A Tribute to the Memory of

Fredrik Vilhelm Hansen

(1862–1929)

Johan Gustaf Richert

(1857–1934)

by Lennart Billfalk and Klas Cederwall

Royal Swedish Academy of Engineering Sciences (IVA)

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Presented at the 2009 Annual Meeting
of the Royal Swedish Academy of Engineering Sciences

by Lennart Billfalk and Klas Cederwall

The Royal Swedish Academy of Engineering Sciences (IVA) is an independent, learned society that promotes the engineering and economic sciences and the development of industry for the benefit of Swedish society. In cooperation with the business and academic communities, the Academy initiates and proposes measures designed to strengthen Sweden's industrial skills base and competitiveness.

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Published by the Royal Swedish Academy of Engineering Sciences (IVA)
and the authors Lennart Billfalk and Klas Cederwall.

We would like to express our gratitude to the picture archives at ABB Sweden, Göteborgs Vatten, National Library of Sweden, National Museum of Science and Technology, Stockholm Vatten, SWECO Group and Vattenfall.

IVA, P.O. Box 5073, SE-102 42 Stockholm, Sweden
Phone: +46 8 791 29 00
Fax: +46 8 611 56 23
E-mail: info@iva.se
Website: www.iva.se

IVA-M 408 • ISSN 1102-8254 • ISBN 978-91-7082-810-2
Editor: Eva Stattin, IVA
Translation: Diane Högsta
Layout and production: Hans Melcherson, Tryckfaktorn AB, Stockholm, Sweden
Printed by OH-Tryck, Stockholm, Sweden, 2009

Foreword

Every year the Royal Academy of Engineering Sciences (IVA) produces a booklet commemorating a person whose scientific, engineering, economic or industrial achievements were of significant benefit to the society of his or her day. The Commemorative Booklet is published in conjunction with the Academy's Annual Meeting.

This year the Commemorative Booklet honours Fredrik Vilhelm Hansen (1862 – 1929) and Johan Gustaf Richert (1857 – 1934); individuals who, by virtue of their extensive knowledge and expertise, have both been instrumental in developing the vital role that hydropower plays in our national energy supply.

At the turn of the last century, at a time of rapid technological and industrial development, they laid the foundations for the expansion of hydropower. They furthered the development of water resources engineering and showed how society's water infrastructure is a strategically important starting point for engineering sciences education and research in urban development.

The two men each contributed to the foundation of two of Sweden's most successful companies in infrastructure, hydraulic engineering and construction: Vattenfall and VBB (originally AB Vattenbyggnadsbyrån, today part of the Sweco Group).

In 1919, 90 years ago, the Swedish Parliament and the Government decided to form a Swedish engineering sciences academy, the Royal Swedish Academy of Engineering Sciences, IVA. Hansen and Richert were part of the exclusive group of the Academy's first 40 members, which were appointed by the Government. The Government also appointed Richert as Vice Chairman of IVA. He took up this post at the fully-fledged Academy's first meeting.

We wish to extend our sincere thanks to the authors, Lennart Billfalk and Klas Cederwall, for the effort they have devoted to this year's Commemorative Booklet.

Björn O. Nilsson
President of the Academy

Mauritz Sahlin
Chairman of the Medals Committee

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Introduction

"There is nothing in the world more important than water.
Without it nothing would come to life or continue to exist."

These are the words of architect Marcus Vitruvius Pollio, author of De Architectura, the only preserved ancient writings on architecture and urban development.

Fredrik Vilhelm Hansen and Johan Gustaf Richert were active during the decades before and after the turn of the last century – a period characterised by a highly dynamic, knowledge-driven period of societal development. The focus of both was water as an essential resource, and hydraulic engineering as a means of utilising this resource. In order to manage water, considering it as both a resource and a risk factor, in the various connections that exist between water, energy, the environment and health, they searched for knowledge across a broad and interdisciplinary front. Through their involvement at the highest level, using their engineering expertise which they applied and implemented effectively in the political sphere, they made significant contributions to the development of society. There were significant humanistic and social dimension to the way in which they worked. Based on their strong leadership qualities they were able to gather and engage experienced colleagues and also communicate their message

with clarity. They were both committed and skilled entrepreneurs whose achievements led to breakthroughs in new technology and new methods within urban development in Sweden.

Hansen and Richert made groundbreaking contributions to the development of water supply and sewage treatment technology. Their work was crucial to the discovery of solutions to the water quality and health problems which, up to the end of the 19th century, were linked to the urban water supply. They both also played a crucial role in the early development of Swedish hydropower; Hansen as an effective entrepreneur and industrialist and Richert as an engineer combining systems analysis with political perspectives.

Richert laid the foundation for the consulting firm Vattenbyggnadsbyrån, which is now a significant part of the SWECO Group, and Hansen was instrumental in the creation of Vattenfall, which is now an international corporation celebrating its 100 year anniversary. Hansen also served as the head of Vattenfall for almost 30 years.

Hansen – pioneer in Swedish hydropower and first head of Vattenfall

Hansen's background

Fredrik Vilhelm Hansen was born in Stockholm in 1862. He was of German descent on both his mother's and his father's side. His paternal grandfather was a head teacher in Flensburg and one of his sons, Hansen's father, emigrated to Sweden and eventually established himself as a wholesaler in the wine industry. Hansen's mother, who was born in Stockholm, came from a family in Lübeck.

