rijke used the argument that he has no time for doing his own research. As we can see, already in 1854 there are calls to lighten the educational burden of the professors for the

[103] Translation: "It has become my ideal to spend my life on that and to be gathered under the army of those who try to add their work to extend the human knowledge on the laws of nature." Baarn-Archive: Letters to his father, 10-9-1853.

[104] Baarn-Archive: Letter from P.L. Rijke to J. Bosscha Sr., 14-9-1853.

[105] In Dutch it is called: 'Natuurkundig Kabinet'. This still conveys the meaning of 'cabinet' - a collection of artifacts: instruments and the like that it was in the time of Rijke. However, later assistants would be appointed as assistants to the new physical laboratory at the Steenschuur.

[106] K. van Berkel (1985), *In het voetspoor van Stevin*, p. 129; F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics", p. 34.

[107] Translation: "Preparing the instruments, trying the devices and doing the experiments before the start of the lecture, the only way to make sure they will not fail during the lecture, takes me the whole morning. I have no time for doing my own research." See W. Otterspeer (1992), *De Wiekslag van hun Geest*, p. 57; originally in Archief van Curatoren, 1815-1877 - Universiteit Leiden (AC2), Ingekomen stukken 1854 no. 92; 1855 no. 133.

advance of own scientific research. According to Van Berkel, the ideal of university professors to do science for science itself and not only be useful to educate society, is a shift from the French utilitarian ideal to the new German model.[108] An example of the direct implementation of the German model was the reorganization of the KNAW in 1855 to include yet again a second section of 'letteren' (humanities), precisely as in the German academies. Furthermore, the new ideal of specialization of a professor in a certain field, apparent already in the previous section, broke with the older German ideal of *Bildung*. In the first half of the 19th century, professors would usually be appointed 'in the faculty' and not in a specific subject. However, as we have seen, most professors were only experts in a certain field.[109] This is consistent with the general cultural shift in the 19th century from 'egalitarian' ideal to 'elitarian' or 'professional' ideal in the Netherlands.[110] Leiden science professors were among the first in the Netherlands to specialize in one field. Although Rijke still flirted with chemistry - which only shows the moving disciplinary boundaries - he only taught experimental physics and all of the dissertations he supervised were on this subject. Equally, Van der Boon Mesch, Kaiser and Verdam only taught courses and supervised theses in their respective fields. In the 1850s, this was definitely not the case in Utrecht - the university that was slowly losing its dominant position from the beginning of the 19th century in the natural sciences in the Netherlands. In fact, even in the 1870s, dissertations in what we would call physics were supervised by either Cornelius Hubertus Carolus Grinwis (1831–1899), Christophorus Buys Ballot (1817–1890) or Van Kerckhoff.[111] The distinguished Utrecht professor of biology Pieter Harting (1812–1885), like his colleagues, was openly opposed to specialization in the sciences.[112]

In any case, the curators accepted to appoint an assistant on the 16th of September 1854 and they also followed Rijke's suggestion to appoint Bosscha. However, it still took a year before the new post was ratified by the ministry and the salary agreed upon. Bosscha started at his new post in January 1856.[113]

During his time as assistant in the Physical Institute, Bosscha not only prepared the demonstrative experiments to be used in Rijke's lectures, but we also see in the *Series Lectionem* from 1857 onwards that he taught daily classes of experimental physics, presumably for more advanced students.[114] Bosscha was most prolific during this period. He wrote about experiments on telegraphy, co-published a popular science journal *Blikken in het Leven der Natuur* and finally

[108] The idea that the Netherlands simply takes over the German model of science has been criticized by Wachelder, instead he believes that the Dutch society simply 'modernized': J. C. M. Wachelder (1992), *Universiteit tussen Vorming en Opleiding*.
[109] K. van Berkel (1985), *In het voetspoor van Stevin*, pp. 128-129.
[110] W. W. Mijnhardt (2004), "De Akademie in het Culturele Landschap rond 1900".
[111] For information on Utrecht dissertations I have consulted their catalog.
[112] K. van Berkel (1998), *Citaten uit het Boek der Natuur*, pp. 160–162.
[113] UB Leiden, AC2, Archief van Curatoren, 1815-1877, Notulen 16-9-1854; 5-5-1855; 16-6-1855.
[114] Studenten-almanak voor het jaar 1857, J.H. Gebhard en Comp., Leiden; F. van Lunteren (1995), "Van Meten tot Weten", p. 116.

experiments on electrical currents that did much to establish experimentally the law of conservation of energy in the Netherlands. This is discussed in more detail in section 2.4. Indeed, Bosscha made name in the scientific community with a popular lecture on the conservation of energy in galvanic currents at the Utrechtsche Genootschap.[115] Here, he introduced the concept of energy, or 'arbeidsvermogen' for the first time for a broad audience of the Dutch scientific community and whoever was interested. For more details, see section 3.1.

As the assistant at the Physical Institute, Bosscha made one more appearance in the *Studentenalmanak*. Although this time he was subject and not author. Dutch poetry writer François HaverSchmidt (1835–1894), better known by the pseudonym Piet Paaltjens, mentioned him in the poem 'Jan van Zutphen' of the bundle *Snikken en Grimlachjes*, which also appeared in the *Almanak*. In the fifteenth verse Bosscha is mentioned:

> Op hem volgen Jan van den Bossche,
> Fel op kloosters en papen gebeten,[116]

This shows Bosscha was an active and well-known figure at the Leiden University at the time - and that he was of outspoken protestant conviction, as the rest of the Bosscha family.

Influence on other dissertations

Bosscha was not only an assistant to the professor, there are three dissertations that clearly show that Bosscha was the main instigator of the research, and not Rijke. The first such dissertation is by Kist. In the introduction of his dissertation, after filling the obligation of thanking the faculty professors, Kist also thanks Bosscha. He writes:

> "Hoe zou ik U hier vergeten, hooggeachte vriend, Dr. J. Bosscha! wiens vriendschappelijke omgang mij, ook voor mijne studiën, zoo belangrijk geweest is; die mijne werkzaamheden op het physisch laboratorium, ook ten behoeve van dit mijn proefschrift, hebt helpen besturen; en zoo menigmaal den weg mij deed vinden, dien ik te volgen had, om het mij voorgestelde doel te bereiken."[118]

[115] J. Bosscha Jr. (1858f), *Het Behoud van arbeidsvermogen in den galvanischen stroom.*

[116] Translation: "After him, John of the forest follows: viciously embittered against monasteries and catholics." See F. HaverSchmidt (2003), "Snikken en Grimlachjes"; D. Welsink (2001), "Who's who in 'Jan van Zutphen's afscheidsmaal' van Piet Paaltjens".

[117] Found in Baarn-Archive.

[118] Translation: "How could I forget to mention here, high-esteemed friend, Dr. J. Bosscha! whose amicable collegiality was so important, also for my studies. Who helped governing my work at the physical laboratory for the purpose of my dissertation; and so often helped me find the way that I was supposed to follow to attain the goal I wanted to attain." A. Kist (1859), *Verhandeling over de Ongelijke Verwarming aan de Poolplaten van een Ontledings-toestel*, pp. ix-x.

Figure 1.11: Lithograph of Bosscha by Johannes Peter Berghaus (1810–1870) in 1854.[117]

The subject of his dissertation was about the mechanical theory of electrolysis, a subject that Bosscha was publishing about in the *Annalen* at the time.[119] The conservation of energy also plays a major role. In the words of Kist the law of conservation of energy shows a particular unity in the otherwise isolated experimental facts:

> "heeft een merkwaardig verband leeren kennen tusschen de opgenoemde verschijnselen, die te voren als even zoovele geïsoleerde feiten ontdekt zijn." [120]

Although Rijke appears to be the official supervisor, Rijke would never have led such a research. Qualitatively, most properties of the electrolysis of water were already known. However, the exact quantitative relations between various properties could be proven with the law of conservation of energy. Such a quantitative research would most definitely not have interested Rijke. It is, however, exactly the type of research that Bosscha would do. Lastly, Kist was one of the first in the Netherlands to copy Bosscha's newly invented word 'Arbeidsvermogen' for what in Britain would be 'energy'; more on this in section 3.1.

The second dissertation in Leiden that shows Bosscha's influence is the dissertation by Adolph Samuel van Oven (1837–1915), who wrote a small textbook on physics in 1863 intended for university students[121] and later became director of the HBS Dordrecht. Although Bosscha was not available anymore at the physical laboratory, the topic and treatment of the subject shows Bosscha's influence. Bosscha's name and contemporary work is mentioned throughout the dissertation and Van Oven uses Bosscha's term 'arbeidsvermogen'. In the preface Van Oven thanks Bosscha's teachings:

> "Al heb ik bij dit werk de hulp Uwer uitstekende talenten moeten missen, Zeergel. Dr. J. Bosscha, toch is het mij eene behoefte ook U een enkel woord van dank toe te spreken voor de welwillendheid, mij vroeger beloond. Het deed mij leed Uwe heldere, duidelijke voorstellingen en Uwe hulp bij mijne practische oefeningen te missen, juist toen ik geleerd had die naar waarde te schatten; [...] Moge ik eenmaal in de gelegenheid zijn U mijne dankbaarheid en hoogachting met daden te toonen." [122]

[119] J. Bosscha Jr. (1857-1858), "Ueber die mechanische Theorie der Elektrolyse, part 1, part 2 and part 3".

[120] Translation: "shows a particular unity between the mentioned phenomena, that before were discovered as so many isolated facts." A. Kist (1859), *Verhandeling over de Ongelijke Verwarming aan de Poolplaten van een Ontledings-toestel*, p. 8.

[121] A. van Oven (1863), *Leiddraad bij de Studie der Natuurkunde*.

[122] Translation: "Even though, while creating this thesis I had to miss the help of your outstanding talents, very learned Dr. J. Bosscha, I feel the need to say a word of thanks for your goodwill that I received earlier. It pained me to miss your clear, unambiguous representations and your help with my practical exercises. [...] May I once be in the opportunity to show you my thankfulness and high esteem with actions." A. van Oven (1862), *De Galvanische Gasbatterij*, p. vii.

Bosscha's influence already transcended Leiden University, as the dissertation of physical chemist Hendrik Willem Schroeder van der Kolk (1836–1867) also shows his influence.[123] He first studied in Leiden while Bosscha was assistant and then Schroeder van der Kolk changed to Utrecht. However, in Utrecht the professor most affiliated with the field of physics, Richard van Rees (1797–1875), was purely a theoretician. This can be shown, for instance, by the fact that almost all of the dissertations under his lead were on theoretical subjects and lacked experimental research. One of the only exceptions is the dissertation of Schroeder van der Kolk. Schroeder van der Kolk writes in his introduction:

> "Hooggeachte vriend, Dr. J. Bosscha Jr. Het zij mij vergund U hier mede te vermelden, nu ik na het schrijven mijner dissertatie, waarbij ook Uwe hulp mij zoo vaak te beurt viel, op het punt sta de academie te verlaten. Reken ik mij gelukkig eenigen tijd te Leiden te hebben kunnen doorbrengen, zoo is dit vooral, omdat ik hierdoor in de gelegenheid was, nader met U in kennis te komen. Wees verzekerd, dat de vriendschap wederkeerig is, die ik in zoo ruime mate van U heb mogen ondervinden [...]" [124]

In this dissertation, Schroeder van der Kolk investigated experimentally the conductance in several metals with the help of Bosscha's method. The emphasis on precision shows that this research is truly Bosscha-an, or, in extension, Kaiserian. Another piece of evidence that Van Rees had little to do with this investigation is the comment of Schroeder van der Kolk on page 47:

> "De proeven werden verrigt op de sectiekamer der anatomie te Utrecht, daar de zaal van het physisch kabinet voor deze proeven minder geschikt was.",[125]

It seems Van Rees had no room for experiments at all; it was Bosscha who helped Schroeder van der Kolk with his experiments.[126] Schroeder van der Kolk remained influenced by Bosscha and the law of conservation of energy. In his further career, Schroeder van der Kolk tried to apply the principles of entropy and of the law of conservation of energy on heat processes in chemistry. He also gave two talks at the *Provinciaal Utrechts Genootschap* about the conservation of energy.[127] Schroeder van der Kolk was appointed teacher at the

[123] F. van Lunteren (1995), "Van Meten tot Weten", pp. 56–57.

[124] Translation: "Highly esteemed friend, Dr. J. Bosscha Jr. It is my pleasure to be allowed to mention you here as well, now that I am on the verge of leaving the academy after writing my dissertation, for which I have received your help so many times. I count myself lucky to have spent some time in Leiden, especially because this created the opportunity to come into contact with you. Be assured, the friendship is mutual, that which I have experienced so much of from you." H. W. Schroedinger van der Kolk (1860), *Over het Meten van den Galvanische Gasweerstand inzonderheid bij Metalen*, pp. XIII-XIV.

[125] Translation: "The experiments were done on the section chamber of anatomy in Utrecht, because the room of the physical cabinet was less fit for these experiments."

[126] Baarn-Archive: Letters to his father, 9-8-1859.

[127] H. W. Schroedinger van der Kolk (1861), *Het Behoud van Arbeidsvermogen bij de Stoomwerktuigen*; H. W. Schroedinger van der Kolk (1865), *Over eene Algemeene Wet van het Behoud van Arbeidsvermogen*.

HBS of Zutphen and subsequently at the HBS and what was left of the Athenaeum of Deventer until his untimely death at the age of 31.[128]

1.3.2 Further Activities

Apparently, the job as assistant, publishing and helping other people's research which was beyond his task, did not fully fill Bosscha schedule. He also taught mathematics at the gymnasium school established by the Leiden mathematical society *Mathesis Scientiaram Genetrix*.[129] Although it is unclear exactly how long he taught mathematics there, it seems he started off in 1852 as the replacement of his friend J.A.C. Oudemans who fell ill, and he quit in 1858, being replaced by his own pupil Kist.[130] It is possible that he quit the teaching position to play another role for the society; in 1859 he became part of the executive board of the society, a role later performed by none other than Van der Waals in 1864-1865.[131] Bosscha was made honorary member for his activities at the society in September 1860.[132]

Bosscha was involved in the weekly Tuesday-evening physics meetings at the Amsterdam society *Felix Merites* from 1853 onwards[133] and a member of the mathematical society of Amsterdam in April 1855.[134] He also became a member of several learned societies. Firstly the *Maatschappij tot Nut van 't Algemeen* (Society to the benifit/utility of the public) for which Bosscha will play a larger role later on, see section 6.2.[135] He became a member of and held some presentations at the *Provinciaals Utrechtsch Genootschap*.[136] He also became a corresponding member of the *Bataafsch Genootschap voor Proefondervindelijke Wijsbegeerte* (Rotterdam Society of Experimental Philosophy),[137] a member of the *Maatschappij der Nederlandse Letterkunde*,[138] an honorary member of the *Nederlands Onderwijskundig Genootschap* (Dutch Education Society),[139] and last but not least, Bosscha was elected member of the *Hollandsche Maatschappij der Wetenschappen* on the 11th of May 1863.[140] The highest institute of the scientific community

[128] H. A. M. Snelders (1971), "Hendrik Willem Schroeder van der Kolk (1836-1867) en de Fysische Chemie".
[129] On Mathesis see D. Beckers (1998), "Het is al Mathesis dat de klok slaat".
[130] Leydse Courant, 27-9-1852 and Handelingen der 81ste Algemeene Vergadering van de Nederlandsche Maatschappij ter Bevordering van Nijverheid, Julij 1858, p. 106. Interestingly, Bosscha already seemed interested in taking this position of teaching in 1852, but then, J.A.C. Oudemans was appointed. UB Leiden AFA FC FK 128, pp. 3-4, Letter of Bosscha Sr. to Kaiser, 12-9-1853. I was unable to read Kaiser's reply of a few days later.
[131] Leydse Courant, 01-8-1859.
[132] Baarn-Archive: Diploma, 15-9-1860.
[133] Algemeen Handelsblad, 20-10-1853, strangely enough he is already called Dr. Bosscha before obtaining his doctorate here.
[134] Baarn Archive: Diploma, 13-4-1855.
[135] Leydse Courant, 24-9-1855.
[136] Algemene Konst- en Letterbode, 11-7-1857.
[137] Algemene Konst- en Letterbode, 8-5-1858; Baarn-Archive: Diploma, 18-8-1858.
[138] Leydse Courant, 22-6-1860; Baarn-Archive: Diploma, 1-8-1860.
[139] De wekker; weekblad voor onderwijs en schoolwezen, vol. 17, no. 26, 29-06-1860; Baarn-Archive: Diploma, 18-5-1860.
[140] Leydse Courant, 20-5-1863.

also acknowledged his achievements by appointing him member of the KNAW on 24th of April 1863.[141]

Lastly, Bosscha became school inspector, as his father was earlier, for the Leiden district in 1860.[142] He only had the last assignment shortly as in September 1860 he obtained his new vocation.

1.3.3 Professor at the Royal Military Academy

In 1859 Bosscha complained about his post as assistant to his father and mentioned that he hoped to succeed Van Rees in Utrecht or to become his assistant.[143] The circumstances in Utrecht would be so much better than in Leiden. In physics, Leiden had nothing to offer him anymore, chemistry 'lacked completely' and Verdam, for mathematics, was unreachable because he was so busy. Therefore, Bosscha thought, Utrecht would be much better as Van Rees could still teach him much about mathematical physics and A.C. Oudemans, who was appointed to the assistant of Mulder could help in chemistry. He complained further, in Utrecht he was 'welcome' but in Leiden he would be at most tolerated. All his ambition was smothered by Rijke, who used Bosscha only for the practicalities at the Laboratory:

> "Ik bespeur dat het ongeduldig verlangen, om vooruit te komen, mijne ambitie, meer dan goed is, opwerkt, mijne stemming menigmaal wrevelig maakt, [...] en dat elke verbetering wordt tegengewerkt door één man, het gevoel van verongelijking soms? Met de bittere gewaarwording van persoonlijke haat vermengt. [...] Het is toch niet meer dan natuurlijk, dat men verlangt tot iets nuttigs werkzaam te zijn, het eenige nut dat ik sticht, bestaat hierin, dat ik Rijke in staat stel, wat langer 's morgens op zijn kamer te blijven en wat vroeger 's middags te gaan wandelen." [144]

Bosscha Jr. asked his father to mediate for him at the government and see if there are no other occupations. Bosscha Sr. suggested a professorship at the Royal Military Academy in Breda - a post that his father occupied earlier, albeit in a different subject.[145]

[141] Jaarboek van de Koningklijke Akademie van Wetenschappen voor 1864.

[142] He was school inspector of the third district of South Holland from the 21st of April until 30st of July 1860. See Nederlands Staatscourant, 24-4-1860; 23-7-1860. Notably, he was not chosen (almost unanimously) the first time he was electable in December 1859. Leydse Courant, 12-12-1859.

[143] Baarn-Archive: Letters to his father, 8-7-1859; 27-7-1859. Note that Bosscha is mentioned in 1867 as a possible successor of Van Rees, but Grinwis became the successor in the end. Nieuw Rotterdamsche Courant, 25-5-1867.

[144] I sense that the impatient longing to move forward arouses my ambition too much and makes my temper spiteful. Every advancement is being opposed by one man. The feeling of injustice maybe? Mixed with a bitter realization of personal hate. [...] Is it not more than natural, that one longs to work on something useful? The only use I am consists of that I enable Rijke to stay in his room a little longer in the morning and go on his afternoon walk a little earlier in the afternoon." Baarn Archive: Letters to his father, 9-8-1859.

[145] Baarn-Archive: Letters to his father, 15-5-1860; 24-5-1860.

In September 1860 Bosscha became professor of at the Royal Military Academy as the replacement of Jacob Badon Ghijben (1798–1870) who turned deaf. He taught mathematics and mechanics there.[146] Bosscha was lauded for the clarity of his lessons:

> "Prof. Bosscha was belast met het algemeen toezicht over het onderwijs in de wiskundige vakken en gaf persoonlijk les aan de cadetten der Artillerie en der Genie van het 4de studiejaar in de Statica en Dynamica. Zoodoende heb ik van zijne lessen genoten in het studiejaar 1860-61. Ik zeg genieten, want de zeldzame helderheid, waarover de heer Bosscha beschikt en die slechts het deel is van hoogst begaafde personen, maakte zijn onderwijs boeiend en aangenaam." [147]

Another student noted that they liked Bosscha's personality because he was most friendly in class:

> "Bosscha was van het eerste oogenblik af bemind om zijn vriendschappelijke omgang en geacht, omdat wij dadelijk het besef kregen te doen te hebben met een man van groote bekwaamheid." [148]

The Royal Military Academy is a military school with, at the time, a little over 300 cadets. The school had four years of training divided in four different departments: Infantry, Calvary, Artillery and the Engineers. There were six different courses, followed for the entirety of the four years: Languages (literature), mathematics and physics, warfare, drawing class, physical exercises and a course in 'practical exercises'. Bosscha had around 40 teaching hours, roughly the same as the cadets, who had 42 hours of courses.[149] It seems plausible that during this period Bosscha did not have much time to do much other than teaching. Indeed, Bosscha did not publish anything during the Breda period. However, Bosscha did give some popular lectures on astronomy for the physics society of Breda and was made honorary member of the society for

[146] Nederlands Staatscourant, 18-6-1860.

[147] Translation: "Prof. Bosscha was responsible for the general supervision of the education in the mathematical subjects and taught the cadets of the artillery and engineers of the 4th year statics and dynamics personally. Consequently, I have enjoyed his lessons of the year 1860-61. I say enjoy, because of the rare clarity that Mr. Bosscha has, that only a few of the highly gifted people have, which made his teachings both enthralling and pleasant". This is a quote from Generaal-Majoor Pieter Cornelis Kool (1842–1920), found in Unknown (1901). "Professor Bosscha". In: *Woord en beeld; geïllustreerd maandschrift* 6 (2). Author Unknown, Possibly R.A. van Sandick, pp. 439–444, p. 441.

[148] Translation: "Bosscha was from the first moment on loved for his friendliness and respected because we were immediately aware that we were dealing with a man of great ability." Found in Unknown (1901), "Professor Bosscha", p. 441.

[149] See Verslag van den staat der hooge-, middelbare en lagere scholen in het Koninkrijk der Nederlanden over 1860-1861, pp. 34-43.

this.[150] It is likely that these lectures were inspired by or written by KAISER.[151] There is also some evidence that BOSSCHA kept up with the international scientific literature at the time, as is shown in the last paragraph of section 2.1.

Due to reorganization of the educational system in the Netherlands, BOSSCHA saw his calling somewhere else in society. The HBS had to be founded, for which BOSSCHA became the inspector. This is discussed in chapter 2. In this chapter we have seen that BOSSCHA's greatest inspiration was KAISER and that BOSSCHA from a young age sought to improve the materials and rooms available for scientific research.

[150] Baarn-Archive: Diploma, 21-10-1863.

[151] The first lecture was on the 14th of October 1861 on the nature of light (Translation of: "Over het Licht"). The next three lectures at the end of 1862 and beginning of 1863 were on the physics of stars. They were called: The movements of the world-ether (Translation of: "De Bewegingen van de Wereldether"), Weight and Size of Stars (Translation of: "Maat en Gewigt der Hemelligchamen") and Composition of the Sun and the Fixed Stars (Translation of: "Zamenstelling van de Zon en vaste sterren"). Bredasche Courant, 13-10-1861; 9-11-1862; 7-12-1862; 11-1-1863.

Chapter 2

Bosscha's Research at Leiden University

Bosscha's early research usually had the subject in common with his supervisor Rijke's research: The research on electrical (galvanic) currents. However, while Rijke's research was purely qualitative and phenomenological, Bosscha was clearly influenced by Kaiser's emphasis on precision, quantitative research and accurate descriptions of the measuring devices.[152] This is already apparent in his first publication (see section 2.1), but 'Kaiserian' physics will remain a binding factor of Bosscha's research throughout his career. Quantitative precision is what I would call the first pillar of Bosscha's research. The second pillar of Bosscha's research was the newly formulated law of conservation of energy. Lastly, unlike leading Dutch physicist Van Rees, Bosscha's research was mainly experimental, much like his supervisor Rijke.

Note that both two pillars of his research: precision measurements and the conservation of the law of energy were at the time brand new in the field of physics. Indeed, it can be argued that both these pillars helped define physics as an independent discipline separated from chemistry and (mixed) mathematics. While early 19th century physicists and chemists purely did experiments to discover new phenomena, at the end of the 19th century quantitative measurement was the norm in physics (and *not* in chemistry); the 'measuring' physicist was born, with Kamerlingh Onnes as the epitome of the Dutch measuring physicist: Inspired by theory, researching with meticulous precision. Secondly, the law of conservation of energy gave physics a clear research field: Physics would become the field that investigated the various forms of conversions of energy, i.e. in modern terms the field that studies (force) interactions. This chapter will establish these two pillars of Bosscha's research.[153]

It seems that Lorentz was not the only polyglot in the Dutch history of science, indeed, it seems quite common in Dutch history of science to write in multiple languages. Bosscha as

[152] It is unclear by how much he was already under the influence of Kaiser's teachings via Van der Willigen in Deventer.

[153] For a more detailed study of Bosscha's research and publications, see J. Wooning (2001), *Johannes Bosscha*, pp. 20–33.

well easily wrote in Dutch, German, French or the occasional English. Most of his articles were published in both German and Dutch - and in a later period also in, what seems to be Bosscha's preferred language, French.[154]

2.1 Measuring the Speed of Sound

Bosscha's first publication was already as a student on a method to measure the speed of sound. The method itself was inspired by Kaiser and Bosscha's main interest in the method was to find out the degree of precision possible with the method; to find out how accurate one could measure the speed of sound with it.[155]

In 1823 Utrecht professor Moll and learned amateur Albertus van Beek (1787–1856) measured the speed of sound by measuring the amount of time between the moment an observer sees a shot fired and the moment the observer hears the shot. The distance between the shot and observer in the particular experiments conducted by Moll was 17.5 km. This simple method allowed for a calculation of the speed of sound.[156] However, a few disturbing influences cannot be ignored. The first is the wind, that effectively carries the sound with it. The second disturbing influence is the large pressure disturbance of the canon fired for the experiment that locally increases the temperature which effectively increases the speed of sound close to the pressure disturbance. Both these disturbing factors were accounted for in the experimental work of Schroeder van der Kolk, who we have seen earlier and was influenced by the methodology of Bosscha and Kaiser. Schroeder van der Kolk obtained a speed of sound of 322.77 meters per second at a temperature of $0^\circ C$. According to Kuenen, this result was the best for a long time using this method.[157]

Both disturbances would not be there if a method was found to measure the speed of sound with weak signals and in a closed environment. Bosscha's method had both of these requirements. Bosscha's method uses two clocks, with a different frequency. For instance clock A ticks at a rate of 60 times per minute and clock B at a rate of 61 times a minute. The moments at which the two ticks of the clocks coincide is written down. If the observer is now closer to clock A than clock B, the coincidence of the two ticks will be a bit later due to the finite speed of sound. By varying the distance between the clocks and the observer, one can deduce the speed of sound

[154] Bosscha was called a francophile by van Lunteren in one of his articles (F. van Lunteren (2013a), "Astronomers and the Making of Modern Physics", p. 34), however I do not find any evidence that Bosscha was inclined to the French state, like his great-uncle was, only that French was his preferred language of choice for publication, as can be inferred from several articles that were translated in French especially for the *Verspreide Geschriften* and the publication of Huygens' *Oeuvrès Complètes* in French. The last choice could be seen as logical, as Huygens himself wrote mainly in French.

[155] J. Bosscha Jr. (1853c), "Over een middel om de snelheid van het geluid in eene beslotene ruimte regtstreeks te meten".

[156] G. Moll and A. van Beek (1825), "Proefneming aangaande de Snelheid van het Geluid".

[157] J. P. Kuenen (1919), *Gedenkboek van het Bataafsch Genootschap*, pp. 85–88.

by the differences in the time delay between the coinciding ticks. The idea to use clocks with a different frequency is due to KAISER, although KAISER used the method for an astronomical purpose.[158] A student of the history of physics cannot fail to notice the similarity of this method to EINSTEIN's (or rather POINCARÉ's) idea of synchronized clocks used some 50 years later to explain part of special relativity.[159]

In 1853, BOSSCHA published his method in the *Algemeene Konst- en Letterbode*. Founded in 1788, this was one of the few Dutch scientific journals of the first half of the 19th century. The article was republished in 1854 in the prestigious POGGENDORFF's *Annalen der Physik*.[160] He introduced his method with the following argument:

> "Ofschoon er omtrent de snelheid van het geluid vele en gewigtige onderzoekingen zijn in het werk gesteld, zoo mag het, vooral wanneer men in het oog houdt, hoe groote onzekerheid nog in sommige deelen van de theorie des geluids blijft heerschen, niet geheel overbodig geacht worden eene nieuwe methode tot hare bepaling mede te deelen." [161]

However, BOSSCHA's method evaded the theoretical difficulties by creating a situation where these difficulties did not arise. The theory of the speed of sound would soon be sufficiently completed by the development of the new statistical thermodynamics by, among others, JAMES CLERK MAXWELL (1831–1879) and LUDWIG BOLTZMANN (1844–1906).

BOSSCHA himself did not perform the measurements at the time, but calculated with what accuracy the speed of sound could be measured by using this method. This is a very explicit proof that BOSSCHA's interest was in precision. His method was used by several physicists in Germany and France to measure the speed of sound and his method obtained more accurate results than MOLL's method before.[162] Nowadays, many different methods of measuring the speed of sound have been formulated, but the most accurate and simple ones still use the idea of a time difference between weak sound signals as to avoid thermodynamical disturbances, measured by electrical signals, between various locations of an observer or a microphone.[163] Not surprisingly, considering the topic of BOSSCHA's dissertation, BOSSCHA also explained in his publication how

[158] BOSSCHA mentions this in the article.
[159] A. Einstein (1905), "Zur Elektrodynamik bewegter Körper".
[160] J. Bosscha Jr. (1853c), "Over een middel om de snelheid van het geluid in eene beslotene ruimte regtstreeks te meten"; J. Bosscha Jr. (1854a), "Ueber ein Mittel, die Schallgeschwindigkeit in einem eingeschlossenen Raume geradezu zu messen".
[161] Translation: "Although there have been many important researches conducted about the speed of sound, because some parts of the theory of sound remain very uncertain, it is not entirely redundant to report a new method for the determination of the speed of sound." J. Bosscha Jr. (1853c), "Over een middel om de snelheid van het geluid in eene beslotene ruimte regtstreeks te meten", p. 401.
[162] J. P. Kuenen (1919), *Gedenkboek van het Bataafsch Genootschap*, pp. 85-88.
[163] In the practical course for first years at the University of Utrecht (2016), some of the basics of measurement precision is explained by the use of such a measurement of the speed of sound.

this method can be applied to measure the speed of a galvanic current, although this last was deemed undoable according to the editors of *Fortschritte der Physik*. *Fortschritte der Physik* was a review journal edited by the *Physikalische Gesellschaft zu Berlin* founded in 1845 by MAGNUS and DU BOIS-REYMOND, and focused on reviewing the developments in physics, as opposed to the *Annalen*, which contained more original publications.[164]

In September 1862 a French astronomer HERVÉ FAYE (1814–1902) claimed in front of the academy of Paris that he found a new method to measure the speed of sound, which happened to be identical to BOSSCHA's method.[165] BOSSCHA quickly responded by sending two letters to the Academy, claiming his priority in the discovery of the method.[166] This was verified in the Dutch *Album der Natuur* and in *Fortschritte der Physik*, where the method and original experimental results were once again discussed.[167] I argue that this small history shows two things. The first is that BOSSCHA, although in his Breda period not publishing or producing anything scientific, still read the international literature and was aware of the developments in the field. The second is that the scientific community was *international* in the sense that scientists, at least on the continent and especially in the Netherlands, read and paid attention to what their foreign colleagues were doing. Of course, in the case of BOSSCHA this is further exemplified by his choice of publication in a foreign journal: the prestigious *Annalen der Physik*.

2.2 Dissertation on Differential Galvanometers

While BOSSCHA was still a student, he received an award for his answer on the prize question called by the faculty 'Over den invloed der warmte op het electrisch geleidingsvermogen van vloeistoffen.' (On the influence of heat on the electric conductance of liquids).[168] BOSSCHA chose to investigate this topic further and to write his dissertation on this topic. On the 31th of March 1854 BOSSCHA obtained his doctorate *magna cum laude* on the dissertation *De Galvanometro Differentiali*.[169] His thesis described and improved upon a certain type of galvanometer: the differential galvanometer invented by ANTOINE BECQUEREL (1788–1878) in 1825. The differential

[164] Rb. (1853), "J. Bosscha jun. Over een Middel, om de Snelheid van het Geluid, in eene Beslotene Ruimte, regtstreeks te Meten".

[165] H. Faye (1862), "Sur le Méthode à la Mesure de la Vitesse du Son".

[166] J. Bosscha Jr. (1862), "Correspondance particulière du COSMOS". BOSSCHA recalls in a letter to his father that he gave a copy of his text to FAYE during his scientific journey in 1854. BOSSCHA thinks that FAYE probably read the article, forgot about it and later did not remember the origin of the method. Baarn-Archive: Letters to his father, 20-11-1862.

[167] Album der Natuur, 1863, p. 7; Rb. (1862). "J. Bosscha. Détermination de la vitesse du son. Cosmos XXI. 533-537." In: *Die Fortschritte der physik. Dargestellt von der physikalischen Gesellschaft zu Berlin* 18, pp. 129–133. The entry in *Fortschritte der Physik* is signed by Rb, possibly PROF. DR. ROEBER, a member with the correct initials.

[168] Algemeene Konst- en Letterbode, 20-2-1852; Studenten-almanak voor het jaar 1852, J.H. Gebhard en Comp., Leiden; Idem 1853.

[169] J. Bosscha Jr. (1854c), *De Galvanometro Differentiali*; UB Leiden AFA inv. no. 26 Album Promotiones 1835-1933.

galvanometer could be used to compare two electrical resistors. In his thesis, we see yet another time that he is interested in improving the precision of existing methods and experimental setups.

A galvanometer is a device to measure the size and direction of an electrical current that flows through a wire. The basic principle used by a galvanometer is the magnetic field induced by the current through a wire. If one places a magnetic needle close to the wire it will direct itself according to the magnetic field of the current. If the wire is wound in a coil, the effect on the magnetic needle is strengthened; such an experimental setup is called a galvanometer. A differential galvanometer is a galvanometer in which the current flows through two coils in opposite directions, such that the effects of the coils on the magnetic needle is (partly) canceled. If one uses the same source for the electricity and the same resistors, the magnetic needle should remain still. If one of the resistors is now varied, one can measure the difference between the resistors by how much the magnetic needle is displaced.

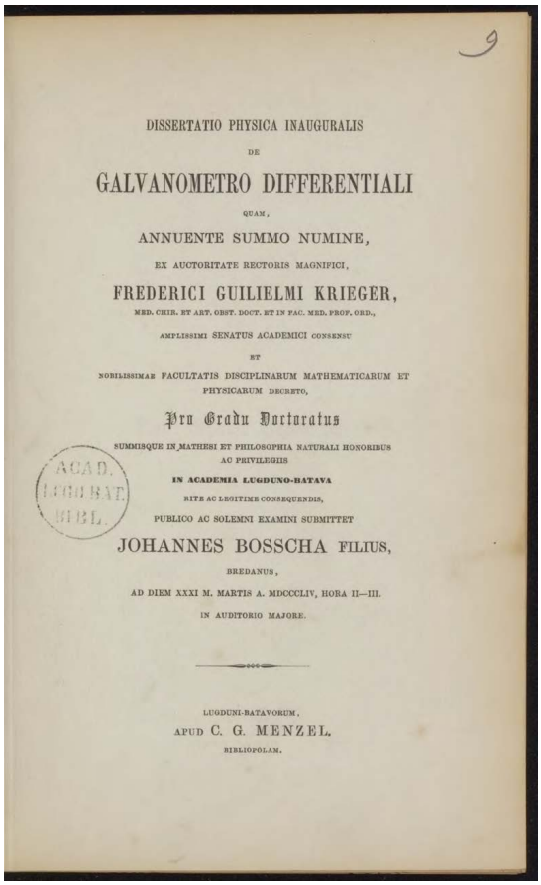

DISSERTATIO PHYSICA INAUGURALIS
DE
GALVANOMETRO DIFFERENTIALI
QUAM,
ANNUENTE SUMMO NUMINE,
EX AUCTORITATE RECTORIS MAGNIFICI,
FREDERICI GUILIELMI KRIEGER,
MED. CHIR. ET ART. OBST. DOCT. ET IN FAC. MED. PROF. ORD.,
AMPLISSIMI SENATUS ACADEMICI CONSENSU
ET
NOBILISSIMAE FACULTATIS DISCIPLINARUM MATHEMATICARUM ET PHYSICARUM DECRETO,
Pro Gradu Doctoratus
SUMMISQUE IN MATHESI ET PHILOSOPHIA NATURALI HONORIBUS AC PRIVILEGIIS
IN ACADEMIA LUGDUNO-BATAVA
RITE AC LEGITIME CONSEQUENDIS,
PUBLICO AC SOLEMNI EXAMINI SUBMITTET
JOHANNES BOSSCHA FILIUS,
BREDANUS,
AD DIEM XXXI M. MARTII A. MDCCCLIV, HORA II—III.
IN AUDITORIO MAJORE.
LUGDUNI-BATAVORUM,
APUD C. G. MENZEL,
BIBLIOPOLAM.

Figure 2.1: Bosscha's dissertation *De Galvanometro Differentiali.*

However, Bosscha's dissertation mainly refutes the usability of ordinary differential galvanometers by showing that there are many more experimental parameters for the magnetic needle can stay in equilibrium. Only if certain experimental conditions were satisfied, a differential galvanometer could be used to measure the difference in resistivity. Lastly, Bosscha described a method to measure the quotient between two 'electromotive forces', i.e. electrical power sources. This method, later known as Bosscha's method, was slightly different from Poggendorff's compensation method and similar to a Wheatstone bridge.[170]

Big parts of his dissertation seem to be republished in Poggendorff's *Annalen*.[171] In some

[170] More on the history of potentiometer systems can be found in D. Rutenberg (1939), "The Early History of the Potentiometer System of Electrical Measurement".

[171] J. Bosscha Jr. (1854b), "Ueber das Princip des Differentialgalvanometers und seine Anwendung zur Vergleichung der Drehungsmomente, welche Leiter von verschiedener Form und Grösse auf die Magnetnadel ausüben, wenn sie von gleich starken Strömen durchflossen werden"; J. Bosscha Jr. (1855), "Ueber eine Bestimmung der

later publications, Bosscha investigated more electrical laws related to those in his dissertation.[172] All the electrical theorems described and experimentally demonstrated by Bosscha at this time can be proved or derived from the laws on electrical circuits formulated in 1845 by Kirchhoff, still known and used today as Kirchhoff's laws.[173]

2.3 A Problem in Telegraphy

Another instance where we can see that Bosscha was interested in precision is in his following research. Subsequently Bosscha tackled a problem in telegraphy. Here, his work was aimed at developing a precise method. In this case, it was the solution to a problem in telegraphy: sending multiple signals through the same telegraph connection. At the time telegraphy was very new and many practical problems, such as the previous, did not have a solution. The inventors Werner von Siemens (1816–1892) and Johann Georg Halske (1814–1890) already found a solution how to send two signals in opposite direction through the same wire. Bosscha tried to find a solution to send two signals in the same direction through one wire, such that in combination with Von Siemens' and Halske's solution the original problem would be completely solved. His article was presented to the KNAW by Bosscha's friend J.A.C. Oudemans, who was already a member. In his article, Bosscha explains how two different signals that are sent at the same time can be distinguished as long as the signals are strong enough and differ enough in strength. As such, he gave a practical solution to a problem in telegraphy.[174] Lorentz calls him the inventor of the 'quadruplex-telegraphy' in an eulogy:

> "Bosscha heeft zijne vinding in bijzonderheden doordacht en beschreven en, al kon hij haar niet in toepassing brengen, hij staat in de geschiedenis der telegraphie bekend als de eerste uitvinder eener methode van dubbelseinen in dezelfde richting, en van de "quadruplex-telegraphie", twee berichten in de ééne en twee in de andere richting."[175]

elektromotorischen Kräfte".

[172] J. Bosscha Jr. (1858c), "Ueber einige Eigenschaften der linearen Verzweigung galvanischer Ströme"; J. Bosscha Jr. (1859c), "Over eene algemeene eigenschap der lineaire verdeeling van galvanische stroomen".

[173] G. R. Kirchhoff (1845), "Ueber den Durchgang eines Elektrischen Stromes durch eine Ebene, insbesondere durch eine Kreisformige".

[174] J. Bosscha Jr. (1856b), "Proeve eener oplossing van een vraagstuk betreffende de electrische telegrafie"; J. Bosscha Jr. (1856a), "Bijvoegsel tot de oplossing van een vraagstuk betreffende de electrische telegrafie"; J. Bosscha Jr. (1856c), "Ueber ein Problem der elektrischen Telegraphie. Gleichzeitige Beförderung zweier Depeschen auf einem Drathe in derselben Richtung"; J. Bosscha Jr. (1856d), "Nachtrag zum Aufsatze über die Doppelcorrespondenz auf einem Drathe in derselben Richtung"; Verslagen en Mededeelingen, IV 1856, p. 127-128: Notulen van de gewone vergadering der afdeeling Wis- en Natuurkundige wetenschappen gehouden den 27sten October 1855.

[175] Translation: "Bosscha has described his well thought-out invention and, even if he could not bring his method into fruition, he is known in the history of telegraphy as the first inventor of the method of double signals in the same direction, and of the 'quadruplex-telegraphy, of two messages in the one and two in the other direction." In H. A. Lorentz (1911), *Rede gehouden door Prof. Dr. H.A.Lorentz gewijd aan de Herdenking van den Overleden Oud-secretaris der Maatschappij, Prof. Dr. J. Bosscha*, p. 393.

The study was reviewed in the Algemeene Konst- en Letterbode by, unsurprisingly, J.A.C. Oudemans.[176] Note that in a short period of time, not one but three other scientists - among who Dr. Bernstein, who we will meet in section 3.2 - at the time published a solution to this problem, showing that this was a hot topic at the time. However, the only one that predated Bosscha in publication was faulty, such that Bosscha was the first to correctly publish a solution to this specific problem.[177]

2.4 Conservation of Energy

Bosscha's research as assistant in the physical laboratory focused on obtaining the quantitative experimental support for the law of conservation of energy in galvanic currents. In the articles he wrote in 1858-1859 he researched the validity of the law of conservation of energy on the electrolysis of water, confirming the law. One of his articles is titled "Over de bepaling van het Mechanisch Aequivalent der Warmte door Galvanische Metingen", which means he was looking for the 'mechanical equivalent', or energy equivalent, of electrical processes. Bosscha was probably the first Dutch physicist to focus experimentally on the law of conservation of energy. In 1858 and 1859 Bosscha would publish a number of articles on various aspects galvanic currents and the law of conservation of energy.[178]

Indeed, later in his popular textbook on physics the law of conservation of energy played a major role. Bosscha's part in introducing the law of conservation of energy is also shown by the use of the term 'arbeidsvermogen' in the Netherlands. Until the 20th century, Dutch physicists will almost exclusively use the term 'arbeidsvermogen'. Later, they used both terms: 'Arbeidsvermogen' and energy. Nowadays, Dutch physicists still use the term 'arbeidsvermogen' from time to time.[179] More on the law of conservation of energy in section 3.1.

All in all we have seen in this chapter that Bosscha's research focused on quantitative precision measurements and methods improving thereupon and secondly, that his research went into the direction of experimental proof for the law of conservation of energy.

[176] Algemeene Konst- en Letterbode, 1-12-1855. Bosscha himself answered some questions in J. Bosscha Jr. (1857a), "Iets over eene veranderde van den telegraaf van Morse".

[177] Algemeene Konst- en Letterbode, 9-2-1856.

[178] J. Bosscha Jr. (1857-1858), "Ueber die mechanische Theorie der Elektrolyse, part 1, part 2 and part 3"; J. Bosscha Jr. (1858d), "Over de jongste onderzoekingen van Favre omtrent de warmte in de verschillende deelen van de galvanische keten voortgebracht"; J. Bosscha Jr. (1858e), "Over een verschijnsel door Magnus waargenomen, bij de galvanische ontleding van een zamengestelden electrolyt"; J. Bosscha Jr. (1859d), "Over de bepaling van het Mechanisch Aequivalent der Warmte door Galvanische Metingen"; J. Bosscha Jr. (1859a), "Ueber das mechanische Aequivalent der Wärme, berechnet aus galvanischen Messungen"; J. Bosscha Jr. (1859b), "Ueber das Gesetz der galvanischen Wärme-Entwicklung in Elektrolyten"; J. Bosscha Jr. (1859e), "Eene proefneming, die eenig licht kan verspreiden over een strijdpunt der chemische theorie van den galvanischen stroom."