His father died when Hansen was just eight years old. Hansen, who showed early signs of being highly gifted, started to teach his school friends for a fee and thereby helped support his family. He received his upper secondary school diploma just before his 16th birthday and started studying at Kungliga Tekniska Högskolan (Royal Institute of Technology) in Stockholm in the civil engineering department. He received excellent grades and just before his 20th birthday he graduated first in his class with a Master's degree in Engineering. Hansen was very active in student life and served for a while as chairman of the student union. In 1876 the programmes at the Institute of Technology in Stockholm were reorganised, new subjects were added, the civil engineering programme was extended from three to four years and in 1877 the name

Fredrik Vilhelm Hansen in Stockholm 1927.

was changed from Teknologiska Institutet to Kungliga Tekniska Högskolan (Royal Institute of Technology). Hansen was one of the first graduates of the new four-year programme.

Water supply for the city of Stockholm

As the Swedish cities grew in the 1800s so did the need for large-scale systems for supply of raw water and for water treatment technology. Stockholm's first waterworks was located at Skanstull and the first section was finished in 1861. Water was taken from Lake Mälaren and cleaned by filtration before being pumped into the city's water mains.

Hansen started to work as an assistant engineer at the Stockholm city waterworks in 1882. Almost immediately he was given considerable responsibility for the city's water supply. Among other things, he was actively involved in the comprehensive development of filtration technology and the introduction of bacterial analysis methods to control the quality of the water. No courses were offered at the Kungliga Tekniska Högskolan that covered these areas in any detail when he was a student there. However, due to the expertise he gained at the Stockholm waterworks, numerous Swedish cities turned to him for advice and help in designing their new waterworks.

While working at the waterworks Hansen was recruited to join the special military branch, Väg- och vattenbyggnadskåren (the civil engineering corps), whose main mission was to provide the military with commanding officers with civil engineering ex-

pertise. His rise through the ranks was rapid, and when he left the corps in 1908 he was awarded the honorary title of colonel. Early on Hansen proved that he had very strong leadership qualities. It is likely that he developed these qualities during his training in the civil engineering corps.

Hansen was appointed head of the Stockholm waterworks in 1897. At that time it was clear that the city of Stockholm needed to expand its water supply system. This presented Hansen with a major challenge. He needed to find a new water source to meet the increasing water requirement of a growing city. Hansen therefore initiated studies of both glacial gravel ridges (rullstensåsar) with extensive groundwater capacity as well as lakes in the Stockholm vicinity. It proved to be impossible to find sufficient amounts of groundwater. Hansen therefore suggested that the new waterworks should be located so that it would be possible to use the groundwater from Ekeröåsen and supplement it with water from Lake Mälaren and nearby Lake Bornsjön.

In 1899 the Stockholm City Council decided to purchase the Norsborg property which was needed in order for Hansen's plan to be realised. Hansen immediately entered into negotiations with the owner of Norsborg. According to witnesses at the time the owner was reluctant to sell the land to the city of Stockholm for the intended purpose. However, Hansen demonstrated his strong negotiation skills and the deal went through. The same negotiation skills would be put to good use later on in Hansen's career.

Under Hansen's leadership the technical designs were implemented for the vari-

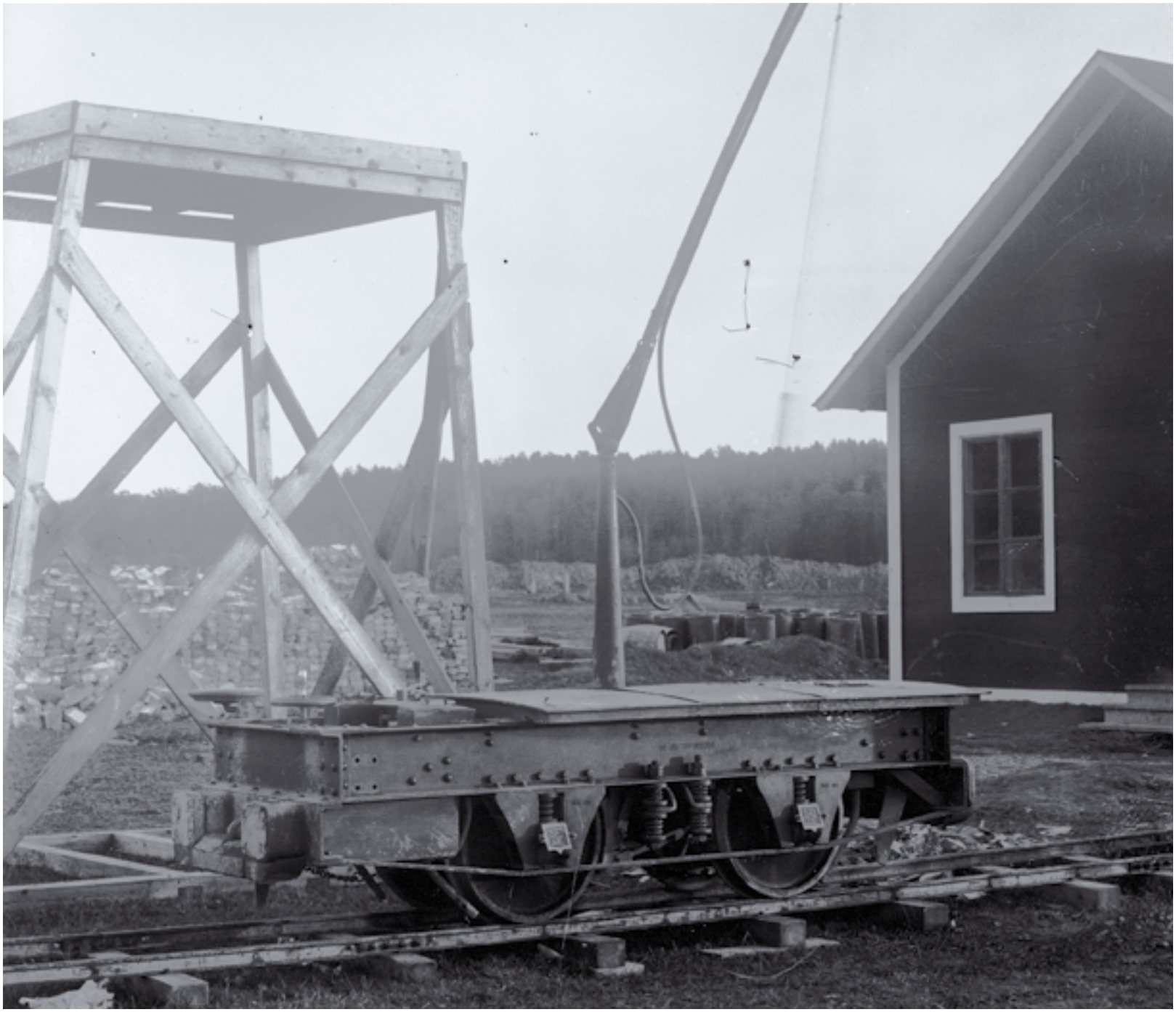
ous elements of the Norsborg project, which consisted mainly of a treatment plant at Norsborg, a pipeline to a new reservoir of 18,300 m^3 at Trekanten and a main pipeline from the reservoir to central Stockholm.

In order to design and construct the various parts of the plant, Hansen needed to expand his staff. A young engineer, Gösta Malm was one of those employed to work at the Stockholm waterworks. Like Hansen, Malm graduated as a civil engineer from the Kungliga Tekniska Högskolan in Stockholm. Despite his youth, when Malm started working at the waterworks he already had a few years of practical experience from both railway and road construction, as well as design and construction of water supply systems and sewage works.

Early on Hansen had shown that he had strong leadership skills and the choice of Malm as his colleague and site manager for the Norsborg project would prove to be a very good decision. For Malm the assignment was also the beginning of a very successful career. After around 15 years under Hansen at Vattenfall, Malm was appointed head of what was then Skånska Cementgjuteriet (now Skanska) and later became Norrbotten County Governor, before he took over from Hansen upon Hansen's retirement as Director General of Vattenfall.

Towards the end of the 1800s unreinforced concrete started to be used in construction. At the turn of the last century reinforced concrete also started to be widely used as a building material. Hansen was very interested in the new technology and he quickly realised that reinforced concrete offered great possibilities. Like Gösta Malm, Hansen

Norsborg plant under construction. Reinforced concrete was used for the first time for large structures in Sweden.



The electric engine delivered to Norsborg by ASEA, today part of ABB, designed for 500 volt, direct current.

embarked on field trips to countries such as France which was leading the development of the new concrete technology at that time. When construction work on the Norsborg plant started there were no reliable calculation methods for reinforced concrete. Following some careful calculation and experimentation with different construction methods, however, it was possible to use reinforced concrete for the first time in Sweden for the construction of large structures. Although the Skånska Cementgjuteriet carried out some work for the Norsborg plant, a French firm with employees who were specially trained in reinforced concrete structures was used for the most complicated assignments.

At the end of the 1800s construction work was normally carried out without the use of machinery. Hansen was very interested in mechanical processes and modern tools and he often came up with new ideas to simplify tasks. These new ideas were, however, only introduced once analysis showed that they would save time and money. At the end of the 1800s engineers started to find practical applications for electric power technology. Hansen quickly understood that this technology had potential, both at construction sites and later to operate plants and installations. Under Hansen's leadership a small power station was built at the outlet of Lake Bornsjön and electric cables were put in place from there to the work site at Norsborg. This was Hansen's first power station construction. Many others would follow during his long career.

A railway line was constructed from Lake Mälaren to the site at Norsborg to reduce the cost of transportation to the Norsborg plant. An electric engine was purchased

from ASEA, today part of ABB, in 1901. The engine was a prototype and the fine-tuning was carried out on site by the supplier's representative Arthur Lindén, who 30 years later would take over from Sigfrid Edström as head of ASEA.

Sweden becomes an industrial nation – Hydropower's breakthrough

Industrialisation in Sweden did not really pick up speed until the 1870s. An important aspect and a prerequisite for this process was the existence of an efficient railway system and a telegraph and telephone network. Towards the end of the 1890s energy consumption started to increase exponentially from relatively moderate levels. Sweden at that time depended heavily on imported coal, which meant that rising coal prices as well as the country's great dependence on imported energy were a cause for concern. This was also the time when electric power technology started to be developed for industrial use. The notion of replacing at least a portion of the imported coal with "white coal," as hydropower was called at that time, was becoming more and more of a realistic option.