[179] Although I think that it has, by now, a slightly different meaning from energy. 'Arbeidsvermogen' is the amount of energy effectively converted into work, while total energy will mean both the work and the lost energy in the form of heat. Thus, 'arbeidsvermogen' can be lost, but energy can not.

Chapter 3

Popularization of Science

In this chapter BOSSCHA's popular science writing is discussed. BOSSCHA became an established figure in the scientific community because of his semi-popular lecture on the law of conservation of energy, see section 3.1, and was the editor for the popular science journal *Blikken in het Leven der Natuur* (Perspectives on the life of nature), see section 3.2. Lastly, he was involved in another publication called *Het Boek der Uitvindingen* (The Book of Inventions), see section 3.3.

In the 19th century science popularization played an important role in the position of scientists in society. The purpose of science popularization was, for most scientists, twofold. According to the scientists, they had a moral obligation to educate and inform the people, because this would enrich the spirits of the people and show them the greatness of God's Creation. MULDER's motivation is described as such by Theunissen:

> "Kennisverspreiding hief de onwetendheid op, bevorderde de zedelijkheid en het volksgeluk, en wekte op tot bewondering voor Gods schepping. Als natuurwetenschapper beschouwde Mulder het daarom als zijn plicht om waar hij maar kon aan de verspreiding en popularisering van natuurwetenschappelijke kennis bij te dragen."[180]

The second purpose of science popularization was, although not often explicitly mentioned as such by the scientists, to legitimize and ascertain the authority of science and her practitioners in society.[181] The last reason is proof of the changing importance of public opinion in the more liberal societies after the revolutionary years of the early 19th century as well as an indication of the changing ideal of specialization. Scientists became more and more specialists and figures of authority in their field and wanted to emphasize their authority as such. The practice of

[180] Translation: "Dissemination of knowledge lowered ignorance, promoted morality and the people's happiness, and inspired to admire God's creation. As a natural scientist, Mulder saw it as his duty to spread and popularize scientific knowledge where-ever he could." B. Theunissen (2000), *Nut en nog eens Nut*, p. 84.

[181] B. Bensaude-Vincent (2001), "A genealogy of the increasing gap between science and the public", p. 100.

science popularization by scientists fulfilled both roles. By educating the general public they could legitimize their scientific work and be a useful part of society. Being useful or 'nuttig' became a very important aspect to mid-century Dutch scientists and the basis of the legitimization towards society. One way through which scientists could be useful is by educating and enlightening the general public, which had both practical and moral value.[182] Secondly, through the practice of science popularization scientists artificially created a distance between the specialists and the general public, ascertaining their authority in matters of science.[183] A last element that helped the sudden boom of science popularization is the growth of the middle class, their education and with it the amount of potential readers. This, according to Van Berkel, made popular science journals profitable and publishers keen on publishing such journals.[184]

From the 1840s on scientists published more popular books and gave more popular lectures. From the 1850s on there were also journals exclusively for popular science such as the highly succesful *Album der Natuur* (1852-1909), founded by Pieter Harting,[185] and *Blikken in het Leven der Natuur* (1854-1863), discussed in section 3.2. Later journals include *Isis* (1872-1881) and *De Natuur* (1881-1943), but many more examples can be found.[186] According to Theunissen, however, after 1870 less and less professors were interested in writing popular literature, because the status of scientists in society was, by then, established firmly, and they left the writing of popular science to others.[187]

A second change, described by Van Lunteren, lies in the moral layer of science popularization. While in the first half of the 19th century knowledge of nature was meant to ennoble the soul and studying the 'book of nature', the so-called second revelation of God, brought you closer to God. In the second half of the 19th century, God or any other positive moral effects cease to be mentioned. Van Lunteren calls it the end of the fysico-theology. In the second half of the 19th century, science meant progress and wealth, noting the introduction of steam engines, railways and telegraphy throughout society. There was no need to call on God to legitimize science, the useful aspect of science sufficed.[188]

[182] For an elaboration of the term 'usefulness' and the need to be 'useful', see: B. Theunissen (2000), *Nut en nog eens Nut*, pp. 185, 189-191.

[183] See for instance F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie"; and Chapter 3 of B. Theunissen (2000), *Nut en nog eens Nut*.

[184] K. van Berkel (1998), *Citaten uit het Boek der Natuur*, p. 189.

[185] *Album der Natuur* is discussed in L. Coffeng (1994), "Het Album der Natuur"; Bosscha was also involved in the earliest two volumes of *Album der Natuur* of 1852 and 1853. His name is listed as one of the publishers of the journal, although he did not write any of the articles in the journal, as far as I can tell. Peculiarly, he is listed as Dr. Bosscha, even before obtaining his doctorate. (It could not have been his father, as his father would be listed as Prof. Bosscha at the time.) See Album der Natuur, 1853.

[186] K. van Berkel (1998), *Citaten uit het Boek der Natuur*, pp. 189–219.

[187] B. Theunissen (2000), *Nut en nog eens Nut*, p. 129; Popular science writing did not stop altogether, although the highly placed professors did stop writing popular science. Presumably the professors left it for their pupils who were at the start of their careers.

[188] F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie"; Note that this idea would dismay the humanities for the coming era as they sought their 'usefulness' in the realm of the sciences.

Bosscha's main inspiration and his exemplar for writing popular literature is Kaiser. Kaiser, and also Bosscha, were intermediate figures in the above development. They both made no mention of God in their popular works, but the moral component was not lost. Educating the public was part of the purpose of the sciences. Not only the practical utility of the sciences was important to the public, but also the 'civilizing' value or enlightenment of the mind through scientific knowledge could not be underestimated.[189] Kaiser's most famous work, *De Sterrenhemel verklaard* is a work of popular science of a sort that Bosscha did not write in popular form.[190] In this book Kaiser systematically expounded the whole subject of astronomy: The starry sky explained, from the sun, to the planets, to the galaxy.[191] Bosscha did use the other two varieties of popular science. Here, we will discuss a semi-popular lecture that established Bosscha's place within the scientific community and society and secondly Bosscha's involvement with one of the earlier popular science journals.

Kaiser laid down the requirements for the writing of popular literature in a booklet *De Eischen van de Populaire Voordragt.*[192] Bosscha would almost exactly copy Kaiser's requirements in his popular writing. First of all, popular science should discuss only the results of science and not the research itself or its methods. This also excludes any descriptions of used instruments. Secondly, all mathematical equations or figures should be avoided, because they are 'lost to those who do not speak the language of mathematics'. Given these requirements, thirdly, popular science writing must be thorough and not superficial. These three requirements posed a challenge for the popular science writer. A challenge that can only be overcome, according to Kaiser, by writers who are experts in their fields, masters of both the language of science and the language of the common, and they must be intimate with human nature. These requirements for both the author and his work are echoed in Bosscha's popular work.[193]

3.1 Introducing the Law of Conservation of Energy

3.1.1 General History of the Law of Conservation of Energy

The origins of the ideas that spawned the law of conservation of energy, if one looks hard enough, can already be found in classical sources. Lucretius, most famously, writes in *De Rerum Natura* in the 1st century BC: "nihil fit ex nihilo", nothing can be made out of nothing. The Roman, of

[189] F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie", pp. 38, 42.
[190] Bosscha's *Leerboek der Natuurkunde*, although following some of the tenets of popular science writing, was a textbook. In some sense textbook writing for beginners is similar to popular science writing and these similarities can be seen in Bosscha's textbook. Most importantly, Bosscha eschewed the higher mathematics in his textbook. For his textbook, see chapter 5.
[191] F. Kaiser (1844), *De Sterrenhemel Verklaard.*
[192] F. Kaiser (1853), *Het Wezen en de Eischen van de Populaire Voordragt.*
[193] See for Kaiser's popular science F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie".

course, was only repeating earlier Greek philosophers, such as Empedocles, who wrote in the 5th century BC: "nothing comes to be or perishes" in his poem *On Nature*. Medieval Christian thinkers modified this into the idea that only God can create something out of nothing. The mechanical world picture of the 17th century further removed God from this kind of active work in Nature. The idea was now formulated that God created a finite amount of 'force' and matter that remained unchanged and constant throughout time. Nature's laws provided the dynamics. Leibniz found, studying Huygens' work, that the quantity $\sum_i m_i v_i^2$ was conserved. He called this quantity *vis viva*. Newton, arch-rival of Leibniz, disagreed and thought that momentum, or $\sum_i m_i v_i$ was the correct conserved quantity, although he did not call it *vis viva*. The focus in mechanics remained on *vis viva* throughout the 18th century and led to the development of Lagrangian and Hamiltonian mechanics.[194]

A second closely related concept is that of a *perpetuum mobile*, a device that runs eternally. Attempts have been made throughout history to construct such devices, but, of course, without avail. In fact, in the 16th century it was already believed to be a fact that such a device was an impossibility. For instance, the famous 'clootkrans'-proof of Stevin depends on it: "De cloten sullen uyt haer selven een eeuwich roersel maken, 't welck valsch is." [195] The impossibility of the *perpetuum mobile* was later proved from the laws of thermodynamics in the late 19th century, of which the first law of thermodynamics was eventually identified with the law of conservation of energy.

In the 19th century, the scope of the law of conservation of energy was expanded far beyond mechanics. A motivation to formulate a more general principle can be found in the discoveries of different conversions of forces from seemingly different branches of physics. For instance, the widely used steam engines converted heat pressure into work. Another example of a more fundamental physical conversion was that of magnetic forces into electrical forces, first discovered in the famous experiment by Hans Christian Ørsted (1777–1851).[196] These conversions gave a sense of unity of nature, further strengthened by German idealism of the 19th century, better known as *Romantische Naturphilosophie*. The first attempt to widen the scope was in an article by German physician Julius Robert von Mayer (1814–1878) in 1842. He used the terminology of 'conservation of force'. In his work three sorts of forces are distinguished: 'falling force', 'kinetic force' and heat. In a later article he added 'being chemically separated' and the

[194] This part is largely based on Frans van Lunteren's unpublished lecture notes on the history of physics. See for the international early history of conservation of energy: T. J. Kuhn (1959), "Energy Conservation as an Example of Simultanous Discovery"; D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", pp. 386–387.

[195] Translation: "The balls will from themselves make an eternal movement, which is false." S. Stevin (1586), *De Beghinselen der Weeghconst*, p. 41.

[196] H. C. Ørsted (1820a), *Experimenta circa Effectum Conflictus Electrici in Acum Magneticam*; H. C. Ørsted (1820b), "Experiments on the Effect of a Current of Electricity on the Magnetic Needle" See more on Ørsted's discovery and the Dutch reception of it in H. A. M. Snelders (1975), "The Reception in the Netherlands of the Discoveries of Electromagnetism and Electrodynamics (1820-1822)"; H. A. M. Snelders (1990), "Ørsted's Discovery of Electromagnetism".

forces of electricity and magnetism. He postulated that heat could be quantitatively related to mechanical force, in other words, that a quantity of heat had a mechanical equivalent.[197] The English physicist James Prescott Joule (1818–1889) also presumed a relation between the different types of forces and tried to quantify this by researching the amount of heat produced by the loss of gravitational potential energy in the so-called Joule-device. Joule published his work in 1845.[198] The scope was further expanded into a truly general principle by the German physiologist Hermann von Helmholtz (1821–1894). He published, after being rejected by Poggendorff's *Annalen der Physik* because his article was too theoretical, in 1847 the famous pamphlet *Über die Erhaltung der Kraft*. In this book, Von Helmholtz presented his 'law of conservation of force' in the first two sections, which was simply a generalization of the conservation of *vis viva*. The total of 'living forces' ('lebendige Kräfte') and 'tensional forces' ('die Summe der Spannkräfte') must remain constant. In the next four sections of his book, he applied this principle to various mechanical, thermal, electrical and electromagnetic phenomena.[199]

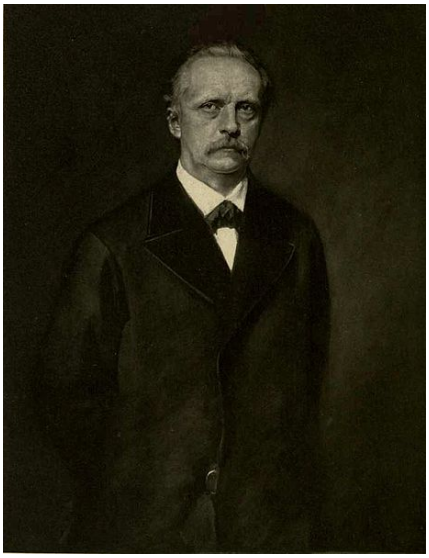


Figure 3.1: Von Helmholtz in 1876

These publications were in general not received very well, except by the Scottish physicist William Thomson (1824–1907) (the later Lord Kelvin), who wanted to incorporate their work with his own 'conservation of energy' that he introduced in two articles in the *Transactions of the Royal Society of Edinburgh* of 1851 to give his concepts international allure.[200] Here, he also introduced two forms of energy: a 'dynamical' form and a 'static' form, later remodeled into kinetic and potential energy by another Scottish physicist William John Macquorn Rankine (1820–1872). These Scottish physicists wanted to make the doctrine of energy into the foundation of all branches of physics.[201] Eventually, this ideal culminated in two famous and very influential textbooks built on the doctrine of energy. The first is Thomson and Peter Guthrie Tait (1831–1901)'s *Treatise on Natural Philosophy* of 1867, more colloquially called 'T and T' in Cambridge circles and by, for instance, Maxwell.[202] The second textbook applies the doctrine

[197] J. R. von Mayer (1842), "Bemerkungen Über die Kräfte der Unbelebten Natur".
[198] J. P. Joule (1845), "On the Existence of an Equivalent Relation between Heat and the ordinary Forms of Mechanical Power".
[199] H. von Helmholtz (1847), *Über die Erhaltung der Kraft*.
[200] W. Thomson (1851a), "On the Dynamical Theory of Heat"; W. Thomson (1851b), "On the Dynamical Theory of Heat. Part V".
[201] See for the history of the conservation law in England: C. Smith (1999), *The Science of Energy*.
[202] W. Thomson and P. G. Tait (1867), *Treatise on Natural Philosophy*.

of energy to a very specific branch of physics: Maxwell's *Treatise on Electrodynamics* of 1873. This textbook also happens to be the first book describing a more or less complete theory of electrodynamics.[203]

What these Scottish physicists did for the reception of Energy in Great Britain is what Von Helmholtz and his mentor Du Bois-Reymond tried to accomplish in Germany. Through popular lectures Von Helmholtz and Du Bois-Reymond aimed to establish the law of conservation of energy as a universally applicable law.[204]

3.1.2 Dutch History of the Law of Conservation of Energy

In the Netherlands, the two Utrecht professors Franciscus Cornelis Donders (1818–1889) and Buys Ballot already wrote in 1845 and 1847 on the conservation of force,[205] indicating that regardless of geographical location, many scientists discovered similar principles to the law of conservation of energy during these years time. Another figure at Utrecht University, professor Van Rees, was aware of the German publications and made these ideas public at the KNAW in 1849 in a lecture about 'conservation of force in a galvanic pile' and at the *Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen* in 1853. It seems that at least in Utrecht the professors in the natural sciences were proponents of the new law of conservation of 'force'. However, as Wegener and van Lunteren show, the law was known to only a select few in the Netherlands and the terminology remained a bit vague.[206] Von Helmholtz original popular lecture of 1854 was immediately translated and published in the Netherlands, but this also seemed in vain for the widespread dissemination of the law in the Netherlands.[207]

It is around this time that Bosscha finishes his dissertation and arrives on the proverbial stage. It is unclear how Bosscha learned of the law but it is likely that he either learned it from these Utrecht professors, or, directly from Du Bois-Reymond during Bosscha's visit to Berlin in the summer of 1854. Bosscha played a major role in disseminating the law of conservation of energy to a larger group and clarifying the terminology: The term 'bestendigheid der kracht' (permanence of force) would be replaced by 'behoud van arbeidsvermogen' (conservation of 'energy').

[203] See for more on Maxwell's Treatise: J. C. Maxwell (1873), *A Treatise on Electricity and Magnetism*; B. J. Hunt (1986), *The Maxwellians*; see for the role of these textbooks at Cambridge: A. Warwick (2003), *Masters of Theory*.

[204] See for a detailed study on the history of the law of conservation of energy in Germany D. Wegener (2009), *A True Proteus*. Note that I do not wish to go into the more cultural aspects and impact of the law of conservation of energy in this study, as Wegener has done in his dissertation.

[205] C. H. D. Buys-Ballot (1847), *Het Karakter der Rede*; F. C. Donders (1845), *Blik op de Stofwisseling*.

[206] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", pp. 388–390.

[207] H. von Helmholtz (1854b), *Über die Wechselwirkung der Naturkräfte*; H. von Helmholtz (1854a), *De Natuurkrachten in hare Onderlinge Betrekking*; F. van Lunteren (2011b), "Johannes Bosscha Jr. en het Behoud van Arbeidsvermogen".

Bosscha successfully promoted the law of conservation of energy in several ways. We have already seen that Bosscha directly researched the law of conservation of energy in his experimental work in 1857, as the first Dutch physicist to do so. Later, we will discuss Bosscha's popular articles on the conservation of energy in heat processes in a popular science journal: *Blikken in het leven der natuur*, see section 3.2. Thirdly, Bosscha incorporated the principle in his textbook and made it the basis for his textbook. See chapter 5. In what follows, we discuss Bosscha's popular lecture at the *Natuurkundig Gezelschap* of Utrecht in 1858 on the new doctrine.

3.1.3 Popular lecture at the *Natuurkundig Gezelschap*

On the 15th of January 1858, Bosscha held a popular lecture at the *Natuurkundig Gezelschap* in Utrecht. This physical society was founded in 1777 as one of the early societies focused on the natural sciences. Bosscha started his lecture with a historic-critical analysis of the impossibility of the *perpetuum mobile*. Indeed, he argues that in Willem Jacob 's Gravesande (1688–1742)'s time it was not unthinkable to create a *perpetuum mobile*, but it was, at the time, unthinkable because, Bosscha says, of the "gevolg van den verbazenden vooruitgang der natuurwetenschappen in dat tijdverloop."[209] The impossibility of a *perpetuum mobile* follows from the underlying principle of conservation of energy that has become 'evident' in this time:


Bij A. W. SYTHOFF, te Leijden, is ter Perse:

Het behoud van Arbeidsvermogen in den Galvanischen Stroom.

EENE VOORLEZING,

DOOR

Dr. J. BOSSCHA Jr.

Deze belangrijke bladen bevatten eene populaire verklaring van de algemeene, zoogenaamde wet van het **behoud der kracht** en van hare jongste toepassingen op de galvanische verschijnselen.

Figure 3.2: An advertisement for the brochure published of Bosscha's popular lecture.[208] One notices that the brochure advertizes that it is about 'conservation of force', although the title shows the new nomenclature.

> "De onbestaanbaarheid van een perpetuum mobile volgt uit een algemeen beginsel, hetwelk men bij de werking van nagenoeg alle bekende krachten heeft opgemerkt en waaraan alle natuurwetten ondergeschikt zijn. Het beginsel *van het behoud van arbeids-vermogen.*[210]

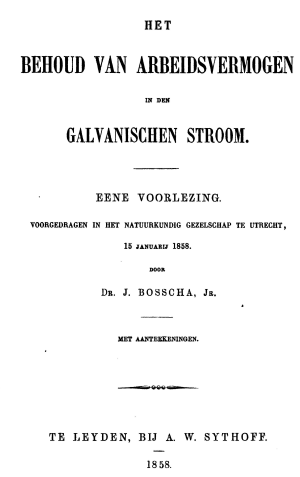
[208] Utrechtsche provinciale en stads-courant, 25-03-1858.

[209] Translation: "result of the surprising advancement of the natural sciences in that course of time." J. Bosscha Jr. (1858f), *Het Behoud van arbeidsvermogen in den galvanischen stroom*, p. 14.

[210] Translation: "The non-existence of a perpetuum mobile follows from a general principle, which has been pointed out for the mechanisms of almost all known forces and under which all laws are subordinated." Ibid.

During this lecture Bosscha encountered a problem with the use of the German term 'Kraft' for energy. This was a direct reaction to one of the spectators: The original German terms did not convey the meaning correctly and were confusing.[211] Bosscha preferred and chose the word 'arbeidsvermogen'[212] over the British word energy, because of the many connotations that the word energy already had that could lead to confusion. The word 'force' meant the cause of movement, thus could also not be used.

> "Ofschoon het beginsel meer bekend is onder den naam "beginsel van het behoud van kracht" (das Princip der Erhaltung der Kraft, principe de la conservation des forces, principle of the conservation of force) zoo heb ik toch gemeend, in plaats van "kracht" de juister benaming van "arbeidsvermogen" te moeten aannemen. De ondervinding heeft geleerd, dat eene verwarring van de vele beteekenissen, waarin het woord "kracht" gebruikt wordt, tot grove misslagen aanleiding geeft. [...] Het is niet zoo gemakkelijke de beteekenis te veranderen, die men altijd aan een woord gehecht heeft, hetwelk zoo oud is als de wetenschap zelve."[213]


HET

BEHOUD VAN ARBEIDSVERMOGEN

IN DEN

GALVANISCHEN STROOM.

EENE VOORLEZING.

VOORGEDRAGEN IN HET NATUURKUNDIG GEZELSCHAP TE UTRECHT,

15 JANUARIJ 1858.

DOOR

Dr. J. BOSSCHA, Jr.

MET AANTEEKENINGEN.

TE LEYDEN, BIJ A. W. SYTHOFF.

1858.

Figure 3.3: The cover of published version of Bosscha's lecture.

He continues to recall the *vis viva* controversy around Leibniz and Newton, but Bosscha lets 's Gravesande speak for Newton's view. Bosscha concludes that the 'arbeidsvermogen' was proportional to the force applied over a distance, according to Leibniz' principle.[214]

[211] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", p. 392; Originally a footnote in J. Bosscha Jr. (1858f), *Het Behoud van arbeidsvermogen in den galvanischen stroom*, pp. 75, 78-81.

[212] I will try a literal translation of the term 'arbeidsvermogen' to convey the slight difference in meaning. 'Arbeid' means work and 'vermogen' means ability, or power. Vermogen has a clear quantified connotation. There is a certain amount of *vermogen*. A term that would come close to arbeidsvermogen is thus 'work-power', energy is the 'amount of power' to do work. According to Bosscha, the term arbeidsvermogen more clearly conveys the meaning of energy than the Greek $\epsilon\nu\epsilon\rho\gamma\epsilon\iota\alpha$ (energeia), which also had mystical connotations such as 'cosmic force'.

[213] Translation: "While the principle is better known under the name "principle of conservation of force" (...), I have thought that instead of 'force' the term 'arbeidsvermogen' is better. Experience has taught that the confusion of the many meanings of the word "force" leads to severe errors. [...] It is not so easy to change the meaning of a word that has always been its meaning, if the word is as old as science itself." Ibid. p. 75.

[214] Ibid. pp. 20-22.

Bosscha did not use Von Helmholtz 'lebendige Kraft' and 'Spannkraft' nor Thomson's 'potential' and 'actual' energy, as these terms did not speak to the imagination of his audience. Thus, Bosscha chose "arbeidsvermogen der beweging en der rust" ('Energy' of movement and of rest).[215] Nomenclature that was clearly meant to appeal to an audience with industrial connections. 'Energy of movement' is the mass of a moving body times its speed and again times half its speed. [216] 'Energy of rest' is the energy that an object has, given the position of the object with respect to another object that exerts a force on the first object.[217] Later, Bosscha added 'chemical energy' and 'heat' as types of energy and applies the principle to the galvanic current. The strength of the law of conservation of energy lies in the fact that, according to Bosscha, it has thus far never failed. Further, it can be used in an explanatory way. For instance, many physicists have questioned the origin of the current of a Voltaic pile, and according to Bosscha, the law of conservation of energy gave a natural solution:

> "Dit is een der merkwaardigste uitkomsten, die de toepassing van de wet, welke wij behandelen, op de galvanische verschijnselen oplevert. Zij beslist den strijd, dien men sedert de ontdekking van het galvanisme over den oorsprong van den galvanischen stroom gevoerd heeft en waarin de grootste natuurkundigen van deze eeuw partij getrokken hebben." [218]

In the lecture he explained that he thought the law of conservation of energy was of greatest importance to physics and it would become very influential to the natural sciences in general:

> "De natuurwet begint allengs de algemeene aandacht tot zich te trekken. De onmiskenbare invloed, dien zij nu reeds in alle vakken van natuurkunde uitoefent, maakt hare kennis onontbeerlijk voor ieder, die daarin op eenigerlei wijze werkzaam is, en belangrijk voor allen, die in den vooruitgang der natuurwetenschappen deelnemen." [219]

After this lecture the law and terminology of 'arbeidsvermogen' seems commonplace, signifying the widespread success of Bosscha's lecture.[220] However, according to Wegener and van

[215] Ibid. pp. 24, 78-79.

[216] I.e. the modern formulation of kinetic energy $E_{kin} = \frac{1}{2}mv^2$.

[217] This equals the modern formulation of for instance the potential energy in a central force field.

[218] Translation: "This is one of the most peculiar results that we find in the application of the law under discussion on galvanic phenomena. It will determine the battle that has been underway since the discovery of galvanism about the origin of galvanic electricity, in which the biggest physicists of this century took part." Ibid. p. 53.

[219] Translation: "The law of nature begins to ask to be in the center of attention. The undeniable influence that she already has in all subjects of physics, makes knowledge of her indispensable, and important for everyone who is in some way working in science or is participating in the progress of science." Ibid. p. v.

[220] For instance in the dissertations of Bosscha's pupils Schroeder van der Kolk (1860) and Van Oven (1862), but in the dissertations several others as well: J. Th. Mouton (1863), A.D. van Riemsdijk (1864), H. van der Stadt (1866), C.H. Thiebout (1866), Jan Nieuwenhuijzen Kruseman (1847–1910) (1872). See footnote 30 of

Lunteren, this does not mean that all the confusion had disappeared. It remained there, only in all publications the formulation changed to Bosscha's terminology. Indeed, the previously 'absolute' concept of energy would continue to change until the early 20th century to the modern version of a 'relative quantity'.[221] What remains true is that after 1858, the concept of energy, or 'arbeidsvermogen' was widespread in the Netherlands. Thanks to Bosscha, the law was disseminated in the Netherlands.

3.2 Popular Journal *Blikken in het Leven der Natuur*

Blikken in het Leven der Natuur was a popular journal founded by the Leeuwarder publisher Gerard Tjaard Nicolaas Suringar (1804–1884), father of Bosscha's fellow student and later professor of botany W.F.R. Suringar. In the 8 volumes that were published between 1855 and 1862 a variety of scientific subjects are treated with the general public in mind. The first volume was still a direct translation of the German volume in the *Allgemeine Deutsche Volks-Bibliothek* titled *Blicke in das Leben der Natur* by well-known German popularizer of physics Aaron Bernstein (1812–1844) in 1853.[222] G.T.N. Suringar was interested in the incentive and made the contents of this book known to the Dutch public with the publication of *Blikken*.[223] According to a description of Suringar's life the main translator of the first volume was Dr. Pierre Jean Hollman (1821–1901), a practicing doctor living in Edam more known for his works on photography, written in his own name and under the pseudonym Photophilus.[224] The same Hollman would later write reviews on the later volumes of *Blikken* under the pseudonym Josua.[225]

The first volume was a great success and it attracted Groningen professor of chemistry Claas Mulder (1796–1867) to work on the second volume. For the second volume Mulder, who wrote half the volume himself, found some young scientists willing to contribute, among whom Bosscha and W.F.R. Suringar. The second volume still consisted of the half of the articles being popular works translated from German, and the other half being original publications by Dutch authors. From the third volume onwards, *Blikken* contained almost exclusively original Dutch publications. From this volume onwards, the editing board would consist of Bosscha, W.F.R. Suringar and Modderman. Bosscha's first article in the second volume was a translated article written by, this will not come as a surprise, Von Helmholtz on vision.

D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", p. 392. 'Arbeidsvermogen' was also copied in several textbooks on physics, see chapter 5.

[221] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", pp. 392–394.

[222] A. Bernstein (1853), *Blicke in das Leben der Natur*.

[223] Blikken in het Leven der Natuur, vol. 1, 1855, Voorwoord.

[224] This is also clear from the letters from Hollman to Suringar between 1854 and 1855. UB UvA.

[225] See M. Nijhoff (1886), "G.T.N. Suringar", pp. 145-146 and H. T. Roosenboom (2006), *De Schaduw van de Fotograaf*, p. 314.

Bosscha, at the start of his career probably sought to establish his name in the scientific community and beyond. His motivation for writing popular literature must stem partly from this. The other two reasons become evident as a red line in Bosscha's activities: To improve the general level of knowledge of the natural sciences and physics in particular, and, to promote the law of conservation of energy. *Blikken* was a perfect vehicle for these aims.

3.2.1 Popularity and Reviews

The newspapers were in general positive about the pieces written in *Blikken*. To make their claims about the decency of the pieces written in *Blikken* plausible, the newspapers explain that the pieces are written by the most learned of Dutch men. Leeuwarder courant writes:

> "De namen der schrijvers [...] zijn ons tot waarborg, dat ook bij voortduring iets goeds zal worden geleverd."[226] and "wij vermeenen op deze onderneming, waarvoor de voornaamsten geleerden in ons vaderland hunne medewerking hebben toegezegd, andermaal te mogen wijzen."[227]

The critical journal *Vaderlandsche letteroefeningen*, founded in 1761, was also very positive. Its reviewers approved of the choice of subjects and lauded the successful use of one of Kaiser's tenets of popular science writing; being able to explain science in a simple and lucid way:

> "Voorwaar, zulke heldere, onbenevelde 'Blikken' in het heerlijk 'Leven der Natuur', als ons hier worden vergund, zijn stichtelijk, en opbouwend, en hartverheffend! Men verwachte hier geene dorre opgave van den inhoud, en evenmin eene beoordeeling der jongst verschenen Afleveringen. [...] De keuze der onderwerpen kwam ons doorgaans allergelukkigst voor, en menige schets getuigt, dat het in Nederland nog niet ontbreekt aan Mannen van Wetenschap, 'die - en 't is geene geringe lofspraak - in hunne voorstelling kunnen afdalen tot onder het bereik van eenvoudigen.' "[228]

[226] Translation: "The names of the writers [...] are our guarantee, that with continuation something good will be delivered" Leeuwarder courant, 29-2-1856.

[227] Translation: "We think we should direct your attention, for which the most prominent scholars of our nation have agreed to collaborate on, to the following undertaking."Leeuwarder courant, 22-8-1856. This appeal to the authority of the editors is also written in another newspaper lauding *Blikken* in 1857: "Een blik op de namen der redacteuren en op de lijst van geleerde medewerkenden geeft de verzekering dat de inhoud dezer werkjes [...] bij voortduring beantwoordt aan de verwachting." Translation: "A view on the names of the editors and the list of learned collaborators gives the insurance that the content of these works [...] with continuation will satisfy the expectations." Middelburgsche Courant, 17-2-1857.

[228] Translation: "Truly, such crystal clear "views" in the exquisite "Life of Nature" as we are adjudged are noteworthy, constructive and exalting. One did not expect a dry summation of content nor a critique of the most recently published Episodes. [...] The choice of subjects was deemed most joyous and many an example shows that there is no lack in Men of Science, who can - and this is not minor praise - descend in their conception to the level of the more simple minds." H. B. (1858). "Blikken in het Leven der Natuur. Te Leeuwarden, bij G.T.N. Suringar." In: *Vaderlandsche Letteroefeningen*, pp. 286–288.

They also agreed and lauded the choice to write original Dutch articles in the journal, instead of copying and translating German articles, showing the nationalist tendencies that would become so important late 19th century:[229]

> "Met genoegen merkten we op - en ook dit strekke tot aanbeveling - dat men zich meer en meer beijvert oorspronkelijke stukken te leveren, en er dus prijs op toont te stellen de 'Blikken in het Leven der Natuur' allengs tot eene echt vaderlandsche onderneming te verheffen. Moge dit loffelijk streven bij voortduring ondersteuning en aanmoediging vinden!" [230]

The content was deemed very useful to society. As stated before, usefulness was an aspect of science that became more and more important in the second half of the 19th century. The moral or theological value of science (or science popularization) faded to the background.[231] As we can read in the formulation of the *Vaderlandsche Letteroefeningen*:

> "*Blikken in het leven der Natuur!* Voorzeker een titel, die veel belooft, maar ook niet geloogenstraft wordt door den inhoud der werks. Het moge eene eenvoudige, onkostbare onerneming wezen, - nuttig en doelmatig is zij zeker. Nuttig, omdat, zonder dat de bedoeling hier is, de beschouwingen der natuur in de dadelijke toepassing te brengen op landbouw of fabrijkwezen, het de zaak zoo *algemeen* mogelijk beschouwt, en de behoeften van *allen* in het oog houdt." [232]

It is said not only in the newspapers, but also in *Vaderlandsche letteroefeningen*, that *Blikken* is truly meant for a popular audience, for it was affordable for everyone.[233] However, another journal claims, concerning *Blikken*, that the content of popular work in general miserably stays within the scientific community, available only to those who do not need it. Why do the rich scientific societies not make these booklets cheaper?

[229] Although this might seem to be expected with a journal called *Vaderlandsche Letteroefeningen*.

[230] Translation: "With great pleasure we noticed - and this also contributes to our recommendation - that more and more of an effort is made to deliver original pieces and therefore shows a great willingness to lift "Blikken in het Leven der Natuur" to the level of a national endeavor. May this noteworthy cause find continuous support and encouragement." Ibid.

[231] B. Theunissen (2000), *Nut en nog eens Nut*; F. van Lunteren (2011a), "Kaisers Populaire Sterrenkunde en het Einde van de Fysiko-theologie".

[232] Translation: " "Blikken in het leven der Natuur" is not only most truly a title that promises a great deal, but is also completely ratified but the contents of the work. It may be a simple, cheap endeavor - it is surely useful and expedient. Useful because, without being written with such purpose, the contemplations of nature in the application of agriculture or manufacturing, are as general as possible, which answers to the needs of all." Groninger courant, 19-3-1856.

[233] Ibid.: "In waarheid - 't ontbreekt niet aan klagten, dat er zoo weinig voor het volk wordt gedaan, en dat de boeken, waaruit wat te leeren valt, zoo duur zijn; maar 't is te vreezen, dat nog velen van die klagers zullen achterblijven, waar zooveel goeds en degelijks, voor zulk een geringen prijs, wordt aangeboden." Translation: "In truth – There is no lack of complaints, that there is so little effort being made for the people, and that the books, from which one could learn, are too expensive; but it is to be feared that many complaints shall remain, even when so much good and quality work, for such a meager price, is being offered."

> "Doch wil men haar verspreiden, dan behoort men zulke geschriften, als het onderwerpelijke [vol. 3, Blikken], kosteloos onder de mindere standen te verspreiden. [...] De jeugd van de klasse der handwerkers bezit geene middelen om zich van deze boekwerkjes aan te schaffen en kent het bestaan daarvan niet. Wat baten toch aan zoo vele genootschappen hunne rijke kassen? [...] De verspreiding van natuurkennis onder ons volk zou vrij wat meer vorderen, als die genootschappen hunne doode fondsen gedeeltelijk besteden wilden, om natuurkundige werkjes bij honderdtallen over het land te verspreiden. [...] Gewoonlijk krijgen alleen de leden der maatschappijen de door haar uitgegevene boekwerkjes, die dezelve het minst noodig hebben."[234]

In another place, it is claimed that the booklets were mainly popular in schools, indicating that it was readily available. It seems that in the end, *Blikken* was popular and reached the intended audience:

> "[...] en bleef de belangstelling gaande, vooral in de schoolwereld waar de uitnemend gestelde populaire opstellen de bijzondere aandacht hadden getrokken."[235]

The journal was most certainly succesful. By 1858, the first volume was already exhausted and reprinted.[236] Up until 1870 demands and sales in the bookshops of *Blikken*, even as far as Batavia, can be found in the newspapers.[237] Even though it was highly popular, the publication of *Blikken* came to an end after the publication of the 8th volume due to the fact that the editors and other collaborators did not write enough popular articles anymore, or at least did not write them in time. At least, this is the conclusion of Nijhoff in SURINGAR's obituary:

> "Maar redactie en medewerkers bespeurden al spoedig dat het gemakkelijker was wetenschappelijke verhandelingen dan populaire opstellen te schrijven, en het gebeurde dikwijls dat het jaar verstreek vóór het vereischte getal afleveringen het licht had gezien. Het noodzakelijke gevolg daarvan was, dat de belangstelling en het debiet verminderde, waarom S. [The publisher, G.T.N. Suringar], na de verschijning van het

[234] Translation: "Yet, if one wants to disseminate it everywhere, then one should distribute such writings as the above mentioned [vol. 3 of Blikken], free of charge to the lower classes. [...] The youth of the class of craftsmen have no means to purchase books such as these and has no knowledge of their existence. What good comes of the filled treasuries of the many societies? [...] The dispersion of scientific knowledge would surely bloom if the societies would spend parts of their dead funds to spread scientific works in hundredfold over the country. [...] Normally only the members of these societies receive their printed works, those who themselves need it the least."Tijdschrift voor staathuishoudkunde en statistiek, pp. 253-254, 1858.

[235] "[...] and remained the enthusiasm, foremost in the world of schooling, where the exceedingly popular writings had drawn special attention." M. Nijhoff (1886), "G.T.N. Suringar", p. 145.

[236] Opregte Haarlemsche Courant, 3-8-1858.

[237] Java-bode, 15-11-1870.

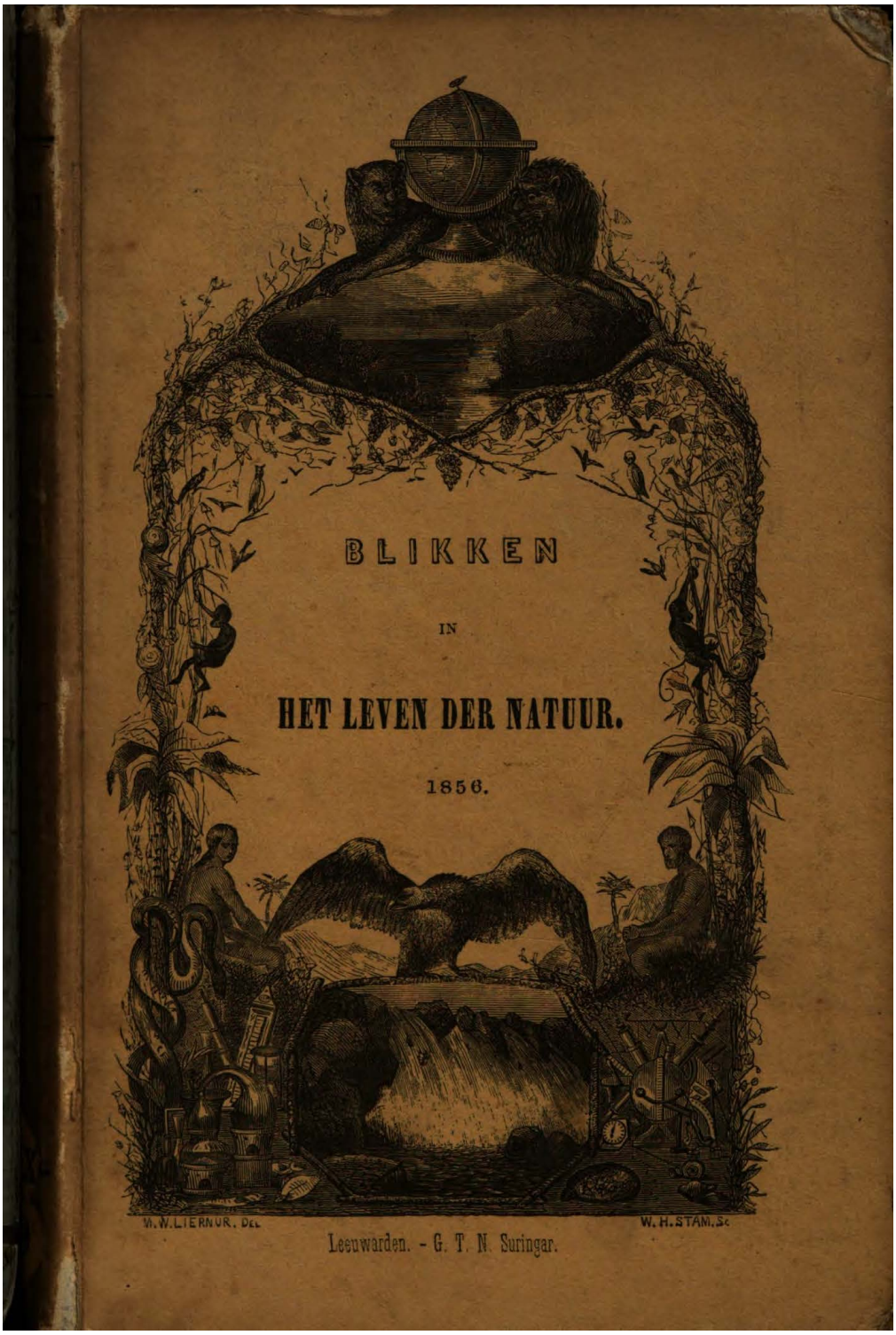


Figure 3.4: Cover of *Blikken in het Leven der Natuur*, 1856.

6e deel [6de deel met redactie] in 1863 besloot de uitgave te staken [...] tot groot genoegen van de redactie."[238]

It is probably true that SURINGAR and BOSSCHA had better things to do than to write popular science at the time and were busy with their offices of professor - and with those vocations did not need to increase their reputation through the writing of popular science anymore. This is not the case for MODDERMAN, who was 'only' assistant at the chemical laboratory in Leiden at the time and would remain a fervent writer of popular literature for the rest of his life, exemplified by being one of the editors of *Album der Natuur* from 1901 to 1909.[239]

3.2.2 An Early Reception of the 'Conservation of Force': A Commentary on Bernstein's Article

One of the translations of BERNSTEIN's articles in the first volume of *Blikken* contains an commentary. The translator HOLLMAN wrote this epilogue.[240] The commentary is interesting because we can read an early Dutch reception of the conservation of 'force' in the Netherlands:

"De schrijver [Bernstein] betoogt dat geen deeltje der stof vernietigd wordt, geen deeltje opnieuw ontstaat. Maar er is meer; men kan er bijvoegen: gelijk geen deeltje stof verloren gaat, kan men tevensniet de kleinste kracht vernietigen. Met andere woorden: de som van alle stofdeeltjes is standvastig dezelfde, evenzoo de som van alle krachten." [241]

So not only matter can not be destroyed, likewise force can not be created or destroyed. What kind of forces exist in nature? HOLLMAN explains that the following forces exist in nature: magnetic, electric, light, heat and the force of cohesion. The sum of these forces is always equal:

"De zwaarte[kracht] evenwel is niet de eenige kracht; buiten haar bestaan nog de magnetische, de electrische krachten, het licht, de warmte, de kracht van zamenhang. Wil men derhalve beweren dat de som van alle krachten te zamen genomen een

[238] Translation: "However the editors and writers quickly noticed that it was far more easy to write scientific papers than popular scientific essays, and it happened more than once that the year passed without a sufficient amount of publications having seen the light of day. The inevitable consequence was that interest decreased and the subscribers diminished in number, which is why S. [The publisher, G.T.N. Suringar], decided to, after the release of the 6th volume [6th volume under the auspices of the editing board], cease the publication. [...] to many a joy of the editorial staff." M. Nijhoff (1886), "G.T.N. Suringar", p. 146.

[239] W. Otterspeer (1986), "De Studententijd van Co Modderman", p. 103.

[240] Letters from P.J. Hollman to G.T.N. Suringar, 11-5-1854, UB UvA.

[241] Translation: "The writer [Bernstein] argues that no particle of matter is destroyed, no particle is created. But there is more; one can add: just as no particle can be destroyed, no force no matter how small can be eliminated. In other words: The sum of all particles is always equal, likewise the sum of all forces." P. J. Hollman (1855), "Narede van den Vertaler", p. 27.