In the late1800s private initiatives had resulted in the construction of a number of small hydropower stations. The benefits of using electric power for industry and society in general were becoming increasingly obvious. At the turn of the century the Government discussed the possibility of using Sweden's hydropower resources and, in doing

so, reduce the increasing coal imports. Initially the Government was mainly interested in electrification of the railway network. In order to investigate more closely the feasibility of this process, the Government formed the so-called Waterfall Committee in 1899. The Committee appointed a team of experts who were tasked with gathering information on hydropower in other countries. The head of this team of experts was Swedish scientist Svante Arrhenius.

Arrhenius and his small team of experts travelled around Europe for six weeks to gather information and experiences from the early development of hydropower in other countries for the electrification of railway networks, among other things. In addition to the purely technical and financial aspects, Arrhenius would also study the legal aspects of using water resources for power production, an issue which, at the time, was not entirely clear based on the existing laws.

In his report to the Ministry of Agriculture in 1901, Arrhenius described Sweden's significant

Svante Arrhenius' report to the Ministry of Agriculture on Sweden's hydropower resources.

hydropower resources. He added that it would be altogether too expensive to electrify the railway in a long and narrow country as Sweden, mainly because transferring electric power over such long distances was not yet technically possible. The amount of electricity needed for the railways varied greatly from one time to another, which also meant that it was not economical to develop hydropower primarily to meet the needs of the railway. The electric power requirement of the fast-growing heavy industry in Sweden was more evenly distributed over time. Thus, the energy requirement of industry was the strongest driving force in the large-scale expansion of hydropower in Sweden.

Trollhättefallen (Trollhättan Falls) – beginning of Vattenfall AB, now celebrating its centennial

At the beginning of the 1880s the head of the enforcement service (kronofogden) in Vänersborg, T.W. Forsell, announced that the Government was interested in the Trollhättan Falls (*Trollhättefallen*). A government commission was formed to look into the matter in 1890 and in 1893 a proposal was presented for the construction of a power station of 10,000 horse power (around 7,400 kW) in Trollhättan.

Private sector parties opposed the Government's plans, however, and the right to use the hydropower resources of the Trollhättan Falls was the subject of a drawn-out struggle between private sector interests and Government needs. In 1898 a company called Trollhättans elektriska kraftaktiebolag was formed for the purpose of exploiting

the hydropower resources of the Trollhättan Falls. One of the founders of the company was Gustaf de Laval who acquired large areas of land along the west bank of the falls on behalf of the company. As the company owned this land, the owners believed they also had the right to use the water in the falls for power production. Johan Gustaf Richert was assigned the task on behalf of the company of developing a design proposal for a hydropower station on the west bank of the falls.

The Government subsequently filed a law suit against Trollhättans elektriska kraftaktiebolag in which it argued that the Crown owned the rights to the falls. The case involved national politicians and many influential people of the day, including Richert who injected himself into the debate on the side of the private sector parties. Following tough negotiations and unsuccessful attempts to settle the matter, the State was granted in 1900 the right to exploit most of the hydropower resources of the Trollhättan Falls.

Hansen, like many of his contemporaries, was very versatile and involved in many things. In 1898 at the age of 36, in addition to being the head of the waterworks in Stockholm, he was appointed Managing Director of Trollhätte Kanalbolag, a privately -owned canal company at that time. This company owned and operated the canals from Lake Vänern to Gothenburg. Hansen's responsibility as head of the canal company gave him a key position in terms of influence over the design and location of the power station the Government intended to build after being granted the rights to the falls. The situation in Trollhättan was complicated however. The hydropower resources

were now largely owned by the Government. The west bank was owned by Trollhätte elektriska kraftaktiebolag and the canal company owned the eastern bank. The solution to the problem was that in 1905 the Government purchased the canal company which was reorganised to become Trollhätte kanal- och vattenverk (Trollhättan canal and waterworks) with Hansen as Managing Director. This newly-formed company became the platform for the Government's hydropower development ambitions in Trollhättan. Hansen now left his post as head of the Stockholm city waterworks and moved to Trollhättan.

Hansen's assignment was now to take responsibility for the administration and operation of the canal and develop the hydropower resources at the Government's disposal in Trollhättan. To kick-start the planning of the power station construction, Hansen again employed Gösta Malm who subsequently left his position at the Stockholm city waterworks. Malm was put in charge of the new development and construction office. Development work proceeded at a fast pace. All previous construction proposals drawn up over the years were reviewed, including Richert's proposal. On 20 December 1906 the Government was presented with a detailed construction proposal for the east bank. The first blasts had already been heard at the site earlier in the year. The construction of the power station was now well under way and Hansen started selling electricity. The first supplier contract was signed with the city of Skara in May 1907. Gothenburg was next, and by 22 June 1908 the power station started delivering electricity to Skara. Despite strong opposition from Gothenburg, following consultation with a number of

One of Richert's many proposals for a hydro power plant at the Trollhättan falls

experts, 25-period alternating current was decided upon. The company soon regretted this decision and after a while Hansen was forced to make a change to 50 periods.