> standvastig getal oplevert, dan brenge men ook die laatsten in rekening. [...] De som van al die krachten te zamen genomen, kon het zijn in ééne maat uitgedrukt, die som is steeds dezelfde." [242]

Hollman continued to explain how light can be converted into heat and conversely that a heated object emits light. He calls it 'very probable' that light can produce electricity, as many chemical reactions are electrical, and light has been shown to induce chemical reactions. The converse, electricity can be converted to light is evident 'to anyone who walks the streets of Paris', noting the new method of lighting the streets. Magneto-electrical devices give the proof that magnetism can be converted to light, heat or electricity. These conversions were always proportional, according to the author. Hollman seems to share Bosscha's emphasis on the empirical justification of the conservation law:

> "Mogen nu al bij sommigen dezer de getallen-waarden ontbreken, waardoor ons aangewezen wordt dat er al weder eene bepaalde verhouding moet zijn tusschen de opwekkende en de opgewekte of omgezette kracht, bij anderen daarentegen zijn die getallen, en daar, waar zij nagevorscht zijn, heeft nimmer een bepaalde verhouding ontbroken; getuige de electromagneten." [243]

In this quote, Hollman shows a definite belief in the validity of the 'bestendigheid der krachten' (conservation of force). The principle has simply never been wrong. Not that this is equal to what Bosscha claims in his 1858 lecture. However, Hollman's explanation of conservation of 'force' is called confusing and speculative by a reviewer in *Vaderlandsche Letteroefeningen*. The reviewer writes that Hollman did not succeed well in presenting Von Helmholtz's principle of *Die Erhaltung der Kraft*:

> "De Schrijver van de Narede heeft getracht een allerbelangrijkst beginsel, dat in den laatsten tijd in de Natuurkunde is opgenomen (die Erhaltung der Kraft, zoo als helmholtz het noemt), in populairen vorm te ontwikkelen, doch is daarin niet gelukkig geslaagd."[244]

[242] Translation: "Gravity is not the only force, other than her, magnetic and electrical forces exist, light, warmth, the force of coherence. Does one want to argue that the sum of all forces remains always equal, one also has to account for all the above mentioned. [...] The sum of all these forces taken together, can be expressed in one measure: their sum remains always the same." Ibid. pp. 32-33.

[243] Translation: "May there be a lack of numerical values for some of these, which shows us that there must again be a specific ratio between generating force and generated or converted force, however in other instances the numbers, and there, where they have been researched, a fixed ratio has never lacked; as is proven by the electromagnets." Ibid. p. 42.

[244] Translation: "The writer of the epilogue has tried to develop in popular form a very important principle that has been included in physics lately (die Erhaltung der Kraft, as Helmholtz calls it), though did not succeed very well." R. (1855). "Blikken in het Leven der Natuur. No. 1-4. Te Leeuwarden, bij G.T.N. Suringar. 1854-1855." In: *Vaderlandsche Letteroefeningen*, pp. 630–640.

What is clear from HOLLMAN's text, that even before BOSSCHA's 1858 lecture on the conservation of energy, the concept was already diffusing in the Dutch scientific literature.[245] Indeed, BOSSCHA writes in his 1858 lecture that much had been written on the law, but most of it was confusing. This forms an argument for BOSSCHA for writing the lecture in the first place, clearing up the confusion about the new concept of energy.[246]

3.2.3 Bosscha's Articles in *Blikken*

BOSSCHA wrote a total of 6 pieces for *Blikken*. These pieces show two things. Firstly, BOSSCHA, inspired by KAISER, followed KAISER's principles for popular science writing. Secondly, the pieces show BOSSCHA's view on science. The first was a translation and slight adaptation of VON HELMHOLTZ's 'Über das Sehen des Menschen', in which the eye and eyesight is explained. Notable departures from VON HELMHOLTZ' text includes mentioning discoveries by Dutch scientists, for example:

> "[...] heeft Helmholtz voor eenige jaren een klein optisch werktuig, den oog spiegel, vervaardigd, hetwelk in de handen van onzen landgenoot, den hoogleeraar Donders, belangrijke verbeteringen ondergaan heeft."[247]

Here we can already see the pride in Dutch science with which BOSSCHA will defend, or honor, Dutch scientists later in his career. Another peculiar departure from VON HELMHOLTZ' text is omitting all Kantian philosophy that VON HELMHOLTZ mentions throughout the article, indicating BOSSCHA's anti-speculative or anti-philosophical view on science. There is no connection to the law of conservation of force or energy in this piece.[248]

The other five pieces are his own original work and all of them concern the concept of heat and work. His own scientific work on this area was illustrated to the reader who was unfamiliar with physics, full of useful examples of daily life and without any mathematical equations. BOSSCHA adapted his language and examples to his audience fully according to KAISER's tenet of popular science writing. At the same time he made clear that conducting physics was of utmost importance. In the first article he introduces this importance as such. If man has knowledge of nature, man can *use* nature. Knowledge of nature was useful, i.e. science was useful:

[245] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", pp. 388–391.
[246] J. Bosscha Jr. (1858f), *Het Behoud van arbeidsvermogen in den galvanischen stroom*, pp. v–vi.
[247] Translation: "[...] has Helmholtz some years ago fabricated a small optic instrument, the eye mirror, which has had many important improvements, by the work of our fellow countryman, professor Donders." J. Bosscha Jr. (1856e), "Hoe Zien Wij?", p. 8.
[248] J. Bosscha Jr. (1856e), "Hoe Zien Wij?"; H. von Helmholtz (1855), *Über das Sehen der Menschen*.

> "De mensch moet zich verdedigen tegen de vijandige natuurmagten, die tot zijnen ondergang schenen zamen te spannen. [...] Stelselmatig sloeg men de natuur in hare talrijke verschijnselen gade, men bespiedde hare wegen en trachtte de geheimen harer tooverkracht meester te worden, en zoo verwierf men eenen buit, de onuitputtelijke bron van nieuwe schatten, de kennis der natuur." [249]

In the first article: "De magt der warmte" Bosscha described a few ways mankind uses heat for their own purposes, such as the melting of ice, separation of salt from sea water and for the functions of the human body. He treated the phenomenon that objects increase in size when heated, although each substance expanded in a different degree and explained the great force that can be exerted by a heated iron bar that is bolted down and subsequently cooled. An exception to this general expansion rule is the formation of ice, which expands upon freezing and therefore floats on the heavier and warmer water. The same happens in air: Hot, light air rises, as is spectacularly shown by air balloons, cold, heavy air declines.

Bosscha further explained that the 'kracht van zamenhang' (force of cohesion) is largest with solid bodies, already a lot less in liquids and zero in gases. Heat decreases this force of cohesion such that bodies at some point change from solid to liquid to gas when heated. Each material has its own melting and boiling point. However, Bosscha tells us that the boiling point is, different than the melting point, and dependent on the pressure of the atmosphere around us. He claims that in vacuum, all liquids would boil automatically, regardless of their temperature. Bosscha further explained that, in case of the melting of ice, heat plays a role in which mechanical work is exerted. If one heats up snow the temperature will not rise, but the snow will only melt. That heat is used mechanically:

> "Die warmte [...] is verbruikt, zij heeft een zekeren arbeid verrigt, zij heeft de kracht van zamenhang der vaste ijskristallen verminderd, en haar in een minder zamenhangend ligchaam, in vloeibaar water, veranderd." [250]

Conversely, the heat that is used is returned when water freezes again. Thus, no heat is lost or gained in the end. Bosscha concludes the article by emphasizing the importance of this science, both practically and morally:

[249] Translation: "Mankind must defend himself against the hostile forces of nature that appear to work together towards Man's demise. [...] Systematically Man has observed nature in her numerous phenomena, one spied on her methods and attempted to master the secrets of her magical powers, and in that way one obtained a prize, the inexhaustible source of new treasures, the knowledge of nature." J. Bosscha Jr. (1857b), "De magt der warmte", pp. 1–3.

[250] Translation: "That heat [...] is spent, it is done a certain work, it has diminished the coherence of the solid ice crystals, and changed them into a less coherent body, into fluid water." J. Bosscha Jr. (1857b), "De magt der warmte", p. 32.

> "Maar reeds het medegedeelde zal de overtuiging gevestigd hebben, dat alleen de kennis der natuur ons in staat stelt, van hare wondervolle werkingen zooveel mogelijk partij te trekken, en dat zij alleen ons de heerschappij over de natuurkrachten kan verschaffen en bevestigen. Niemand, die de natuurverschijnselen wil toepassen, kan straffeloos en zonder schade die kennis ontberen. En met de vermeerdering van ons verstandelijk inzigt zal ook het schouwspel van de natuur meer kunnen bij dragen tot onze geestelijke en zedelijke vorming, het einddoel van ons bestaan." [251]

Thus, according to Bosscha, science was not only useful, but contributed to our moral and ethical development. This shows a typical mid-19th century view on science that Bosscha shares: Scientific knowledge civilized the mind. In the review Hollman, under the pseudonym Josua, criticizes some small details of the article, but most interestingly he criticizes the way of popular writing. He believes that it is better to write an entire book to expound a particular subject than to write small pieces on various subjects:

> "Is het moeijelijk in bevattelijken vorm voor het volk over eenige wetenschap te schrijven, die moeijelijkheid wordt nog vergroot, wanneer het slechts een klein gedeelte geldt, en men dus niet onophoudelijk op het voorgaande verwijzen kan. [...] Daarom zijn wij geene voorstanders van geschriften voor het volk als het onderhavige; beter voldoen volledige werken, gelijk bijv. de sterrenhemel van Kaiser, de natuurkunde van van den Burg en dergelijken."[252]

This is peculiar, considering his involvement with the first volume of *Blikken*. Perhaps, in the end, he did not agree with the way G.T.N. Suringar wanted to shape the journal and moved on to criticize the journal instead.[253]

In the second article: "De oorsprong der warmte", Bosscha shows how heat can be obtained from the infinite resources of the earth and sun. He does not go into speculation where the heat of the earth comes from, as that would lead to speculation on the formation of the earth, about which nothing is certain:

[251] Translation: "But the before mentioned shall have brought on the conviction, that only the knowledge of nature enables us, to fully profit from her magical workings and that only she can give us full reign and ratification over the forces of nature. No one lacking this knowledge, who wants to apply the phenomena of nature, can achieve this unpunished and without damage. And with the increase of our intellectual insights the spectacle of nature shall evermore attribute to our spiritual and moral education, the ultimate goal of our existence." Ibid. p. 48.

[252] Translation: "It is already challenging to write in understandable terms for the common man about any science, that challenge is even increased, when it only entails a small part, and one can therefore not refer withouth limit to previous writings; [...]. Therefore we do not support writings for the common people like the here mentioned; better suited are complete works, like The Starry Sky by Kaiser, Physics by van den Burg and similar works." P. J. Hollman (1858a), "Blikken in het Leven der Natuur. 3de Jaargang, 1ste, 2de en 3de Stukje."

[253] To G.T.N. Suringar Hollman writes that he had no more time due to the wave of cholera patients in his busy doctor's practice. Letters from P.J. Hollman to G.T.N. Suringar, 10-10-1855, UB UvA.

> "Omtrent den oorsprong dier warmte kan men niet anders dan gissingen maken. De vraag naar de wijze, waarop de warmte der aarde ontstaan of haar geschonken is, hangt buiten twijfel innig te zamen met de vraag naar de wijze, waarop de aarde zelve is ontstaan, en daar omtrent weet men zeer weinig zekers te zeggen."[254]

Speculation without empirical evidence, as we can see, is not one of Bosscha's favorites.[255] First, he described heat as the result of friction and of course asked whether the produced heat and work were proportional:

> "[...] dat altijd, wanneer door wrijving of botsing arbeid verdwijnt, eene zekere hoeveelheid warmte daarvoor in de plaats treedt. [...] Bestaat er nu niet eene zekere betrekking tusschen de hoeveelheid verloren arbeid en gewonnen warmte? Gelijk bij alle natuurverschijnselen zoo is ook hier weder het hoeveel aan vaste wetten gebonden. Voor elke hoeveelheid arbeid, die verloren gaat, wordt een bepaalde hoeveelheid warmte gewonnen."[256]

Here he also defines the unit of work as the 'elpond':

> "Men is overééngekomen allen arbeid in een zekere maat uit te drukken, en heeft daar voor den arbeid gekozen, die noodig is om een pond op een hoogte van een Ned. el te brengen. Die arbeid wordt bij verkorting een elpond genoemd." [257]

Was there truly consensus in the scientific community about this phrase? Abroad, similar terms were used, but it seems more likely that this Dutch word is another invention by Bosscha that was readily copied by others in textbooks on physics.[258] It did not become as popular as

[254] Translation: "Concerning the origin of this heat, one has no choice but to guess. The question about the way, the heat of the earth was created, or given to her, is without question intimately linked to the question about the way the earth itself originated, and concerning that, very little of certainty can be said." J. Bosscha Jr. (1857c), "De oorsprong der warmte", pp. VG202-203.

[255] Neither is it of Bosscha's pupil Kamerlingh Onnes. See D. van Delft (2005), *Heike Kamerlingh Onnes*.

[256] Translation: "[...] that always, whenever work disappears through friction or collision, a certain amount of heat replaces it. [...] Is there not a correlation between lost work and heat gained? Equal to all natural phenomena the amount is bound yet again by fixed laws. For every certain amount of labor lost, a certain amount of warmth is won."J. Bosscha Jr. (1857c), "De oorsprong der warmte", pp. VG208-209.

[257] Translation: "It has been agreed upon to express all work in a certain measure, and one has chosen to use the work needed to lift a [Dutch] pound to the height of an [Dutch] el. This labor will be known by the abbreviation 'elpond'." Ibid. p. VG210.

[258] Bosscha also used the elpond in his *Leerboek der Natuurkunde* and in his popular lecture on the conservation of energy. Note that the Dutch el and pond have been defined to be equal to the meter and kilogram in the first half of the 19th century. It was only during the second half of the 19th century that the use of the terms el and pond eroded. Before, the Dutch pond was roughly half a kilogram. This colloquial use of ponds is still in use in the Netherlands for the purchase of weighed food such as meat, potatoes or vegetables, and, amusingly, it is the only used unit for the mass of new born babies. The term elpond was copied for example in the textbooks of Elisa van der Ven (1833–1909), Wilhelmus Martinus Logeman (1821–1894) and Johannes Hubertus van den Broek (1815–1896). See E. van der Ven (1866), *De Beginselen van Theoretische en Toegepaste Mechanica*; W. M. Logeman (1866), *Natuurkundige Stellingen, een Handboekje ten Gebruike bij het Onderwijs in de Physica aan Hoogere Burgerscholen*; J. H. van den Broek (1867), *Beginselen der Natuurkunde*.

'arbeidsvermogen' as it was quickly replaced by the metric term 'kilogrammeter'. I did not find any instances of 'elpond' before the usage here. Nevertheless, what is most important here is that Bosscha is aware of the experiments of Joule and similarly defines a heat equivalent to the elpond:

> "Nu heeft een Engelsch natuuronderzoeker bevonden, dat de hoeveelheid warmte, die noodig is om één pond water één graad van de honderddeelige schaal warmer te maken, in staat is een arbeid te verrigten van 423 elponden, dat wil dus zeggen, een gewigt van 423 ponden één el hoog of één pond 423 el hoog zou kunnen optillen. Wanneer nu omgekeerd een pond van een hoogte van 423 ellen valt dan zal, zoo de schok geene blijvende vorm veranderingen te weeg brengt de geheele hoeveelheid warmte door de botsing opgewekt een pond water één graad van de honderddeelige schaal warmer kunnen maken." [259]

Bosscha calls this the most important experimental discovery of the century. Now, heat through friction can hardly be used in practical applications. For that, Bosscha turns to chemical reactions. He used the heat produced in burning processes as examples of chemical reactions that can be efficiently used for work. For example he explains chemical processes in which oxygen is affixed to a fuel. To cancel out such a chemical reaction, a proportional amount of heat is needed again in the form of 'chemical work', as Bosscha named it. This is not something we humans can achieve on a greater scale. After all, we have used up the work provided by the heat of the reactions. However, the products of burning: water and carbon dioxide, are molded together again into burnable components by the work of the sun through growth in plants and this work is stored throughout a great many of years into coal etc.

This knowledge of the forces of nature gives power over nature: "Kennis is macht" as is explained in the first article, and wealth through application of this knowledge: "Kennis is rijkdom" as we read in the second article. Reviewer Hollman was very positive about this article too. It was clear, understandable and useful for the readers:

> "Deze standvastige betrekking tusschen arbeid en warmte behoort tot de gewigtigste ontdekkingen onzer eeuw. Op haar bouwt de S. [Bosscha] vele zijner volgende redeneringen; hij doet dit zeer duidelijk en verstaanbaar. De lezers der 'Blikken'

[259] Translation: "An English scientist has now discovered, that the amount of heat needed, to heat one pound of water one degree on a centigrade scale, can perform the amount of labor of 423 elponds, that means it could move a weight of 423 pounds to a height of one el, or move one pound of weight to the height of 423 els. When now conversely one pound of weight would fall from a height of 423 els, then if the shock does not result in permanent shape changes, the warmth released could increase the temperature of one pound of water, one degree on a centigrade scale." J. Bosscha Jr. (1857c), "De oorsprong der warmte", pp. VG211-212.

kunnen veel nut trekken uit dit stuk van den heer Bosscha: het behoort zeker tot de best gelukte van den geheelen bundel."[260]

The third article is about the heat of the human body. Interestingly, BOSSCHA's view is contrasted with physiologists who explained that the heat produced by the human body was because of the 'life force'. BOSSCHA calls it no explanation at all:

"Het is duidelijk, dat men zoodoende slechts de moeijelijkheid verschuift en eene onbegrijpelijke zaak wil verklaren door een onbegrijpelijk woord."[261]

Science has yet again prevailed over speculative philosophies and was able to explain body-heat without resorting to inexplicable vitalism:

"De geschiedenis der natuurwetenschappen heeft ook hier weder geleerd wat het onverdroten onderzoek vermag en hoe dwaas de hoogmoedige eigenwaan diergenen is, die alles wat zij met hunne kennis niet kunnen doorgronden tot de van nature onverklaarbare dingen rekenen. Het onderzoek naar den oorsprong der dierlijke warmte heeft eene zoo volledige oplossing van het vraagstuk opgeleverd, dat er slechts weinig verschijnselen zijn, waarvan wij zoo volkomen rekenschap kunnen geven." [262]

BOSSCHA continues to give a thorough account of body heat and the conservation of chemical energy and heat. We breathe in the oxygen and the substances we burn are to be found in the food we take in. The chemical products can be found in the 'smoke' that we breathe out.

"Wij kunnen derhalve ons ligchaam eenigermate vergelijken bij eene kagchel, waarin een vuur gestookt wordt. Ons voedsel is de brandstof, de lucht die wij uitademen de rook, onze uitwerpselen de asch, en op dezelfde wijze als eene brandende kagchel warmer blijft dan de lucht, die haar omringt, blijven ook wij warmer dan de dampkring, waarin wij leven."[263]

[260] Translation: "This fixed relation between work and heat belongs to the most significant discoveries of our century. On it, S. [Bosscha] bases many of his following arguments; he does so in a very lucid and intelligible way. The readers of 'Blikken' can draw a lot of use from this work of Bosscha; it surely belongs to the most well executed ones of the whole volume." P. J. Hollman (1858b), "Blikken in het Leven der Natuur; 3de Jaargang, 4de, 5de en 6de Stukje."

[261] Translation: "It is clear that one only evades the problem, when trying to elucidate something incomprehensible, through incomprehensible words." J. Bosscha Jr. (1858a), "De dierlijke warmte", p. VG228.

[262] Translation: "The history of the natural sciences has taught us here yet again what assiduous research can achieve and how foolish the haughty esteem is of those, who account all which they cannot explain with their knowledge to inexplicable things. The research on the origin of the animal has produced such a complete answer to the question, that there are only a few phenomena, of which we can give such a thorough account." Ibid.

[263] Translation: "We can therefore compare our body to an oven, in which a fire is lit. Our food is the fuel, the air we breathe out the smoke, our excrement the ash, and in the same way as an oven remains warmer than the air, which surrounds it, we also remain warmer than the atmosphere around us." Ibid. p. VG232.

We can find these physiological explanations in the popular works of the physiologists Von Helmholtz and Du Bois-Reymond as well, who likewise showed the universal applicability of the law of conservation of energy by applying it to physiological phenomena. The unity of nature is easily shown with the conservation of energy and this appealed to a wide audience, precisely because it could be applied to everything. The same 'anti-vitalistic' physiological view that Bosscha expounds can be seen in Du Bois-Reymond's interpretation of Von Helmholtz's pamphlet[264]

The rest of the article Bosscha continues to explain the heat production and stability of the human body, including a calculation of how heat and the work done by the chemical reaction of food with oxygen can be quantitatively related to each other. The last two articles treat heat conduction and radiation and continue more or less in the same way as the previous articles. There is one interesting passage that again shows Bosscha's anti-philosophical inclination. We are fully able to trust our senses, but, maybe not our intellect. The tactile sensation of cold or heat is in all cases correct, but the inference about the temperature of the warm or cold object with respect to our body is faulty. The sensation is not in error, but the mind is. If something feels colder it only means that the particular body extracts our heat faster. The last has two explanations: either the object is colder or it has a higher coefficient of conduction. This interesting passage I will quote in full:

> "Intusschen, zoo wij achtereenvolgens een stuk hout, een stuk marmer en een stuk ijzer aanraken, zullen wij het ijzer kouder dan marmer en het marmer weer kouder dan hout noemen. Is dit een zinsbedrog? Kunnen wij zoo weinig onze zintuigen vertrouwen? Is er dan inderdaad tegenstrijdigheid mogelijk tusschen hetgeen ons de waarneming leert? Geenszins, het bedrog wordt door ons verstand, niet door onze zintuigen gepleegd. [...] Wanneer nu omgekeerd een voorwerp sneller de warmte van onze hand tot zich trekt dan een ander, besluiten wij, dat het kouder moet zijn en wij vergeten geheel, dat nog eene andere omstandigheid de snelheid der warmteverspreiding kan doen verschillen: het warmte-geleidend vermogen. [...] Ieder weet, dat men zich aan ijzer eerder brandt dan aan glas, porselein of hout. Het is dus geen zinsbedrog, dat ons tot eene tegenstrijdigheid bragt, maar de redenering die wij bezigden. Onze huidzenuwen leerden ons alleen, dat de hand het spoedigst afgekoeld werd, wanneer zij ijzer aanraakte, en bedroog ons verstand ons nimmer, dan zouden wij aanstonds uit onze waarneming het verschillend warmte-geleidend vermogen der ligchamen erkend hebben. Zoo treffen wij hier wederom een dier voorbeelden aan, die ons leeren, hoe oppervlakkig en ongerijmd de bewering is diergenen, die de waarnemingen onzer zintuigen bedriegelijk, en de uitspraken van ons verstand, wanneer het alle waarneming

[264] D. Wegener (2009), *A True Proteus*, pp. 39, 45–54.

uitsluit, voor onfeilbaar verklaren." [265]

This concludes Bosscha's contributions to the journal *Blikken*. Bosscha remained in the editing board after becoming professor at Breda, but he did not write any more articles for the journal. It is clear that Bosscha advanced the law of conservation of energy through his popular treatment of the conversions of heat. Like Du Bois-Reymond, Bosscha shows the wide applicability of the law with physiological processes and cosmological processes, keeping in mind not to dwell on speculative matters.

3.3 Boek der Uitvindingen

A most peculiar publication to which Bosscha's name is attached is the *Boek der Uitvindingen, Ambachten en Fabrieken*, a popular work on civilization and technology of German origin. I say peculiar, because on the one hand it was popular science, thus important to Bosscha, on the other hand the scientific level of this book was not on the level of Bosscha's standards that he has shown us in *Blikken*. As it turns out Bosscha only wrote the foreword to the book and translated some, presumably small, parts, but due to the obscure authorship of the book, the entire book is sometimes contributed to him.[266] In this introduction, we can again read Bosscha's view on science. No translator or author is ever mentioned in the Dutch editions, so it seemed reasonable to assume that the only name mentioned in the work was the author.[267] The book treats the developments all over the world in human civilization and goes on to describe all the different technological inventions in industry and agriculture.

Of the German original *Buch der Erfindungen, Gewerbe und Industriën*, the earliest edition I have found was the second edition of the first volume *Buch der Erfindungen*, which lists as the authors Louis Thomas (1815–1878), a Burgerschüle teacher, and Dr. Leo Bergmann, an

[265] Translation: "Meanwhile, if we consecutively touch a piece of wood, a piece of marble, and a piece of metal, we shall call the iron colder than the marble and the marble colder than wood. Is this an illusion of the senses? Can we trust our senses so little? Is there indeed contradiction between the things perception teaches us? Not in the slightest, the deception is brought on by our intellect, not our senses. [...] When conversely an object draws the heat of our hand towards itself more quickly, we decide, that it is colder and we completely forget, that another circumstance can influence the speed of the dispersion of heat: thermal conductivity. [...] Everyone knows that one is more easily burned by a piece of iron, rather than by glass, porcelain or wood. Therefore, it is not a deception of our senses that brought on a contradiction, but the reasoning we applied. The nerves of our hand, merely taught us that the hand was most quickly cooled, when touching iron, and if our minds had never deluded us, then we would have promptly recognized the difference in thermal conductivity through our sensory observation. And so, we are again confronted with numerous examples, that teach us how shallow and incongruous the allegation is of those, who call our senses deceitful, and the claims of our minds, when they disqualify all observations, infallible." J. Bosscha Jr. (1858b), "De warmte-geleiding", VG259-260.

[266] Letters to Sijthoff, 12-6-1857, UB Leiden SYT A 1857.

[267] De Hollandsche revue 7 (11), 23-11-1902; De ingenieur; Weekblad gewijd aan de techniek en de economie van openbare werken en nijverheid 47 (20), 13-5-1932. Very interestingly, the last source notes that the Japanese first learned to create railways from the Dutch who sent them such textbooks as 'Handboek voor de kennis der spoorwegen of J.C. Loman Jr. from 1849 and 'Het Boek der Uitvindingen, enz.' by 'J. Bosscha', 1858. Indicating that the book was used throughout by engineers.

architect. However, the later and much expanded editions of the book have a 'Redaktion' and multiple authors. It is likely that the Dutch editions came to be in a similar fashion with multiple authors and translators.[268]

The Dutch translation of the book was a project from Leiden publisher Albertus Willem Sijthoff (1829–1913), who we will meet again when we will discuss Bosscha's *Leerboek der Natuurkunde*. The book's first and second edition were published between 1857 and 1863, the third renewed edition was published between 1863 and 1868, and following the new editions of the German version, a fourth edition was published between 1873-1875,[269] a fifth around 1891 and the sixth and final edition between 1900 and 1910.

It seems from letters that have survived from the publisher that not Bosscha but Sijthoff's friend Dr. Henrik Marinus Christiaan van Oosterzee (1806–1877) was the main translator of the first edition of the work. In the autobiography of Van Oosterzee it is said that he was the main translator of the book, although his name does not appear in the work itself.[270] Sijthoff, though, sent Van Oosterzee's translations to Bosscha to correct and to ask if Bosscha agreed with the changes that Van Oosterzee made to the original German text.[271] Bosscha did not always agree with the contents of the book, but it is unclear whether these were Van Oosterzee's errors or problems of the German original:

> "Met deze post verzend ik drie vellen proef aan het Boek der Uitvindingen, door mij nagezien en hier en daar verbeterd. Ik stuitte nog op vele denkfouten en durf geenzins verzekeren, dat er niet nog velen te vinden zijn."[272]

The two reviewers of the book agree with Bosscha that some parts are shaky and that style and language are not always perfect. To the reviewers, it was not crystal clear that Bosscha did not write the book and that it had a German original at all.[273] By closer inspection, although the authorship of the book is shrouded in clouds, as was often the case in translations and adaptations. The preface is clearly written by Bosscha and the rest is not. In the preface Bosscha repeats the importance of diffusing scientific knowledge, or in his words:

> "Kennis der natuur en van die der vele toepassingen, welke deze kennis vindt in het dagelijksch bedrijf der menschen." [274]

[268] L. Thomas and L. Bergmann (1854), *Das Buch der Erfindungen.*
[269] R. van der Meulen (1876), *Bibliografie der Technische Kunsten en Wetenschappen 1850-1875*, pp. 15–17.
[270] H. W. T. Tydeman (1878), "Levensschets van H.M.C. van Oosterzee", pp. 84–85.
[271] R. van der Meulen (1891), *A.W. Sijthoff*, p. 58; N. Maas (1996), "Altyd Waek Saem", p. 39.
[272] Translation: "With this letter I send three preliminary pages of the Book of Inventions, read by me and corrected here and there. I still encountered many fallacies, and in no way dare to ensure that there are not many to be found yet." Letters to Sijthoff, 1-8-1862; 5-8-1864, UB Leiden SYT A 1862; 1864.
[273] W. M. Logeman (1858), "Boekaankondigingen: Het Boek der Uitvindingen, Handwerken en Nijverheid"; P. J. Hollman (1860), "Het Boek der Uitvindingen, Ambachten en Fabrieken".
[274] Translation: "Knowledge of nature and the many uses, this knowledge enables, in the daily life of people."

In particular, Bosscha is very explicit here about the Kaiserian prerequisites that an popular science author ought to display. The author should be a master of his subject and able to explain the phenomena with easy, understandable common day examples. Thus, a certain "menschkundige tact" is required to alternate between scientific explanation and daily life example. Bosscha, himself, showed his skill in this way of popular writing in *Blikken*, although in the preface, Bosscha is not entirely enthusiastic about the 'artificial' examples ("kunstgrepen") the translator has chosen to elucidate the subject matter.[275]

Lastly, I have to mention the popular scientific journal *De Natuur. Tijdschrift ter bevordering van de kennis der natuur* that was published between 1859 and 1861 at publisher A.W. Sijthoff and was discontinued because of a lack of readers. Bosscha seems to have been involved in this publication, although I have not been able to find any copy or mention of this journal in the letters with Sijthoff.[276]

This concludes Bosscha's popular writing. Bosscha did not involve himself much in popular writing after 1863. For this I have two possible reasons. The first reason is that Bosscha had contributed enough to the start-up of popular science writing in the 1850s. In the 1860s, this important obligation for scientists to write popular literature to educate society was already done by a plethora of beginning scientists. Bosscha might have felt there was no need for him to contribute any further to the vast amount of popular writing as it would not further improve his status as a professional scientist in society. The second reason might be even simpler. After 1863, Bosscha was already occupied with another extensive writing task: the publication of his famous textbook on physics, the 'Leerboek der Natuurkunde', which would occupy him until at least 1875.

We have seen in this chapter that Bosscha used popular science writing to establish his position in the scientific community and that he used popular means to advance the law of conservation of energy. Lastly, some aspect of Bosscha's views on science can be deduced from his writings.

J. Bosscha Jr. (1875a), *Het boek der uitvindingen, ambachten en fabrieken*, p. v.

[275] Ibid. p. vi.

[276] Bosscha is mentioned as collaborator in R. van der Meulen (1891), *A.W. Sijthoff*, p. 59. In the following article, the journal is reviewed: A. Winkler Prins (1860), "De natuur".

Part II

Inspector of 'Middelbaar Onderwijs' (1863-1873): The HBS and the Textbook of Physics

Chapter 4

The *Hoogere Burger School* (Higher Civil School)

This chapter discusses Bosscha's time as inspector of middle class education. Apart from being 10 years of Bosscha's life and showing that Bosscha was next to a scientist a man of education, the impact of the HBS can not be underestimated. Indeed, the HBS was the first attempt of a nationwide school system beyond the age group of 6 to 12 for the age group of 12 to 16. Moreover, it was the first school, apart from a few exceptions, that systematically incorporated the natural sciences in its curriculum. Lastly, it was the first general secondary education that was not exclusively for the upper class, not counting the low quality French schools and 'ambachtsscholen' (technical schools; meant to prepare you for a single occupation.), drastically increasing the amount of children that followed secondary education. Naturally, the schools were a positive impulse in the level of education in general and especially in the natural sciences and technical industry. This was already perceived by contemporaries, for instance by Kamerlingh Onnes, himself a graduate of the HBS, in an obituary of Bosscha:

> "[Bosscha] had, een belangrijk aandeel gehad in de organisatie der Hoogere Burgerscholen, een tak van onderwijs, die ons land in hooge mate ten zegen is geworden. Op het tijdstip, waarover ik spreek, begon men reeds te bespeuren, hetgeen later zoo duidelijk is gebleken, dat de Hoogere Burger Scholen de beoefening van de natuurwetenschappen in ons Vaderland een nieuwe vlucht deden nemen en dat zij een der belangrijkste voorwaarden vervulden voor het hier te lande tot bloei geraken der techniek."[277]

[277] Translation: "Bosscha had an important part in the organization of the HBS, a branch of education that has become so much a blessing for our country. At the time of which I speak, man already began to discern what later became so clear. The HBS launched the practice of the natural science in our country to new heights and was one of the prerequisites for the flourishing of our countries technical industry." H. Kamerlingh Onnes (1911a), "In Memoriam Prof. Dr. J. Bosscha".

The success of the HBS has been mythologized strongly by its graduates and by certain historians, often first noting that all the Dutch Nobel prize winners were graduates or in some other way connected to the HBS - Van der Waals was a teacher there, for instance. As of today, there are still meetings to commemorate the 'greatness' of the HBS. For instance the symposium called 'HBS, the best school ever?', held in Dordrecht on the 22th of April, 2017. It is true that most of the big names in the natural sciences at the end of the 19th century were HBS graduates. The question remains whether the school was just better at preparing students for the natural sciences, or that other arguments can explain the success of its graduates as well.

For instance, as Klaas van Berkel worded it at the symposium: Maybe the HBS students were simply better because they were better from the start. While most people from the gymnasium went on to university, the HBS graduates that chose this path must show perseverance and sheer will. Often from lower standings than the upper class gymnasium graduates, they could scarcely afford going to university. Not to mention they had to first pass the mandatory Latin and Greek exams, which took most HBS graduates between 1 and 2 years, despite that Bosscha believed one could pass these exams with a couple of months of work.[278] Moreover, indicating the high level required for the HBS, not many finished the 5-year program. With that kind of motivation and work ethic, no wonder that once they arrive at university, they were better than their peers.

I argue both mechanisms can be at play. Both the sheer work ethics of the HBS abiturients and their better preparation made them excel in comparison with their peers. With the amount of natural science in the curriculum of the HBS it simply was a better preparation for the natural sciences, but also for the study of medicine. Meanwhile, by the time a HBS graduate was allowed to start at university, the student was strongly motivated and less likely to fail. We shall see that there have been discussions, almost since the beginning, about whether to allow HBS students to university and whether the HBS was a better preparation for an academical study in the natural sciences. (Bosscha was in favor of the last, of course.) Until the law of 1876 access for HBS students to university was often obtained by receiving dispensation for the exams of Latin and Greek, or, after 1876, by simply doing these exams in Latin and Greek, an easy task, according to Bosscha.

For this study, we are interested in the consequences of the HBS for the natural sciences and for physics education in particular and what role Bosscha played in these developments. Bosscha set up the laboratories of the HBS in a more modern way - meaning with a laboratory fitted with the latest instruments - than was presently the case at the universities. Secondly, Bosscha appointed many of the HBS teachers as the first step in their scientific career after obtaining their doctorates and helped them further in their, often academic, career. Lastly, the level of the HBS teachers was sufficient to use them as part of the scientific community on several occasions.

[278] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, pp. 24–25.

In order to understand the significance of this new school to Bosscha's influence and science itself I will sketch the institutional layout of the Dutch educational system until 1863, then Bosscha's involvement with the school as inspector and the consequences for Dutch science.

4.1 Reorganization the Dutch Education System[279]

First, we will sketch the organization of the Dutch education system up until 1863. In the 18th century, the system of education in the Netherlands was in organizational disarray, apart from maybe the deteriorated universities and athenea. There was no central organization and the level of education was generally very low. Everything changed with the military takeover of the country by the centrally organized French regime. The Netherlands became a nation state with a centralized organizational structure. Earliest in 1796, the idea was advanced in the Netherlands to organize education on a national level as well. The first concern here was the organization of a primary education system and it was promptly organized in the law of lower education of 1806. King Lodewijk Napoleon Bonaparte (1778–1846), who was king of the Netherlands between 1806 and 1810 and brother of the Emperor Napoleon I (1769–1821), wanted to modernize the rest of the Dutch education system and called in the help of Jean Henri van Swinden (1746–1823) to write a report on how to organize the education in the Netherlands. In this report, published in 1809 the trichotomy of lower, middle and higher public education was formalized based on the class system of the general public, the bourgeoisie and the "learned" or upper class. Van Swinden proposed a separate public school next to the existing Latin schools in which the modern languages as well as mathematics and the natural sciences would be taught. None of these plans came to fruition as the Netherlands was incorporated in the French empire in 1810 and the school system was shaped after the French education system. The idea for a separate middle class education system was, however, very similar to the HBS that Thorbecke would finally erect in 1863.[280]

On the 22th of October 1811 by Imperial decree the whole system of universities and athenea, middle and lower education was likened to the French central system. The trichotomy of école primaire, école secundaire and école definitive was implemented, with drastic changes for the pre-existing institutions. The only athenea were Leiden and Groningen. The universities of Franeker and Harderwijk were abolished. The University of Utrecht, together with the athenea illustre were demoted to middle schools, or 'école secondaires'. The modern separation of the

[279] Sources used for this section: G. Bolkestein (1914), *De Voorgeschiedenis van het Middelbaar Onderwijs*; A. Bartels (1963), *Een Eeuw Middelbaar Onderwijs*; C. A. Mandemakers (1996), *Gymnasiaal en Middelbaar Onderwijs*; C. A. Mandemakers and H. van Dijk (1985), "Secondary Education and Mobility at the Turn of the Century"; H. T. A. Amsing (2002), *Bakens verzetten in het voortgezet onderwijs*, pp. 53–66.

[280] G. Bolkestein (1914), *De Voorgeschiedenis van het Middelbaar Onderwijs*, pp. 55–84; J. H. Swinden (1809), *Vertoog over de Universiteiten*. Note that Van Swinden was part of the original meter committee and made a lot of effort to implement the meter in the Netherlands. Furthermore, he was one of the founders of the Koninklijke Instituut van Wetenschappen, predecessor of the KNAW, founded in 1808.

artes-faculty into the sciences and the humanities plus philosophy also originated here. However, this decree was executed partially at most, and almost all of these changes were undone with the re-establishment of Dutch sovereignty and the coming of the prince of Orange in 1813.[281]

Quickly, Willem I (1772–1843) assembled a committee to organize the lower, middle and higher education and this culminated into the 'Organiek Besluit' of August 2d, 1815. In this decree, at least on paper, the higher, middle and lower education were separated. At least in name, because in practice there were no real 'middle' schools and no one really knew what was meant by middle schools. The decree placed the Latin schools as (preparatory) higher education and the French schools and boarding schools were placed with the lower education. The only secondary schools existing were not organized by the state but were small local establishments, such as technical schools that prepared for a certain profession. Higher education was re-established with the old universities and athenea illustre, with the sole change that artes faculty remained split into the new science and humanities faculties. In fact, during the period 1815-1848 there was no general public education for the age group 12 to 16-17 outside of the Latin schools, where they, at present, taught only Latin and Greek. Only in 1826 an extra subject was added to the curriculum of the Latin schools, namely mathematics.[282]

The fast industrializing society and the schools could not wait on slow legislation and started to reform to answer the demand of the middle class to provide their children a level of education that was demanded by high positions in industry. There was a new demand for a school that could educate these children for technical or managerial tasks in trade and industry. In other words, there was a need for education in the modern languages, trade and the natural sciences. Subsequently, there were many complaints about the lack of education in the modern languages and the sciences. Thus, from 1838 onwards many Latin schools were reformed into 'gymnasia' and were supplemented with a so called 'second division' in which these subjects were taught.

> "De scholen werden gesplitst in twee afdeelingen, de eene voor leerlingen die zich voorbereidden voor de universiteit, de andere voor leerlingen, die een loopbaan zochten, waarbij Grieksch en Latijn niet onmiddelijk vereischt werden, en waarvoor de z.g. Fransche scholen onvoldoende waren."[283]

Bosscha's Latin school in Amsterdam was reformed into such a gymnasium by the time he graduated there in 1848. Each school had its own extended curriculum that was completely outside of the 'Latin school'-part that consisted of the Latin and Greek and mathematics and

[281] K. van Berkel (1985), *In het voetspoor van Stevin*, pp. 102–103.
[282] Note that mathematics at the time also consisted of applied mathematics, such as mechanics.
[283] Translation: "The school were split in two departments, the one for students who prepared themselves for university, the other for students who aspired a career in which Greek and Latin were not immediately required, and for which the so called French schools were unsatisfactory." G. Bolkestein (1914), *De Voorgeschiedenis van het Middelbaar Onderwijs*, p. 149.

was governed by the law of 1815. The law of 1863 can thus be seen as a formal ratification of this new school type. After the foundation of the HBS in 1863 these second divisions were reformed into HBS or disappeared into thin air.

It is important to stress that the equality education of the French system where division was based on age group did not really take hold in the Netherlands after 1815, although there was much discussion and confusion on the subject. It was totally unclear what the term 'middelbaar onderwijs' exactly designated. In fact, there was much discussion about what was meant with 'middelbaar onderwijs' until the early 20th century, even after the law of 1863. Some believed it should simply be secondary education for people in the age group of 12-18, some others believed it meant education to the middle class. In Dutch, the word 'middelbaar' has the simple meaning of being between lower and higher. The discussion was whether this meant class or age group. Whilst the lower education was provided by primary schools and educated children from all social classes - albeit there were, of course, separate schools for the different social classes -, secondary and tertiary education were separated according to class. Therefore, in the *Organiek Besluit* the gymnasia were sorted into the higher education, as being preparatory for university and not into middle education. The second division of the gymnasia should, thus, be understood as middle class education formed out of necessity on the otherwise higher education school. This separation in class, according to this view on education, had implications for the curriculum of the schools. Latin and Greek prepared ones mind for the learned class and for an education at university. The natural sciences and modern languages, the 'nuttige vakken' (useful subjects) did not, in the spirit of the 19th century, civilize, cultivate, or, refine ones mind for the needs of academic learning but were solely 'useful' to someone working in trade or industry. These differences in view on education continued to be discussed in the entire 19th century in what is called the 'schoolstrijd' (battle for the schools).[284]

The law of 1863 effectively restored this separation into middle schools for the middle class and high schools for the upper or learned class. It was only at the close of the 19th century that this class system completely broke down in the Netherlands. There was, however, enough confusion as to what could be understood as middle education that, after the ratification of the new constitution in 1848, the question was raised again on how to draw the lines between the different kinds of education. In the 50s this culminated into a committee[285] - in which Bosscha Sr. played a major role - that proposed a new law for lower and middle education. Due to lack of political consensus between different fractions and an opposing conservative government this was thinned to a new law that only discussed lower education. The law was ratified in 1857.

[284] See chapter 6 for more on the 'schoolstrijd'.

[285] Nederlands Staatscourant, 1-3-1855. It is not, as is sometimes mentioned Bosscha Jr. that sat in this committee together with Thorbecke, but Bosscha Sr., member of parliament at the time, who played a role in the preparation of the law of 1857. Bosscha Jr. was too young at the time and none of his activities indicate political involvement. See for more information on Bosscha Sr.'s involvement in the law of 1857: "De Onderwijsvraag", De Gids, 1857.

Together with Thorbecke, Bosscha Sr. prepared the new law. Bosscha Sr., as a member of Parliament, was also active in the discussions in parliament about the law. Bosscha Sr. sought to add an amendment to the law, which would later be called the Bosscha-amendment.[286] The amendment sought a place in the law for the new school type that had appeared and that taught the modern, foreign, languages for one or two years on top of the primary schools. The amendment placed these schools in lower education instead of, what would be expected. middle education. These schools crystallized into the MULO schools ('Meer Uitgebreid Lager Onderwijs', or More Expanded Lower Education). This type of school was basically a primary school, but 'expanded' with a few years in which the modern languages were taught.[287] It lasted until the 'Mammoetwet' (Mammoth law) in 1968 and was a direct competitor to the new HBS after 1863, especially with the 3-year variant. A different consequence of the law of 1857 is that it defined public schools to be neutral in religion and that the state does not publicly fund confessional schools. This last consequence will remain a point of discussion in the 'schoolstrijd' until 1917, with an article in the new constitution that dictates that denominational education and public education must be treated equally before the law, effectively meaning that the schools should be treated equally with respect to state funding as well.