The success of the first large power station in Trollhättan and the reconstruction of the Trollhättan canal lead to the Government in April 1908 proposing that the Trollhätte kanal- och vattenverk be replaced by a waterfall board. As a result of this

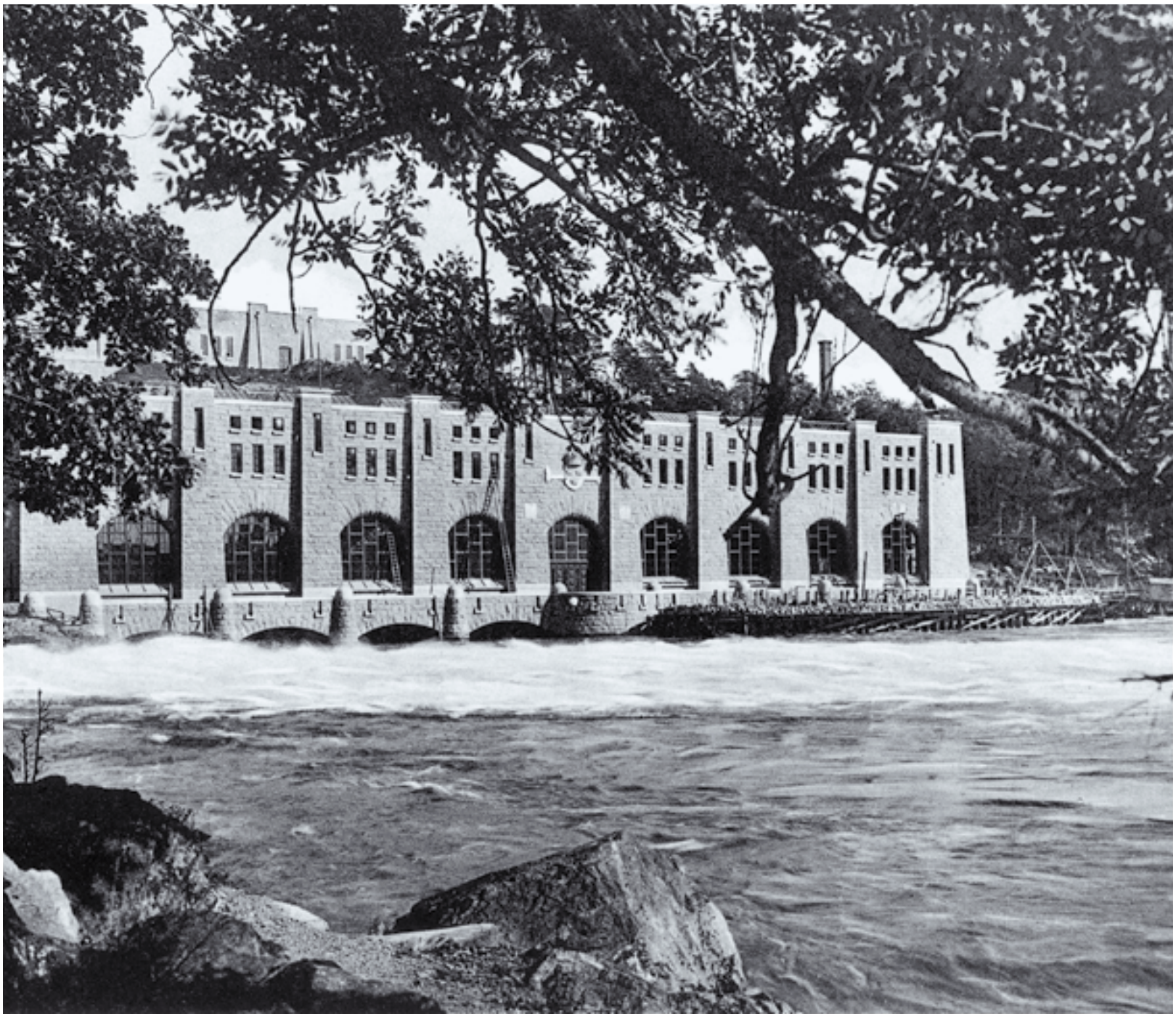


Photo of Trollhättan power plant. First power delivery started 22 June, 1908.

decision the Swedish Parliament decided in January 1909 to form Kungliga Vattenfallsstyrelsen (the Royal Board of Waterfalls) with Hansen as chairman and director. This was the beginning of the state-owned company Vattenfall AB, which is celebrating its 100-year anniversary this year. Work got under way immediately to plan power station construction in Älvkarleby and in the rivers in the Norrland region. A royal instruction for the Board of Waterfalls was signed at Stockholm Castle by King Gustav V and the Minister of Civil Affairs, Hugo Hamilton.

Under Hansen's inspirational leadership, several of Sweden's first major hydropower stations were built, including the pioneering ones at Porjus and Älvkarleby. Hansen left his position as head of Vattenfall in 1928, one year before his death.