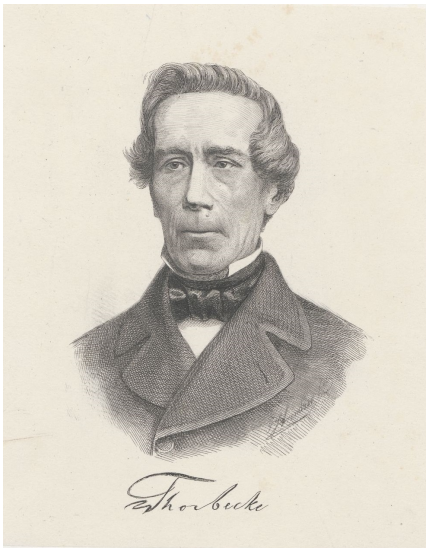


Figure 4.1: Johan Rudolph Thorbecke (1798–1872)

Indicative of Thorbecke's view on the separation of middle and higher education is the placement of the newly founded Polytechnical School with middle education. This school was more advanced than the gymnasia, but it belonged to middle education precisely because it did not prepare students for the learned class, but for a profession that belonged to the middle class. Many, however, disagreed with Thorbecke on this point, but in the end the opposition did not want the entire law to be rejected because of the, in some eyes, archaic class system of the law. Almost all but the most extreme conservatives saw the benefits of the new law.[288]

All in all, we can conclude that science education in the age group 12-18, before going to university was fragmentary at best before 1863. All science education was done in the gymnasia, athenea and universities for the upper class. This changed tremendously with the new HBS.

[286] D. J. Steyn-Parvé (1863), *De Wet tot Regeling van het Middelbaar Onderwijs*, p. 40.
[287] Algemeen Handelsblad, 31-1-1870.
[288] *1863-1963. Een Eeuw Middelbaar Onderwijswet Herdacht* (1963). Groningen: J.B. Wolters, pp. 6–13.

4.2 The Law of 1863

In 1838, as we have seen, some of the gymnasia created a second division with more emphasis on science and economy. Although these schools were basically outside of the laws on education, they are an indication that there was a great need for this type of school. In 1863, THORBECKE proposed a law that provided room for a new type of school. The law on middle class education was ratified on the 2d of May 1863.[289] The HBS that it erected was meant for that part of society that did not continue to university but was in need of a broad general education, necessary to fulfill important roles in trade and industry. The school was meant, in the spirit of the law, as the final education one would follow. Alternatively, as the preparation for the Polytechnical School in Delft and the Royal Military Academy in Breda. However, later on, many of the natural scientists of the Netherlands at universities will have originated from the HBS.

The law itself was mainly written by BOSSCHA's old professor RIJKE and his final draft was hardly edited by THORBECKE, although undoubtedly inspired by their many discussions.[290] The law was extremely liberal and did not state much more than that it would govern the schools that the law would erect, together with a list of subjects that would be taught at those schools:

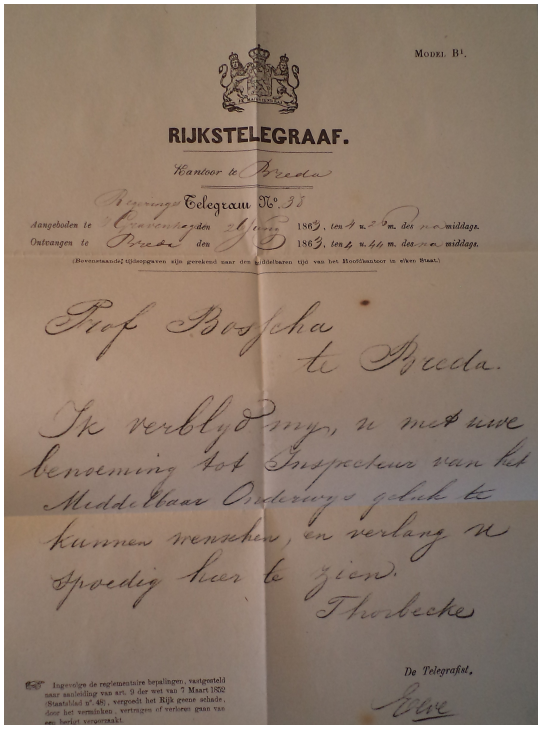
> "Art. 1. Tot het middelbaar onderwijs worden gerekend te behooren alle vakken, welke volgens deze wet onderwezen worden aan de scholen, waarover zij zich uitstrekt."[291]

The law covered two more important aspects: The level of the exams was organized on a national scale (the 'Staatsexamen') and the profession of teacher became protected: One could only become a teacher after obtaining the necessary diploma ('acts of competence') or by obtaining a doctorate at university.

The new law governed four types of schools. The first type is called 'burgerschool' and these schools were actually the pre-existing technical schools. The second is a new type of school: 'hoogere burgerschool'. The third is another new type of school: The agricultural school, which we will not discuss in this study.[292] The fourth is the Polytechnical School, which is discussed in section 6.3.2, as BOSSCHA will play a major role in its history later.

[289] D. J. Steyn-Parvé (1863), *De Wet tot Regeling van het Middelbaar Onderwijs*.
[290] J. Krüger (2014), *Actoren en Factoren*, pp. 236–237.
[291] Translation: "Article 1. Those subjects that are according to this law taught to the schools about which this law is are part of middle class education." D. J. Steyn-Parvé (1863), *De Wet tot Regeling van het Middelbaar Onderwijs*, pp. 201-202.
[292] A study on the history of agricultural school is H. van den Bosch (1986), *Landbouwscholen in Wageningen*.
[293] The note, dated 26th June 1863, says: "Prof. Bosscha te Breda. Ik verblijd mij, u met uwe benoeming tot Inspecteur van het Middelbaar Onderwijs geluk te kunnen wenschen, en verlang u spoedig hier te zien. Thorbecke." Translation: "Prof. Bosscha of Breda. I rejoice to be able to wish you luck with your appointment to Inspector of Middle Class Education and I wish to see you here soon. Thorbecke." Baarn-Archive.

The HBS was divided between schools with a curriculum of three years and five years. THORBECKE initially had a ratio of 2 three-year HBS to 1 five-year HBS in mind. Initially, the motivation for the two types of schools is that the less rich parents will not be able to finance their kids going to school for 5 years more, and in this 'class' of society a three year education would suffice anyway. However, the three-year schools declined in number very quickly and ceased to exist in the 20th century. The three-year schools were supposed to be more general and covering the first three years of the five year education. The subjects taught here were mathematics, physics, chemistry, botany, zoology, geology, history, the modern languages and accounting. The five-year schools also taught mechanics, technological instruments, cosmography and mineral science.


MODEL B¹.

RIJKSTELEGRAAF.

Kantoor te Breda

Dienst Telegram N°. 35

Aangeboden te Groningen den 21 Juni 1863, ten 4 u. 9 m. des n.m. middags.

Ontvangen te Breda den 21 Juni 1863, ten 4 u. 44 m. des n.m. middags.

(Bovenstaande tijdsopgaven zijn gerekend naar den middelbaren tijd van het Hoofdkantoor te elven Staat.)

Prof Bosscha
te Breda.

Ik verblijd mij, u met uwe benoeming tot Inspecteur van het Middelbaar Onderwijs gelijk te kunnen wenschen, en verlang u spoedig hier te zien.
Thorbecke

De Telegrafist.

Ingevolge de reglementaire bepalingen, vastgesteld naar aanleiding van art. 9 der wet van 7 Maart 1852 (Staatsblad n° 49), verpondt het Rijk geene schade, door het vermisken, vertragen of verloren gaan van een bericht veroorzaakt.

Figure 4.2: A telegraph from THORBECKE to BOSSCHA to congratulate him on his new position.[293]

Three days after the ratification of the law, BOSSCHA sent an open letter to THORBECKE in which he introduced and recommended himself for the post of inspector. Two months later, on the 25th of June 1863,[294] he was appointed to inspector of 'Middelbaar Onderwijs' (secondary education) of the provinces Utrecht, Gelderland, Noord-Brabant and Limburg together with DANIËL JAN STEYN PARVÉ (1825–1883), who was appointed over North and South Holland and Zeeland, and WINAND STARING (1807–1877), who was appointed over the northern provinces as well as the agricultural schools.[295] Already for a year or so, BOSSCHA wanted the job of inspector, together with his friend at Breda, MARK PRAGER LINDO (1819–1877), and he discussed in length with his father how to best proceed in obtaining the vocation.[296] This shows BOSSCHA at the time was more interested in elevating the level of education in the Netherlands than staying close to science. As we will see, it is rather in reverse: BOSSCHA would bring science and scientific research close to education.

[294] Nederlands Staatscourant, 27-6-1863.

[295] Nationaal Archief, Archief van de 5e afdeling onderwijs van het ministerie van binnenlandse zaken (2.04.08), inv. nr. 449, 6-5-1863; 27-6-1863. The allotment of provinces is not Holland for BOSSCHA, this is wrongly stated in A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, p. 21.

[296] Baarn Archive, letters with his father, 10-6-1862; 18-3-1863; 10-4-1863; 5-5-1863; 12-5-1863. Although at first BOSSCHA wanted to work together with LINDO, by 1873 he advised against LINDO and recommended a natural scientist. Algemeen Handelsblad, 17-1-1873.

The most important other inspector Steyn Parvé studied natural philosophy in Groningen and obtained his doctorate, on research of a mathematical subject: 'de curvis funicularis' in 1847. Already in January 1848 he became professor in mathematics at the Royal Academy of Maastricht. After ten years, he was appointed to a post in the government, internal affairs, section of education in which he played an active role in the preparation of the law on middle school education of 1863. Not surprisingly, with his experience in education and administrative issues he was appointed to inspector of middle school education. Indeed, Steyn Parvé made the HBS his life work and in many writings the HBS is called 'his creation'. In his many publications on the HBS he described, criticized the schools and defended them with the same vigor from, in his eyes, wrong accusations.[297] Most successes of the HBS, if they can be attributed to someone in particular, could most probably also be attributed to Steyn Parvé. As Bolkestein writes in 1913:

Figure 4.3: Daniël Jan Steyn Parvé (1825–1883)

> "ons geheele middelbaar onderwijs nog beheerscht wordt door den vèrstrekkenden invloed van het inzicht van Steyn Parvé." [298]

It is hard to distinguish Bosscha's influence on the HBS as separated from Steyn Parvé's, they worked together on most occasions and there is no significant difference in opinion between the two men. We might say that Bosscha and Steyn Parvé together created Thorbecke's legacy. Together they worked hard for the success of the HBS. That being said, it is often Bosscha who is attributed the particular state-of-the-art laboratories and Steyn Parvé usually gets credit for the success of the HBS 'as a whole'. [299]

I too, would like to quote a part of Thorbecke's speech at the end of the discussion in the senate, that shows the vigor of the law:

> "Wij gaan, Mijne Heeren, eene groote en blijvende weldaad aan het land bewijzen. Wij gaan krachten en instellingen in het leven roepen, die de intellectueele, het praktisch

[297] N. W. Posthumus (1883), "Dr. D.J. Steyn-Parvé"; Dr. Steyn Parvé in: P.J. Blok, P.C. Molhuyzen (1927), Nieuw Nederlandsch Biografisch Woordenboek 7, p. 943-945.

[298] Translation: "The whole of our middle class education is still reigned by the far-reaching influence of Steyn Parvé's insights." Cited in A. Bartels (1963), *Een Eeuw Middelbaar Onderwijs*, p. 201.

[299] In most short descriptions of Bosscha's life Bosscha is held responsible for the level of the laboratories.

voortbrengend vermogen van de kern des volks moeten verhoogen." [300]

The 'core of the people' here meant the rich middle class, as THORBECKE saw it. As BOSSCHA describes it in his *Autobiography* on the other hand, he was intrigued just to bring decent scientific education to people of the Netherlands. According to BOSSCHA the education in the Netherlands in the natural sciences was lacking completely. His life's duty was to increase the level of education in the natural sciences, as this knowledge was useful for the upbringing of the youth.

> "De voorname aantrekkelijkheid van het ambt van inspecteur bestaat in het bevorderen van het onderwijs in natuurwetenschappen dat tot 1863 geheel verwaarloosd was. Alleen in de technische school te Utrecht met een klein getal leerlingen bestond er iets van. Door de eischen van het eindexamen der h.b.s. op behoorlijk peil te stellen, te zorgen over goede schei- en natuurkundige laboratoria van de h.b.s. werd van den aanvang af gestreefd dit onderwijs op de hoogte van zijne werkelijke waarde voor de opvoeding van jongeren te brengen. Tot ditzelfde doel werd het schrijven van een leerboek van de natuurkunde ondernomen. [...] Naar mijne schatting is mijn invloed op de ontwikkeling van de natuurwetenschappen, speciaal van de natuurkunde in ons land het boek geweest wat ik in mijn leven heb kunnen uitrichten."[301]

Another way of increasing this level, as BOSSCHA calls it, is by writing his *Leerboek der Natuurkunde*. See next chapter for more on his textbook. As he call it, it was his most important contribution to the development of the natural sciences in the Netherlands. Thus, according to BOSSCHA the natural sciences had to be 'developed', i.e. the level had to be increased in comparison with the state it was before. This is his main motivation to meddle in educational affairs: Increase the level of the education in the natural sciences. Note that the technical school in Utrecht mentioned, was absorbed in to a five year HBS in 1865. STEYN PARVÉ and BOSSCHA did not think highly of the level of education at this school and saw the HBS as a big improvement to an otherwise good initiative:

[300] Translation: We are, gentlemen, going to prove a great and lasting benefaction to the country. We are going to call to life forces and institutions that will heighten the intellectual and practical producing abilities of the core of the people." Cited from A. Bartels (1963), *Een Eeuw Middelbaar Onderwijs*, pp. 17–18, originally from the Memorie van Toelichting, Handelingen der Staten-Generaal 1862/1863, p. 232.

[301] Translation: "The main attraction of the vocation of inspector consists of improving the level of education in the natural science that has been neglected completely until 1863. Only in the technical school of Utrecht, with a small amount of students, something of the sort existed. By setting the requirements of the exam of the HBS on a reasonable level, and by ensuring good chemical and physical laboratories of the HBS were available, from the start it was strived to bring this education to the level for which it was of true value for the upbringing of the youth. For the same goal I wrote the textbook of physics. [...] To my estimation, my greatest influence that I have exerted in my life on the development of the natural sciences in the Netherlands and on physics in particular was this textbook." Baarn-archive: Autobiography.

> "Steyn Parvé achtte deze school een tweede verdieping van een gebouw, waarvan de eerste zeer gebrekkig was."[302]

Bosscha was in essence against the class system of the law of middle class education. Bosscha believed in the equality of all people, no matter the ancestry. Not only his efforts for the HBS, a school for the general public, show this ideal, but also his position at the Polytechnical School instead of a position at university that he declined multiple times (Leiden, Amsterdam). A peculiar anecdote we read from his granddaughter. It is from Bosscha's Delft period and shows that Bosscha would break the conventions that bound the stiff class society. Bosscha went ice skating with his daughter on the canals, a very unconventional deed for someone from the upper class:

> "Had mijn Grootvader niet jaren te voren, toen Grootpapa Directeur van de Polytechnische School daar werd, de stijve Delftsche gemeenschap gechoqueerd, door met zijne dochter naar hartelust te gaan schaatsenrijden op de ijsbaan, de grachten en de kanalen? Men was het eerst jaar stom van verbazing en schudde de hoofden over zóóveel onconventionaliteit. Het tweede jaar deden eenige ondernemende dames mee, en toen was in figuurlijken zin het ijs gebroken en zag men al spoedig alle defitige burgeressen van Delft op de schaatsen."[303]

All in all, Bosscha strived to increase the general knowledge of the natural sciences in the Netherlands and did not think in boundaries of class. To Bosscha there was only hard work.

4.3 Bosscha's Tasks as Inspector

Inspection on the HBS was formalized into two institutions. The local inspection committees and the national inspectors. The local inspection committees provided the national inspectors with statistics and made sure the regulations were being followed. The inspectors of middle school education had a broad task description. An article from a draft of the law of 1863 describes that they must 'be informed' about the state of the schools:

[302] Translation: "Steyn Parvé thought this school the second floor of a building of which the first was very faulty." G. Bolkestein (1914), *De Voorgeschiedenis van het Middelbaar Onderwijs*, p. 165.

[303] Translation: "Did my grandfather not, years ago when he became director of the Polytechnical School, shock the stiff community of Delft by going ice skating with his daughter to their heart's content on the ice skating court and the canals? The first year everyone was stupended and shook their heads about so much unconventionality. The second year some adventurous ladies joined in and the metaphorical ice was broken. Soon all the distinguished female citizens of Delft were on their ice skates." A. E. M. C. Bergsma-Bosscha Erdbrink and J. Brewer (2012a), *Carmen, herinneringen 1894-1904*, pp. 161–162.

[304] Verslag van den staat der hooge-, middelbare en lagere scholen in het Koningrijk der Nederlanden over het jaar 1866-1867, p. 36.

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gepaard gaan met de herinnering aan de belangrijke diensten door haar aan het middelbaar onderwijs bewezen in een tijd toen zij, vooral sedert de uitbreiding van haar leerplan in 1856, met de tweede afdeeling van het athenaeum te Maastricht, het eenige voorbeeld was van instellingen, die gezegd konden worden eenigzins aan de eischen van middelbaar onderwijs te voldoen.

Er waren alzoo 25 hoogere burgerscholen in 1866, waarvan 6 Rijksscholen, 18 gemeentelijke scholen en 1 bijzondere school door Rijk en gemeente gesubsidieerd.

De gemeenten waar deze scholen gevestigd zijn, met aanwijzing van het getal leerlingen in elke klasse en het bedrag van het schoolgeld, zijn in de volgende tabel aangewezen:

GEMEENTEN.	GETAL LEERLINGEN.								SCHOOLGELD PER JAAR.	
	1ste klasse.	2de klasse.	3de klasse.	4de klasse.	5de klasse.	TOTAAL. Voll. onderwijs.	TOTAAL. Enkele lessen.	ALGEMEEN TOTAAL.	Volledig onderwijs.	Enkele lessen.
a. *Rijksscholen.*										
Tilburg	31	»	»	»	»	31	5	36	f 30	f 7 tot f 14
Gouda	23	7	5	»	»	35	3	38	30	id.
Middelburg	19	23	17	5	2	66	17	83	40	id.
Utrecht	26	9	10	17	1	63	11	74	60	10 tot 20
Groningen	44	27	22	10	5	108	8	116	50	7,50 » 15
Roermond (1)	20	16	16	4	5	61	12	73	30	5 » 10
b. *Gemeentescholen.*										
Arnhem	37	21	13	2	»	73	4	77	60	6 en hooger
Zutphen	14	10	12	7	6	49	15	64	60	10 per vak.
Nijmegen	15	14	5	»	»	34	1	35	60	5 per uur 's weeks.
's Gravenhage	31	37	15	13	10	106	»	106	60	
Rotterdam	20	31	27	6	5	89	»	89	60	
Leiden	21	20	8	6	1	56	35	91	60	10 tot 25
Dordrecht	24	16	7	4	1	52	7	59	54 tot 72	10 » 15
Delft	24	27	28	27	10	116	9	125	70	10 » 30
Transporteren	349	258	185	101	46	939	127	1066		

(1) Bovendien 10 leerlingen in eene voorbereidende klasse.

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GEMEENTEN.	GETAL LEERLINGEN.								SCHOOLGELD PER JAAR.	
	1ste klasse.	2de klasse.	3de klasse.	4de klasse.	5de klasse.	TOTAAL. Voll. onderwijs.	TOTAAL. Enkele lessen.	ALGEMEEN TOTAAL.	Volledig onderwijs.	Enkele lessen.
Per transport	349	258	185	101	46	939	127	1066		
Amsterdam	33	33	24	13	6	109	»	109	f 180	
Haarlem	42	30	29	7	9	117	15	132	60	f 10 tot f 25
Zaandam	27	21	»	»	»	48	15	63	60	20 per vak.
Goes (1)	13	6	4	»	»	23	6	29	40 tot f 50	5 tot 12
Sneek	22	31	23	7	3	86	15	101	30 » 50	5 » 15
Harlingen	11	8	12	3	»	34	14	48	40	2 » 6
Deventer	12	9	8	9	3	41	35	76	50 tot 60	3 » 12
Veendam	32	27	»	»	»	59	15	74	20 » 50	
Maastricht	41	28	18	15	3	105	7	112	30	
Venlo	12	7	3	»	»	22	»	22	22	
c. *Bijzondere scholen.*										
Twentsche industrie- en handelsschool te Enschedé	6	10	15	»	5	36	6	42	70	3 » 20
Totaal	600	468	321	155	75	1619	255	1874		
In 1865	502	395	249	117	38	1301	165	1466		
Vermeerdering	98	73	72	38	37	318	90	408		

(1) Bovendien 18 leerlingen in eene voorbereidende klasse.

10

Figure 4.4: List of HBS from 1866-1867. Note that the total number of students at the HBS in that year was 1874.[304]

city	*financed*	*type*	*founded*	*teachers*	*salary*
Groningen	state	5-years	1864	Dr. J.M. van Bemmelen	*f* 3000-
				Dr. F.G. Groneman	*f* 2400-
Roermond	”	”	”	H.J. Hardeman	*f* 1800-
Zutphen	city	”	”	D.G. Cramer	*f* 1800-
Leiden	”	”	”	Dr. D. de Loos	*f* 2500-
				Dr. C.J.E. Brutel de la Rivière	*f* 1800-
Delft	”	”	”	Dr. P. van Geer (until 1867)	*f* 2000-
				Dr. M. Snellen	*f* 2000-
				Dr. Th. Knottenbelt	*f* 1800-
Haarlem	”	”	”	Dr. E. van der Ven	*f* 2200-
				W.M. Logeman	*f* 1700-
				B.J.C. Hazelhoff Roelfzema	*f* 1700-
Sneek	”	”	”	B. Verver	*f* 2800-
				S.R.J. van Schevichaven	*f* 2300-
				J.C. Eger	*f* 1600-
				A. Harms	*f* 2000-
Deventer	”	”	”	Prof. M.J. Cop	*f* 3000-
				Prof. V.S.M. van der Willigen (until 1865)	*f* 1700-
				Dr. H.W. Schroeder van der Kolk (until 1867)	*f* 1600-
				Dr. J. Sirks	*f* 1500-
Maastricht	”	”	”	K.W.E. Zickwolff	*f* 2800-
				J. Hoffmans	*f* 1750-
Middelburg	state	”	1865	Dr. G. van Hennekeler	*f* 2200-
				H.F. Seelheim	*f* 2000-
				Dr. H. van Hall	*f* 2000-
Gouda	”	3-years	”	K. Mars	*f* 1800-
Nijmegen	city	5-years	”	acaburg	*f* 2300-
				R.J. Opwijrda	*f* 1050-
’s Gravenhage	”	”	”	acawaals	*f* 2500-
				Dr. H. Hartogh Heijs	*f* 2000-
Rotterdam	”	”	”	J.P.A. François	*f* 4000-
Dordrecht	”	”	”	Dr. A.S. van Oven	*f* 1800-
Amsterdam	”	”	”	Dr. H.C. Dibbits	*f* 2500-
				Dr. A. van Hennekeler	*f* 2500-

city	*financed*	*type*	*founded*	*teachers*	*salary*
Goes	”	”	”	Dr. C. Walig	*f* 1600-
				E. Huizinga	*f* 1600-
Harlingen	”	4-years	”	N. van de Wall	*f* 2100-
Tilburg	state	5-years	1866	W.H. Fenger	*f* 3000-
				F.W. Krecke	*f* 1800-
Utrecht	”	”	”	Dr. H.G. van de Sande Bakhuyzen	*f* 2500-
				Dr. J.L. Hoorweg	*f* 2500-
				C. Bellaar Spruyt	
Helmond	”	3-years	”		
Arnhem	city	5-years	”	Dr. R.S.T. Modderman	*f* 3300-
				Dr. H. van der Stadt	*f* 2200-
Veendam	”	”	”	Dr. G. de Jager Meezenbroek	*f* 2360-
Zaandam	”	4-years	”	A. Pelt	*f* 1800-
Venlo	”	3-years	”	W.C. Hedick	*f* 1800-
Leeuwarden	state	5-years	1867	Prof. C.P. Burger	*f* 3500-
				Dr. E. A. van der Burg	*f* 2400-
				Dr. J. Zaaijer	*f* 2000-
Zwolle	”	”	”	Dr. H.F. Kuyper	*f* 2400-
				Dr. F.H. Julius	*f* 2400-
Zalt-Bommel	”	3-years	”		
Alkmaar	”	”	”	A. Langerhuizen van Uven	*f* 1800-
’s Hertogengosch	”	”	”	A.L. Lamers	*f* 2500-
				J. Schüngel	*f* 1800-
Breda	city	3-years	”	Dr. J.H.H. Hülsmann	*f* 2400-
				Dr. L. Aronstein	*f* 1800-
Sappermeer	state	3-years	1868	H. Wefers Bettink	*f* 1800-
Warffum	”	”	”	G.Reinders	*f* 1800-
Assen	”	”	”	A. van Hasselt	*f* 1800-
Kampen	city	5-years	”	Dr. B. Meilink	*f* 2400-
Hoorn	”	4-years	”	E.H. Groenman	*f* 1700-
Enschedé	”	?	?	Dr. A.J. van Rossum	*f* 1600-

Table 4.1: List of HBS at the end of 1868. The teacher column is not meant to be complete but only mentions those that are appointed in the natural sciences. The salary is a yearly salary. For the source of the data, see footnote 307.

> "De Inspecteurs zorgen door schoolbezoeken voortdurend bekend te blijven met den toestand der scholen, waarvan hen het toezigt is opgedragen. Zij trachten door overleg met de gemeentebesturen en met de onderwijzers den bloei van het middelbaar onderwijs te bevorderen. Zij lichten Onzen Minister van Binnenlandse Zaken voor over alle onderwerpen, waarvan hun oordeel wordt gevraagd, [...]" [305]

To find out more in detail what the inspectors in fact did in these early years I have investigated the 'Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederland' that was published each year in which the minister of internal affairs described the state of all institutions of education. After one year of the law in effect, this report described the effective activities of the first inspectors:

> "Behalve het aandeel door de inspecteurs aan de acten-examens in 1864 genomen, bestond hun arbeid hoofdzakelijk in de aanvankelijke regeling van het middelbaar onderwijs. Talkrijk waren dien ten gevolge hunne bijeenkomsten, zoo gezamelijk als afzonderlijk, met den Minister of onder zijne leiding. Doorgaans hadden die bijeenkomsten den last om met gemeentebesturen, raadscommissien of commissien tot regeling van het middelbaar onderwijs in overleg te treden, ten gevolge. Uit het hierboven gegeven overzigt van hetgeen in 1864 tot stand kwam of voorbereid werd, blijkt dat het de inspecteurs ook in dit opzigt niet aan arbeid heeft ontbroken. Met ijver en belangstelling kweten zij zich van hunne taak." [306]

The tasks of the early inspectors can be seen as threefold: Firstly the inspectors had to inspect the state of the schools that already existed. Secondly, they presided over the examination of the acts of competence to select competent teachers for the HBS. Thirdly, and this comprised the main task at least for the first five years or so, was founding the new HBS schools.

Thus, in the beginning, Bosscha task *de facto* meant playing a major role in setting up the first HBS. By the end of 1868 a total of 37 HBS were installed, of which 15 were financed by the

[305] Translation: "The inspectors ought to keep informed about the state of the schools under their watch with school visits. They try to to consult with the municipalities and the teachers to promote the prosperity of the middle class education. They inform our minister of internal affairs about every subject for which their judgment is requested." Draft of an article of the law, cited in J. Krüger (2014), *Actoren en Factoren*, pp. 258–259.

[306] Translation "Except for the part that the inspectors had in the exams of the acts of competence in 1864, their labor consisted mainly of the initial regulation of middle class education. Many were their meetings, separate or together with the minister or under his supervision. Usually these meetings were to discuss with the municipalities and (advisory) committees or about the regulation of the middle class education. From the above survey of what has been established or prepared in 1864 it is clear that the inspectors did not lack work in this aspect. With vigor and interest they performed their task." Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederland over het jaar 1864-1865, p. 67.

state, according to the original designation in the law of 1863. See table Table 4.1 for a list of these schools.[307]

4.3.1 Foundation of the HBS

In the image that manifests from the newspapers researched, Bosscha's active task in the foundation of the schools comprised of facilitating the negotiation between the government and the municipalities, and, appointing directors and teachers in consultation with the municipalities. For instance, for the HBS of Wageningen Bosscha recommended a director and spoke at the opening of the school.[308] In the case of Roermond, Thorbecke initiated the negotiations by telling the city that Bosscha will be sent to discuss the matter.[309] Apparently in this case, Bosscha advised against including lessons in Latin, which he deemed useless ('nutteloos') and to make it a 3-year HBS. Against Bosscha's advice, Roermond would become a 5-year HBS.[310] In Tilburg, Utrecht and Wageningen, Bosscha gave a speech at the opening of the school.[311] In 's Hertogenbosch, Bosscha brokered the deal that the city would be allowed a state financed 5-year HBS, if and only if the city provided the extra rooms that were necessary. The state would provide the funds for the teachers.[312]

As inspector, Bosscha advised for all the HBS, whether they were state funded or not. However, if it was not state funded, the municipal could exert more power over the appointment of teachers. Sometimes, a state's subsidy was declined, but the municipal decided to found a school anyway, such was the case in Amersfoort.[313] The subsidy was probably declined because the aim of a minimum of 15 state schools was already reached, and because more state funding would not be accepted by Thorbecke's opposition. Not many more state schools were founded after 1869, in 1898 there were only 5 more. One notable case which I have left out of consideration is the women's HBS (Also called Middelbare Meisjes School or MMS) founded in Arnhem by Bosscha: Bosscha was, like Steyn Parvé, who opened the first women's HBS in Haarlem in 1867, an advocate for the education of women and was a proponent of the women's HBS.[314]

[307] D. J. Steyn-Parvé (1869), "Overzicht van het Middelbaar Onderwijs bij het Einde van 1868"; D. J. Steyn-Parvé (1870), "Overzicht van het Middelbaar Onderwijs bij het Einde van 1869"; Verslag van den staat der hooge-, middelbare en lagere scholen van het Koninkrijk der Nederlanden over 1863-1864 pp. 21–24; 1864-1865 pp. 21, 28–45; 1865-1866 pp. 26–44; 1866-1867 pp. 35–56; 1867-1868 pp. 32–55; 1868-1869 pp. 24–35.

[308] Arnhemse Courant, 12-7-1869; Utrechtsch provinciaal en stedelijk dagblad, 13-9-1869.

[309] De wekker: weekblad voor onderwijs en schoolwezen 21 (13), 25-3-1864.

[310] Venloosch Weekblad, 13-5-1865.

[311] De Wekker: Weekblad voor onderwijs en schoolwezen 23 (16), 20-4-1866; Utrechtsch provinciaal en stedelijk dagblad, 25-9-1866.

[312] De Noord-Brabanter, 26-9-1868.

[313] Nieuw Rotterdamsche Courant, 7-10-1869; D. J. Steyn-Parvé (1875), "De Hoogere Burgerscholen in 1874".

[314] Arnhemse Courant, 10-1-1870; 7-2-1870. It is interesting to see that many of the Dutch physicists were in favor of women's education and rights. Most notable here is the influence of Aletta Catharina Kaiser (1858–1931), wife to Lorentz, through which Lorentz must have been inclined to supervise the doctorates of three out the first five women in the Netherlands. See A. van Steen (2011), "Aletta Lorentz-Kaiser en de Vrouwenbeweging in Leiden". Bosscha's unmarried daughter Jacoba Bosscha (1858–1924) was also a strong advocate of women

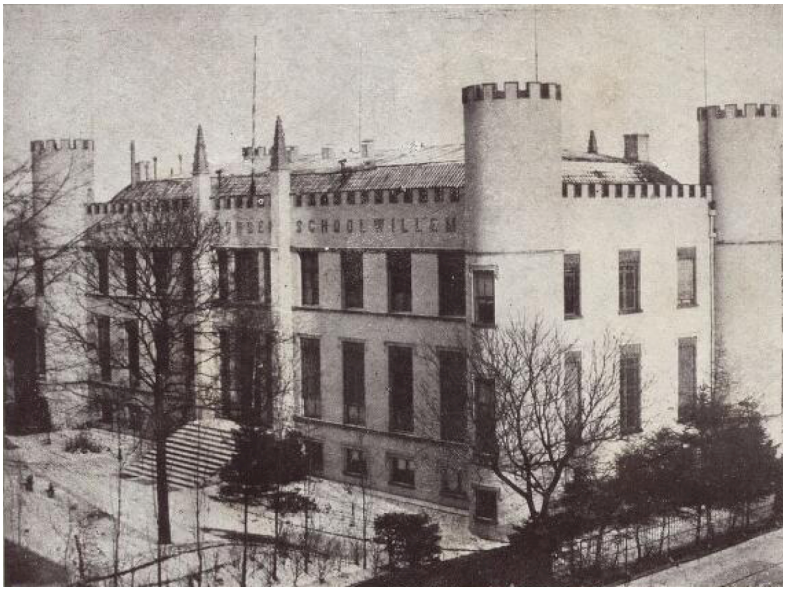


Figure 4.5: The HBS Koning Willem II in Tilburg, ca. 1900, Regionaal Archief Tilburg.

The case of Tilburg is a little bit better known because of an article written by G.H. Franssen about the foundation of that school.[315] Bosscha advised Thorbecke on all of the positions of teachers and director and was able to acquire the palace of the late Willem II (1792–1849) for the purposes of the HBS. We learn that on the north side of the palace a new building was erected for gymnastics and to house the physical and chemical laboratories. What we have learned here is that Bosscha played a big role in the appointment of teachers and the requirements of the buildings.

It must be noted here that in the southern provinces, there was a lot of resistance to the new school system from the Catholics. The Catholics were against an education with an emphasis on the natural sciences as they believed it led to materialism and atheism. Moreover, in these regions were the most fervent advocates of denominational, confessional education, of which the public and neutral HBS is basically the opposite. Bosscha, thus, actively sought catholic teachers who could appease the confessionals in these provinces:

> "Door godsdienstige gezindheid [katholiek] is hij [Huijsmans] meer dan anderen geschikt de bevolking van Tilburg en Brabant vertrouwen in te boezemen voor de school." [316]

rights. See A. E. M. C. Bergsma-Bosscha Erdbrink and J. Brewer (2012a), *Carmen, herinneringen 1894-1904*, pp. 157–158.

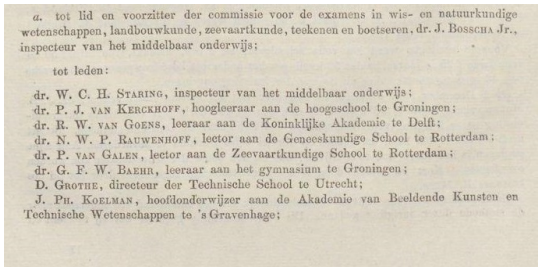
[315] G. H. Franssen (1990), "De Rijks-HBS 'Koning Willem II'".

[316] Translation: "Because of his religious beliefs [catholic] is Huijsman more than others fit to inspire trust in the people of Tilburg and Brabant." G. H. Franssen (1990), "De Rijks-HBS 'Koning Willem II'", p. 44.

We will see more of this confessional resistance to the schools in section 6.1. Lastly, together with Steyn Parvé, Bosscha wrote the first regulations for the HBS.

4.3.2 Acts of Competence

The second main task as inspector of Bosscha was presiding the acts of competence. One of the strong points of the law of 1863 is that it protected the profession of middle school teacher. One could now only become a teacher, on the penalty of a big fine, and even jail time, by obtaining the correct acts of competence or completing a university study.[318] This could guarantee the level of the prospective teachers. It also shows the increased importance of professionalism in society. Together with Steyn Parvé, Bosscha divided the examinations of the acts of competence ('aktes van bekwaamheid') between the two of them. From the start Bosscha was head of the committee for the examinations of the acts of competence for mathematics, then natural sciences, agriculture, maritime science, drawing and sculpting. Steyn Parvé was head of the committee for Dutch language and literature, history, political sciences, economy, the modern languages and literature, penmanship and gymnastics. Every year, the committee wrote a report to the minister on the results of and issues with the acts of competence and this was published in the 'Verslag van den staat der hooge-, middelbare en lagere scholen' that I have consulted for this study.


a. tot lid en voorzitter der commissie voor de examens in wis- en natuurkundige wetenschappen, landbouwkunde, zeevaartkunde, teekenen en boetseren, dr. J. Bosscha Jr., inspecteur van het middelbaar onderwijs;

tot leden:

dr. W. C. H. Staring, inspecteur van het middelbaar onderwijs;
dr. P. J. van Kerckhoff, hoogleeraar aan de hoogeschool te Groningen;
dr. R. W. van Goens, leeraar aan de Koninklijke Akademie te Delft;
dr. N. W. P. Rauwenhoff, lector aan de Geneeskundige School te Rotterdam;
dr. P. van Galen, lector aan de Zeevaartkundige School te Rotterdam;
dr. G. F. W. Baehr, leeraar aan het gymnasium te Groningen;
D. Grothe, directeur der Technische School te Utrecht;
J. Ph. Koelman, hoofdonderwijzer aan de Akademie van Beeldende Kunsten en Technische Wetenschappen te 's Gravenhage;

Figure 4.6: The first committee of the acts of competence of 1864.[317]

These exams were notoriously hard.[319] In the first year, only 9 out of the total 25 examined succeeded in obtaining their act of competence. In the second it was even worse, 14 out of 42 passed, an these percentages persisted throughout the years. Bosscha clearly required a high level from his prospective teachers:

> "Aan de eischen, bij het examen in natuur- en scheikunde gesteld, konden alleen diegenen behoorlijk voldoen, die de akademische lessen hadden bijgewoond. Het schijnt uiterst moeijelijk om in deze vakken degelijke kennis te verkrijgen door eigen studie, wanneer men niet beschikken kan over de hulpmiddelen van een welvoorzien

[317] Verslag van den staat der hooge-, middelbare en lagere scholen in het Koningrijk der Nederlanden over het jaar 1864-1865, p. 66.
[318] D. J. Steyn-Parvé (1863), *De Wet tot Regeling van het Middelbaar Onderwijs*, pp. 208–209.
[319] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, p. 12.

natuurkundig kabinet en van een goed ingerigt chemisch laboratorium. Dààr vooral is praktische oefening voor den aanstaanden onderwijzer onmisbaar." [320]

Clearly, an academic level was required as well as some competence in practical exercises. In this position as examiner Bosscha met and examined Van der Waals and Diederik Johannes Korteweg (1848–1941).[321] In fact, Van der Waals is implicitly mentioned in the report that Bosscha wrote:

"Ten opzigte van de laatstgenoemde acte A zij het nog opgemerkt, dat één van de beide candidaten, die zich hiervoor hadden aangemeld, reeds de acte van bekwaamheid voor verder voortgezet onderwijs in wis- en natuurkunde volgens art. 72 der wet van 13 Augustus 1857 verkregen had. [...] De Commissie achtte het daarom onnoodig bij dezen candidaat onderzoek te doen naar de bekwaamheid in de wis- en natuurkunde."[322]

Van der Waals did, in fact, obtain his act in July 1864 and already obtained several of the older acts.[323] Already in the first year of the committee, it was required for the prospective teachers to be able to do practical exercises. In the exams they were asked to show their competence in the preparation of instruments, preparation of chemicals, etc.:

"Aangezien het onderwijs in de natuurwetenschappen niet vruchtbaar kan gemaakt worden zonder proefnemingen en zonder uit eigen aanschouwing verkregen kennis der voorwerpen uit de onderscheidene natuurrijken, zoo heeft de Commissie het noodig geoordeeld, van den aanstaanden onderwijzer ook praktische kennis in dezen te eischen. Daarom zijn bij het examen in praktische natuur- en scheikunde de examinandi in de gelegenheid gesteld om toestellen in orde te brengen, eenige stoffen te bereiden en bedrevenheid in handgrepen te toonen." [324]

[320] Translation: "Only those who followed the academical lessons could pass the requirements the exams in physics and chemistry. It seems to be very difficult to obtain decent knowledge in these subjects by self-study when one does not have the tools of a well equipped natural cabinet or a well furnished chemical laboratory available. Especially there practical training for the prospective teacher is indispensable." Verslag van den staat der hooge-middelbare en lagere scholen in het Koninkrijk der Nederland over het jaar 1864-1865, Bijlage, p. 10-11.

[321] Baarn-Archive: Autobiography

[322] Translation: "In the case of the last mentioned act A it must be noted that one of the two candidates that had registered already had obtained an act of competence for secondary education in mathematics and physics according to article 72 of the law of August 13th 1857. The committee deemed it unnecessary to conduct further investigation of this candidate's competence in mathematics and physics." Verslag van den staat der hooge-, middelbare en lagere scholen in het Koninkrijk der Nederlanden over het jaar 1864-1865, Bijlage, p. 10.

[323] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, pp. 8–9.

[324] Translation: "Noting that the education in the natural sciences cannot be effective without experiments and without seeing by observing the obtained knowledge of the objects from the different realms of nature, the committee deemed it necessary to require practical knowledge from the prospective teacher as well. That is why in the exams of practical physics and chemistry the candidates were given the opportunity to prepare the instruments and some chemicals to show their competence in practical work." Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederland over het jaar 1864-1865, Bijlage, p. 7.

Bosscha remained head of this committee until 1871 and was a regular member in 1874, 1875, 1877 and 1878. He was also part of a committee to examine government officials bound for the Dutch Indies from 1864 to 1868. Thirdly he was the head of the committee of exams of HBS students in Limburg 1867, Gelderland 1868, Utrecht 1870 and Gelderland again in 1871. Lastly, almost every year until his 'retirement' in 1885, Bosscha was part of the exam committee of the Polytechnical School.[325] Note that Van der Waals was in the Utrecht committee together with Bosscha in 1870, shortly before Bosscha and Van der Waals worked together on capillarity, see section 5.3.

It is still an open historical question what the exact contents of the exams were or what the exact program of the lessons in physics and chemistry at the HBS was. Although it is known which subjects were taught and how many hours,[326] little is known about the subject material discussed in the lessons, or, in fact, which textbooks were used.[327] The regulations only stated that the schools should send their program of lessons to the minister of internal affairs each year. To ensure the quality of the education the inspectors advised to make entry and passing exams mandatory, but Thorbecke did not deem this necessary. This, however, was too liberal to work in practice and the level of the students dropped because students followed courses that were above their current level. Eventually, but only after the death of Thorbecke in 1873, these mandatory exams were implemented.[328]

We can only infer by knowledge of Bosscha's ideals on science that quantitative measurements and insight of the phenomena played a role in the physics education and practical exercises at the HBS. The fact that the level of education in the sciences rose, is evident already because there was hardly any education in these subjects before 1863 and because of the excellent teachers that were attracted to the HBS.

[325] Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederland over het jaar 1864, until 1884; Nederlandse Staatscourant, 22-9-1864; 8-6-1865; 9-6-1865; 30-7-1865; 12-8-1865; 25-5-1866; 29-5-1866; 12-11-1866; 23-2-1867; 11-5-1870; 18-6-1872; 1-2-1873; 11-6-1873; 1-2-1873; 11-6-1873; 9-6-1875; 20-10-1875; 7-6-1876; 31-5-1877; 7-6-1878; 9-6-1879; 31-10-1879; 14-2-1880; 30-10-1880; 23-5-1881; 30-12-1881; 22-5-1883; 9-10-1883; 13-5-1884; 24-11-1884.

[326] See for instance D. J. Steyn-Parvé (1875), "De Hoogere Burgerscholen in 1874".

[327] The only subjects for which this has been thoroughly researched is mathematics and history: See J. Krüger (2014), *Actoren en Factoren*; H. T. A. Amsing (2002), *Bakens verzetten in het voortgezet onderwijs*. A good starting point for research on the contents of the lessons at secondary education in the Netherlands is the local archives of the schools themselves and their commemorative books to find out which textbooks were used and subsequently compare the contents of these textbooks. Moreover one could look at the archives of the minister of internal affairs: The schools were obliged to send in their program of lessons. For a study on physics textbooks in France and Germany, see J. Simon (2012), "Secondary Matters".

[328] A. Bartels (1963), *Een Eeuw Middelbaar Onderwijs*, pp. 94–95.

[329] H. G. van de Sande Bakhuyzen (1911), "J. Bosscha".

Figure 4.7: Bosscha in 1871.[329]

4.3.3 Teachers at the HBS

The inspectors were able to attract the very best teachers because they offered a great salary. Many teachers who taught at a predecessor school obtained double the salary after switching to an HBS.

> "Aanvankelijk scheen de moeijelijkheid om voor de talrijke in een betrekkelijk kort tijdsverloop opgerigte scholen geschikte leeraren te vinden niet gering. De ondervinding toonde evenwel dat men zich zonder grond bezorgd had gemaakt. De behoorlijke jaarwedden aan de nieuwe betrekkingen verbonden hebben velen, niet alleen onderwijzers bij het lager en hooger onderwijs, maar ook officieren, ingenieurs, advocaten en predikanten, uitgelokt in het middelbaar onderwijs eenen nieuwen werkkring te zoeken."[330]

This made the HBS and, indirectly, the academic study to become doctor in the natural sciences, popular. Becoming a teacher at an HBS was now an interesting perspective for the student of the natural sciences, outside of an academic career. The high salary also indicates the higher social status for practitioners of the natural sciences, which is reflected in their increasing importance in industry and impact in society. Conversely, because of the high salary, the inspectors could set the bar very high and at the same time attract excellent teachers.