Hansen, the person

Hansen was described by his colleagues and friends as a very happy and harmonious person with an optimistic outlook. An example of his sense of humour is the invitation he wrote to Albert Engström on 27 October 1921:

"In order to improve my appearance to the greatest extent possible, I am currently undergoing a relaxation and nutrition cure with my wife in the country and it is not bad at all here! Flowers and pike and sunshine, at least on the inside. Not to mention fried fresh Baltic herring with a dram. Come for an inspection some time and bring some boozers from the mainland."

Hansen also permitted a jovial atmosphere during serious discussions.

Hansen greatly appreciated the company of a diverse circle of friends. He was a fine orator who also liked to sing. He composed a number of songs which were per-

Hansen (left) liked the good life and the company of good friends.

formed in the company of good-humoured friends. He was a member of Samfundet SHT, and there is probably a good deal of truth in the memories recounted by SHT members after Hansen's death. Within SHT Hansen was called Kilo Wattuman. The association's yearbook from 1929 contains the following quotation from a speech made in his memory:

"Kilo was a force of nature, a giant. He struggled with huge tasks, with the most powerful forces of nature. He led the roaring waterfall in the direction he wanted it to go and sent strong current through copper wires around the country. There was also something robust and rugged, an element of untamed nature about his being. But he was also somewhat of a smiling rogue with a twinkle in his eye as he enjoyed a play on words or an amusing thought, or a gentle dreamer whose eyes teared as he listened to a choir singing a beautiful melody."

Johan Gustaf Richert – foresighted urban planner and pioneer in developing Swedish hydraulic engineering

Richert's background

Johan Gustaf Richert (generally known as J. Gust. Richert) was born in Stockholm in 1857. His father, Josef Gabriel Richert, was the son of district court judge Johan Gabriel Richert, who has been described as the father and pioneer of Swedish liberalism. As a judge he was said to exercise his official duties with kindness, with the true qualities of a humanitarian and with a clear optimism about the future of the human race.

Johan Gustaf's father was employed for many years as an engineer for Drätselkommissionen in Gothenburg. He was a pioneer in the development of the technical infrastructure of the modern industrial city. This would affect and influence Johan Gustaf Richert in his commitment to and interest in large hydraulic engineering projects. Studying to become a civil engineer was therefore a natural choice for him. In 1877 he applied to Kungliga Tekniska Högskolan in Stockholm and was one of the first students to study at the university following the extension of the programmes at what was previously called Teknologiska institutet to four years. In 1881 he graduated with a Master in Engineering. At university he met Vilhelm Hansen for the first time and this was the beginning of a life-long collaboration between the two men. During Richert's

Photo of Johan Gustaf Richert from around 1901.

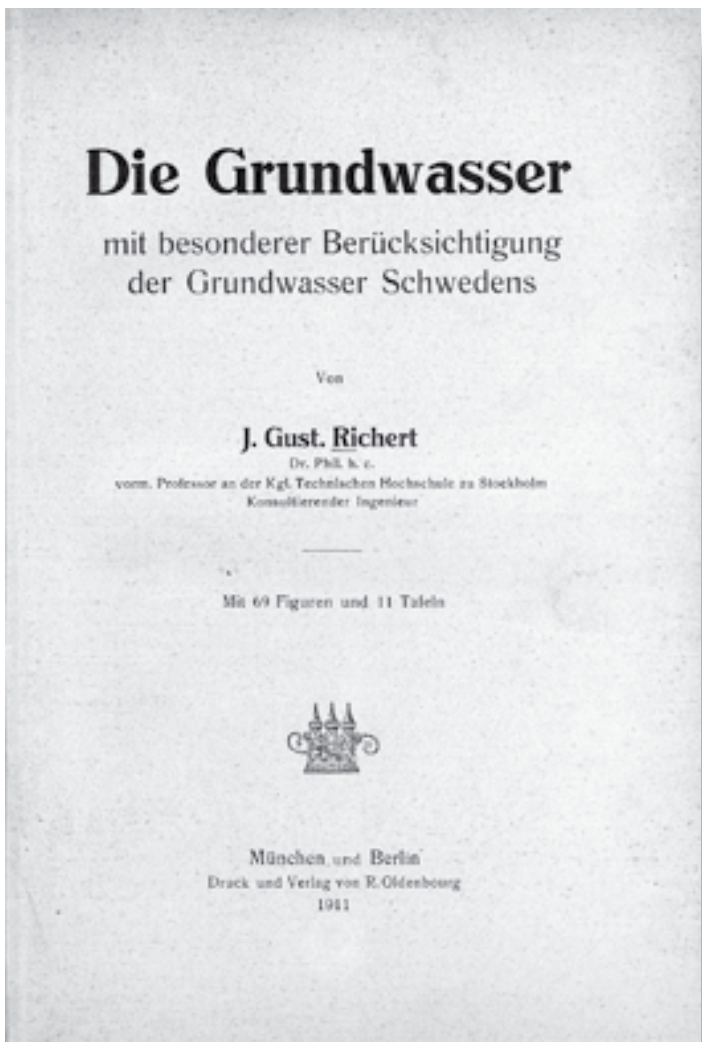
education, P.W. Almquist was a professor of civil engineering and his lectures were particularly inspiring, most notably providing a good overview of the field of hydraulic engineering.

Hydraulic engineering

In Swedish the original term was *Vattenbyggnadskonst*, hydraulic engineering as a combination of engineering science and artistic, creative technology. It describes the ability to use experiences and knowledge for a creative purpose. This knowledge has several dimensions; it is intuitive and can sometimes be unconscious – "tacit knowledge" – but is often very tangible. Knowledge and art complement each other, just as both intuitive knowledge and intuitive ideas are so important in science. Richert's most important source of knowledge was hydraulic engineering in this sense.

At the beginning of the 1880s an intensive period of science-oriented engineering knowledge development began with Germany as the focal point. Richert went on a number of field trips around Europe and participated in this development process. He became involved in various engineering issues, such as the many fundamental problems in society and the complex situations which now demanded more advanced solutions. He stressed the importance of interdisciplinary knowledge, highlighting the connections between, for example, hydrology, meteorology, geology and engineering. In 1886 Richert went on a long trip to study the water supply and sewage system problems in

Hamburg, Altona, Berlin, Dresden, Hannover, Frankfurt am Main, Munich and Vienna. This resulted in a paper: *On water systems and sewers in a number of German and Austrian cities.* Early on he came into contact with science-oriented advocates of the hydraulic engineering processes of the day. These experts were invited to assist in developing the field in Sweden. In Germany groundwater was an important water resource and more than half of all cities with a water supply system based their supply on groundwater. It was probably on this trip that Richert came up with the idea of supplying the city of Gothenburg with water by using groundwater in combination with artificial infiltration of water from the Göta älv river, which became known as Richert's *groundwater factory.* Richert's theories and projects gained international recognition.


Die Grundwasser

mit besonderer Berücksichtigung der Grundwasser Schwedens

Von

J. Gust. Richert

Dr. Phil. h. c.

vorm. Professor an der Kgl. Technischen Hochschule zu Stockholm

Konsultierender Ingenieur

Mit 69 Figuren und 11 Tafeln

München und Berlin

Druck und Verlag von R. Oldenbourg

1911

In 1911 Richert published a book on groundwater entitled Die Grundwasser mit besondere Berücksichtigung der Grundwasser Schwedens.

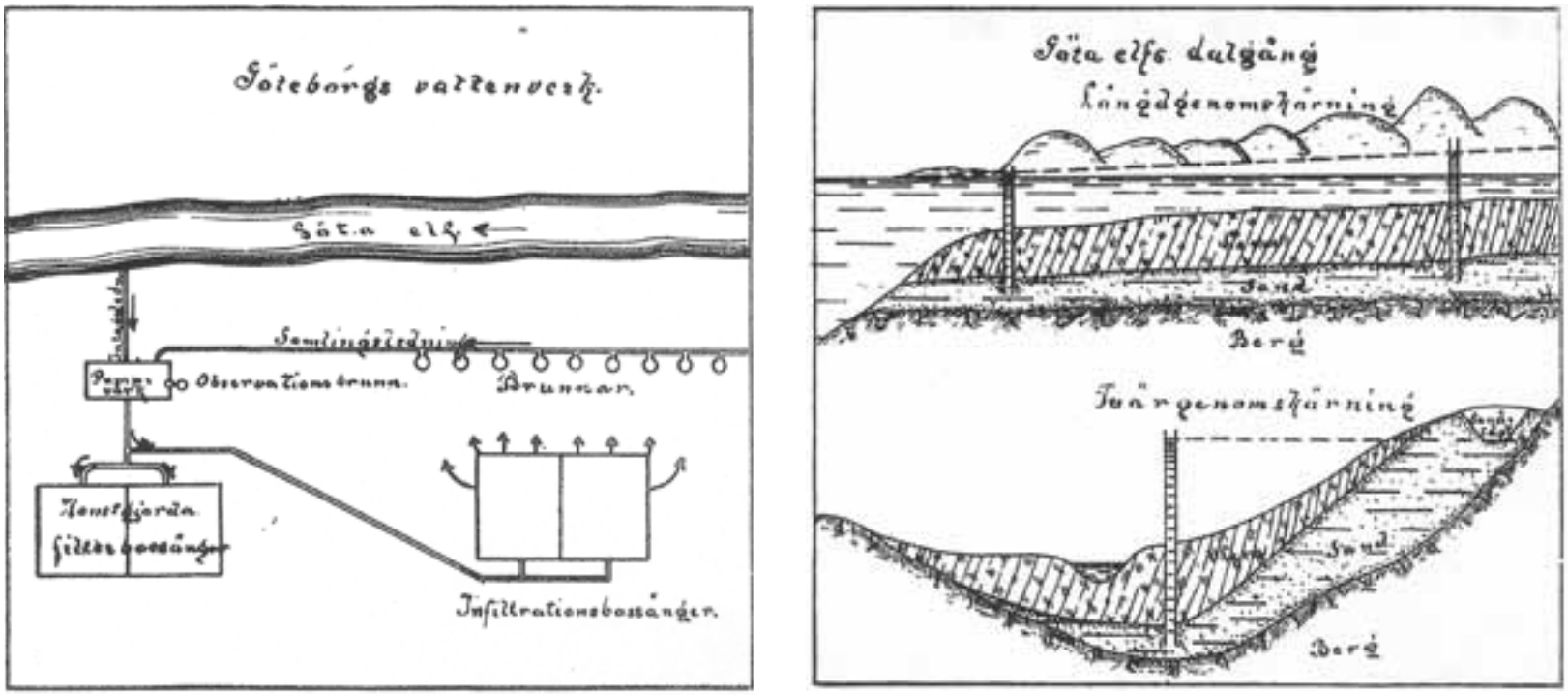
At a meeting of Tekniska Samfundet (Polytechnic Society) in Gothenburg in October 1891 Richert gave a speech: *On the presence and use of groundwater.* The speech was published among the Society's documents. Richert provided a broad description and analysis of hydrological/geohydrological and geoeconomic aspects of groundwater and the exploitation of groundwater resources. Twenty years later in 1911 he published his book on groundwater in Berlin entitled *Die Grundwasser mit besondere Berücksichtigung der Grundwasser Schwedens.* Of the many works produced by Richert, this was probably the one that can be characterised as a fully developed scientific work. It contains the theoretical and methodological elements found in the science today. Groundwater is also the area where Richert's many valuable contributions have had the most profound impact.