As one might recognize in Table 4.1, many of the teachers at the HBS in the natural sciences were excellent. Many of them later became university professors: Van Bemmelen became professor of chemistry in Leiden, Pieter van Geer (1841–1919) became professor of mathematics in Leiden, Van der Waals became professor of physics in Amsterdam, Hendrik Cornelis Dibbits (1838–1903) and Hendrik Wefers Bettink (1839–1921) became professors of respectively chemistry and pharmacy in Utrecht, Van de Sande Bakhuyzen professor of astronomy in Leiden, Cornelis Bellaar Spruyt (1842–1911) became professor of philosophy at Amsterdam, Modderman became professor of chemistry in Groningen, Eduard Alexander van der Burg (1833–1890) became professor of pharmacology in Leiden, L. Aronstein (1841–1913) became professor at the Polytechnical School. Some of the teachers were already professor at the Polytechnical School or athenea: Marinus Johan Cop (1818–1876), Van der Willigen and notably Combertus Pieter Burger (1825–1908). Note that we find the names of two of Bosscha's pupils from chapter 1: Schroeder van der Kolk and Van Oven. Many of the others remained closely related to scientific endeavors, which they were able to do, because of the

[330] Translation: "Initially it seemed hard to find the many competent teachers for the schools founded in the relatively short time. Experience has shown that we have worried without cause. The lofty salary that came with the new occupations have evoked not only many teachers of lower and higher education, but also generals, engineers, lawyers and pastors to find a new sphere of action with the middle class education." Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederlanden over het jaar 1866-1867, p. 42.

excellent laboratories at their disposal. The most notable of these was probably the interesting historical figure Logeman, who founded *Album der Natuur* together with Harting in 1852 and subsequently *Wetenschappelijke Bladen*, a Dutch scientific review journal in 1856.

In fact, the scientific world and the world of education were not wholly separate worlds at the time. In 1867 Bosscha invited the teachers of the HBS to do astronomical observations to aid Prof. Martinus Hoek (1834–1873) of Utrecht in his research on meteorites.[331] The teachers of the HBS were supposed to aid science with the tools available in their laboratories. The second proof that the teachers of HBS were considered part of the physical scientific community stems from a complaint at the fourth biannual Nederlandsch Natuur- en Geneeskundig Congres: Physicists (including the teachers) were performing too few experiments and the cause of this was that they lacked the good instruments. A committee was assembled consisting of Kamerlingh Onnes, Haga and Bosscha to write a report on how to perform high level experiments with few tools. Two years later at the next congress the report presented by Bosscha was crystal clear. No advanced instruments were necessary to perform significant experiments. In fact, there was a great need for the verification and calibration of simple instruments and preparation of pure substances for research. Here, in precision, the teachers could make themselves useful. All the teachers needed was 'study, practical competence and sheer will.'[332] The HBS teachers in many aspects bridged the gap between science and society. They were sometimes considered part of the scientific community and in any case many had an academical degree and would continue in an academic career. On the other hand the teachers, as teachers of a public school, had a public function and stood in the middle of society. We see not only many popular science publications, but also purely scientific publications by HBS teachers at this time.

4.3.4 Reorganizaton of the Royal Military Academy of Breda

In 1867, as inspector, Bosscha was called in to advise on the reorganization of the Royal Military Academy.[333] The level of education and organization of the Royal Military Academy was long thought to be narrow-minded and faulty. However, the minister of war completely ignored the councils of the committee and implemented 'an even worse system'.[334] Bosscha complains about it to his father:

> "Met al die [onleesbaar] vind ik den tijd niet om mijne gedachten te verzamelen voor het een of ander protest tegen de onvergefelijke wijze waarop de minister, met voorbijgaan van het rapport der commissie, thans het onderwijs der Militaire Akademie

[331] Delftsche Courant, 26-11-1867.
[332] F. van Lunteren (1995), "Van Meten tot Weten", pp. 102–103; J. Bosscha Jr., H. Kamerlingh Onnes, and H. Haga (1895), "Rapport omtrent physische onderzoekingen die met weinige hulpmiddelen zijn te volvoeren".
[333] Bredasche Courant, 10-1-1867. See for the advice: Dagblad van Zuidholland en 's Gravenhage, 11-7-1867.
[334] Nieuwe Rotterdamsche courant, 6-6-1867.

geregeld heeft. In allen ernst houd ik de vroegere regeling voor beter dan de thans ingevoerde." [335]

The main problem seems to be is that the committee proposed to cancel the admission exam if aspirants have graduated from a 5-year HBS, but that the minister implemented a "medieval" (according to Bosscha) admission exam that promoted only going to a MULO school (an extended primary school) and subsequently preparing solely for the KMA exam. This was basically a setback for the possibilities of students after graduating from the HBS,[336] and shows the conservative and anti-HBS disposition of the current minister of internal affairs Jan Heemskerk Azn. (1818–1897). For more about the role of conservatism, see chapter 6.

4.4 The 'Laboratories' of the HBS

We have already mentioned that it was required for the teacher at the HBS to be able to perform practical exercises in physics and chemistry. In the 'memorie van toelichting' (explanatory memorandum) that Thorbecke gave in 1863, Thorbecke explained that it was only 'natural' that the students needed to do practical exercises in the natural sciences:

"Onder toepassingen [der natuurkunde] en [der scheikunde] worden geenszins alleen technische toepassingen, maar ook kennis, toegepast op het dagelijksch leven en op verschijnselen, die elk om zich ziet of kan waarnemen, verstaan. Dat de leerlingen in de gelegenheid gesteld zullen worden zich ook praktisch in de scheikunde te oefenen, spreekt van zelf." [337]

This is peculiar, because, for physics at least, laboratories and practical exercises at schools were unprecedented in the Netherlands. Chemistry was connoted with laboratory work since centuries, but a physical laboratory was basically a new idea. Thus, according to Thorbecke each school needed, apart from normal classrooms, laboratories for physics and chemistry. It seems plausible that given Bosscha's ideal on research in the natural sciences, Bosscha set them up in a modern way. This feat is often attributed to Bosscha and is mentioned in every short biography or description of his life, for example:

[335] Translation: " With all these [unreadable], I do not find the time to collect my thoughts for a protest against the unforgivable way the minister organized the education at the military academy, completely neglecting the report of the committee." Baarn-archive: Letter from J. Bosscha Jr. to J. Bosscha Sr., 17-5-1867.

[336] Dagblad van Zuidholland en 's Gravenhage, 2-8-1867.

[337] Translation: "By applications of physics and chemistry by no means do we only mean technical applications, but also knowledge applied on daily life and on phenomena that everyone can see around him. That the students should be given opportunity to train themselves practically in chemistry follows naturally". Cited in D. J. Steyn-Parvé (1863), *De Wet tot Regeling van het Middelbaar Onderwijs*, p. 227.

> "Dat hij bijzondere zorg had voor het totstandkomen van afzonderlijke zalen voor het natuur- en scheikundig onderwijs en bijbehoorende laboratoria aan elke Hoogere Burgerschool zal wel geen bevreemding wekken."[338]

In the 'Verslagen' we read that there was a strong emphasis on the availability of these rooms for the natural sciences and that it was of utmost importance that the schools obtained good rooms and instruments: Whether or not the 'rooms for physics and chemistry' were satisfactory was almost always mentioned in the report. For example in Middelburg, it was a prerequisite that these rooms were made available:

> "De gemeente Middelburg wenschte eene Rijksschool van vijfjarigen cursus. De Minister, [...] wilde dit verlangen gaarne in overweging nemen; doch wenschte vooraf te vernemen [...]: Zou de gemeente de noodige localen ter beschikking stellen, en zoo ja, welke? In de tweede plaats behoort zekerheid gegeven te worden, dat van de verschillende aanwezige hulpmiddelen voor natuurwetenschappelijk onderwijs voor de te stichten school partij kunne worden getrokken." [339]

The instruments and rooms for the HBS are usually acquired by the city and the state subsidizes these purchases. Interestingly, the declining local scientific societies happily donated their instruments to the HBS on several occasions. For instance in Zutphen:

> "Reeds bij de opening was de school in het bezit van eene niet onbelangrijke verzameling van hulpmiddelen voor het onderwijs. Een in de gemeente gevestigd natuurkundig gezelschap had eene verzameling van natuurkundige instrumenten en toestellen en van natuur-historische voorwerpen welwillend ten gebruike bij het onderwijs der hoogere burgerschool afgestaan."[340]

The situation in Zutphen was very positive indeed, because they already had special rooms for the laboratories:

[338] Translation: "that he took care of the establishment of separate rooms for education in physics and chemistry, with accompanying laboratories, at each HBS will not be perceived as out of the ordinary." H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 114.

[339] The municipality of Middelburg desired a state funded school with a 5 year program. The minister, [...] would gladly consider this wish but wants to inquire beforehand [...]: Would the municipality make the necessary rooms available, and if so, which ones? Secondly it must be certain that the several tools already present for education in the natural sciences are available for use at the to be founded school." Verslag van den staat der hooge- middelbare en lagere scholen in het Koninkrijk der Nederlanden over het jaar 1863-1864, p. 22

[340] Translation: "Already at the opening of the school, the school was in possession of a not unimportant collection of instruments for education. A physical society based in the city donated a collection of physical instruments and machines and a collection of natural-historical objects for use in education." Ibid. 1864-1865, p. 30.

> "Het gebouw [...] bevat [...] eene leerzaal voor scheikunde met twee laboratoria, eene leerzaal voor natuurkunde met een vertrek voor het natuurkundig kabinet en een laboratorium." [341]

In Deventer and Maastricht, the Athenaeum, - which in case of Deventer would later be absorbed into the HBS and in case of Maastricht was already discontinued - provided the collection of scientific instruments and also the already available rooms for laboratories.[342] Several other examples in which it is explicitly mentioned that appropriate rooms for physics and chemistry were available with a collection of tools and laboratories include the HBS of Gouda, Roermond and 's Hertogenbosch.[343]

According to many later anecdotes, these rooms were state of the art and better than most of the academic laboratories at the time. For instance the paleontologist Eugène Dubois (1858–1940) calls everything excellent at the HBS, the teachers, the laboratories, the collections and the garden:

> "De hbs te Roermond [...] is voor mij misschien van meer beteekenis geweest dan de universiteit [...]. Ik geloof, dat als ik op een gymnasium was gekomen, veel van mijn natuurwetenschappelijken aanleg ware verloren gegaan [...]. De hbs te Roermond is voor mij een kleine universiteit geweest [...]. [Zij was] voorzien van voortreffelijke leeraren en ingericht wel zoo goed als de universiteiten van dien tijd, uitmuntend chemisch laboratorium, groote zoölogische, mineralogische en petrografische verzameling, en mooie plantentuin."[344]

Kamerlingh Onnes, when he first went to university, complained about the state of the chemistry laboratory of the University of Groningen, and deemed the laboratory of the HBS superior:

> "Heike klaagde steen en been over de gang van zaken in het Chemisch Laboratorium. [...] De manier van werken op het Chemisch Laboratorium vond Heike 'geknoei' en de kwalitatieve analyses die er dagelijks uitgevoerd werden bestempelde hij als een

[341] Translation: "The building contains a study room for chemistry with two laboratories and a room for physics with a chamber for the physical cabinet and laboratory." Ibid. 1865-1866, p. 30.
[342] Ibid. 1864-1865, p. 31–32.
[343] Ibid. 1865-1866, p. 28–29; Ibid. 1867-1868, p. 48.
[344] Translation: "The HBS in Roermond has maybe been of more importance to me than the university. I believe, that if I had been at a gymnasium, many of my talents for the natural sciences would have been lost. The HBS of Roermond has acted as a small university for me. She was equipped with excellent teachers and furnished as well as the universities were. Excellent chemical laboratory, big zoological, mineral and petrographic collection and a nice botanical garden." Cited from B. Willink (1998), *De Tweede Gouden Eeuw*, p. 32.

> 'modderpoel'. Teleurgesteld liet hij zich weer inschrijven bij het chemisch practicum op de hbs." [345]

The Nobel prize winners Jacobus van 't Hoff (1852–1911) and Lorentz used the laboratories of the HBS to do experiments as well. Van 't Hoff 'broke into' the school in weekends to perform experiments[346] and Lorentz went to the laboratory on Sunday mornings:

> "Occasionally, on Sunday mornings, [Lorentz and Otto Lincker, assistant at the school!] we would go to the little laboratory connected with the High School, where van de Stadt was teaching at the time, and of which he later became headmaster. We did this without asking his permission, always taking care, however, that we left everything in proper order."[347]

All in all, the HBS provided excellent education in the natural sciences and many of its graduates went on to university. Notable examples in the physics are Lorentz, Zeeman and Kamerlingh Onnes, in chemistry: Hendrik Bakhuis Roozeboom (1854–1907), Van 't Hoff. Conversely, a teacher's position at the HBS was for many the step between their doctorates and an academic career. The opposite of what Thorbecke had in mind also happened. Because of the excellent education in the natural sciences, some parents from the upper class also sent their children to the HBS. Notable examples here are van Van 't Hoff and Willem Einthoven (1860–1927).

4.4.1 The Laboratory of Utrecht

A direct consequence of the foundation of the HBS is that the amount of university students in the exact sciences increased. On the one hand this was possible because the graduates of the HBS were more interested in the natural sciences, and on the other hand it was now possible to have some career perspective with a study in the natural sciences. Interestingly, the quality of the practical exercises at the HBS was so high that the university students of Utrecht started to complain about the state of their education in practical exercises. In 1867 in the Studenten Almanak, the students complained that the laboratory rooms of the HBS were better than at the University:

[345] Translation: "Heike complained bitterly about the way things went in the chemical laboratory. The way of working at the chemical laboratory was 'messy' according to Heike and qualitative analyses that were done daily he branded a 'mud-pool'. Disappointed he registered again at the chemical exercises of the HBS." D. van Delft (2005), *Heike Kamerlingh Onnes*, p. 60. 'Modderpoel' was a reference to chemistry Prof. Modderman, who was supposedly better at writing popular science than at science itself.

[346] B. Willink (1998), *De Tweede Gouden Eeuw*, p. 99.

[347] G. L. de Haas-Lorentz (1957), *H.A. Lorentz*, pp. 27-28.

[348] "Johannes Bosscha" (1881). In: *Illustrirtes Konservations-Lexikon.* Vol. 9. Leipzig und Berlin: Otto Spamer.

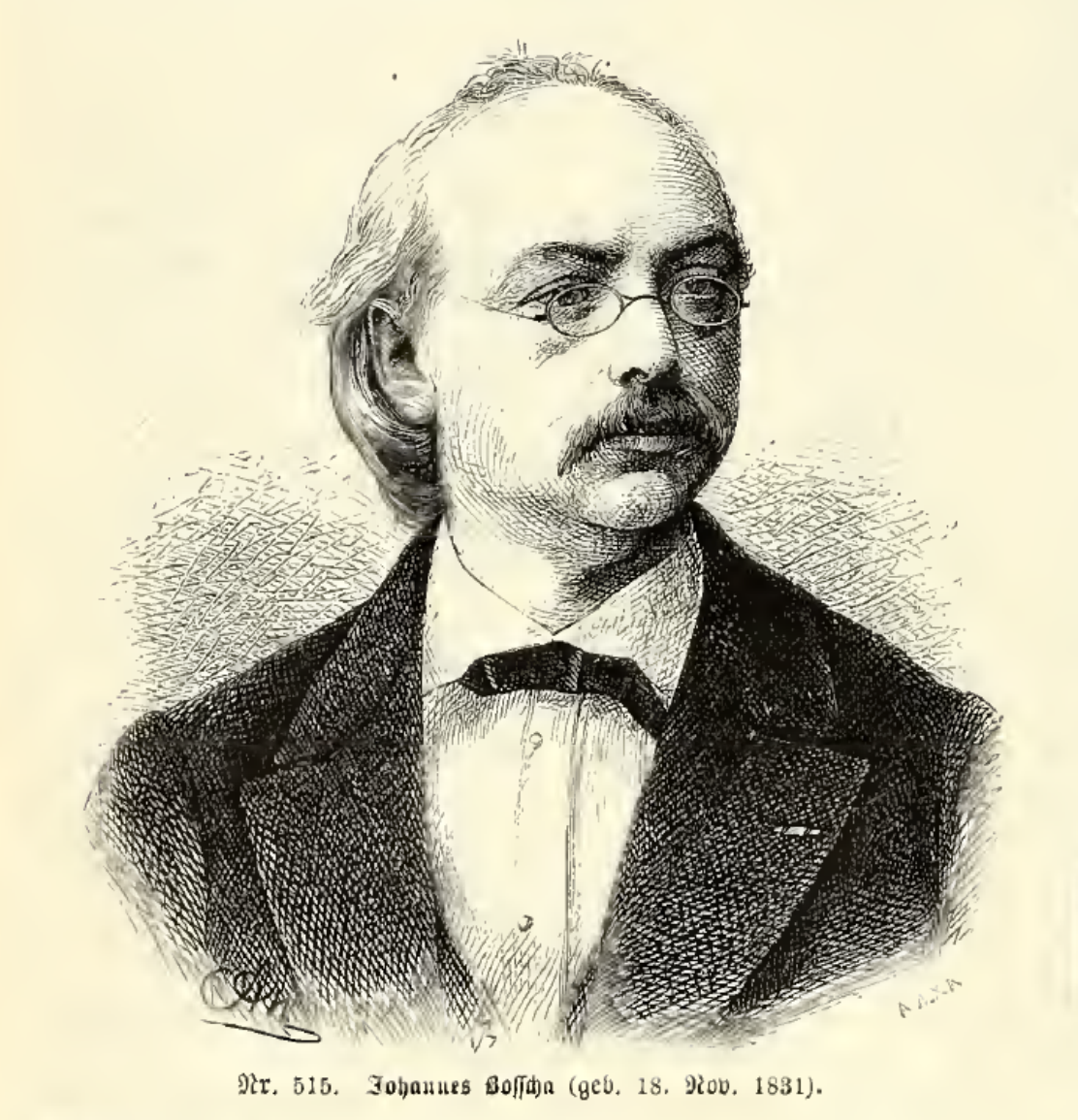


Figure 4.8: Bosscha as inspector.[348]

> "Wie, die de eerste uitvoering van de wet beleefde, herinnert zich niet de flinke, oordeelkundig ingerichte gebouwen met hunne ruime leerzalen en hun fonkelnieuwe laboratoria. Te Utrecht b.v. wekte de H.B.S. 5-j.c. den naijver op van den academieburger, die daaraan uiting gaf door in den Studenten Almanak (van 1867) boven elkaar te plaatsen afbeeldingen van het oude Academiepoortje en de Rijks Hoogere Burgerschool in de Kruisstraat. Vergeleken bij de gebouwen voor M.O. leek alles oud, ouderwetsch en verouderd. Inderdaad, de Hoogere Burgerschool nam de leiding!" [349]

In 1870 the students (and later professors) Victor August Julius (1851–1902), uncle to Dutch founder of solar physics Willem Henri Julius (1860–1925), and Hendrik Jan Rink (1847–1883) asked for a better laboratory and an assistant for practical exercises.[350] They explicitly mentioned, that they must become competent in practical exercises in order to able to teach at the HBS. Together with the complaints of Buys Ballot this resulted in a new physical laboratory that opened its doors in 1877. Maurits Snellen (1840–1907), teacher at the HBS of Delft was appointed as the assistant. To be noted, this laboratory was for a long time not for research purposes, but solely used to become competent in practical exercises.[351] Indirectly, Bosscha's endeavors established not only the laboratories of the HBS, but also a new academic laboratory of Utrecht. Note that this laboratory and it's instruments would remain unused until Julius became assistant in the laboratory in 1882.[352]

4.5 A Better Preparation for the Sciences

The general idea in Western Europe was that the classical languages were essential to become civilized with a refined mind and for having a coherent education. This is the so-called *Bildung* in Germany or *culture générale* in France. In the Netherlands, this idea was dominant as well. HBS students, therefore, lacking the classical languages, in principle could not go to university, unless they did additional admission exams in Greek and Latin. This was an eyesore to the modern ideals of Bosscha who was a strong advocate of access to the university for HBS students. At the International Conference on Education in London, 1884, Bosscha explained to the conference how the secondary education system in the Netherlands worked.[353] He explained that after

[349] Translation: "Of those who experienced the first implementation of the law, who does not remember the grand, expertly equipped buildings with their spacious class rooms and brand new laboratories. In Utrecht for example the HBS with 5 year program made the 'academy-citizen' jealous, who expressed this in the Studenten Almanak (of 1867) by placing pictures of the old academy gate next to the States HBS in the Kruisstraat. Compared to the buildings of the Middle Class education everything looked old, old-fashioned and outdated. Indeed, the HBS took the lead!" Algemeen Handelsblad, 30-4-1913.

[350] Note that Rink also studied at the Polytechnical School under Bosscha and Bosscha presented one of his papers at the KNAW. Nederlandsche Staatscourant, 2-2-1877.

[351] F. van Lunteren (1995), "Van Meten tot Weten", pp. 51, 57–59.

[352] H. G. Heijmans (1992), "De ontwikkeling van het Utrechts Natuurkundig Laboratorium tot Fotometrisch Instituut".

[353] Bosscha was representative of the Dutch government. Nederlandsche Staatscourant, 7-7-1884.

1863 there was the HBS and the gymnasia, both of which in practice provided students for university. According to the statistics published by Dr. D. de Loos, many HBS abiturients ended up studying at university and quite successfully too. Bosscha notes that many of these were appointed as assistants of the professors in laboratories and hospitals, vouching for their excellence in their respective fields.

> "The successful education of such a large number of ex-scholars of the 'hoogere burgerscholen' may be deemed sufficient proof that the natural philosophy and medicine may be studied with quite satisfactory results without a classical education."[354]

Bosscha, as we can see, was an advocate of the new education ideal.[355] Moreover, in 1878 there was a shortage of doctors, so the government decided to open up the study of medicine to a larger group. The HBS students would now be allowed to apply for the study of medicine, without any additional exams. They could become doctor in this way, however, they formally did not obtain the academic doctorate and the option of obtaining a doctorate.[356]

In 1885, Bosscha's lifelong friend Prof. J.M. van Bemmelen wrote an article where he argued that the HBS was in fact a better preparation for the study of medicine than the gymnasium. He backed up his argument with the statistics of the propedeutic exams of the medicine students coming from either the HBS or the gymnasium between 1876 to 1884. The results were highly in favor of the HBS. Still, Van Bemmelen argued that not only the difference between the curriculum of the two school types is important. The HBS was populated with people from lower classes than the gymnasium. While almost all of the gymnasium students went to university, only the most daring, willing and successful students of the HBS went on to university, because of the many obstacles on their path. Van Bemmelen concludes that the students from the HBS should be allowed to study medicine and the natural sciences. [357] It would take until 1917 until the HBS students would be allowed to go to university without any additional exams.

[354] J. Bosscha Jr. (1884), "On Secondary Education in the Netherlands".
[355] H. T. A. Amsing (2005), "Modern versus classical education: The Dutch case 1863-1917".
[356] H. T. A. Amsing (2002), *Bakens verzetten in het voortgezet onderwijs*, pp. 80–86; C. Bellaar Spruyt (1887), "De kwalen van ons gymnasiaal onderwijs".
[357] J. M. van Bemmelen (1885), *De opleiding der aanstaande studenten in de geneeskunde aan de gymnasia en aan de Hoogere Burgerscholen*; De wekker; nieuwe bijdragen voor het onderwijs 42 (87), 31-10-1885.

Chapter 5

Bosscha's Textbook on Physics

Bosscha wrote a most successful textbook on physics initially designated to be used at the schools. The title: 'Leerboek der Natuurkunde en haar voornaamste toepassingen' (Textbook of physics and her most important applications) was exactly the same as the course title at the HBS: 'Natuurkunde en haar voornaamste toepassingen'. In this chapter I will discuss the history of the writing process, the success and influence of the textbook as well as the connections Bosscha made via the textbook to the physics community in the Netherlands.

Bosscha's own research in physics in this period is always related to the contents of the textbook. Indeed, a most peculiar aspect of the textbook is that Bosscha incorporated his own and very recent experimental results into the book.[358] section 5.2 and section 5.3 discuss Bosscha's research on respectively thermometry and capillarity that was incorporated into the textbook. Bosscha saw this as one of the strong points of his textbook. The method in which Bosscha treats the molecular forces in his textbook, guided by original experiments, shows the true value of his book; it is academic:

> "Mijns inziens kan men, zoo men reeds daarvoor moeite wil geven, het daarin veel verder brengen dan men gewoonlijk meent en de proeven die ik daarvan in mijn tegenwoordig leerboek gegeven heb in het hoofdstuk van de moleculaire krachten van geluid en van licht, proeven die geheel oorspronkelijk zijn bewijzen dit. Juist in deze wijze van behandeling en de daarmede verkregene uitkomsten zie ik de eigenlijke waarde van mijn boek."[359]

[358] This is not unprecedented, as, for instance, Maxwell did the same for his new theoretical results in the *Treatise for Electrodynamics*, which was a textbook for Cambridge mathematicians.

[359] Translation: "In my opinion, if someone would take the effort, he would be able to make it a lot further than is usually assumed, and the experiments that I have given in my current textbook in the chapter of molecular forces of sound and of light, experiments that are entirely original prove this. Especially in this treatment and with the given results I see the true value of my book." Letters to Sijthoff, 24-3-1876, UB Leiden SYT A 1876.

LEERBOEK.

DER

NATUURKUNDE

EN

VAN HARE VOORNAAMSTE TOEPASSINGEN

DOOR

Dr. J. BOSSCHA Jr.

EERSTE DEEL.

TE LEIDEN, BIJ A. W. SIJTHOFF.

1875.

Figure 5.1: The cover of the '75 edition of Bosscha's textboook.

As we recall from the previous chapter, Bosscha saw the textbook as his most important contribution to the field of physics. This shows again that Bosscha thought education to be most important.

5.1 History of the Textbook

Already in 1857 Bosscha was approached by Sijthoff to write a Dutch textbook on physics called *Handboek der Natuurkunde.*[360] However, "velerlei omstandigheden hebben mij belet aan de zaak gevolg te geven,"[361] and nothing came to be.

As professor in Breda, the Royal Military Academy asked Bosscha to write a new textbook on physics to be used in the courses on physics at that school. The school still used Willem Wenckebach (1803–1847)'s *Natuurkundige Stellingen* from 1842. He does not seem overly happy to have to do this, as the needs of the Academy will force him to keep it short: "waarschijnlijk zal ik bij de samenstelling daarvan wel gedwongen zijn eenige beknoptheid in acht te nemen."[362] Bosscha's aim was much higher. He wanted to write a textbook to be used at the Hoogere Burgerscholen and the Polytechnical School, - those schools did not exist at the point of writing this letter to Sijthoff, - not aimed only at being a textbook, but at being a 'book of study': "Hetgeen thans bedoeld wordt is niet zoozeer een leerboek, als wel een studieboek, een schoolboek voor hoogere studie."[363] Bosscha did not doubt the success of his own textbook or the sales as the plans of the government would include at least 100 students a year, of whom all would need to buy his textbook. Lastly, his textbook would include better figures than in the existing textbooks:

> "Onder de voorwaarden die ik meen te kunnen bedingen, [...] maar ook eene zeer zorgvuldige uitvoering wat [...] figuren aangaat, en dit laatste ook in uw belang, want ik houd mij overtuigd dat de zeer gebrekkige figuren in de leerboeken van Crüger, Logeman, en van Steyn Parvé het debiet werkelijk benadelen."[364]

[360] Letters to Sijthoff, 12-6-1857, UB Leiden SYT A 1857. In F. van Lunteren (2000), "Aantrekkende Krachten", p. 253, this date is wrongly set at 1864. This is probably the date that Sijthoff and Bosscha agreed on writing a textbook *intended for* the HBS. The confusion is natural: Bosscha himself writes in the introduction of the '75 edition of his textbook: "Toen de uitgever, de heer Sijthoff, mij in 1864 aanzocht ten behoeve der middelbare scholen een leerboek der natuurkunde samen te stellen..." Translation: "When the publisher, Mr. Sijthoff, asked me in 1864 to write a physics textbook intended for the middle class schools..." J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, p. vi.

[361] Translation: "many circumstances have kept me from carrying out the matter." Letters to Sijthoff, 1-8-1862, UB Leiden SYT A 1862.

[362] Translation: "I probably will be forced to keep in mind some brevity in assembling [the textbook]." Letters to Sijthoff, 1-8-1862, UB Leiden SYT A 1862.

[363] Translation: What I intend at this moment is not just a textbook, but also a book of study, a school book for higher learning." Ibid.

[364] Translation: "I hope to bargain for these conditions. About the careful implementation of figures, this is also in your favor, because I am convinced that the faulty figures in the textbooks of Crüger, Logeman, and of Steyn Parvé truly hurt their sales numbers." Ibid.

5.1.1 The Competition

The textbooks Bosscha mentioned in his letter are: Two translations of Ferdinand Emil Johannes Crüger (1822–?)'s *Grondbeginselen der Natuurkunde* and *Handleiding tot de Beoefening der Natuurkunde*, Steyn Parvé's *Leerboek der Natuurkunde* and Logeman's *Natuurkundig Schoolboekje*. Both Logeman and the translator of F.E.J. Crüger's work J.H. van Kooten were teachers at a gymnasium. Logeman would later become teacher at and director of an HBS, and as we have seen, he was the founder of *Album der Natuur*. In a second edition of Logeman's book, he explicitly changes the name of his book to show that it was intended for the HBS: *Natuurkundige Stellingen, een Handboekje ten Gebruike bij het Onderwijs in de Physica aan Hoogere Burgerscholen*. Steyn Parvé also explicitly states that his textbook is intended for the HBS:

> "Bij de zamenstelling van dit leerboek is het voornamelijk mijne bedoeling geweest het zoodanig in te rigten, dat het geschikt was om bij het middelbaar onderwijs gebruikt te worden. Wel is waar is het er nog verre van af, dat in alle gymnasien en andere middelbare scholen de natuurkunde onderwezen wordt; maar het is te verwachten, dat bij eene regeling van het middelbaar onderwijs aan deze belangrijke wetenschap de haar toekomende plaats onder de leervakken zal worden toegekend."[365]

He is positive that the future law on 'middelbaar onderwijs' would include education in the natural sciences. Steyn Parvé, as the first one to do so, treats the law of conservation of energy in his textbook. Steyn Parvé seemingly uses Bosscha's terminology of 'arbeidsvermogen':

> "Het beginsel van het behoud van het arbeidsvermogen, dat tegenwoordig bij de verklaring der natuurverschijnselen hoe langer hoe meer eene belangrijke rol speelt, heb ik gemeend met eenige uitvoerigheid te moeten behandelen. [...] Ik hoop, dat ik er in geslaagd mag zijn dit gedeelte, dat tot dusverre, voor zooveel mij bekend is, nog in geen leerboek op die wijze behandeld is, op eene bevattelijke wijze voor te stellen."[366]

In the first parts that were published, Steyn Parvé used the old terminology of the law of 'bewaring van kracht' and uses 'arbeidsvermogen' occasionally, but not as 'the law of conservation

[365] Translation: "While composing this textbook it has been my intention to arrange it in such a way that it could be used in middle class education. Although it is far from reality that in all gymnasia and other middle class schools physics will be taught, it is to be expected that in a new arrangement of middle class education this important science will obtain her entitled place between all of the subjects." D. J. Steyn-Parvé (1860), *Leerboek der Natuurkunde*, p. v.

[366] Translation: "The principle of conservation of energy, that currently plays a more and more important role in the explanation of natural phenomena, I was of the opinion to treat it somewhat extensively. I hope that I have succeeded in this part, that thus far, as far as I know, has not been treated in a clear manner in any textbook." D. J. Steyn-Parvé (1860), *Leerboek der Natuurkunde*, p. vii.

of *arbeidsvermogen*' In the second and third part, while he has defined 'the law of conservation of *kracht*' he seamlessly moves to 'the law of conservation of *arbeidsvermogen*'. According to Wegener and van Lunteren, Steyn Parvé was initially confused to use 'arbeid' broader than its usual physiological sense.[367] Thus, we see Bosscha's terminology from 1858 was truly inspired by physiology, as the original proponent of the law Von Helmholtz was.

This was not the only competition on the market. By 1863 - before any parts of Bosscha's book were published - there were several other books available. The fourth edition of Pieter van der Burg (1808–1889)'s *Eerste Grondbeginselen der Natuurkunde* came out in 1861. (The first edition was from 1847). Van der Burg was a teacher at a gymnasium and subsequently at the HBS of Nijmegen. Van der Burg also treated the conservation of energy with Bosscha's terminology:

> "Door het geheele boek schemert het beginsel van 't behoud van arbeidsvermogen of het arbeidsaequilvalent der warmte door." [368]

Another publication by Van der Burg as translator is the translation of Adolphe Ganot (1804–1887)'s famous textbook *Traité Élémentaire de Physique* into Dutch: *Leerboek der Proefondervindelijke en Toegepaste Natuurkunde*, which directly competed with his own book. Van der Burg, answering to comments by the instigator of the translation Van Rees, reworked the book to include the law of conservation of energy:

> "De aanmerking van de heer Van Rees, dat er genoegzaam niets over het behoud van arbeidsvermogen bij de warmte en de galvanische elektriciteit, [...] spoorde mij aan om dat ontbrekende aan te vullen." [369]

At the time of publication of Bosscha's textbook these five textbooks were the main competition. Later on, Bosscha's book had strong competition from Hendrik van der Stadt (1842–1915) *Beknopt Leerboek der Natuurkunde* intended for the HBS - the HBS teacher at Arnhem who had Lorentz among his pupils - and from Lorentz's *Beginselen der Natuurkunde* intended for students at university. As we can see in Table 5.1, there was a steady stream of textbooks on physics for various intended audiences.

Bosscha, as inspector, usually did not advise the teachers on which book they should use in class, but seemingly made exceptions once in a while:

[367] D. Wegener and F. van Lunteren (2012), "Verspreiding en Ontwikkeling van de Wet van Behoud van Energie in Nederland", pp. 394–396.

[368] Translation: "In the whole book the principle of conservation of energy or work equivalent heat plays a role." P. van der Burg (1861), *Eerste Grondbeginselen der Natuurkunde*, p. II.

[369] Translation: "The comment of Mr. van Rees that there is hardly anything about the conservation of energy in the topics of heat and galvanic electricity encouraged me to supplement what was missing." A. Ganot (1859), *Leerboek der Proefondervindelijke en Toegepaste Natuurkunde*, pp. iv–v.

year	author	title
1842	W. Wenckebach	*Natuurkundige Stellingen* (many eds.)
1847	P. van der Burg	*Eerste Grondbeginselen der Natuurkunde*
1851	J.H. van den Broek	*Handleiding der Natuurkunde*
1853	G.K. Timmer	*Natuurkundig Schoolboek*
1856	W.M. Logeman	*Natuurkundig Schoolboekje*
1856	F.E.J. Crüger	*Grondbeginselen der Natuurkunde*
1859	A. Ganot	*Leerboek der Proefondervindelijke en Toegepaste Natuurkunde*
1859	J.H. van Kooten	*Handleiding tot de Beoefening der Natuurkunde*
1860	D.J. Steyn Parvé	*Leerboek der Natuurkunde* (many eds.)
1861	P. van der Burg	*Eerste Grondbeginselen der Natuurkunde* (4th ed.)
1863	A.S. van Oven	*Leiddraad bij de Studie der Natuurkunde*
1866	W.M. Logeman	*Natuurkundige Stellingen, een Handboekje ten Gebruike bij het Onderwijs in de Physica aan Hoogere Burgerscholen*
1866	E. van der Ven	*De Beginselen van Theoretische en Toegepaste Mechanica*
1867	J.H. van den Broek	*Beginselen der Natuurkunde*
1873	B. Stewart	*Beginselen der Natuurkunde*
1874	J.C. Jamin	*Leiddraad bij het Onderwijs in de Natuurkunde*
1875	J. Bosscha Jr.	*Leerboek der Natuurkunde*
1876	P.M. Brutel de la Rivière	*Handleiding tot de Beoefening der Natuurkunde*
1878	J.E. Enklaar	*Grondbeginselen der Natuurkunde*
1881	H. van der Stadt	*Beknopt Leerboek der Natuurkunde*
1888	H.A. Lorentz	*Beginselen der Natuurkunde*
1888	H. Japikse	*Leerboek der Natuurkunde*
1889	V.A. Julius	*Leerboek der Natuurkunde*
1891	L. Steenhuis	*Leerboek der Natuurkunde*
1893	J.L. Hoorweg	*Beknopt Overzicht der Natuur- en Werktuigkunde* (2d ed.)

Table 5.2: List of textbooks on physics published between 1840 and 1900. Note that this list is not exhaustive. This list invites a comparative study on the contents of textbooks in physics in the Netherlands.

> "Het drukken van de logarithmen tafels van v. Pesch kan ik u zeer goed aanbevelen. Zij zullen wel op alle scholen worden in gebruik genomen. Ofschoon ik niet gewoon ben boeken bij leeraren aan te bevelen is het toch mijn stellige voornemen bij alle leeraren in mijn district er op aan te dringen deze tafels in te voeren." [370]

Bosscha did exert influence the other way around. He influenced slightly which books were made available. For instance, Bosscha advised Sijthoff on which books he thought would be popular or suitable for the HBS. For instance: 'De Zoogdieren' of Dr. Hermann Schlegel (1837–1884) was not extensive enough and a textbook in this subject should treat all of zoology. The *Analytische Meetkunst* translated by P. van Geer would be too technical for the HBS, but suitable for the Polytechnical school.[371] Bosscha had a positive view on the authors and expected their work to become quite popular:

> De namen der door u genoemde schrijvers voor de leerboeken van Delfstof- Aard- Plant- en dierkunde zijn zeker eene goede recommandatie, en zoo die Heeren nu de eischen van het Middelbaar Onderwijs goed in het oog houden, zullen hunne werken werkelijk eengoed debiet vinden. [...] Van Bemmelen is wel in staat eene goede scheikunde te leveren. [Het boek] van Gunning is mij op het oogenblik te weinig bekend, om mij te doen oordelen of het wenschelijk is dit laatste werk te verdringen." [372]

Thus, there were several other textbooks on the market and the first of those to use the law of conservation of energy were Van der Burg's and Steyn Parvé's textbooks. Notably, they used Bosscha's terminology of 'arbeidsvermogen'. From here on out it seems common place in textbooks of physics to treat the law of conservation of energy. The fact that they all used Bosscha's terminology and had a paragraph on 'the conservation of energy in the galvanic current',- the title of Bosscha's dissertation - goes a long way to prove Bosscha's pivotal role in the introduction of the law of conservation in the Netherlands.

5.1.2 The Textbook

[370] Translation: "I can recommend printing the logarithmic tables of v. Pesch to you. They will probably be used at all schools. Although I am not used to recommend certain books to teachers, it is my firm intent to insist the teachers to use these table in my district." Letters to Sijthoff, 18-4-1870, UB Leiden SYT A 1870.

[371] Letters to Sijthoff 16-8-1863, UB Leiden SYT A 1863.

[372] Translation: "The names of the writers of the textbooks of mineralogy, geology, botany and zoology that you mentioned are surely to be recommended. And if these gentlemen keep track of the requirements of the Middelbaar Onderwijs, their works will surely be sold. [...] Van Bemmelen is able to deliver a good chemistry [textbook]. The book of Gunning I am too unfamiliar with at the moment to give a proper evaluation whether it is desirable to displace it." Letters to Sijthoff, 5-11-1863, UB Leiden SYT A 1863.

[373] J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, vol. 2, p. 96.

Having established the playing field in the previous section, and discovering that Bosscha's optimism about a monopoly on the HBS students to be unfounded, let us go back to Bosscha's textbook.

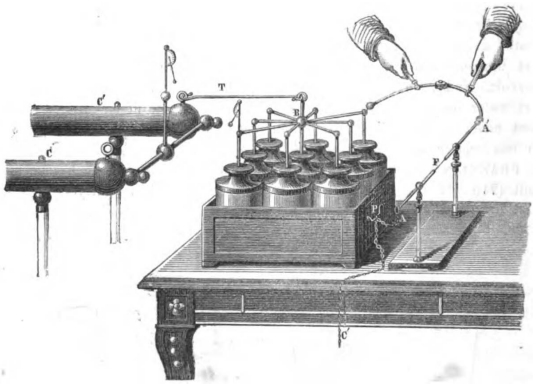


Figure 5.2: A figure of a 'battery' from Bosscha's textbook[373]

At first, Bosscha wrote to Sijthoff, he expected to be able to use the French book *Cours Élémentaire de Physique* by the French physicists Augustin Boutan (1820–1900) and Joseph-Charles d'Almeida (1822–1880) which was used in French Lycea and to simply translate it with small adaptations, because he thought he would not have time with his busy occupation as inspector to write a full textbook from scratch.[374]

The first volume indeed followed the structure of the French original, but because the French book did not include the law of conservation of energy, Bosscha, of course, rewrote certain parts to include the law. Bosscha motivates this by arguing that in the last decades only few 'accidental' discoveries had been made. Most experiments were devised and reasoned from theory. Especially the law of conservation of energy was fruitful in this aspect:

> "Zij heeft nieuwe betrekkingen doen vinden tusschen de verschillende uitwerkingen eener kracht, een verband leeren opsporen tusschen vele verschijnselen, welke samenhang vroeger nauwelijks werd vermoed, en den weg geopend tot de kennis van het wezen der warmte en van de natuur van gassen en vloeistoffen."[375]

He made sure there were enough notes on the scientific contributions of Dutch researchers. This is one of the first indications that Bosscha would become a fervent nationalist, a most common trait at the end of the 19th century and one that he shared with his father Bosscha Sr. Lastly, Bosscha thought the figures in all current textbooks were inadequate, as he complained strongly in a letter to Sijthoff when some figures ended up faulty in his own publication:

> "Waar kan dit misverstand door ontstaan zijn? [...] Ik kan het haast niet denken, omdat ik mij meen te herinneren, altijd waar ik figuren uit B et d'A zoo noodig

[374] J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, pp. vi-vii; Letters to Sijthoff, 5-8-1864, 16-10-1864, UB Leiden SYT A 1864.

[375] "It has made possible to find new relations between different manifestations of a force and find relations between many phenomena of which previously a relation was hardly ever presumed. It has opened the way of knowledge of the essence of heat and the nature of gases and liquids" J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, p. v.

hebben, [...] aan geheel nieuwe figuren voorkeur gegeven te hebben. De figuren uit B en d'A zijn gebrekkig. Ik hoop nu maar, dat de gravures der nieuwe figuren met zorg bewerken zal. In afl. 4 2de stuk zijn er verscheidenen die lelijk zijn." [376]

Indeed, he calls the figures in Steyn Parvé's textbook: "belachelijk" (laughable), and thought his own book was more popular simply for this reason.[377]

The second and third volume of the French original were inadequate as they did not treat the recent developments in Germany and England especially in the fields of thermodynamics and electromagnetism, Bosscha thought. He rewrote them completely:

"Ik voorzie, dat volgende uitgaven van de Natuurkunde nog aanzienlijke omwerking zullen behoeven. [...] Ik weet wel, dit is bij vertalingen eene ongewone zaak, doch hoe meer ik vorder, te meer zie ik allengs den Hollandschen tekst van den Franschen afwijken, en bij de tweede uitgave en de derde, is er misschien behalve de algemeene rangschikking en hier en daar een goed bewerkt stuk niet veel meer van het Fransche werk te herkennen." [378]

Indeed, he was not satisfied with the current knowledge on thermometry and capillary forces (heat and molecular forces) that he would be able to put in the textbook and thus started research on the subject himself. The last culminated in two scientific papers and a fruitful collaboration with Van der Waals, see section 5.3. For Bosscha's research on thermometry, see section 5.2.

For the scientific collaboration with Van der Waals, Bosscha expressed his gratitude in the introduction of his textbook, and to Jan Anthony Snijders (1844–1922) for the expert manufacturing of figures, later professor at the Polytechnical School:

"Het is mij eene aangename plicht hier mijn dank te betuigen aan de heeren Dr. J.D. van der Waals en J.A. Snijders Czn. die mij behulpzaam zijn geweest, de eerste in het bijeenbrengen van het omvangrijke materiaal dat de behandeling van de leer der moleculaire krachten en der trillingen vereischt, de tweede door de vervaardiging van nieuwe figuren." [379]

[376] Translation: "How can this misunderstanding be? [...] I can hardly believe it, because I think to remember that always when I needed figures from B et d'A I preferred entirely new figures. The figures from B and d'A are faulty. I now hope that the engravings of the new figures will be done with care. In episode 4 second part there are numerous that are ugly." Letters to Sijthoff, 16-8-1874, UB Leiden SYT A 1874.

[377] Letters to Sijthoff, 23-9-1874, UB Leiden SYT A 1874.

[378] Translation: "I foresee that the following editions of the textbook on physics will need a thorough conversion. I know that this is unusual in a translation, but the more I progress, the more I see the Dutch text differ from the French. In the second edition and a third, there will be hardly anything to recognize from the French work, apart from maybe the general arrangement and in some places a properly converted piece." Letters to Sijthoff, 9-11-1864, UB Leiden SYT A 1864.

[379] Translation: "It is a pleasant duty to express my gratitude here to the gentlemen Dr. J.D. van der Waals and

On the other hand, Bosscha lashes out strongly against Steyn Parvé and the teachers when the popularity of his textbook declines a little. He calls the textbooks of his competition superficial and imprecise. Bosscha took the effort to find new representations of the materials and if these are unclear, it is because the teachers try to hide their slowness and laziness. I quote in full:

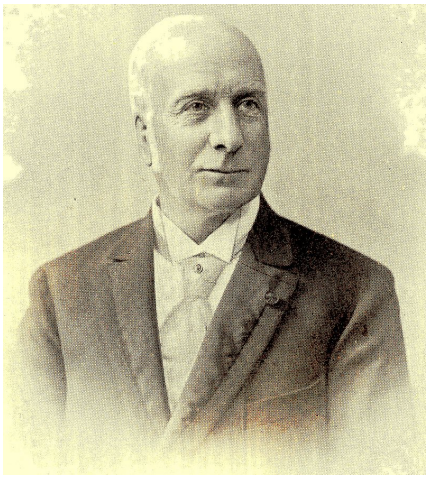


Figure 5.3: The publisher Albertus Willem Sijthoff (1829–1913)

> "Uwe mededeling betreffende het verminderend debiet is niet opbeurend. Het is voornamelijk om de oppervlakkigheden en onnauwkeurigheden van de in gebruik zijnde nederlandsche leerboeken te [onleesbaar] te gaan bij het onderwerp, dat ik het ondernomen heb iets te geven dat grondig en duidelijk is. Het heeft mij heel wat moeite gekost daartoe nieuwe voorstellingswijzen te vinden, die eenigermate den toets van grondigheid konden verdragen. Dat dit voor vele docenten nieuwe en ongewoon was en daarom studie eischte zal wel de oorzaak zijn, waarom sommigen hunne traagheid trachten te verbergen door van onduidelijke stijl te spreken. Voor zulke menschen, die inspanning schuwen of meenen dat men zonder inspanning kennis van eenige beteekenis kan verkrijgen, voor dilettanten en dergelijke kan ik geen *leerboek* schrijven. Er schijnt thans een derde druk van Parvé te zullen verschijnen. Het is mogelijk dat de heer Parvé den heer Brongersma heeft opgedragen mijn leerboek nog meer te plunderen dan de heer Parvé in zijne tweede uitgaaf gedaan heeft. Mij dunkt wij dienen dit af te wachten en dan te zien wat wij doen zullen." [380]

Clearly, Bosscha's relation with Steyn Parvé was far from ideal, as Steyn Parvé 'plunders' Bosscha's textbook. What is more, in this quote we read that in Bosscha's ideal, to obtain

J.A. Snijders Czn. that have been helpful, the first in collecting the vast materials necessary for the treatment of the theory of molecular forces and vibrations, the second for manufacturing new figures." J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, p. viii.

[380] Translation: "Your message about the decrease in sales is not uplifting. It is mostly because of the superficiality and inaccuracies of the textbooks currently in use that I have endeavored to publish something clear and thorough. It has cost me a lot of effort to find new ways of representations that suffice for the requirement of thoroughness. That this is for many teachers new and unusual and therefore required some study and this is probably the reason why some of them tried to hide their slowness and spoke of an unclear style. For these kind of people, that avoid effort or believe that without effort one can obtain any significant knowledge, for dilettantes and so forth I can not write a textbook. At this moment the third edition of Parvé seems to appear. It is possible than Parvé has ordered Brongersma to plunder even more of my textbook that Parvé has done in his second edition. In my opinion we should wait and see after his publication what we will do." Letters to Sijthoff, 23-9-1874, UB Leiden SYT A 1874.

Publication	Episode	*Edition*
July 1865	1	first
May 1866	2	first
September 1867	3.1	first
October 1868	3.2	first (KNAW notes; guess)
August 1871	4.1	first
August 1871	3.1	second
September 1871	1	second
January 1874	4.2	first
January 1875	4.3	first
September 1877	3.1	third
December 1877	1	fourth
December 1877	4.3	second
October 1878	3.2	third
June 1882	1	fifth
September 1882	3.2	fourth
June 1885	2	fourth
June 1887	4.2	fourth
October 1887	3.2	fifth
August 1888	4.3	second
December 1890	2	fifth
June 1894	I.1	seventh
October 1899	II	sixth, J.P. Kuenen
January 1900	I.2	fifth, W.C.L. van Schaïk
October 1902	IV.1	sixth, R. Sissingh
October 1903	III.1	seventh, C.H. Wind
December 1906	IV.2	fifth, R. Sissingh
June 1896	1	W.C.L. van Schaïk
December 1897	3.1	W.C.L. van Schaïk
June 1898	3.2	W.C.L. van Schaïk
March 1901	2	J.P. Kuenen and W.C.L. van Schaïk
January 1904	4.1	D. van Gulik and C.H. Wind
May 1906	1	H.A.J. Valkema Blauw (2ed)
April 1909	3.1 3.2	H.A.J. Valkema Blauw (2ed)

Table 5.4: List of publication dates from the sources: *Nieuwsblad voor den boekhandel* and the letters to Sijthoff. The adaptation of 1894-1909 is set up slightly differently.The last section of the table considers the 'small textbook'.

knowledge was hard work and teachers should not fail to put in this work.

After 11 years, in 1875, the three volumes of Bosscha's *Leerboek der Natuurkunde* were finished and published. Bosscha followed some of the tenets of popular science writing in his textbook. He tried to explain complex physical phenomena in the most simple way, used various analogies and eschewed the higher mathematics, in order to keep his book easily approachable.

That all of physics was treated, including the most complex phenomena, seems strange for a textbook meant for high school students. But, according to Bosscha, only in this way it is possible to "diep tot het wezen der verschijnselen door te dringen."[381] Most subjects are treated more extensively than is required for the students of an HBS. Indeed, in 1876, Bosscha wrote Sijthoff to explain that he wants to extend his textbook further. To make the book better it was imperative to encompass more materials, regardless of the suitability to the HBS. Writing a *good* and thorough book as an introduction to scientific physics was deemed incompatible with writing a textbook that contains only that which they teach at the HBS:

> "Naar mijne overtuiging heeft mijn boek om goed te worden bepaalde uitbreiding noodig. [...] Wordt het boek daardoor niet minder bruikbaar voor de hoogere burgerschool? Ik geloof het wel. Maar voor de instelling van hooger onderwijs zal het beter voldoen en het boek als geheel wordt zonder twijfel beter. Een goed boek te maken die de inleiding zal zijn tot wetenschappelijke natuurkunde is niet te vereenigen met het maken van een boek dat juist omvat, wat men op de hoogere burgerscholen moet hebben."[382]

These extensions, published in the editions of 1878 and 1882, lead to a decline in the use of the book at the HBS. However, the book remains popular and used at the universities:

> "Het doet mij genoegen te vernemen dat, hoewel het leerboek op de hoogere burgerscholen weinig gebruikt wordt, men toch over het debiet niet te klagen heeft. Het schijnt aan de Universiteiten geregeld gebruikt te worden." [383]

At this point, he thinks a book perfectly suited for the HBS should be written in a completely different way. But what can he say?

[381] Translation: "to penetrate deeply in the essence of the phenomena." J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, p. viii.

[382] Translation: "In my opinion to become good my book needs a certain extension. Will the book not lose in usefulness for the HBS? I think so. But for the institutions of higher education it will suffice better and the book will doubtless become better as a whole. To make a good book that will be the introduction to scientific physics is not unifiable with a book that only contains just that what is taught at the HBS." Letters to Sijthoff, 24-3-1876, UB Leiden SYT A 1876.

[383] Translation: "I take joy in the news that, while the book is not used much at the HBS, one does not have to complain about the sales. It seems to be used often at universities." Letters to Sijthoff, 20-9-1883, UB Leiden SYT A 1883.

> "Nu geldt terecht het spreekwoord "le style c'est l'homme", daarin kan men zich niet door een ander laten vervangen. Ik hoop evenwel niet dat u zich aan mij voor de uitgave van een kleiner boek gebonden acht. Dit is geenszins mijne bedoeling." [384]

It is hard to gauge the popularity of the work as there are no comparative sales numbers available, nor a complete list of which textbooks were used at which HBS. Bookstores throughout the country sold the book, and it was sold even as far as Batavia.[385] By 1867, we know that of the first episode 2013 were sold, of the second 1469 and of the third part one 1253. By 1868, episode 3 part 2 has comparable sales numbers of 1514. If we compare this by the amount of students at the HBS in the year 1866-1867, namely 1466, we may conclude that a significant part of the HBS used Bosscha's textbook, and, moreover, that it was used beyond the HBS.[386] At the least, the book was used by Dr. Johann Heinrich Hermann Hülsmann (1836–1907) in the HBS of Breda in 1867, by Van der Waals and his successor in The Hague and by F.G. Groneman in Groningen.[387]

We have some proof that the book is indeed used by students at the university. Before the publication of the second edition of 1875, a total of five students mention Bosscha's textbook in their dissertations. This is a clear indication that the textbook is used on the academic level.[388] The secondary literature always emphasizes that Bosscha's book was the only one used, for instance: "It became the standard textbook throughout the Netherlands."[389] Indeed, Kamerlingh Onnes recommended it to his students and called it a masterpiece:

> Zelf zwoer [Kamerlingh Onnes] bij het *Leerboek der Natuurkunde* van Bosscha, 'in alle hoofdstukken een meesterstuk van beredeneerde proefneming'." [390]

Bosscha's textbook was known abroad. The publisher Hans Ambrosius Barth (1834–1887) was in contact with Bosscha in 1878 about a German translation of the book, although the negotiations with Sijthoff failed, and no translation was made.[391]

[384] Translation: "Now the expression justly applies: "the style makes the man", in that aspect one cannot be replaced by someone else. I do hope that you do not bind me to the publication of a smaller book. That is by no means my intention." Letters to Sijthoff, 20-9-1883, UB Leiden SYT A 1883.

[385] In various editions of *Nieuwsblad voor den boekhandel* between 1868 and 1906 bookstores requested Bosscha's *Leerboek der Natuurkunde* in the HBS cities of Den Haag, Amsterdam, Kampen, Leiden, Tilburg, Haarlem, Alkmaar, Rotterdam, Utrecht, Delft, Veendam and Gorichem, but in Edam, Hengelo and Hellevoetsluis as well. For Batavia, De Locomotief: Samarangsch handels- en advertentie-blad, 28-4-1879.

[386] Letters to Sijthoff, 20-9-1867; 7-10-1868, UB Leiden SIJT A 1867, 1868; Verslag van den staat der hoogere middelbare en lagere scholen in het Koninkrijk der Nederlanden over het jaar 1866-1867, p. 27.

[387] See respectively Bredasche Courant, 29-9-1867; F. van Lunteren (2000), "Aantrekkende Krachten", p. 256; De wekker; nieuwe bijdragen voor het onderwijs 40 (79), 3-10-1883; D. van Delft (2005), *Heike Kamerlingh Onnes*, p. 48.

[388] These students are: Snellen (1865), J. Zaaijer (1867), F. van Wageningen (1871), A. van Vleuten (1873) and H.S. Brongersma (1873).

[389] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, p. 22.

[390] Translation: "Himself, Onnes swore by the textbook of Bosscha. In all chapters a masterpiece of reasoned experiments" D. van Delft (2005), *Heike Kamerlingh Onnes*, p. 194.

[391] Baarn-archive: 9 letters between J. Bosscha Jr., J. Ambrosius Barth and Hulsmann, all dated 1878.

Whenever Bosscha felt it was necessary to update the book with the most recent developments in physics, he did so. For instance, between the '75 and '78 edition, Bosscha introduced the field concept and potential formulation in electromagnetism to include Michael Faraday (1791–1867)'s field lines and concepts.[392] In the 1894 edition he wrote a motivation:

> "De snelle vorderingen der natuurkunde maakten het telkens noodig, niet alleen de beschrijving van nieuwe verschijnselen op te nemen, maar ook nieuwe voorstellingen over den aard der natuurkrachten te vermelden."[393]

In 20 years all parts of the book had 5 to 7 new editions. Somewhere at the end of the 80s, Sijthoff and Bosscha made the plan rework the entire *Leerboek* and bring it up to date with the latest developments in physics. The idea of writing a textbook for the HBS was completely let go. This version would be suitable only for higher education. Bosscha recruited the help of several young physicists. This was very beneficial to these young physicists as they received a generous salary and came into contact several other physicists. At first, Bosscha divided up the work between Prof. Snijders (electricity), Dr. Sissingh (light), both working at the Polytechnical School, Dr. Van Schaïk (sound), teacher at the HBS of Rotterdam, and Prof. Kuenen (heat and molecular forces), Dutch physicist, but professor at Dundee University at the time.[394] In the end Wind took over Snijders' portion, but only the first part was ever published. The second part never appeared. Bosscha also sought the help of Prof. Kamerlingh Onnes to comment on their work on various occasions.[395] Apart from the 'big textbook' a smaller textbook was edited by Van Schaïk to be used at the HBS: 'Dr. van Schaik's Leerboek der Natuurkunde'. After the death of Van Schaïk, Bosscha recruited the HBS teacher at Haarlem and fellow member of the curatorium of the *Koninklijk Nederlandsch Meteorologisch Instituut* Dr. Valkema Blauw for the final edition of this textbook.[396]

To conclude, we have seen that Bosscha's textbook, although by no means the only textbook available, was a popular and influential physics textbook in the Netherlands. We have seen yet again, through the textbooks of Bosscha and the competition that Bosscha played a pivotal role in the introduction of the terminology of 'arbeidsvermogen' in the Netherlands. Bosscha finally used his textbook to give some extra salary to, i.e. help the careers of some young physicists at the end of the 19th century. In these collaborations we see that Bosscha is a central figure in the Dutch scientific world. In the next two sections we will discuss Bosscha's research during

[392] Many more of these examples could be studied in a comparative textbook study. J. Bosscha Jr. (1878d), *Leerboek der Natuurkunde*, pp. 80-90.

[393] Translation: "The fast progress of physics make it necessary again and again, not only to describe the new phenomena, but also to treat the new representations of the nature of the forces of nature." J. Bosscha Jr. (1894), *Leerboek der Natuurkunde en haar voornaamste toepassingen: Algemene Beschouwingen van Lichamen en Krachten*, p. v.

[394] Letters to Sijthoff, 15-12-1891; 27-1-1892; 2-12-1897; 11-10-1898, UB Leiden SYT A 1891, 1892, 1897, 1898.

[395] Letters to Sijthoff, 31-10-1893; 29-4-1897, UB Leiden SYT A 1893, 1897.

[396] Letters to Sijthoff, 24-8-1904, UB Leiden SYT A 1904.

his period as inspector. Research that was intended to be included in the textbook. The last section describes the collaboration with Van der Waals.

5.2 Regnault's Thermometry

In his years as inspector Bosscha was never fully away from scientific research. Although he did not have a laboratory at the time, he scrutinized the results of the French experimental researcher Henri Victor Regnault (1810–1878) whom he met during his scientific trip to France in 1854.[397] Bosscha first spoke about Regnault's experiments on a KNAW meeting in December 1865, in which he criticized Regnault's findings: "Het is hem gebleken, dat de naauwkeurigheid van de berekening der proeven van Regnault te wenschen overlaat."[398] Bosscha probably needed to research Regnault's experiments for the second part on heat of his textbook that was published mid-1866. It is again clear in his work on Regnault that Bosscha's emphasis in research lays in precision. Bosscha's work on Regnault consists of a new adaptation of the experimental results of Regnault. Regnault documented his research very systematically and complete, as Bosscha says:

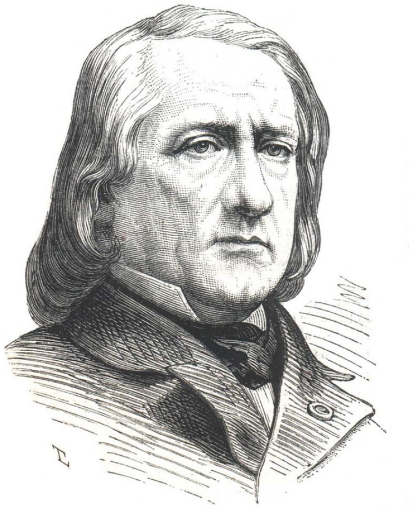


Figure 5.4: Henri Victor Regnault (1810–1878)

> "De proefnemingen door Regnault verricht [...] zijn hare hooge wetenschappelijke waarde niet alleen verschuldigd aan het uitstekend talent van den beroemden waarnemer, maar vooral ook aan de zorg, die deze genomen heeft om alle gegevens en alle omstandigheden der waarneming zoo volledig mogelijk mede te deelen."[399]

The research itself was about the true and apparent dilatation of mercury, where the true dilatation is the sum of the apparent dilatation together with the dilatation of the container. The use of and knowledge about a proper mercury thermometer was of utmost importance:

[397] Baarn family archive: Autobiography; Letter to his father, 8-6-1854.

[398] Translation: "He has concluded that the accuracy of the calculations of the experiments was lacking." De Nederlandse Spectator, 6-1-1866.

[399] Translation: "The experiments conducted by Regnault owe their highest scientific significance not only to the excellent talent of the famous observer, but especially to the care that he has taken to describe all data and circumstances of the observations as complete as possible." J. Bosscha Jr. (1869d), "Over de ware uitzetting van kwikzilver, volgens de waarnemingen van Regnault", p. 38.

> "Intusschen moeten deze [proefnemingen van Regnault] als de grondslag beschouwd worden [...] van elke bepaling van de constanten, die in de theorie de stoomwerktuigen en in de nieuwere warmteleer eene belangrijke rol vervullen." [400]

Bosscha criticized Regnault for not using enough of his own measurements to come to his conclusion and that only two series of measurements were not enough for the obtained relation in Regnault's work. Bosscha re-evaluated Regnault's measurements and tried to find a relation between the dilatation and heat in which all of Regnault's measurements were included. Bosscha presupposed that the change of volume with temperature was proportional to the volume, from which he mathematically deducted that the volume could be written as $v = v_0 e^{\alpha T}$. If the constant α was determined, the volume could be determined for any temperature. The extensive calculations of Bosscha led to this relation that was faithful to Regnault's measurements up to 280 °C and was more accurate than Regnault's linear model, at least up to 280 °C.[401]

In a second article, Bosscha criticized Regnault's results on the dilatation of the container in which the mercury or air was placed. The container itself will show dilatation as well and Bosscha showed that two thermometers made from a different material can diverge by half a degree between 0 °C and 100 °C, and this could not be neglected as Regnault did.[402] Bosscha communicated the results of these two articles to the *Academy Française* by sending them a letter, instigating a heated debate between Bosscha and Regnault. Regnault himself responded at the academy. He agreed and lauded Bosscha's effort on the first article, but was not so keen on the second and he defended his own method and choice of container.[403] A third and last article on the experiments of Regnault was about the surface tension of steam in which Bosscha found a systematical error. After correcting for this deviation, Regnault's original formula for the surface tension was much more accurate.[404] This last article can also be seen in connection

[400] Translation: "Meanwhile these experiments of Regnault should be seen as the foundation of every determination of constants that play an important role in the theory of steam engines and the new theory of heat." J. Bosscha Jr. (1869e), *Aanspraak bij de opening van de 84ste algemeene vergadering der Maatschappij tot Nut van 't Algemeen, gehouden den 10den Augustus 1869*, p. 39.

[401] J. P. Kuenen (1919), *Gedenkboek van het Bataafsch Genootschap*, pp. 105-109; J. Bosscha Jr. (1869d), "Over de ware uitzetting van kwikzilver, volgens de waarnemingen van Regnault"; J. Bosscha Jr. (1869a), "Sur la dilatation absolue du mercure d'après les expériences de M. Regnault"; J. Bosscha Jr. (1871b), "Ueber die absolute Ausdehnung des Quecksilbers nach den Versuchen des Hrn. Regnault".

[402] J. Bosscha Jr. (1869h), "Over de schijnbare uitzetting van kwik in glas en den gang van den kwikthermometer tusschen 0° en 100°, volgens de waarnemingen van Regnault"; J. Bosscha Jr. (1869c), "Sur la dilatation apparente à celle du thermomètre à air, d'après les expériences de M. Regnault"; J. Bosscha Jr. (1871c), "Over de schijnbare uitzetting van kwikzilver en den gang van den kwikthermometer, vergeleken bij dien van den luchtthermometer, volgens de waarnemingen van Regnault"; J. Bosscha Jr. (1871a), "Ueber die scheinbare Ausdehnung des Quecksilbers und den Gang des Quecksilberthermometers verglichen mit dem des Luftthermometers, nach den Versuchen des Hrn. Regnault".

[403] J. Bosscha Jr. (1869f), "Sur la dilatation absolue du mercure, et sur la comparaison des thermomètre à air"; J. Bosscha Jr. (1869g), "Note concernant les observations faites par M. Regnault sur une Lettre précédente"; J. Bosscha Jr. (1869b), "Note concernant les observations de M. Regnault sur la lettre adressé à l'académie des sciences de l'institute de France".

[404] J. Bosscha Jr. (1871d), "Over de temperatuursbepalingen in Regnault's onderzoek van de spanningen van waterdamp"; J. Bosscha Jr. (1872), "Les déterminations des températures dan les expériences de M. Regnault sur

with Bosscha's own research on capillarity that we will discuss in the next section.

5.3 Van der Waals and Capillarity

The second main research topic that interested Bosscha in these years was capillarity. The fourth episode, first part of his *Leerboek* was on molecular forces, a great part of which leaned on cohesion and capillary phenomena. Not surprisingly, before publishing this part of his *Leerboek*, Bosscha published and spoke a couple of times on capillarity. In 1870 Bosscha spoke at the KNAW on capillarity. He recounted the method with which Pierre-Simon Laplace (1749–1827) and Gauss obtained the constraints for the equilibrium of the surface of a liquid. Bosscha declares to have found an easy method to derive the results of both these mathematicians. Secondly, he believed that the surface tension of a liquid could theoretically be derived from the operation of molecular forces.[405] A year later, Bosscha spoke again at the KNAW about capillarity. He spoke of an experiment which he deemed important for the theory of capillarity. This experiment showed, according to Bosscha, that even at surfaces of two mixing liquids capillary phenomena play a role. The same as for liquids that do not mix or at the surface of a single fluid or between two gases for that matter.[406] The main motivation for this research was, again, his textbook. Bosscha only published a scientific article on this matter in 1876.[407]

An extensive treatment of capillarity is highly unusual for textbooks of physics at the time. The low cohesion with the surrounding chapters seems to make it more likely that Bosscha simply wanted to discuss a matter which interested him a lot. It seems likely, that he discussed these matters with Van der Waals, who was also living in The Hague at the time and that Bosscha steered Van der Waals into the topic of his dissertation: molecular forces. [408]

Johannes Diderik van der Waals (1837-1923) was a carpenter's son and thus came from a completely different class in society than Bosscha. After finishing his primary school (a MULO) he became apprentice teacher and obtained all diplomas for teaching that were possible to obtain. After 1863, that also meant the acts of competence. Here, he was examined by Bosscha. Van der Waals was recommended by Kaiser to fill the mathematics post at the HBS of Deventer, but due to a mix-up by Rijke, not the mathematics post but the physics post was available. After obtaining another act of competence Van der Waals started his job at Deventer and gained experience with experimental physics. In 1866 Van der Waals became a teacher at

les forces élastiques de la vapeur d'eau"; J. Bosscha Jr. (1874), "Ueber die specifische Wärme des Wassers bei verschiedenen Temperaturen, nach Regnault's Versuchen".

[405] J. Bosscha Jr. (1870c), "Over de grondvergelijkingen van de leer der capillariteit".

[406] J. Bosscha Jr. (1870a), "Capillaire werkingen bij onderling mengbare vloeistoffen"; J. Bosscha Jr. (1870d), "Over drupvorming"; J. Bosscha Jr. (1871e), "Physique Moléculaire".

[407] J. Bosscha Jr. (1876c), "Over het evenwicht van een druppel tusschen twee horizontale platen"; J. Bosscha Jr. (1876a), "Sur l'équilibre d'une goutte entre deux plaques horizontales".

[408] The interaction between Van der Waals and Bosscha has been studied in detail in an article by Frans van Lunteren. F. van Lunteren (2000), "Aantrekkende Krachten".

the HBS of The Hague, where he came into contact again with Bosscha through the society Diligentia, of which Van der Waals became a member in 1868. At that time Bosscha was part of the board of Diligentia.[409]

Diligentia was a physical society in The Hague founded in 1793 that held many lectures on physics and the natural sciences. One look at their historical list of lectures gives away that many of the important Dutch scientists from the 19th century have given lectures, including Van Rees, Lorentz, Van der Waals, Franciscus Johannes Stamkart (1807–1877), Bosscha, Hugo de Vries (1848–1935), J.A.C. Oudemans, Snijders, Van Bemmelen, Einthoven, etc.[410]

Figure 5.5: Johannes Diderik van der Waals (1837–1923)

In his spare time Van der Waals started studying physics in Leiden, obtained his doctoral exam and wrote his world famous dissertation: *Over de Continuiteit van den Gas- en Vloeistoftoestand.*[411] According to Kamerlingh Onnes, it was Bosscha who motivated Van der Waals to write a dissertation in the first place. In the article of Van Lunteren, Van Lunteren has shown that Bosscha and Van der Waals held a correspondence at the start of 1871 on capillarity with mutual benefits for both scientists.[412] Bosscha, needed the fruitful discussion and comments on these topics of his textbook and Van der Waals profited from Bosscha's experience and knowledge of experimental physics.[413] The last section of the chapter on capillarity of Bosscha's textbook anticipated directly on Van der Waals dissertation:

> "In hoeverre dus de moleculen van een gas elkander aantrekken, kan blijken uit de meer of mindere nauwkeurigheid, waarmede die gassen bij hunne samendrukking de wet van Boyle volgen." [414]

[409] Bosscha was part of the board somewhere between 1859 until 1882 under the president Agnites Vrolik (1810–1894). Source: http://natuurwetenschappen-diligentia.nl/geschiedenis-3/bestuurslijst/, consulted 28th June 2017.

[410] Source: http://natuurwetenschappen-diligentia.nl/geschiedenis-3/sprekerslijst/, consulted 28th June 2017. This society seems interesting for investigating the role of scientific societies in the 19th century apart from professionalization and exclusive societies such as the KNAW.

[411] J. D. van der Waals (1873), *Over de Continuiteit van den Gas- en Vloeistoftoestand.*

[412] Note that this correspondence can by found in the Baarn family archive.

[413] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, pp. 11-21.

[414] Translation: "How much the molecules of a gas attract each other, could appear from the better or worse accuracy with which these gases follow Boyle's law when compressed." J. Bosscha Jr. (1875b), *Leerboek der Natuurkunde*, pp. III, 73.

Van der Waals continuity equation in his dissertation is exactly that: a correction for Boyle's law. The correction was required, Van der Waals argues, because of the mutual attraction of molecules. Bosscha also helped the renown of Van der Waals' dissertation. In the correspondence that Bosscha held with the blind Belgian experimental physicist Joseph Plateau (1801–1883), he asked Plateau to include his own and Van der Waals publications in the *Statique expérimentale et théorique des liquides soumis aux seules forces moléculaires.*[415] In this well-received encyclopedia on surface tension phenomena, Bosscha and Van der Waals work was placed in the extensive bibliography. This attracted some international attention on the dissertation, for instance of none other than Maxwell.[416]

Van der Waals taught at the HBS with Bosscha's textbook and even taught Bosscha's son with his father's textbook. Bosscha handed Van der Waals the prestigious position of the committee of the acts of competence.[417] When the chair of physics of the newly founded Amsterdam University became available, Bosscha, by declining the position himself, helped Van der Waals to his professorship by recommending him to the curators:

> Voor een professoraat in de Natuurkunde zijn trouwens goede kandidaten te vinden, zoodat ik het Amsterdamsche bestuur door mijn terugtreden zeker niet in moeielijkheid breng. Dr. J.D. van der Waals, directeur der hoogere burgerschool alhier, lid der koninklijke akademie, in het buitenland bekend door zijne voortreffelijke dissertatie behoeft bijna niet aanbevelen te worden. Dr. Rink van de hoogere burgerschool te Delft, zou in de 2de plaats in aanmerking kunnen komen. [418]

Note that Bosscha declined also after J.L. de Koning, presumably curator of the University, had promised him that there would be no 'financial problems', i.e. Bosscha could ask what he wanted.[419]

In this section we have seen that Bosscha and Van der Waals worked closely together on Van der Waals' initial research and Bosscha's textbook. Bosscha's influence on Van der Waals becomes less after Van der Waals becomes professor of physics, but warm contact remained. Bosscha and Van der Waals sat in several KNAW committees together and

[415] J. A. F. Plateau (1873), *Statique Expérimentale et Théorique des Liquides Soumis aux seules Forces Moléculaires.*

[416] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, p. 51; Baarn-Archive: Three letters on capillarity dating early 1872 from J. Plateau to J. Bosscha Jr, J. Plateau to R. van Rees and G. van der Mensbrugghe to J. Bosscha Jr.

[417] F. van Lunteren (2000), "Aantrekkende Krachten", pp. 256-257.

[418] Translation: "For a professorship in physics there are good candidates to be found, by the way. So even if I decline I will not cause the Amsterdam board any difficulties. Dr. J.D. van der Waals, director of the HBS here, member of the KNAW and well known abroad for his excellent dissertation nearly needs no recommendation. Dr. Rink of the HBS in Delft could in second place be considered." Baarn Archive: Letter of J. Bosscha Jr. [draft] to J.L. de Koning, (presumably) curator of the University of Amsterdam, 4-6-1877.

[419] Baarn-Archive: Letter of J.L. de Koning to J. Bosscha Jr, 24-5-1877.

Bosscha translated Van der Waals' articles for publication in the *Archives Neérlandaises.*[420] Lastly, in 1897 Bosscha was one of the founders of the Van der Waals fund in honor of the 25th year of Van der Waals' dissertation. The fund was meant for experimental research in connection with the theoretical work of Van der Waals.[421]

[420] A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, pp. 112-113; F. van Lunteren (2000), "Aantrekkende Krachten", p. 264.
[421] F. van Lunteren (2004), "J.D. van der Waals en de Afdeling Natuurkunde".

Chapter 6

Bosscha's Political Career and Further Activities

It is important to sketch the political situation in the Netherlands around this time,– which we will do in this chapter,– as the polarization between the conservatives and the liberals rose to a new height because of the new public schools. In fact, the 'schoolstrijd' was the central topic in the elections in the late 60s. The political field was basically split into a few different groups: the THORBECKIANS, the anti-revolutionaries, the conservatives and the confessionals (religious). In the issue of the 'schoolstrijd' the first two groups were in favor and the latter were fervently against the new publicly funded schools, although for different reasons. The conservatives had a reactionary resurgence in the 50s and the 60s after the constitution of 1848 that basically made the Netherlands into a democracy. Note that the conservatives called themselves the true liberals and they called the 'liberals' radicals. The liberals, or THORBECKIANS often thought of themselves as a-political as they put the 'interests of the country' and the 'interests of the people' first, regardless of religious belief or diverging opinions.

The basic difference between the conservatives and the liberals was the regulation of anything nationwide. The conservatives believed in a government that was as small as possible and abhorred any national regulation whatsoever. The liberals sought to organize the nation in a collective way, but still with liberal tenets. The conservatives were against the constitution of 1848, against a parliamentary democracy and in extension against influence of the people that did not belong to the upper class, therefore against expanding the electorate to include the less rich. The Netherlands at the time was a census democracy. One could vote only if one payed above a certain amount of taxes. This system of voting slowly eroded along with the conservatives in the 19th century.[422]

It is understandable from this perspective that the new public schools were an eyesore to

[422]For more on conservatism in the 19th century, see: A. A. G. M. van Raak (2000), *In Naam van het Volmaakte.*

the conservatives. They were against the tremendous costs the schools brought with them for the government and believed that organizing a national school system was not a task for the government. Moreover, the conservatives had a different educational ideal, they believed in the formative function of education. Education in the "nuttige vakken" (useful subjects) was not deemed suited for this need. However, the political battle about public schools made some of the conservatives switched to the liberal camp as they were split over the educational ideals and some did see the benefits of the new school system for society at large. The confessionals were afraid that the new 'normaalscholen' (neutral schools) would leave no place for the 'bijzondere' (denominational) schools, or in particular the Catholic seminars. They were also against the privileged funding towards the public schools.

During Bosscha's time as inspector he also became politically active so that he could promote education by political means.[423] He tried a couple of times to become a member of Parliament, but every time he tried he was blocked by the conservatives and confessionals because they did not agree with his 'radically progressive' ideas on education. These discussions show there was still a large opposition to the law of 1863, despite of the seemingly triumphant successes of the schools in several cities and of its benefactor, see section 6.2, the *Maatschappij tot 't Nut*.

6.1 Parliament Elections

6.1.1 The Election of 1867

Bosscha's meddling in political affairs started in 1867, when he was elected to candidate for Parliament of the new liberal 'voting' party ('kiesvereniging') in The Hague called *Nederland*.[424] To sketch the voting system in the Netherlands in place since the constitution of 1848 until 1917: The Netherlands was divided into districts, each allowing for a certain number of representatives, - the number based on population,- together making up the 80(1869) members of Parliament. Districts could provide more than one representative, such as, the most important, Amsterdam, which provided 6 representatives at the time.[425] Bosscha mentions in his autobiography that Thorbecke's influence caused Bosscha to become interested in politics:

> "Thorbecke had de eigenaardigheid, regeeringsmaatregelen bij voorkeur te laten bewerken door personen buiten het kader van de ambtenaren van zijn departement: Als vanzelf raakte ik daardoor in de politiek verzeild." [426]

[423] Note the parallel with Bosscha Sr. Bosscha Sr. was member of Parliament and also strived to promote education in politics.

[424] Dagblad van Zuidholland en 's Gravenhage, 27-6-1867.

[425] See https://www.parlement.com/id/vglrdyd9plkn for more information. Consulted on 17-5-2017.

[426] Translation: "Thorbecke had the peculiar characteristic to order people outside of the clerics from his department to redact governmental dealings. Automatically I became caught up with politics." Baarn-archive:

The image we obtain from the newspapers is one of polarization and sharp *ad hominem* remarks. The newspapers themselves are obviously of strong political color. The conservative *Dagblad van Zuidholland en 's Gravenhage* will write anything about Bosscha, or about any other 'radical' for that matter, to slander his name. The liberal *Nieuwe Rotterdamsche courant* and *Arnhemse courant* always defend Bosscha's candidature. I will let the newspaper of The Hague speak for itself:

> "Met al de onstuimigheid, aan het radicalisme doorgaans eigen, treedt zij echter met een eigen kandidaat op en stelt aan de kiezers in dit district de keuze voor van dr. J. Bosscha. Daar de heer Bosscha als ultra-radicaal bekend staat en tevens ultra-moderne begrippen op godsdienstig gebied belijdt, heeft zijne kandidatuur te weinig kans van slagen, dan dat wij zouden meenen haar breedvoerig te moeten bestrijden. 's Gravenhage zou toch ontrouw worden aan de beginselen, die het met zooveel warmte in achtereenvolgende verkiezingskampen voorstond, als het zijn vertrouwen kon schenken aan den kandidaat der radicalen, die eenige rigting vertegenwoordigt, waarmede dit district, naar wij hopen, voor goed heeft gebroken. Dat een man als de heer Bosscha, doordrongen als hij is van denkbeelden, met de dierbaarsten overtuigingen der Nederlandsche natie in strijd, de gewigtige betrekking van inspecteur van het middelbaar onderwijs bekleedt, is zeker een treurig feit. Het zou evenwel nog oneindig beklagenswaardiger wezen als hij zijne verderfelijke beginselen ook in 's lands vergaderzaal zou kunnen verkondigen. De vaderlandslievende en edeldenkende gezindheid der 's Gravenhaagsche kiezers moge Nederland daarvoor bewaren."[427]

Autobiography.

[427] Translation: "With all the turbulence usually connected to radicalism, she comes forward with her own candidate and proposes for the voters in this district the choice of dr. J. Bosscha. Because Mr. Bosscha is known as ultra-radical and at the same time professes ultra-modern concepts in the religious domain his candidature has no chance of succeeding and we do not think we have to contest it too elaborately. The Hague would be disloyal to those precepts that it has endorsed with so much interest in the past elections if it would give her trust to the candidate of the radicals, who represents an alignment with which this district, we hope, has turned her back to indefinitely. That a man such as Mr. Bosscha, imbued as he is of ideas that clash with the most precious ideas of the Dutch nation, is in the important function of inspector of middle class eduction is already a sad fact. It would be even infinitely more pitiful if he would be allowed to proclaim his maleficent principles in our land's Parliament. May the patriotic and noble attitude of the voters from The Hague guard us for that." Dagblad van Zuidholland en 's Gravenhage, 30-6-1867. Note that Bosscha, at least later in life, was an atheist: "In tegenstelling tot zijn Vader - met wien hem echter een diepe sympathie en liefde had verbonden - was hij, evenals een groot deel der intellectueelen van zijn tijd, ongelovig, en wel ontsproot deze geesteshouding bij hem niet uit navolging van anderen of uit aangeboren onverschilligheid, maar was zij een weldoordachte en in alle consequenties aanvaarde levensbeschouwing. Hij had dan ook geenszins, zooals het meerendeel van hen, die zich atheïsten noemen, een haat tegen of minachting voor het geloof, en ook miste hij volkomen de angst voor den dood, die zoo vele oude wel- of niet-geloovigen kenmerkt. Hij stond daarboven, en had daarbij een volkomen evenwicht en moreele superioriteit bereikt, die ik nooit door iemand anders geëvenaard heb gezien." Translation: "Contrary to his father - with whom he was connected with a deep sympathy and love - he was, like many intellectuals of his time, an atheist. Although this disposition did not sprout from following others or from a native indifference. Rather it was a well thought out philosophy of life, with acceptance of all consequences. He did not have in the slightest, like the plurality of those who call themselves atheist, a hatred or contempt for religion, and he also completely lacked fear of death, which characterizes so many other old believers or non-believers. He stood above this, and he was completely in balance and had reached a moral superiority that I have not seen equaled in anyone else." See A. E. M. C. Bergsma-Bosscha Erdbrink and J. Brewer (2012a), *Carmen, herinneringen 1894-1904*, p. 16.

The other newspapers lauded Bosscha's broad knowledge, and especially his work for the HBS, that was so important for industry:

> "De heer Bosscha is genoeg bekend op wetenschappelijk gebied, als kenner van Nederlandsch staatsregt en de geschiedenis, als Inspecteur van het voor de industrie en de ambachten zoo belangrijk middelbaar onderwijs, en behoeft onze aanprijzing niet."[428]

Regardless of the public opinion displayed in these newspapers, Bosscha lost the elections in 1867. According to the *Arnhemse Courant* simply because he wasn't known enough politically, but the *Dagblad van Zuidholland en 's Gravenhage* basically calls the *Arnhemse Courant* 'idiots' and says that no candidate of the 'radical' party will ever win in The Hague.[429]

6.1.2 The Elections of 1869: Gouda

Bosscha did not give up after this defeat. In May 1869, Bosscha was chosen as a candidate for the liberal party of Gouda 'de Grondwet'.[430] Here, he had to compete against the conservative Jhr. Willem Maurits de Brauw (1810–1874) after a second voting round[431]: "Te Gouda is de strijd over het onderwijs al zeer sterk verpersoonlijkt bij de herstemming tusschen de heeren de Brauw (1122) en Bosscha (1068)."[432] Quickly, the discussions raged about the school system. In fact, for all candidates it was important what their position was regarding the state schools as this was the central issue and their positions were mentioned without fail in the newspapers. The 'schoolstrijd' was the central political issue at the time. A political mud fight ensued in the newspapers, of which we shall not mention all the details. Notice the difference in the way they speak about Bosscha. The first quote, of *Nieuwe Rotterdamsche Courant*, puts Bosscha on a silver platter, but the second quote, of *Dagblad van Zuidholland en 's Gravenhage*, thinks Bosscha's ideals despicable:

> "Allen die eenen vertegenwoordiger verlangen, die onze grondwettige beginselen lief heeft en deze mildelijk wil toepassen; die vooral de Nederlandsche Volksschool,

[428] Translation: "Mr. Bosscha is known enough in the scientific world, as a specialist in Dutch law and history and as inspector for middle class education so important for the industry and crafts, and he does not need our praise." Nieuwe Rotterdamsche courant, 2-7-1867. Note that it is peculiar that Bosscha is seen as specialist on history and law. It seems that they are mistaking him for his father Bosscha Sr., who was in fact expert in these fields. I think it is at this time implausible that they are confusing them as both are important figures in Dutch society at the time and I think that the newspapers might simply have had a tendency to exaggerate in the public debate they were involving themselves in.

[429] Dagblad van Zuidholland en 's Gravenhage, 6-7-1867; Arnhemse courant, 5-7-1867.

[430] Nieuwe Rotterdamsche Courant, 21-5-1869.

[431] Dagblad van Zuidholland en 's Gravenhage, 10-6-1869.

[432] Translation: "In Gouda the battle for education is very much personified by the reelections between the gentlemen de Brauw and Bosscha." De Noord-Brabanter, 14-6-1869.

dat dierbaar kleinood van ons Nederland, wil handhaven en verdedigen tegen alle rechtstreeksche of zijdelingsche aanvallen; die onafhankelijk is; die uitmunt niet alleen door uitgebreide bekwaamheden, maar ook door een edel gemoed, hebben reden de candidatuur van den heer Bosscha met alle macht te steunen." [433]

"De heer de Brauw vertegenwoordigt dus de vrijheid, de ware beschaving, den waren vooruitgang en bovenal de ware liberaliteit. De heer Bosscha Jr. vertegenwoordigt de radicale dwangleer, de valsche beschaving en een vooruitgang, die teruggang is, en bovenal de voorgewende - hoewel als 'zuivere' geijkte - vrijzinnigheid." [434]


ADVERTENTIEN.

NEDERLAND.
NAAMLOOZE VENNOOTSCHAP VAN VERZEKERING OP HET LEVEN
Verzekering bij overlijden en bij overleving, met onmiddellijk ingaande risico. Dadelijk ingaande lijfrente.
Overlevingskassen. — Spaarkassen ter bekoning van eene som Gelds
Nederlandsche Maatschappij TER BEVORDERING VAN VLAS-INDUSTRIE.
Algemeene Vergadering
De Kiesvereeniging „DE GRONDWET" TE GOUDA,
J. BOSSCHA Jr.
DE CREDITEURen
Hoofdkiesdistrict Gouda.
Jhr. Mr. W. M. de Brauw,
TE 'S-GRAVENHAGE.
De Kiesvereeniging Koning en Vaderland, TE WORDEN.
Jhr. Mr. W. M. DE BRAUW.
KONING EN VADERLAND in het Hoofdkiesdistrict Gouda,
Jkhr. Mr. W. M. DE BRAUW, te 's HAGE.
OPROEPING.
OPROEPING.
Batavia
NOACH II,
JAPAN.
ADMIRAAL DE RUYTER,
ROTTERDAM EN HULL, Stoombootdienst
TE ROTTERDAM
Batavia,
HENRIETTE GERARDINA SUSANNA;
ROTTERDAM EN LEITH.
ROTTERDAM EN HULL.
STOOMBOOT STAD VLISSINGEN N°. 2,
VLISSINGEN EN ROTTERDAM,

6.1 Advertisements in the newspapers.

Figure 6.1: Advertisements in the newspapers.[435]

One nasty, but effective strategy the conservatives used, is of some interest to us. They distributed a pamphlet that tried to impress the voters with the immense costs of the HBS:

"Met welke middelen het gelukt is den heer de Brauw voor de conservatieve partij te behouden, blijkt o.a. uit een strooibiljet tot aanbeveling van dien candidaat, waarvan

[433] Translation: "All that desire a representative that cherishes the principles of our constitution and wants to apply them richly; all those that especially want to maintain and defend our Dutch public school, that Dutch gem, from direct or indirect attacks. All those that want a candidate that is independent, who excels not just by his extensive competences, but also by a noble mind, have reason to support the candidature of Bosscha with all their power." Nieuwe Rotterdamsche Courant, 1-6-1869.

[434] Translation: "Mr. de Brauw represents freedom, true civilization, true progress and above all true liberality. Mr. Bosscha Jr. represents the radical doctrine, the false civilization and progress that is in fact regress, and above all represents feigned 'free-thinking'." Dagblad van Zuidholland en 's Gravenhage, 6-6-1869.

[435] Nieuwe Rotterdamsche Courant, 20-6-1869.

ons uit het district Gouda een exemplaar is toegezonden. In dat biljet worden de kosten van het Middelbaar Onderwijs voor land en gemeenten opgesomd in een uitvoerigen staat, met opgaaf in het bijzonder van hetgeen de Hoogere Burgerschool te Gouda kost. Die cijfers (waarvan, om indruk te maken, de totalen in letters en in cijfers worden opgegeven) moesten dienen om dr. Bosscha, die Inspecteur is van het Middelbaar Onderwijs, te bestrijden. Een man, die in deze betrekking zijn deel ontvangt van de millioenen, die aan het Middelbaar Onderwijs worden ten koste gelegd, naar de Kamer af te vaardigen, wie zou het wenschen?"[436]

The fact that Bosscha lost the elections[437] is an indication that not all citizens were too happy with the new system of HBS and that the resistance against the new school system was very much alive.

6.1.3 The Elections of 1869: Amsterdam

In October of the same year, Bosscha was elected to candidature at the liberal party of Amsterdam called 'Burgerpligt'. with his main rivals being a local business man and liberal candidate Nicolaas Jacob den Tex (1836–1899) and the conservative candidate Eduard Herman 's Jacob (1827–1912). Indeed, Den Tex was elected to candidate for the second liberal party in Amsterdam called 'de Grondwet'.[438] This unfortunate circumstance of two liberal candidates did not do well for them, for 's Jacob was chosen.[439] Again, the discussion raged about the new school system. The battle for the new school was not over, Bosscha thought: "Zijns inziens zou dit het terrein blijven, waarop de groote staatspartijen elkander het eerst in slagorde zouden ontmoeten."[440] This time, however, - ignoring the mud fight between the *Dagblad van Zuidholland* and the *Algemeen Dagblad*[441] - the heart of the argument was not about the financial situation, but the neutrality of the school. Just in 1868, some of the bishops of the Netherlands called upon the catholic parents not to send their children to state schools, the HBS.[442] The writers of the Jewish newspaper were

[436] Translation: "With what means they have succeeded to keep Mr. de Brauw for the conservative party is shown, among others, with a pamphlet for recommendation of their candidate, of which from Gouda a copy has been sent to us. In that pamphlet the costs of the Middle Class Education are enumerated for us in an extensive manner, with especially the overview of the costs of the HBS in Gouda. Those numbers (of which the totals were written in letters and numbers, to impress) had to serve to contest the candidature of Dr. Bosscha, who is inspector of the Middle Class Education. To delegate a man to Parliament, who in this occupation receives his part from the millions that are spent on Middle Class Education, who would want it?" Nieuwe Rotterdamsche Courant, 25-6-1869.

[437] Utrechtsch provinciaal en stedelijk dagblad, 24-6-1869.

[438] Algemeen Handelsblad, 2-10-1869; 7-10-1869.

[439] Algemeen Handelsblad, 14-10-1869.

[440] Translation: "In his opinion this would remain the field on which the big state parties will meet each other in battle." Nieuwe Rotterdamsche Courant, 2-10-1869.

[441] Dagblad van Zuidholland en 's Gravenhage, 3-4-1869; Algemeen Handelsblad, 4-10-1869; 9-10-1869; Dagblad van Zuidholland en 's Gravenhage, 10-10-1869; Algemeen Handelsblad, 12-10-1869.

[442] "Kerk en School. Naar aanleiding van het Bisschoppelijk Mandement." (1868), "Kerk en School. Naar aanleiding van het Bisschoppelijk Mandement."

pro-Bosscha because they were afraid for the neutrality of the public schools in the southern provinces:

> "En toch zouden wij den kiezers moeten aanraden, dr. Bosscha te kiezen. Hij is eene specialiteit in zaken van het schoolwezen. Zijne gewigtige betrekking als inspecteur van het middelbaar onderwijs maakt hem bijzonder geschikt, als kampvechter tegen de vijanden der neutrale school op te treden. Wij weten reeds, dat ook het middelbaar onderwijs aan verschillende aanvallen heeft blootgestaan. [...] Zoo lang mannen als Groen van Prinsterer en Nuijens zich niet als overwonnen beschouwen; zoo lang zij het zwaard niet in de scheede steken; zoo lang zij de banier voor de bijzondere school hoog opheffen, mogen wij de handen niet slap laten hangen. [...] Ultramontanen en anti-revolutionairen laten hunne vrienden in den steek, wanneer er kans bestaat, een geestverwant de overwinning te doen behalen. [...] Onze geloofsbroederen hebben in de hoofdstad over honderd stemmen te beschikken. Zij kunnen dus veel gewigt in de schaal leggen, wanneer zij als één man opkomen en hun burgerpligt naar behooren waarnemen. Wij twijfelen dan ook geenszins, of zij allen zullen willen medewerken om het beginsel der openbare school in stand te houden."[444]

KIEZERSVEREENIGING
DE GRONDWET.

De Kiezers worden uitgenoodigd, op Dingsdag den 12den October 1869 hunne stemmen uit te brengen voor het Lidmaatschap der TWEEDE KAMER der STATEN-GENERAAL, (rood stembriefje) op den Heer
Mr. N. J. DEN TEX,
Secretaris der Kamer van Koophandel,
en voor het Lidmaatschap van den GEMEENTERAAD (wit stembriefje) op den Heer
H. M. DE VRIES,
Hoofddirecteur der Surinaamsche Bank.
Namens de Kiezersvereeniging *de Grondwet:*
ABR. DE VRIES, President.
(26965) W. W. VAN LENNEP, Secretaris.

KIEZERSVEREENIGING
"AMSTERDAM."

Bij de verkiezing op 12 October e. k. worden door de Vereeniging aanbevolen:
Voor de **TWEEDE KAMER DER STATEN-GENERAAL,** de Heer
Mr. E. H. 's JACOB,
(Oud Lid der Tweede Kamer)
en voor den **GEMEENTERAAD,** de Heer
Mr. J. B. CORVER HOOFT,
(Oud Wethouder van de Gemeente).
Namens het Bestuur:
W. VAN DER VLIET,
Voorzitter.
J. A. MOLSTER,
(27036) Secretaris.

Vereeniging
„Regt voor Allen."

De Vereeniging heeft de eer, bij de verkiezingen van **DINGSDAG, 12 DEZER,** aan te bevelen:
Voor het Lidmaatschap der TWEEDE KAMER,
den Heer **Mr. E. H. 's JACOB.**
Voor het Lidmaatschap van den GEMEENTERAAD,
den Heer **Mr. J. B. CORVER HOOFT,**
Oud-Wethouder
J. A. ALBERDINGK THIJM, Voorzitter.
A. B. J. STERCK, fung. Secretaris.
AMSTERDAM, 8 October 1869. (27385)

Kiesvereeniging
BURGERPLIGT.

De KIESVEREENIGING BURGERPLIGT heeft in hare vergadering van 30 September jl., bijgewoond door 97 leden, tot candidaten gesteld: Voor het LIDMAATSCHAP van de TWEEDE KAMER DER STATEN GENERAAL,
(rood stembriefje)
Dr. J. BOSSCHA Jr.,
Inspecteur van het Middelbaar Onderwijs,
en voor het LIDMAATSCHAP van den GEMEENTERAAD
(wit stembriefje)
H. M. DE VRIES,
Hoofd-Directeur van de Surinaamsche Bank.
De Vereeniging noodigt de Kiezers met aandrang uit om **DINGSDAG 12 OCTOBER E. K.** getrouw ter stembus te gaan en hunnen stemmen te vereenigen en hunne

Figure 6.2: Advertisement.[443]

[443] Algemeen Handelsblad, 12-10-1869.

[444] Translation: "And still we must recommend to our voters to choose dr. Bosscha. He is a specialist in matters of the school system. His important occupation as inspector of middle school education makes him particularly apt to act as the champion against the enemies of the neutral school. We already know that the middle class education has been attacked from various sides. As long as men like Groen van Prinsterer and Huijens do not consider themselves defeated, as long as they do not sheath their swords, as long as they lift up high the flag of the denominational school we may not rest. Ultramontanes and anti-revolutionaries abandon their friends whenever there is a chance to let a kindred thinker win. Our religious brethren have over a hundred votes in the capital city. They can put much weight in if they participate in the elections as one man and do their civil duty properly. We do not doubt that they will all cooperate to maintain the principle of the public school." Nieuw Israelietisch weekblad, 8-10-1869.

Two southern and catholic newspapers are against the neutral schools and therefore against Bosscha's candidature. The "schoolstrijd" was long from gone from the minds of the Catholics. It must have been difficult for Bosscha to perform his duties in the south of the Netherlands in that political climate.

> "De heer Bosscha is een geprononceerd schoolwet man en hevig anti-katholiek. Geen wonder dat het Handelsblad hoog met hem ingenomen is. De uitslag dezer verkiezing wordt met buitengewone belangstelling afgewacht. De verdeeldheid der liberale kiezers kon hen ditmaal wel eens hun doel doen missen." [445]

> "Wij willen niet ontkennen dat deze verpletterende nederlaag van den schoolwetsman bij uitnemendheid ons een bijzonder genoegen gedaan heeft. Hieruit blijkt dat de liberalen nog niet zoo ver zijn, als zij zich verbeelden. [...] Door den heer Bosscha niet te kiezen, heeft de volksstem zich duidelijk tegen de schoolmanie geuit." [446]

This shows that a large part of the opposition to the HBS stemmed from religion. While some of them only wanted the freedom to teach with their own religious tenets, some religious factions despised the natural sciences because they led to materialism and atheism. Bosscha did not mourn his defeats all too long and was happy in the end he was not completely separated from science in this way, his honor was slightly hurt:

> "Het succes scheen zeker te Amsterdam (dat dan ook alle kandidaten van Burgerplicht zag zegevieren), twijfelachtig in Gouda. Tegenstander van dubbele kandidatuur koos ik Gouda en leed de nederlaag tegen Jhr. de Brauw. Mijne eerzucht werd teleurgesteld, doch ik zelf behouden voor het intreden in een loopbaan, die mij zeker niet bevredigd zou hebben en geheel onttrokken aan de wetenschap."[447]

Bosscha remained somewhat active in politics for the following period. He was head of the board of the liberal party 'de Grondwet' for The Hague from March 1871 until July 1875,[448] at

[445] Translation: "Mr. Bosscha is a pronounced proponent of the school law and heavily anti-Catholic. No wonder that the Handelsblad thinks highly of him. The result of this election is awaited with extreme interest. The division between the liberal voters may make them miss their target." De Noord-Brabanter, 13-10-1869.

[446] Translation: "We do not want to deny that this heavy defeat of the proponent of the school law has done us extremely well. It proves that the liberals are not so far as they sometimes imagine themselves to be. By not choosing Bosscha, the public voice has expressed itself against the school-manic." Venloosch weekblad, 23-10-1869.

[447] Translation: "Success seemed evident in Amsterdam (that has seen all candidates of Burgerplicht prevail), doubtful in Gouda. Opposed to double candidature I chose Gouda and suffered a defeat against Jhr. de Brauw. My ambition was tarnished, but I have kept myself from entering a career that would not have satisfied me and withdrawn me completely from science." Baarn-archive: Autobiography.

[448] De wekker; weekblad voor onderwijs en schoolwezen 38 (13), 31-03-1871; Algemeen Handelsblad, 14-7-1875. Note that the board and the party were not united in their opinion anymore and this is also one of the reasons Bosscha quit.

which point he moved to Delft. He became head of another liberal party 'Nederland' in Delft in November 1880, which became part of the 'Liberal Union' in February 1885. Bosscha resigned from his membership and his position as representative of the party at the Liberal Union in July 1885 following his illnes and move to Haarlem.[449]

6.2 *Maatschappij tot Nut van 't Algemeen*

The *Maatschappij tot Nut van 't Algemeen* (Society to the Benefit of the Common) was founded in 1784 and had as goal the improvement of the welfare and culture of society at large, in particular of the lower class. One can see that education of the common man, like at the HBS, was exactly in line with the goal of the Society, for it meant a direct improvement of the general education level and thus opportunities of a larger part of the population. Indeed, in the HBS, *'t Nut* saw one of its main goals accomplished. *'t Nut* was obviously of liberal political signature and was often denounced by the conservatives.

It is not surprising that Bosscha, who thought education was very important, played an active role in the Society. In 1869, he was chosen chairman of the yearly assembly and in 1872 he was part of the board of the local department of The Hague.[450] In the former position he gave a speech, defending the school system and proclaiming it a 'daughter' of the Society, completely in line with the goals of the Society: "want onze volksschool is de dochter van onze Maatschappij, eene dochter, die in aanleg en karakter op hare moeder gelijkt."[451] He continues explaining how the neutral public schools were exactly in line with the goals of the Society and even with *'t Nuts* tenet of neutrality. He sharply attacks the opponents of the neutral school as they did not heed tolerance:

> "Wij staan lijnrecht tegenover elkander: uwe ergernis is onze roem. *Wij* zoeken wat menschen vereenigt, *gij* hebt slechts oog en hart voor 't geen menschen verdeelt. Wij, die eensgezindheid in het practische leven bestaanbaar achten met verschil van geloofsovertuiging, wij moeten het opgeven hen te vreden te stellen, die zelfs verdraagzaamheid niet verdragen."[452]

[449] Delftsche Courant, 14-11-1880; 15-2-1885; 31-7-1885.

[450] Baarn-Archive: Letter of Maatschappij tot Nut van het Algemeen, departement 's Gravenhage to J. Bosscha Jr., 22-6-1872; Nieuwe Rotterdamsche Courant, 10-5-1869.

[451] Translation: "Because our public school is the daughter of our Society and a daughter that resembles her mother in talent and character." J. Bosscha Jr. (1869e), *Aanspraak bij de opening van de 84ste algemeene vergadering der Maatschappij tot Nut van 't Algemeen, gehouden den 10den Augustus 1869*, p. 6.

[452] Translation: "We are directly opposed: Your annoyance is our fame. We search for what unites people, You only have eyes and heart for what divides people. We, who think that unanimity in practical life is possible with difference of opinion in belief, we must give up to satisfy those who can't even tolerate our tolerance." J. Bosscha Jr. (1869e), *Aanspraak bij de opening van de 84ste algemeene vergadering der Maatschappij tot Nut van 't Algemeen, gehouden den 10den Augustus 1869*, p. 11.

The proponents of the denominational schools struck back at *'t Nut* and Bosscha's speech. They proclaimed that *'t Nut* tried to monopolize the education system and that the freedom of education was undermined. Note again the religious argument against the schools:

> "Inderdaad, wij zijn zeer erkentelijk voor deze officiëuze kennisgeving, die ons zonder omwegen en zonder er doekjes om te winden inleidt in de zaken van het Nut, om ons te leeren, hoe en wat het Nut denkt van het onderwijs, dat in Nederland aan de jeugd wordt *opgedrongen* onder den naam van Staatsonderwijs, of gemeenteschool, of nationale school, of neutrale school, en niets van dit alles is, dan alleen Nutsschool, dat is: school van de maatschappij tot Nut van 't Algemeen, die bij ons sinds 50 jaren het voorportaal is geweest van de vrijmetselarij, en sinds gelijken tijd heeft gearbeid, om het geloof in Christus buiten en in de school te ondermijnen."[453]

6.2.1 Schoolverbond

In 1869 P. Harting and his brother founded the 'schoolverbond', a society that tried to promote schoolgoing, in particular going to secondary education.[454] Bosscha Sr. was the first head of the society, but Bosscha Jr. also played an active role: the rules and regulations were written by Bosscha Jr., and he was head of the society in 1872.[455] There was a lot of interest in the society. By 1870, it had over 6000 members.[456] However, in the end, it turned out that the biggest obstacle to schoolgoing was child labor and this was only properly fought by changing the law itself. The first law against child labor dates 1874.[457] However, the law was not sufficiently enforced, leading to a petition (co-signed by Bosscha) in 1882 to more strongly enforce the law.[458]

[453] Translation: "Indeed, we are very thankful for this semi-official notification that without reservations introduces us in the dealings of the Nut and to teach us how and what the Nut thinks about the education that is forced upon the youth in the Netherlands under the name of State Education or Municipal School or National School or Neutral School and how nothing of this is anything else then Nutsschool, that is, the school of the Society to the Benefit of the Common, that has since the 50s been the gate to freemasonry and for the same period has worked to undermine the belief in Christ within and outside the school." De Tijd, 12-8-1869; Dagblad van Zuidholland en 's Gravenhage, 17-8-1869.

[454] De wekker; weekblad voor onderwijs en schoolwezen 26 (35), 27-8-1869.

[455] De wekker; weekblad voor onderwijs en schoolwezen 36 (49), 3-12-1869; 39 (19), 10-5-1872.

[456] Arnhemse Courant, 5-3-1870.

[457] Algemeen Handelsblad, 31-3-1898.

[458] Algemeen Handelsblad, 27-10-1882.

6.3 De Nederlandsche Spectator

Often, in newspaper articles by the conservatives, Bosscha was attacked because he belonged to those 'Spectatorvolk', the group of editors of the *Spectator*. *De Nederlandsche Spectator* was founded by Bosscha's friend Lindo in 1856. He also called it: 'het weekblad van de oude heer Smits' after his pseudonym. It mingled serious scientific articles with satire, but it became more serious after a fusion with the scientific journal *Algemene Kunst- en Letterbode* in 1860. It was an outspoken liberal journal with the goal to ensure the "schoone verband tusschen Wetenschap, Kunst en Schoone Letteren".[460] Bosscha was added to the list of editors in 1865.[461]

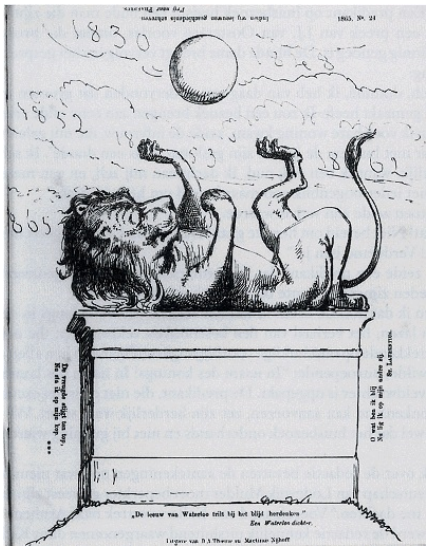


Figure 6.3: The satirical image of the lion of Waterloo on its back.[459]

However, quickly he was under attack, together with the other two inspectors, for a satirical picture in the journal depicting the lion of Waterloo on its back, playing with a ball. Napoleon's defeat had just been commemorated in 1865, with a hero's role for our King Willem II in the battle. According to the Spectator this was emphasized and commemorated too much: "het piëtistisch en overdreven gezeur"[462] The Dagblad of Zuid-Holland was quick to deny the inspectors their right to be inspectors of the Netherlands:

> "Een voorbeeld uit honderd: de twee genoemde heeren inspecteurs hebben toegelaten of gewild, hebben misschien zelven uitgelokt, dat de leeuw van Waterloo op den rug liggende werd voorgesteld, spelende met een bal, omgeven van platte en Nederland tergende woorden. De heeren Bosscha en Steijn Parvé hebben daarmede deels uitgedrukt de wijze, waarop zij de geschiedenis van Europa en van het vaderland verstaan en gaarne beoefend zijn, en zeker alle regt verbeurd, om, waar op de middelbare scholen de geschiedenis wordt bespot en belasterd door leermeesters of leerlingen, eenige aanmerkingen te maken. Wis- en natuurkunde in volle mate, en geen waarborgen, dat de leeuw van Waterloo niet zal worden gelasterd: Ziedaar den geest dier nieuwe scholen, waarmede het goede volk zich laat verblinden, waarvoor het gebouwen sticht en schatten uitgeeft, om alweder, als het te laat is, in te zien, hoe men zich zelven den

[459] N. Maas (1997), "Documenten over De Nederlandsche Spectator", p. 60.
[460] Translation: "the beautiful relation between science, art and literature."
[461] See for the history of the *Spectator* N. Maas (1997), "Documenten over De Nederlandsche Spectator".
[462] Translation: "pietistic and exaggerated moaning". By Carel Vosmaer (1826–1888) Cited ibid. p. 60.

strop om den hals heeft toegesnoerd."[463]

These and other attacks compelled Bosscha to ask to remove his name from the list of editors. Mainly, because it made it more difficult to perform his duties as inspector. The Catholics misused the Spectator against him in his work.[464] In July 1867 his name was scrapped from the list of editors. He must not have been the only one with these problems, for at the start of the year 1868 all the names of the editors were scrapped. However, the newspapers during the elections, did not forget that Bosscha was once part of the journal. For instance, in the elections of 1869. Note how they call the new theories of physics 'unworthy of man':

> "De heer Bosscha behoort tot de Spectator-rigting, dat is de rigting, die door spotprenten de eerbiedswaardigste mannen des lands tracht belagchelijk te maken [...] die spot met alle geloof en gezag, speelt met de dierbaarsten beginselen en om de toekomst der natie zich niet bekreunt, of het moest zijn dat haar streven, om de meest menschonteerende natuurkundige theoriën ingang bij de jeugd te verschaffen, een zorgen voor de toekomst kan heeten." [465]

Indeed, the *Spectator* was a target for many such accusations. The elections of 1869 contained another outrage: A satirical book called *Parlementaire Portretten* was published by the pseudonym Sagittarius. The book made fun of and criticized the half of Parliament that were at the end of their term of office, presumably to influence the coming elections in favor of the liberals. George Willem Vreede (1809–1880) accused Bosscha and Lindo among others, as being part of the Spectator, of writing this book.[466] However, Bosscha and Lindo were quick to deny these accusations and Vreede in turn apologized.[467] It turns out that all these accusations were wrong and that fellow member of parliament Prof. Willem Joseph Andries Jonckbloet (1817–1886) was the writer of the book.[468]

[463] Translation: "One example from dozens, the mentioned gentlemen inspectors have permitted or wanted or provoked themselves that the lion of Waterloo was depicted laying on its back playing with a ball surrounded by vulgar and biting words aggravating the Netherlands. The gentlemen Bosscha and Steijn Parvé have with this partly expressed the way in which they understand the history of Europe and of our country and how they would like to see it practiced. And they have certainly lost the right to any comments on the high schools in which history is mocked and defamed by teachers or students. Mathematics and physics entirely and no guarantees that the lion of Waterloo will not be slandered. Lo and behold the spirit of the new schools with which the people let them be blinded, for which they spend their riches and founds buildings to realize, when it is already too late, how they have themselves tightened the noose around their necks." Dagblad van Zuidholland en 's Gravenhage, 13-7-1865. I hardly think Bosscha would indulge in such mockery. His father wrote a biography on Willem II and Bosscha, at the time, was very positive about this publication in the letters to his father.

[464] N. Maas (1997), "Documenten over De Nederlandsche Spectator", p. 61.

[465] Translation: "Mr. Bosscha belongs to the Spectator group. That is the group that tries to ridicule the most respectable men by making caricatures of them, that mocks all belief and authority, toys with the most precious principles and does not concern itself with the future of the country, or it must be her aim to introduce the most degrading physical theories to the youth that can be called a worry for the future." Dagblad van Zuidholland en 's Gravenhage, 6-6-1869.

[466] Nieuwe Rotterdamsche Courant, 15-6-1869.

[467] Algemeen Handelsblad, 24-6-1869.

[468] W. J. A. Jonckbloet (1869), *Parlementaire Portretten*.

Bosscha wrote four articles for *De Nederlandsche Spectator*. The first: "Een Benaauwde Droom" reviewed an article by Prof. Willem Gerard Brill (1811–1896), in which Brill criticized the HBS and the Universities.[469] The Second: "De geneeskundige Staatsregeling in en buiten de Kamer" he discussed a political question: Public healthcare and healthcare laws.[470] The third: "Natuurstudie" was to emphasize the importance of research in the natural sciences and to review meetings of the newly founded society of to the improvement of public health that was founded after a cholera epidemic.[471] The last was the necrology of Van Rees.[472]

6.3.1 Bosscha and Healthcare

Bosscha's review articles on health care issues are not completely out of the blue. As assistant to the laboratory in Leiden, Bosscha had facilitated the practical exercises for students of medicine. Moreover, Bosscha was part of the 'geneeskundige raad van Zuid-Holland' for many years, advising on health care issues.[473] During his Haarlem years, he was also part of the overseeing committee of the psychiatric institute Meerenberg.[474]

Lastly, Bosscha Sr. was the first president of the Dutch division of the Red Cross.[475] Bosscha Jr. was also active in the organization and was sent by his father to Düsseldorff to help the casualties in the Franco-German war of 1870.[476] Bosscha was awarded a medal for his efforts from the Red Cross of the Netherlands (by his father).[477] He was awarded the 'croix de bronze' by the *Société Française de Secours aux Blessés et Malades de Armeés de Terre et de Mer*.[478] Germany's society for healthcare lauded Bosscha Jr. for his efforts in 1873.[479]

6.3.2 Anti-Dagblad Zegelverbond

There were plans to start a new 'neutral' newspaper called *Dagblad van Nederland* with most of the editors of the Spectator, the founders would have been among others, Bosscha, Lindo,

[469] J. Bosscha Jr. (1864b), "Een Benaauwde Droom".
[470] J. Bosscha Jr. (1865), "De geneeskundige Staatsregeling in en buiten de Kamer".
[471] J. Bosscha Jr. (1867), "Natuurstudie".
[472] J. Bosscha Jr. (1876d), "R. van Rees".
[473] Bosscha was part of this council for the years 1867, 1870, 1873, 1877, 1880 and 1883. See Nederlands Staatscourant, 31-12-1866; 16-12-1869; 25-12-1872; 29-12-1876; 18-12-1879; 15-12-1883. Note that the meetings of this council took place at *Diligentia*, see for instance: Rotterdamsch Nieuwsblad, 2-8-1879.
[474] From at least 1887 until May 1900. Baarn-archive: Letters of De Gedeputeerde Staten van Noordholland to J. Bosscha Jr., 20-6-1887; 30-5-1900.
[475] W. J. Knoop (1875), "Levensbericht J. Bosscha", pp. 36–37.
[476] See Algemeen Handelsblad, 28-8-1870; 29-8-1870. He already returned one week later for the duties of his occupation: Algemeen Handelsblad, 6-9-1870. Bosscha Jr. wrote a rapport of the situation printed in the newspapers: Het Nieuws van den Dag: Kleine Courant, 1-9-1870.
[477] Baarn-archive: Diploma, signed by J. Bosscha Sr., 14-12-1871.
[478] Baarn-archive: Diploma, signed by De Beaufort, 2-7-1871.
[479] Baarn-archive: Diploma, signed on 20-4-1873.
[480] Baarn-Archive.

Vosmaer. They would start if, and only if, half a million would sign up.[481] However, they wanted to make this newspaper twice as big and at same price, which was virtually impossible because of a special tax on newspapers, the so called: "zegelbelasting", which would already take up half of the budget.[482] The special tax on newspapers was implemented in 1812 and was at such an exorbitant amount that newspapers were very expensive and only available to the upper class.

In 1867, wholly in line with the developments in society and the goals of *'t Nut*, a union: *Anti-Dagbladzegel Verbond* was established that had as goal the "afschaffing van het dagbladzegel te bevorderen". The members of this union were of the opinon that "het dagbladzegel eene belasting is, die drukt op de sociale, politieke en intellectuele ontwikkeling der natie." Members of this society were among others: Prof. Jacobus Anthonie Fruin (1829–1884), Bosscha, Lindo, Prof. Johannes Theodoor Buys (1826–1893), Prof. Jacob Leonard de Bruyn Kops (1822–1887) and Modderman.[483] Bosscha was the head of the union, as he opened the meetings of the union held at *Diligentia*.[484] The protest against the 'dagbladzegel' was supported on a national scale by many of the newspapers, and under pressure of these protests the government abolished the tax on the first of July 1869. Shortly before, the members of the union deemed their task complete and dissolved the union.[485] To my knowledge, in the end the *Dagblad van Nederland* was not established.

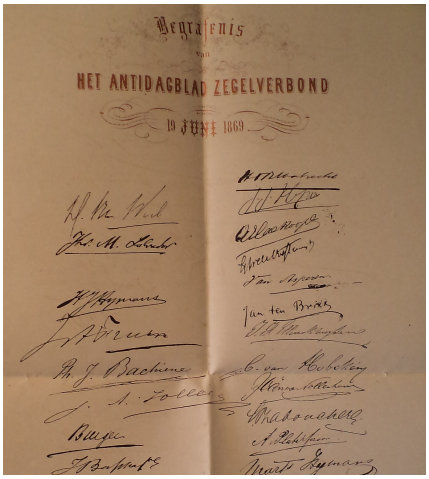


Figure 6.4: The 'funeral' of the union against the newspaper tax.[480]

[481] Arnhemse Courant, 13-12-1866.
[482] Arnhemse Courant, 18-1-1869.
[483] Nieuwe Rotterdamsche courant, 18-4-1867.
[484] Utrechtsch provinciaal en stedelijk dagblad, 4-10-1867.
[485] Nieuwe Rotterdamsche Courant, 20-6-1869. Also consulted Wikipedia, 25-5-2017.
[486] Baarn-Archive.

Figure 6.5: Bosscha painted by his daughter Jacoba Bosscha.[486]

Epilogue:
Bosscha's Influence and Legacy

While the previous two parts established Bosscha's ideals and position of influence in the Netherlands, this epilogue will sketch in what ways Bosscha was able to exert his influence on the field of physics in the Netherlands. Bosscha was an active member of the KNAW and played a pivotal role in the international committee for the meter. More specifically, in the Delft period Bosscha stood at the brink of the foundation of various laboratories, instilling the ideal of precision physics into a next generation of physicists. In the Haarlem period, Bosscha advocated the image of a 'Dutch science' with his work on the journal of the Hollandsche Maatschappij der Wetenschappen *Archives Neéerlandaises des Sciences Exactes et Naturelles*, by being active in the society of the *Nederlandsch Natuur- en Geneeskundig Congres* (Dutch Physics and Medicine Conference, abbreviated NNGC henceforth) and lastly by promoting the names of Dutch historical figures of Huygens and Van Marum.

Academic Aspirations at the Polytechnical School in Delft (1873-1885)

On the 1st of February 1873 Bosscha became professor of applied physics of the Polytechnical School of Delft[487] as the successor of Van de Sande Bakhuyzen, who became professor of chemistry in Leiden. One of the reasons for his appointment in Delft was his concurrent appointment as secretary of the international meter committee.[488] This post required Bosscha to have a laboratory and to be able to travel to Paris often. His previous occupation had neither of the two requirements. In his inaugural lecture, Bosscha made himself clear. Only through thorough theoretical knowledge of physical phenomena one can start working on applications. Bosscha distanced his practice from the universities, but nevertheless sought to 'academize' the Polytechnical School, i.e. increase the theoretical level:

[487] Nederlandsche Staatscourant, 4-1-1873; Baarn Archive: Letter of Willem III to J. Bosscha Jr., 25-1-1873.
[488] Nederlandsche Staatscourant, 21-10-1872.

> "Geen uitgebreider vak kan men zich denken; elke eigenschap waarvan in de techniek gebruik wordt gemaakt, [...] wordt uit de natuurkrachten afgeleidt. [...] De ingenieur moet indringen in den geest van de natuurkunde; theoretiesch zal de cursus zijn, niet als aan de hoogescholen waar de wetenschap om de wetenschap zelve wordt beoefend, maar theoretiesch in verband met de toepassingen."[489]

The Polytechnical School in Delft was founded in 1864 as part of the middle class education law of 1863. Although at a higher in level of education than the HBS or even the gymnasia, the goal of the education at the Polytechnical School was not 'preparation to the learned class' but 'preparation to a technical occupation in society', thus, according to THORBECKE it belonged to middle class education.[491] This division based on class would remain an eyesore for the engineers, who felt subordinated, until 1905 when the Polytechnical School was lifted out of the law of 1863 and added to the higher education laws.[492] This division in class was similar in many German states, but not in Pruissen and Austria where poly-technical education was set equal to university education.[493] One of the more important arguments for lifting the Polytechnical School to the University level is that the education at the Polytechnical School was already at an academic level, as it was mostly provided by University laureates and was highly theoretical. Interestingly, in practice, more practical schooled engineers were preferred over the theoretically schooled Delft technicians.[494] In 1905 the Polytechnical School became the 'Technische Hoogeschool' and obtained the right to award doctorates. The

Figure 1: BOSSCHA in 1884 as professor.[490]

[489] Translation: "Man can not imagine a more extensive subject; every property that is used in technology is derived from the forces of nature. The engineer must penetrate the very soul of physics; the course will be theoretical, not like at the universities where science is practiced for science itself, but theoretical with respect to the applications." He warned practitioners who do not understand the theory with the words of Mefistofeles from GOETHE's Faust:

> Grau, theuer Freund, ist alle Theorie
> Und grün des Lebens goldner Baum.

Originally in Het Vaderland, found in De Nederlandsche Spectator, 8-2-1873.

[490] Found here: gallica.bnf.fr/ark:/12148/btv1b8452931q/f1.item.

[491] H. T. A. Amsing (2002), *Bakens verzetten in het voortgezet onderwijs*, pp. 60–61.

[492] The feeling of injustice about this situation is, for instance, written out here: De Ingenieur, 8-7-1905.

[493] H. W. Lintsen (1992-1995), *Geschiedenis van de Techniek in Nederland. De Wording van een Moderne Samenleving 1800-1890*, pp. 119–120.

[494] G. P. J. Verbong (1993), "Delftse Ingenieurs tussen Wetenschap en Industrie (1875-1900)".

first doctorate awarded was an honorary doctorate to Bosscha, for his many services to the Polytechnical School as professor and later director.[495]

The Polytechnical School was the continuation of the Koninklijke Academie voor Ingenieurs (Royal Academy for Engineers) that was founded in 1842. The old Academy was in bad financial weather and through the law of 1863 it gained financial support from the government.[496] Bosscha was already familiar with the Polytechnical School before he became a professor here due to his occupation as inspector of middle education. After all, by law, the Polytechnical School was part of the middle education. In this role, Bosscha appointed the first director of the Polytechnical School: Lewis Cohen Stuart (1827–1878), whom he probably knew via Kaiser,[497] and, Bosscha was head of the committee of exams of the Polytechnical School, as we have already noted in chapter 4.

According to Prof. Kamerlingh Onnes, Bosscha did much for the Polytechnical School and especially labored to elevate the Polytechnical School to an academic level. Kamerlingh Onnes writes:

> "Een zelfde taak als door Bosscha voor de Hoogere Burgerscholen vervuld was, had hij daarna weder gevonden in de reorganisatie van het onderwijs aan de Polytechnische School, tot de verheffing van welke hij, eerst als hoogleeraar, later als hoogleeraar-directeur zoo veel heeft bij gedragen, dat men in hare eindelijke officieele verheffing tot 'Technische Hoogeschool' de kroon op door hem ingeleid werk mag zien."[498]

Here, Kamerlingh Onnes calls the elevation to University something Bosscha has started with the reorganization of the education at the Polytechnical School.

The Laboratory of the Polytechnical School

Bosscha indeed did much to 'academize' the Polytechnical School. When Bosscha first became professor, upon accepting his post at the Polytechnical School, he demanded a whole new physical laboratory and several rooms for practical exercises to be built. Moreover, he requested to appoint assistants in the new laboratory.[499] This started with an electro-technical and physical laboratory,

[495] Baarn Archive: Letter of Pekelharing to J. Bosscha Jr., 19-12-1906; De ingenieur, 12-1-1907.

[496] On the history of the Polytechnical School, see H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*; A. F. Kamp (1955), *De Technische Hogeschool te Delft 1905-1955*; H. Baudet, H. J. A. Duparc, and J. H. Makkink (1992), *De lange weg naar de Technische Universiteit Delft*.

[497] Kaiser awarded Cohen Stuart with a doctorate in the natural sciences *honoris causa* for his work on triangulation in 1863.

[498] Translation: The same task as Bosscha accomplished for the HBS he had found in the reorganization of the Polytechnical School, for which elevation he, first as professor then as director, has contributed much, so much that her final official elevation to 'Technical University' can be seen as the crown on the work introduced by him." H. Kamerlingh Onnes (1911a), "In Memoriam Prof. Dr. J. Bosscha".

[499] H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 114.

but also heralded the start of a series of new buildings, including the Geodesy building that was built during his directorate of the Polytechnical School. Practical exercises were introduced for not only the advanced students but for all students from the beginning, as was already the norm at the HBS, and would soon be copied by the academic institutions, notably by medicine.[500]

Not only the laboratory received an upgrade thanks to Bosscha. When Bosscha was approached for the professorate of Amsterdam (for which Bosscha recommended, with success, Van der Waals) he was motivated to stay in Delft with an increase in salary of $f1000,-$. Bosscha did not agree that he would earn more than his colleagues so he argued that *all* professors should earn $f1000,-$ more and all lectors $f500,-$ more. When Bosscha became director of the Polytechnical School in 1878,[501] his requirement was granted.[502]

Bosscha's Influence: The Laboratories throughout the Netherlands

We have already mentioned that the new physical laboratory of Utrecht University was constructed to accommodate the high standards that the HBS required of prospective teachers, and thus, of the students at Utrecht. In fact, Bosscha's influence can be shown in the construction or reorganization of all university laboratories in the Netherlands.

Firstly, Van der Waals, who was already in scientific contact with Bosscha before Bosscha's Delft period and was helped to his professorship by Bosscha, was inspired by the Laboratory of the Polytechnical School and the new, but slightly unused, building of the Laboratory of Utrecht University when he planned to build a new laboratory for the University of Amsterdam.[503] However, Van der Waals being a theoretician, did not use the laboratory so much.[504]

Secondly, Kamerlingh Onnes, who became Bosscha's assistant at the Polytechnical School in 1878 until 1882, was very positive about Bosscha and was influenced by Bosscha's methodology of the 'measuring physicist'.[505] Indeed, Kamerlingh Onnes' famous motto: 'door meten tot weten' (through measurements to knowledge), can be seen as an extension of Bosscha's experimental ideals.[506] Kamerlingh Onnes writes in an eulogy: "Maar meer dan dit laboratorium trok mij Bosscha als voortreffelijke leermeester. Reeds op de schoolbanken had zijn

[500] J. A. Snijders (1905), "Het tot stand komen en de Inrichting van het Electrotechnisch en Natuurkundig Laboratorium te Delft"; F. van Lunteren (1995), "Van Meten tot Weten".
[501] Nederlandsche Staatscourant, 7-8-1878.
[502] H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 115.
[503] A. J. P. Maas (2001), *Atomisme en Individualisme*, p. 50.
[504] F. van Lunteren (1995), "Van Meten tot Weten", pp. 133–134.
[505] D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 124–132.
[506] Kamerlingh Onnes, apart from promoting this sentence to his motto, expresses his gratitude to Bosscha as his teacher in his inaugural lecture. H. Kamerlingh Onnes (1882), *De Beteekenis van het Quantitatief Onderzoek in de Natuurkunde*.

Leerboek, [...], tot mij van Bosscha's liefde voor metend onderzoek gesproken."[507] Kamerlingh Onnes continues. Bosscha's research about the new standard meters would allow Kamerlingh Onnes to see physical research of the highest significance from a close range. "Het assistentschap bij Bosscha overtrof echter nog mijne verwachtingen."[508] Kamerlingh Onnes lauds Bosscha's organization of his clear lectures, practical exercises and the critical discussions on experimental results.

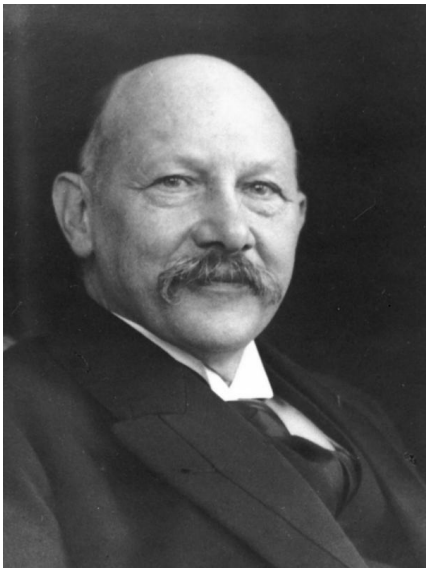


Figure 2: Heike Kamerlingh Onnes (1853–1926)

> "De wijze waarop Bosscha zijne glasheldere en boeiende collega's voorbereidde, de organisatie van de practische oefeningen, het diep indringen in de kritiek van waarnemingen en in de discussie van uitkomsten, het was alles even leerzaam. Het werken volgens Bosscha's aanwijzingen en de gedachtenwisseling over allerlei vraagpunten, waartoe hij altijd bereid was, hebben onvergetelijke indrukken van die jaren bij mij achtergelaten. Daarbij schonk hij mij zijne bezielende leiding met eene vaderlijke hartelijkheid, die eene vriendschap voor het leven deed ontluiken. Door zijne vertrouwelijkheid wist ik van nabij hoe het hem om wetenschap en om deze alleen zonder bijoogmerken te doen was en mocht ik zien hoe hij in gloed kwam voor waarheid en recht."[509]

This quote shows Kamerlingh Onnes' admiration for Bosscha and the fact that they became friends. When Rijke became emeritus in 1882, his position went to Kamerlingh Onnes. This did not go easily. Rijke was against Kamerlingh Onnes because, next to Lorentz, he believed Leiden needed a practically oriented professor. Kamerlingh Onnes, as a student of Bosscha

[507] Translation: "More than this laboratory, I was interested in Bosscha as an outstanding teacher. Already at school his textbook spoke to me of Bosscha's fondness of measuring research." H. Kamerlingh Onnes (1911a), "In Memoriam Prof. Dr. J. Bosscha".

[508] Translation: "Being assistant of Bosscha exceeded all my expectations." Ibid.

[509] Translation: "The way in which Bosscha prepared his crystal clear and engaging lectures, the organization of the practical exercises, the thorough penetration in the criticism of observations and in the discussion of results, all of it was very instructive. Working according to Bosscha's instructions and exchanging ideas about any issues, for which he was always available, have left me with unforgettable memories of those years. Moreover, he gifted me with his inspiring leadership with a fatherly cordiality that budded into a life long friendship. Because of his cordiality I knew from close by how he was interested in doing science without any ulterior motives and how he lightened up for truth and justice." Ibid.

was too theoretical and meticulous.[510] Both Lorentz and Bosscha worked hard to install Kamerlingh Onnes as professor at the University of Leiden. When the name of Wilhelm Conrad Röntgen (1845–1923) was mentioned, Bosscha wrote a strong plea in favor of two Dutch scientists, slightly favoring Kamerlingh Onnes over Van der Waals, as Kamerlingh Onnes, according to Bosscha, would become even more prominent than Van der Waals. It would be madness to search abroad for candidates:

> "Toch verwacht ik dat Onnes hem [Van der Waals] overvleugelen zal. Onnes is scherpzinniger en denkt dieper door. Zijn benoeming zou voor de Leidsche Academie en voor de physica in Nederland zeer wenschelijk zijn. Hij is in staat een school te maken en dit kan van weinigen gezegd worden. Onnes en Van der Waals zijn de eenige Nederlanders die in aanmerking komen en dan zou het dwaasheid zijn om in het buitenland te zoeken."[511]

All in all, we see that Bosscha helped Kamerlingh Onnes in becoming professor in Leiden and that Kamerlingh Onnes was inspired by Bosscha's methodology from the start. The subsequent high precision and cryogenic laboratory of Leiden that Kamerlingh Onnes would erect, inherited Bosscha's measuring ideals.[512]

A similar story can be told of Haga, who did research under Bosscha's supervision in the laboratory of the Polytechnical School. When Haga was appointed to professor in Groningen, he immediately made sure the students did more practical exercises. Moreover, he installed a new laboratory fit for high precision magnetic research built without any iron and put on top of massive vibration absorbing stone pillars. Bosscha instilled his methodology of high precision into Haga. Unfortunately, the municipal built a tram line right next to the laboratory which rendered the whole building useless for high precision magnetic research.[513]

Research at the PS

Bosscha, at the Polytechnical School, was mainly busy with reforming the education at the

[510] This might seem strange, but at the time, Kamerlingh Onnes's name was only connected to his fairly theoretical dissertation and one treatise on the theory of liquids. Bosscha knew more about Kamerlingh Onnes's practical experience as Kamerlingh Onnes assisted him with the practical exercises in Delft. H. Kamerlingh Onnes (1879), *Nieuwe Bewijzen voor de Aswenteling der Aarde*; H. Kamerlingh Onnes (1881), *Algemeene Theorie der Vloeistoffen*.

[511] Translation: "Still I expect that Onnes will surpass him [van der Waals]. Onnes is sharper and thinks more deeply. His appointment would be very desirable for the Academy of Leiden and for physics in the Netherlands. He is able to make a school and this cannot be said about most. Onnes and Van der Waals are the only Dutch that are to be considered and in that case it is stupidity to search for someone abroad." H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, pp. 116–117.

[512] See for more on the succession of Kamerlingh Onnes and the laboratory of Leiden: J. L. Oosterhoff (1984), "De Opkomst van een "Vaderlandse Natuurkunde""; D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 124–145.

[513] F. van Lunteren (1995), "Van Meten tot Weten", pp. 131–133.

Polytechnical School, but it can be surmised that he supervised the research of his students and let them publish under their own name. The research that he himself did was almost always connected to the establishment of the official meter. It must be noted that in the 19th century, a central system of units was the step forward for scientific cooperation in precision science. The decimal system of meter and kilogram were defined in 1790 by the original French committee of the meter, in which Van Swinden played a role. Electrical units were only established in 1883 by an international conference, for which Bosscha was of course the representative for the Dutch government.[514]

In 1869 a new international committee was created in order to update the situation in which many countries had more or less well done copies of the original meter. The Dutch representatives of this committee were Kaiser and Stamkart and they had as task to obtain a copy of the original meter for the Netherlands. When Kaiser died in 1872, Bosscha succeeded him in his position and was made secretary of the international committee. Here, he did much to establish the new copies of the meter, but, he did not agree with a centralized institute for measurements on the units, the to be founded *Bureau International de Poids et Mesures*. For this reason, the Netherlands did not sign the meter convention of 1875 that included this institute. Bosscha reported this to the KNAW.[515] The Netherlands still had the right to a new copy of the meter so a new government and KNAW committee with Bosscha, Stamkart and J.A.C. Oudemans was made to obtain copies of the original meter for the Netherlands, which were in 1880 finally received and brought to Delft.[516] The meters were stored in Delft because Bosscha wanted to make sure the meters were cared for correctly and to do measurements with new the standard of unit that was best done at the metrological laboratory of Delft.[517] The fact that the meter was brought over to Delft and not to the KNAW in Amsterdam, led to much commotion in the KNAW, heated discussions between Bosscha and Donders and their eventual estrangement of the KNAW in 1887.[518] However, Bosscha remained the Dutch representative for the government and expert on the subject and the Netherlands did not enter the international committee of the meter until after Bosscha's death.[519]

[514] J. Bosscha Jr. (1883), "Verslag aangaande de internationale conferentie tot vaststelling van electrische eenheden, gehouden te Parijs van 16 tot 26 Oktober 1882".

[515] At the 29-5-1875 meeting of the KNAW, Nederlandsche Staatscourant, 3-6-1875; To the government, Nederlandsche Staatscourant, 14-11-1876; J. Bosscha Jr. (1876b), "La commission internationale du mètre et la conférence diplomatique du mètre".

[516] Nederlandsche Staatscourant, 24-5-1876. See for their reports: Nederlandsche Staatscourant, 14-6-1878; 30-5-1879; 21-11-1879; 8-11-1880.

[517] J. Bosscha Jr. (1885, 1886), "Relation des expériences qui ont servi à la construction de deux mètres étalons en platine iridié, comparé directement avec le mètre des archives"; J. Bosscha Jr., J. A. C. Oudemans, A. D. van Riemsdijk, et al. (1886), "Rapport der commissie voor standaardmeter en -kilogram".

[518] J. Bosscha Jr., J. A. C. Oudemans, A. D. van Riemsdijk, et al. (1887), "Rapport der commissie voor standaardmeter en -kilogram II"; J. Bosscha Jr. (1887a), "Antwoord van J. Bosscha op het advies van den heer F. C. Donders". For a detailed discussion: F. van Lunteren (2004), "J.D. van der Waals en de Afdeling Natuurkunde"; J. Wooning (2001), *Johannes Bosscha*, pp. 34–42.

[519] J. Bosscha Jr. (1890), "Verslag over de werkzaamheden van de Conférence générale des poids et mesures"; J. Bosscha Jr. (1892), "Les Équations des nouvelles copies du mètre des Archives"; J. Bosscha Jr. (1904), "Les Équations des nouvelles copies du mètre des Archives. Conclusion".

Figure 3: Bosscha sketched by Haverman.[520]

Two other topics of research at the Polytechnical School were inspired by discussions at the KNAW: a new type of telescope and the telephone.[521]

Bosscha helped further academize the Polytechnical School by creating a scientific journal called the *Annales Polytechnique de Delft* in 1885. By his successors, he was made 'honorary member' of the editing board.

Committees of the KNAW

In this period of time Bosscha was also very active in the KNAW. Firstly, he sat in a committee that defended Huygens's honor when some fake letters surfaced that defamed him and later on to evaluate whether the KNAW would publish all Huygens's letters.[522] Secondly, to evaluate possible research on the solar eclipses in the Dutch Indies in 1869 and 1871.[523] Thirdly, to evaluate how water flows through sand, which was a very important topic for the Netherlands. As it meant knowledge about how to defend the Netherlands from water.[524] Fourthly, Bosscha sat in the various instances of the lightning-protection committees.[525] Lastly, Bosscha presented many articles written by his students at the Polytechnical School and was called in to evaluate the scientific articles written by several young physicists, notably for treatises of Lorentz and Kamerlingh Onnes.[526]

[520] H. A. Lorentz (1910), "Prof. Dr. J. Bosscha", p. 73.

[521] J. Bosscha Jr. (1878c), "Over kijkers met veranderlijke vergrooting"; J. Bosscha Jr. (1878a), "Sur des lunettes à grossissement variable"; J. Bosscha Jr. (1879), "Over de algemeene eigenschappen van gecentreerde optische stelsels"; J. Bosscha Jr. (1870b), "Metingen over de gevoeligheid van den telephoon en de electriciteitshoeveelheden door het trillende plaatje in beweging gebracht"; J. Bosscha Jr. (1878b), "Sur l'intensité des courants électriques du téléphone de Graham Bell".

[522] J. Bosscha Jr., P. Harting, and F. Kaiser (1868), "Rapport Commissie Huygensbrieven"; J. Bosscha Jr., D. Bierens de Haan, and H. A. Lorentz (1884), "Rapport der Huygenscommissie"; J. Bosscha Jr., D. Bierens de Haan, and H. A. Lorentz (1885), "Rapport van de Huygenscommissie II".

[523] J. Bosscha Jr., M. Hoek, and C. I. Matthes (1869), "Rapport Commissie Expeditie Zonne-eclips"; J. Bosscha Jr., M. Hoek, and V. S. M. van der Willigen (1871), "Rapport betreffende de zon-eclips van 12 december 1871".

[524] J. Bosscha Jr., J. M. van Bemmelen, and G. van Diesen (1879a), "Rapport Commissie Zanddiluvium"; J. Bosscha Jr., J. M. van Bemmelen, and G. van Diesen (1888), "Rapport van de commissie zand-diluvium". Note that this is the topic Bosscha's son, Jan Bosscha dissertation, which was printed as a gift from Sijthoff. J. Bosscha (1879), *Beschouwingen over het Zanddiluvium in Nederland*.

[525] J. Bosscha Jr., J. D. van der Waals, and P. L. Rijke (1880), "Rapport over bliksemafleiders op rijksgebouwen te Delft"; J. Bosscha Jr., J. D. van der Waals, and C. H. C. Grinwis (1881a), "Rapport over de beproeving van bliksemafleiders"; J. Bosscha Jr., J. D. van der Waals, and C. H. C. Grinwis (1882), "Rapport over de inrichting van bliksemafleiders op rijksgebouwen te Medemblik"; J. Bosscha Jr., J. D. van der Waals, and H. A. Lorentz (1888), "Rapport over de plaatsing en inrichting der bliksemafleiders op het rijks-museum van schilderijen te Amsterdam"; J. Bosscha Jr., J. D. van der Waals, and H. A. Lorentz (1889b), "Rapport over de beproeving der bliksemafleiders op het rijksmuseum te Amsterdam"; J. Bosscha Jr., J. D. van der Waals, and H. A. Lorentz (1889a), "Rapport over een brief des Ministers van Binnenlandse Zaken, handelend over het plaatsen van bliksemafleiders op de Abdij te Middelburg". See for a discussion on these matters: A. Y. Kipnis, B. E. Yavelov, and J. S. Rowlinson (1996), *Van der Waals and Molecular Science*, p. 94; F. van Lunteren (2004), "J.D. van der Waals en de Afdeling Natuurkunde".

[526] J. Bosscha Jr. and J. D. van der Waals (1880), "Rapport omtrent een verhandeling van H. A. Lorentz"; J. Bosscha Jr., J. D. van der Waals, and C. H. C. Grinwis (1881b), "Rapport over de verhandelingen van Dr. H. Kamerlingh Onnes"; J. Bosscha Jr., J. D. van der Waals, and C. H. C. Grinwis (1881c), "Rapport over de verhandelingen van Dr. H. Kamerlingh Onnes"; J. Bosscha Jr. and J. D. van der Waals (1889), "Rapport over eene verhandeling van den heer Dr. P. H. Dojes".

Secretary of the *Hollandsche Maatschappij der Wetenschappen* (1885-1911)

In the early 80's, Bosscha's health was precarious and in 1884 he presumably suffered from a stroke.[527] This led to his resignation from the Polytechnical School in 1885 and appointment in a less imposing position: secretary of the *Hollandsche Maatschappij der Wetenschappen*. In this position Bosscha made a lot of effort in erecting a strong image of Dutch science and would remain to do so until his resignation in 1909.[528] Bosscha would have resigned earlier to give Lorentz a chance to lessen his teaching obligations and focus on research, but Lorentz declined.[529] The main task Bosscha had, was the publication of the Dutch scientific journal written in French, the *Archives Neérlandaises*. This allowed Dutch scientists to publish their work in the more internationally accessible french language to increase the impact of their work. More important for the image of Dutch science were two other activities of Bosscha. He became a historian of science and played a role in the NNGC. Most of his historical work was presented at the NNGC.

Bosscha's Historical Work

In this period Bosscha defended the images of Dutch scientists Huygens and Van Marum. As Kuenen formulated it, rather painfully considering the way Antoine Laurent Lavoisier (1743–1794) died, Bosscha was no objective historian and sometimes exaggerated the significance of these Dutch scientists in comparison with foreign ones and they became his heroes:

> "Bosscha was in dergelijke quaesties geen rustig, objectief historicus. [...] De mannen, wier partij hij gekozen had, werden voor hem helden, die hij, zoo veel als zijn geweten het toeliet, verheerlijkte. Van Marum hier en daar zijn hoofd uitsteekt boven Lavoisier en Newton naast Huygens bijkans een tweede plaats inneemt"[530]

When a statue for Baruch de Spinoza (1632–1677) was erected, Bosscha sat in the committee.[532] At the first NNGC, Bosscha held a lecture on Van Marum and his importance

[527] A. E. M. C. Bergsma-Bosscha Erdbrink and J. Brewer (2012a), *Carmen, herinneringen 1894-1904*, p. 15.
[528] Algemeen Handelsblad, 18-3-1885; 21-2-1909.
[529] G. L. de Haas-Lorentz (1957), *H.A. Lorentz*, p. 99.
[530] Translation: "Bosscha was not an objective historian in these issues. The men for which side he had taken became his heroes, that he idolized, as much as his consciousness would let him. Van Marum stands above (with his head) Lavoisier and Newton takes second place next to Huygens" H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 105.
[531] Baarn-archive.
[532] De Nederlandse Spectator, 22-1-1876.

for the history of physics in the Netherlands.[533] Later, he would also publish the letters between Volta and Van Marum.[534] More important was his work on Huygens.

Already in 1858 a prize question was written out from the *Provinciaal Utrechtsch Genootschap* to write about the life and works of Huygens.[535] In 1868 the society *Diligentia* sent a letter to the KNAW with the question if the KNAW wanted to cooperate in erecting a statue for Huygens to be placed in The Hague. The KNAW agreed, but the municipality would not hear of it and the statue was never erected. When the funds were donated in the will of Leffman Bleekrode (1846–1905) in 1905, the municipal was willing to talk to Bosscha about the possibilities.[536] However, in the end the stubborn governing body of The Hague did not feel 'obliged' to place it and thus refused.[537] As a consolation to Bosscha, it was presented to him by the *Hollandsche Maatschappij* when Bosscha resigned from his post as secretary. Bosscha gifted it back to be placed in the garden of the society.[538]

Figure 4: The menu for the dinner at Bosscha's resignation in 1909. Note that the statue on the bottom left is the Huygens statue.[531]

To erect such tributes for great historical Dutch figures was a very common phenomenon in the late 19th century. Apart from the Spinoza statue mentioned above, in this period statues were erected of Joost van den Vondel (1587–1679), Rembrandt van Rijn (1606–1669), Michiel de Ruyter (1607–1676) and Herman Boerhaave (1668–1738).[540] This expression of nationalism did not only show in

[533] J. Bosscha Jr. (1887b), "Over het leven en de werken van van Marum"; J. Bosscha Jr. (1898b), "Martinus van Marum".
[534] J. Bosscha Jr. (1905), *La correspondance de A. Volta et M. van Marum*.
[535] Verslag van de algemene vergadering van het Provinciaal Utrechtsch Genootschap, 29-6-1858.
[536] Het Nieuws van den Dag, 22-05-1905; Haagsche Courant, 16-01-1908; 4-4-1908; 03-06-1908.
[537] Het Nieuws van de Dag, 26-4-1909; Algemeen Handelsblad, 10-9-1909.
[538] Algemeen Handelsblad, 24-4-1909.
[539] Baarn-archive.
[540] J. T. M. Bank (1990), *Het Roemrijk Vaderland*; K. van Berkel (1998), *Citaten uit het Boek der Natuur*, pp. 221–240. Note that Bosscha aided the art museum of Amsterdam with his scientific knowledge in the placement of Rembrandt's *Nachtwacht*. See J. Bosscha Jr. (1903), "Schrijven aan Dr. P. H. Ritter, Hoofdredacteur van het "Nieuws van den Dag", naar aanleiding van het Rapport der Rijkscommissie tot het nemen van proeven betreffende

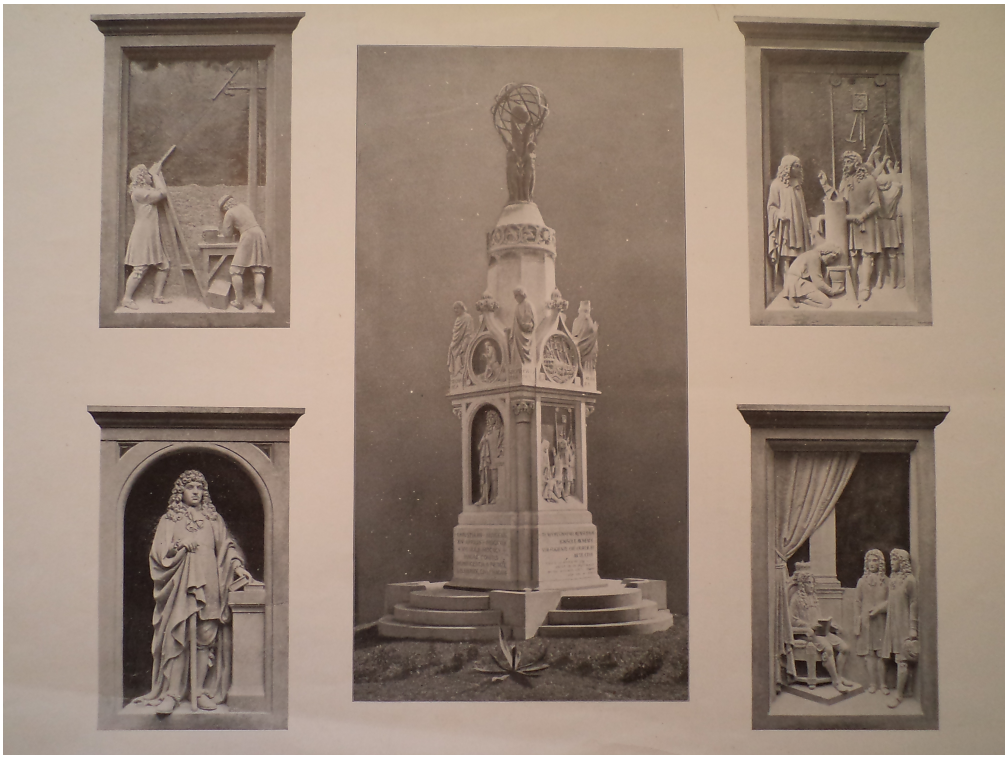


Figure 5: The five models of the HUYGENS statue. The middle one ended up in the garden of the *Hollandsche Maatschappij*.[539]

the placement of statues, but also for instance in the formation of the *Nederlandsch Natuur- en Geneeskundig Congres* (NNGC) in 1887. This biannual congress for medicine and the natural sciences saw it as its task to promote *Dutch* natural sciences as much as possible. Their tendency was very nationalistic and they saw science as one of the most important contributions to the welfare of the nation.[541] BOSSCHA, was active in the society as he was head of the section of physics for the 2nd congress in 1889,[542] and head of the congress when the 7th congress was organized in Haarlem in 1899.[543]

BOSSCHA's major activity in these last years of his life was the publication of the collected works of HUYGENS. In 1882 the KNAW discussed whether it was possible to publish an extensive biography of HUYGENS. This culminated into a committee in 1883 of which BOSSCHA was a

de verlichting van Rembrandt's "Nachtwacht"".

[541] R. P. W. Visser (1991), "Het 'Nederlands Natuur- en Geneeskundig Congres' over de Relatie Natuurwetenschap en Samenleving, 1887-1900."

[542] J. Bosscha Jr. (1889), "Toespraak bij de opening der vergadering van de sectie voor natuur- en scheikunde van het Tweede Nederlandsch Natuur- en Geneeskundig Congres".

[543] For which he gave the opening lecture. In the opening lecture, BOSSCHA summarized the current situation of the natural sciences at the end of the 19th century, emphasizing the Dutch contributions of the last centuries. J. Bosscha Jr. (1899), "Openingsrede, uitgesproken op het Zevende Nederlandsch Natuur- en Geneeskundig Congres".

member. In 1885 the KNAW requested the *Hollandsche Maatschappij* to finance the publication, resulting in that the *Hollandsche Maatschappij* took over the project. It became an immense work spanning 22 volumes and it was published between 1888 and 1950. Bosscha worked with vigor on seven of those volumes from 1895 until his death in 1911.[544] Bosscha had great interest in Huygens. According to Lorentz, this was because Huygens and Bosscha had similar admirable traits:

> "Waarom juist in het Huygens-werk voor Prof. Bosscha zoo groote bekoring ligt, kan voor wie hem van nabij kennen, geen raadsel zijn. Hij moest zich wel sterk aangetrokken gevoelen door wat wij in Huygens in zoo hooge mate bewonderen: de oprechte waarheidsliefde, den eenvoud en de grondigheid in de behandeling van wetenschappelijke vraagstukken, den afkeer zoowel van oppervlakkigheid als van noodeloos geleerdheidsvertoon. Bovendien gold het hier de eer der Nederlandsche wetenschap."[545]

Apart from the publication of *Les "Oeuvres Complètes de Christiaan Huygens"*, Bosscha gave a lecture at the 5th NNGC in 1895 - this talk was also published in German independently - and published several articles about Huygens.[546] All in all, we see that in the late period of his life, Bosscha seems obsessed by Huygens and adamant to increase the stature of Dutch science through his work for the NNGC and publications about Huygens, Van Marum and Marius.

Legacy

In the last decade of his life Bosscha was showered with honors. Bosscha sat in two prestigious boards. He was president curator of the Koninklijk Nederlandsch Meteorologisch Insitituut from 1899 to 1903.[547] In his function as curator of Leiden University from 1900 to 1907 he could help the funding of Kamerlingh Onnes' laboratory.[548] He was awarded a honorary membership of the Mexican Société Scientifique "Antonio Alzate", an honorary membership of the Natuurkundig

[544] J. Bosscha Jr. (1895-1908), *Les "Oeuvres Complètes de Christiaan Huygens"*.

[545] Translation: "Why for Bosscha especially in the Huygens-work lies so much charm should not be a mystery for those who know him well. He must feel strongly attracted to the aspects that we admire so much from Huygens: The love of truth, simplicity and thoroughness of treatment of scientific issues. The aversion of superficiality and needless display of scholarship. Moreover the honor of Dutch science was at stake." H. A. Lorentz (1910), "Prof. Dr. J. Bosscha", p. 74.

[546] For the lecture see: J. Bosscha Jr. (1895a), "Christiaan Huygens, Rede op den 200sten Gedenkdag van zijn levenseinde"; J. Bosscha Jr. (1895b), *Christian Huygens*; J. Bosscha Jr. (1896), "Christiaan Huygens". For the other articles: J. Bosscha Jr. (1900b), "Oeuvres Complètes de Christiaan Huygens"; J. Bosscha Jr. (1908), "Note relative à la remarque de Huygens sur les démonstrations géometriques de la Dioptrique de Descartes"; J. Bosscha Jr. (1909c), "Programma voor het jaar 1909 bevattende de memorie van Prof. Bosscha"; J. Bosscha Jr. (1911), "Christiaan Huygens".

[547] Nederlandsch Staatscourant, 22-7-1899; 16-3-1903.

[548] Nederlandsch Staatscourant, 28-12-1899; 27-5-1907; D. van Delft (2005), *Heike Kamerlingh Onnes*, p. 267.

Genootschap of Groningen, an honorary membership of the Koninklijke Instituut van Ingenieurs and became 'Commandeur in de orde van den Nederlandsche Leeuw' in 1901.[549] The first honorary doctorate of the Polytechnical School in Delft was awarded to Bosscha on the 8th of January 1907 and he received the Croix de Chevalier de l'Ordre National de la Légion d'Honneur de France in 1907.[550]

The biggest honor was the gift by Sijthoff, Kamerlingh Onnes and Lorentz. They prepared the collected works by Bosscha under the title *Verspreide Geschriften*. In it almost all of his published work was printed in three volumes spanning over a 1000 pages.[551] One more gift was given by these three: The 'Recueil de Travaux', a special volume of the *Archives Neérlandaises* in which 74 articles by Dutch and foreign scientists in honor of Bosscha were published. This shows that Bosscha was well-known abroad, as some of the big names of physics wrote a contribution for this volume such as Max Planck (1858–1947), Lord Kelvin and Lord Rayleigh (1842–1919).[552] Bosscha expresses his utmost gratitude for these gifts in a letter to Sijthoff.[553]

When Bosscha died on the 15th of April 1911 in his house in Heemstede, nearly all newspapers and weekly periodicals published an article in which they described Bosscha's life.[554] Note that they also did so for Bosscha's 70th Birthday in 1901 and 50th anniversary of his doctorate in 1904. A couple of newspapers mentioned whenever Bosscha was ill and narrated his funeral in detail. Many important physicists, such as H.E.J.G. du Bois (1863–1918), Zeeman, Lorentz, Haga and Van der Waals expressed their condolences to the family by letter.[555]

To remember Bosscha, Paul Ehrenfest (1880–1933), Kamerlingh Onnes' successor in the experimental physics chair of Leiden University, and Lorentz established a reading room in the Physics Laboratory in Leiden devoted to theoretical physics called the 'Bosscha'-reading room. Until the 1960s, when the small building housing the Lorentz Institute for Theoretical Physics was rebuilt, this was home to a small library, and home to the wall with all the signatures of the physicists who gave a talk at the famous Ehrenfest colloquia.[557] Ehrenfest wanted to create a reading room similar to the one that he remembers from his time as a student,

[549] Baarn-Archive diplomas. Bosscha held a correspondance with the Mexican king shortly before. Bosscha was already knight in the order of the Dutch Lion since 1873 for his work as inspector.

[550] Baarn-archive.

[551] J. Bosscha Jr. (1901b), *Verspreide Geschriften*.

[552] *Recueil de Travaux offert par les Auteurs à J. Bosscha à l'Occasion de son 70me Anniversaire le 18 Novembre 1901* (1901). Den Haag: Martinus Nijhoff. Note that a similar gift was given by Bosscha to Lorentz a year before.

[553] Letters to Sijthoff, 20-11-1901. UB Leiden SIJT A 1901.

[554] For instance: Nieuwe Rotterdamse Courant, 16-4-1911; De Telegraaf, 16-4-1911; Het Nieuws van den Dag van Dinsdag, 18-4-1911; Nieuwsblad van het Noorden, 18-4-1911; Leeuwarder Courant, 19-4-1911; De Sumatra Post, 29-5-1911.

[555] Baarn-Archive.

[556] See www.lorentz.leidenuniv.nl/history/il1921/IL_1921.html, consulted May 2017.

[557] This wall is still intact and preserved in the Oort building next to the (newer) Kamerlingh Onnes laboratory in Leiden. See lorentz.leidenuniv.nl/history/colloquium/muur_heel.html, consulted May 2017.

Figure 6: The opening of the Bosscha reading room. At the front we see Ehrenfest.[556]

organized by Felix Klein (1849–1925) in Göttingen. To finance the reading room, Ehrenfest asked Lorentz for help. Lorentz contacted the wealthy son of Bosscha: K.A.R. Bosscha, who happily donated enough money for the small library in honor of his father.[558] Theoretical physicists in Leiden might recognize Bosscha's name because his portrait that hangs in the hallway of the Lorentz Institute of Theoretical Physics on the second floor of the Oort Building at Leiden University. The portrait hangs next to that of Lorentz next to the Henk Casimir (1909–2000) room.

The story of Bosscha's biological legacy, his son K.A.R. Bosscha, is another interesting history. He moved to Dutch Indies in 1887 where he worked for his uncle and fellow student of his father E.J. Kerkhoven and later for his older brother Jan Bosscha. After this, he founded his own tea-company and became a wealthy 'theeplanter' (tea plantation owner).[559] He subsequently developed many industrial, trade and scientific enterprises. Notably K.A.R. Bosscha founded

[558] F. van Lunteren (2003), "Paul Ehrenfest", p. 11; M. J. Klein (1970), *Paul Ehrenfest*, pp. 8-10; R. Boeyink (2005), *Wetenschappelijke Worstelingen van Paul Ehrenfest*, p. 53; M. Hollestelle (2010), *Paul Ehrenfest*, pp. 42-43.

[559] In this position he is one of the main characters of H. S. Haasse (1992), *Heren van de Thee*.

the Technical University of Bandoeng in 1920 and the Bosscha astronomical observatory in Lembang in 1924 that still exist today.[560] Lastly, like father, like son, K.A.R. Bosscha was responsible for promoting and implementing the metric system in the Dutch Indies.[561]

One more laboratory was named after Bosscha, already during his life: The Bosscha physical laboratory in Berlin set up by private funds of Du Bois,- who studied under Bosscha between 1881 and 1883,- somewhere between 1887 and 1906.[562] A marble bust exists at the Hollandsche Maatschappij der Wetenschappen (Holland Society of Sciences),[563] and lastly, Bosscha's name is still carried by the society for the history of electrical engineering in Delft, because he is seen as one of the founders of education in electrical engineering in the Netherlands.[564]

[560] See G. R. Bosscha-Erdbrink (1979), "'Bosscha, Karel Albert Rudolf (1865-1928)'"; C. Schuring (1994), "De Nieuwe Heren van de Thee".

[561] R. P. W. Visser (2006), "K.A.R. Bosscha (1865-1928) en de Bevordering van de Natuurwetenschappen in Nederlands-Indie".

[562] From 1908 to 1914 there were regular papers in the *Communications*, the journal of the KNAW, as 'Communications from the Bosscha Laboratory'. It was here that Wander Johannes de Haas (1878–1960) and Einstein discovered the Einstein-De Haas effect: the phenomenon that an iron bar displays a tendency to rotate when magnetized. It is unclear what happened to this private laboratory after Du Bois fled to the Netherlands after the outbreak of the war in 1914, but it is likely to have been dismantled. See H. A. Lorentz (04-01-1919), "Ter Herinnering aan H.E.J.G. du Bois"; D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 529-530; A. Einstein and W. de Haas (1915), "Experimenteller Nachweis der Ampèreschen Molekularströme".

[563] G. van Dijk (2014), *Biografische Schetsen II*.

[564] H. Baudet, H. J. A. Duparc, and J. H. Makkink (1992), *De lange weg naar de Technische Universiteit Delft*, p. 442.

[565] Baarn-archive.

Figure 7: Bosscha with his wife P.E. Kerkhoven.[565]

Conclusion

Bosscha Jr., as we have seen, is one of the key figures in one of the great turning points of Dutch science. Although his name is not connected to an important discovery or theory, his influence on the formation of the field of physics in the Netherlands can not be underestimated. Especially Bosscha's work on the establishment of the law of conservation of energy and the units of measurement (meter, kilogram and electrical units) proved indispensable for a science that, especially in the late 19th century, revolved around precise measurements and became unified through the law of conservation of energy. As we have seen, Bosscha was influenced by Kaiser's astronomical methods of precision. Bosscha implemented these methods into his own research and subsequently instigated these values into the new generation of physicists. Bosscha became influential during his inspectorate and professorship and helped set up scientific education at the new HBS and Universities that were lacking in materials previously. The modern physical laboratory of Delft, Bosscha set up himself. The magnetic research facility at the University of Groningen was set up by his pupil Haga and the 'cold-factory' of Leiden was set up by his assistant Kamerlingh Onnes. The Utrecht laboratory was set up due to the needs of the HBS, which shows that the laboratories of the HBS were state of the art. All in all, it was Bosscha's influence on Dutch physicists and school teachers that these laboratories were set up at all.

His strong nationalistic tendencies that he showed with his involvement with the NNGC, publications on Huygens and Van Marum helped shape a strong image of 'Dutch science'. After all, the scientists from the self-proclaimed second golden century were very proud of Dutch science. Even his work for the HBS and the publication of his textbook can be explained by Bosscha's aspiration to elevate the level of Dutch education and science. It is also thanks to Bosscha that Dutch physics was able to flourish at the end of the 19th century, resulting in several Nobel prizes.

Bosscha, I have shown, was influential not only because of his scientific values but also practically by helping the careers of many young physicists. Lorentz, Van der Waals, Kamerlingh Onnes, Haga, Sissingh, Wind, Kuenen and many others were at some point helped by Bosscha. Bosscha either vouched for them at obtaining a new vocation or argued for an increase in their salary. These links with physicists in the last quarter of the 19th century

could be further researched and may shed light on the patronage relations between the physicists, both in their larger group of natural scientists. It is known that Bosscha and the other Leiden natural scientists were in close personal contact with each other.[566] However, it could still be researched whether these connections had any influence on their scientific work. One example of this might be given. It was Bosscha who hinted on Einthoven to try the hook up the cardiogram to a telephone line to create a telecardiogram.[567]

The new ideal of precision science, although preeminent in the late 19th century did not last. The new quantum mechanics led to new problems that were not always resolvable by simply measuring more precisely. Casimir, in his autobiography, criticizes Kamerlingh Onnes for his extreme meticulous measurement program. Though Kamerlingh Onnes did not err, his successors would have discovered more qualitative physical phenomena if only they obsessed less about the exact details of measurements. The precision science of the late 19th century was already in decline in the beginning of the 20th century.[568]

Nevertheless, Bosscha was named the 'nestor of Dutch physicists'.[569] He became very influential on the field of physics in the Netherlands during the 19th century and instigated his values for experimental research in a number of Dutch physicists.

[566]There are few hints about these close relations between Bosscha and the Leiden professors. In *H.A. Lorentz* Bertha Lorentz said that Kamerlingh Onnes and Lorentz after their appointment to professor were "soon received in the family circle of Bosscha." G. L. de Haas-Lorentz (1957), *H.A. Lorentz*, p. 37. More strong evidence come from two small notes that Bertha Lorentz writes to Bosscha to thank Bosscha for borrowing a book while she was but a small child. Baarn-Archive, note of G.L. Lorentz to J. Bosscha. At Bosscha's home in Delft, Kamerlingh Onnes sat at the table with Bosscha's circle of scientists or organized pick-nicks with Bosscha's family, and together with Van der Waals visited Bosscha often D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 126,128,130. Van de Sande Bakhuyzen's circle of intellectuals in Leiden also included Bosscha. J. L. Oosterhoff (1984), "De Opkomst van een "Vaderlandse Natuurkunde"", p. 109.

[567]N. M. Hjelm and H. W. Julius (2005), "Centenary of Tele-Electrocardiography and Telephonocardiography".

[568]H. B. G. Casimir (1983), *Haphazourd Reality*, pp. 161, 336–337; D. van Delft (2005), *Heike Kamerlingh Onnes*, pp. 171–172.

[569]For instance by Du Bois in a letter to the daughter of Bosscha, 19-4-1911, Baarn-Archive, and at the 11th NNGC in 1907, Handelingen van het 11e Nederlandsch Natuur- en Geneeskundig Congres, 1907, p. 99. Lastly here H. H. R. Roelofs Heyrmans (1906), *Gedenkschrift*, p. 251.

Samenvatting

Er wordt vaak gepostuleerd dat de Nederlandse wetenschap en in het bijzonder de natuurkunde aan het eind van de negentiende eeuw in bloei kwam in de zogeheten 'tweede gouden eeuw'. De vele nobelprijswinnaars in de natuurkunde: Lorentz, Van der Waals, Zeeman en Kamerlingh Onnes dragen bij aan dit beeld van excellentie.

In deze studie wordt de invloed bekeken van Bosscha Jr. op de discipline en disciplinevorming van natuurkunde in de tweede helft van de negentiende eeuw. Bosscha kan als de meest belangrijke figuur binnen de natuurkunde voorafgaande aan de bloei van het einde van de negentiende eeuw worden beschouwd.

Bosscha werd in zijn studietijd, maar ook al ervoor via Van der Willigen, beïnvloed door Kaiser's methode van 'astronomische precisie'. In deze methode speelde precisiemetingen, maar ook het precies karakteriseren van de meetapparatuur een belangrijke rol. Kaiser had deze methode weer afgekeken van de wiskundige, natuurkundige en sterrekundige Gauss die deze methode had geïntroduceerd in Duitsland en daarom spreken we wel van gaussische wetenschap. Bosscha nam deze methode grotendeels over in zijn eigen wetenschappelijke werk.

Een tweede aspect van Bosscha's onderzoek is de wet van behoud van arbeidsvermogen. Bosscha bestudeert deze wet met name in het kader van electrische stroom, bijvoorbeeld in zijn dissertatie van 1854. In eigenlijk al Bosscha's vroege onderzoek speelt deze wet een belangrijke rol. Dit weet Bosscha vervolgens naar buiten te brengen door een aantal populair wetenschappelijk publicaties in het tijdschrift en in zijn beroemd geworden rede voor het Utrechts *Natuurkundig Gezelschap* in 1858, waarin hij het woord 'arbeidsvermogen' introduceert. Daarnaast publiceerde hij over dit onderwerp ook een aantal belangrijke wetenschappelijke artikelen in het prestigieuze Poggendorff's *Annalen der Physik* in 1857. Deze activiteiten vestigen voorgoed Bosscha's naam binnen de Nederlandse wetenschap.

Bosscha maakte snel carrière. Spoedig na zijn afstuderen werd hij door Rijke aangesteld als assistent voor het fysische laboratorium, een positie die speciaal voor hem gecreëerd werd. In 1860 had Bosscha hier echter genoeg van en kon door bemiddeling van zijn invloedrijke vader Bosscha Sr. worden aangesteld tot professor aan de Koninklijke Militaire Academie in Breda. Ook in deze

tijd wordt Bosscha aangenomen als lid bij verschillende wetenschappelijke genootschappen, de belangrijkste van deze de Koninklijke Nederlandsche Academie van Wetenschappen. Na drie jaar te hebben lesgegeven op de KMA stuurt Bosscha een sollicitatiebrief aan minister Thorbecke voor de nieuwe post van inspecteur van het middelbaar onderwijs.

In 1863 werd namelijk de wet op middelbaar onderwijs aangenomen. Deze wet hield in dat er een nieuw schooltype werd opgericht dat, in tegenstelling tot het gymnasium voor de bovenklasse van de maatschappij, voor de gegoede burgerij was bedoeld. De nadruk lag bij deze nieuwe school, de *Hoogere Burgerschool* (HBS), dan ook niet op 'geleerde vorming' maar op 'nuttige vorming', waarbij de natuurwetenschappen en de moderne talen een centrale rol speelden. Deze nieuwe scholen worden in de literatuur vrijwel altijd aangeduid als het beste dat Nederland overkomen is op onderwijsgebied en als de nieuwe motor voor het Nederlands natuurwetenschappelijk onderwijs, verantwoordelijk voor de bloei aan het eind van de 19e eeuw.

Bosscha's taak als eerste inspecteur van het middelbaar onderwijs, samen met Steyn Parvé en Staring, was het opzetten van deze nieuwe scholen en het samenstellen van de eisen die aan het nieuwe middelbare onderwijs werden gesteld. Twee belangrijke aspecten die bijdroegen aan de excellentie van de nieuwe scholen waren de leraren en de nieuwe laboratoria.

De inspecteurs kregen van de overheid namelijk ruime middelen om de meest excellente docenten aan te trekken en een deel van de kracht van de HBS lag dan ook hierin besloten. Veel jonge afgestudeerde doctoren in de natuurwetenschappen, maar ook oude bekenden van de athenea, vonden een nieuwe baan in het middelbaar onderwijs met een royaal salaris. Was men niet afgestudeerd in de natuurwetenschappen, dan was het alsnog mogelijk docent te worden in het middelbaar onderwijs door het behalen van de aktes van bekwaamheid, waarbij Bosscha voorzitter was van de commissie die deze aktes afnam. Een belangrijk voorbeeld van iemand die op deze manier aan de HBS werkzaam werd is Van der Waals.

Het tweede aspect dat bijdroeg aan de excellentie van de HBS waren de nieuwe practicalokalen voor natuur- en scheikunde, waarbij leerlingen al op vroege leeftijd bekwaam werden in het zelfstandig uitvoeren van praktische oefeningen. Bosscha wordt in de literatuur altijd verantwoordelijk gehouden voor het opzetten van deze schoollaboratoria. Dit idee strookt volkomen met Bosscha's wetenschappelijke normen en waarden en wordt bevestigd door Bosscha zelf in zijn stenografische autobiografie.

Niet alleen de laboratoria op de middelbare scholen werden hierdoor gemoderniseerd, maar ook die van de Universiteit Utrecht. Immers vroegen de studenten expliciet om een nieuw laboratoriumgebouw vanwege het feit dat ze later, als ze afgestudeerd zouden zijn en een betrekking zouden hebben als leraar op het middelbaar onderwijs, de leerlingen van de HBS moesten bekwamen in praktische oefeningen. Om deze reden moesten de studenten zelf tijdens hun studie wel de mogelijkheid hebben om zich te bekwamen in praktische oefeningen. Enfin, er

moest een nieuw laboratorium komen van de Universiteit Utrecht.

In deze tijd schreef Bosscha ook zijn beroemd geworden *Leerboek der Natuurkunde*, bedoeld voor de HBS, waarin hij de nieuwste ontwikkelingen opnam. Natuurlijk schoeide hij deze op de nieuwe wet van behoud van arbeidsvermogen. Ook zijn eigen onderzoekingen uit deze tijd, die hij overigens deels samen met Van der Waals ondernam, kregen een plek in het leerboek. Bosscha noemde het zelf een van de beste aspecten van zijn leerboek. Dat het niveau van het *Leerboek* al snel de HBS-leerling te boven ging, gaf niet, en in latere edities werd het idee ook losgelaten dat het boek voor de HBS bedoeld was en omarmd dat het meer geschikt werd voor het hoger onderwijs. Er kwam zelfs een speciale bewerking van het leerboek voor de HBS.

Dat de onderwijskwestie een centraal vraagstuk is in de Nederlandse politiek uit die tijd wordt wel duidelijk in Bosscha's pogingen om tot tweede kamerlid te worden verkozen in 1867 en tweemaal in 1869. In alle gevallen wordt hij tegengehouden door de conservatieven die het niet eens waren met de enorme financiële lasten die de nieuwe staatsscholen met zich meebrachten. Andere argumenten tegen de nieuwe openbare school kwamen van de katholieken, die bang waren voor de vrijheid om godsdienstig onderwijs te geven te verliezen. Ook kwam van de conservatieve en confessionele kant het bezwaar dat scholing alleen nuttig was als vorming en dat de 'nuttige vakken' van het HBS daar totaal niet voor geschikt waren. Enkel Latijn en Grieks konden de geest van de jongeling goed vormen.

In 1872 maakte Bosscha weer een stap richting de pure wetenschap door te worden verkozen tot secretaris van de internationale metercommissie. In deze commissie heeft hij grote invloed gehad, wat zich toont door het Nederlandse besluit om op advies van Bosscha niet de meterconventie te tekenen. Pas na Bosscha's dood treedt Nederland alsnog toe tot dit verdrag.

In 1873 werd Bosscha aangesteld tot professor toegepaste natuurkunde aan de Polytechnische School - deze school is ook een uitvloeisel van de wet op middelbaar onderwijs. Hier draagt hij bij aan het academiseren van het Delftse onderwijs. Bosscha eiste bij de aanvang van zijn professoraat dat er een geheel nieuw laboratorium werd gebouwd met ook lokalen voor praktische oefening voor de studenten. Hij introduceerde het practicum voor eerstejaars en deze traditie werd al spoedig overgenomen door de universiteiten. Als Bosscha in 1878 directeur wordt van de Polytechnische School bedingt Bosscha een salarisverhoging voor alle professoren van de Polytechnische School.

Toen Bosscha's assistenten Kamerlingh Onnes en Haga werden aangesteld als professor experimentele natuurkunde in Leiden en Groningen volgden zij de voetsporen van hun leermeester en vernieuwden de universitaire laboratoria, zodat deze geschikt werden voor precisiewetenschap. In het geval van Kamerlingh Onnes resulteerde dit in het beroemd geworden cyrogene laboratorium dat als eerste in de wereld het helium bedwong vloeibaar te worden. In het geval van Groningen, waar Haga een geheel nieuw ijzervrij gebouw had bedongen voor magnetisch

onderzoek, was het verloop veel minder gunstig doordat de gemeente niet veel later een tramlijn naast het gebouw aanlegde. Ook VAN DER WAALS, die in Amsterdam het experimenteel onderzoek leidde, putte zijn inspiratie uit BOSSCHA's laboratorium te Delft. Hiermee is in deze studie BOSSCHA's invloed aangetoond voor de vernieuwing van alle vier de Universiteitslaboratoria voor de natuurkunde alsmede die van de Polytechnische School.

In 1885 wordt BOSSCHA, na een langdurige ziekte, benoemd tot secretaris van de *Hollandsche Maatschappij der Wetenschappen*, een prestigieuze positie die bijvoorbeeld VAN MARUM voor hem en LORENTZ na hem heeft bekleed. In deze periode maakt BOSSCHA zich sterk voor het imago van de Nederlandse wetenschap door zijn activiteiten binnen het Nederlands Natuurwetenschappelijk en Geneeskundig Congres en het publiceren van de brieven van HUYGENS en VAN MARUM. In deze periode onderhoudt BOSSCHA ook warme wetenschappelijk contacten met veel van de Nederlandse natuurwetenschappers. Echter zou dit stuk van BOSSCHA's leven nog verder kunnen worden onderzocht.

Al met al was BOSSCHA als een van de belangrijkste figuren uit de Nederlandse natuurkunde van het midden van de 19e eeuw verantwoordelijk voor een algemene verhoging van het niveau van het Nederlands natuurwetenschappelijk onderwijs. Binnen de natuurkunde was BOSSCHA verantwoordelijk voor de introductie van de wet van behoud van arbeidsvermogen in Nederland en de methodologische ontwikkeling naar een precisiewetenschap met een strak omlijnd onderzoeksgebied. BOSSCHA wordt dan ook niet voor niets door zijn tijdgenoten de nestor van de Nederlandse natuurkunde genoemd.

Bosscha's Writings

Most of his published works have been reprinted in the celebratory bundle *Verspreide Geschriften* of 1901. This list of his publications is more complete than that in the *Verspreide Geschriften*.

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