The growth of modern municipal engineering

When Richert was born the growing cities of Gothenburg and Stockholm had major public health problems – high infant mortality, frequent epidemics of diseases such as cholera, diphtheria, etc. The cities were also plagued by homelessness, overcrowding, poor hygiene and poverty. Studies carried out in other countries showed that poor sanitation was the main cause of many of the serious problems that were typical during this period in so many European cities. There was an urgent need for an efficient water supply system and a system to deal with sewage and waste water. Urban overcrowding

was a serious problem and there was a need to improve hygiene both in private homes and public buildings.

Gothenburg's expansion plan, which was launched in the 1860s, not only addressed the water supply and sewage issues but also drainage and land reclamation, all crucial to urban development. When Josef Gabriel Richert handed over responsibility for Gothenburg's hydraulic engineering projects in the 1880s to his son Johan Gustaf, the latter would face some new hydraulic engineering challenges. The rapidly growing city and industrial development meant that more was required in terms of the capacity of the technical infrastructure while continuing to focus on environmental and health issues. The new infrastructure would have to meet the needs of the municipal water supply, waste water and sewage treatment and solid waste management, as well as traffic and transit systems and various public facilities. Both theoretical and practical knowledge needed to be developed in diverse fields, and not least in the field of construction engineering. At the end of the 1880s the situation in Gothenburg was critical. One could say that Richert inherited the problem of "inadequate capacity" from his father. The water capacity of Delsjöarna (nearby lakes) was inadequate for a city that had doubled its population over a twenty-year period, from just over 50,000 in 1870 to more than 100,000 at the beginning of the 1890s. The problems were complex and fundamental. Particularly troublesome was the fact that the buildings within "the walls" were at or sometimes even below the water level in the city's canal system and the Göta älv river. There was an imminent risk of flooding and the sanitation problems



Sketches of Richert's groundwater factory that he used to show the principles of this method.

associated with it. In many respects the problems faced today in Gothenburg and other similarly situated cities are of the same type, especially as the sea level is expected to rise significantly within the next thirty years as a result of climate change.

In 1890 when he was barely 33 years old, Richert made a fundamental contribution while head of *Göteborgs Vattenledningsverk* (Gothenburg Waterworks) by coming up with an ingenious solution to the city's water supply problem. He suggested that the artesian groundwater flow to the Göta älv river valley should be reinforced as a possible

source of raw water for Gothenburg through artificial infiltration of the river water in adjacent sand pit along the river. This important principle was the beginning of a period of extensive water resources activity where several Swedish communities turned to Richert to solve their water supply problems.

While working in Gothenburg Richert saw an opportunity in each project to find an overall solution, i.e. the beginning of a systems engineering approach. He presented a comprehensive paper (63 pages) to the city's administration containing "a complete plan for the drainage of all of the city's low-lying areas." In his paper he described his views on the main issues being debated at the time, i.e. separate or combined systems, the water flushing system and upgrading of the canal system. Richert identified two important aspects of the task at hand. The first was to create new opportunities for urban development, sites for new residential areas, new businesses, wharfs, specific location requirements etc. Second was the improvement of the old infrastructure systems by renovating existing water mains, reconstructing culverts that had downstream controlled "back water," separating overflow drains etc. Richert presented his *Water drainage plan for Gothenburg,* which contained carefully elaborated ideas and principles. His plan for the drainage system was based on the principle of draining water off to low points and pumping it from there. Both his principles and the details in the proposal were scrutinised by experts from Sweden and abroad. The proposed new concepts were initially not accepted, then revised and then surprisingly changed back to the original version again before construction work could be carried out from 1911 to 1917.

In 1882 Richert took part in a conference arranged by Hälsovårdsföreningen (health-care society) in Stockholm on the sanitary conditions in the city and the connection to the rise in epidemics of diseases such as cholera, typhoid fever and dysentery. Although it was clear that contamination from sick people was getting into drinking water, no one had managed to find a way to isolate the "poison" in the water or in human faeces. Richert took notes at the meeting where he wrote that... "typhus has spread because water closets are located directly adjacent to water pipes and excrement is entering the water pipes and being carried by the water into the dwelling below."

The same year the German doctor Robert Koch used a microscope to isolate tuberculosis bacteria and the following year, cholera bacteria. Despite these discoveries, the question still remained: How does cholera occur and spread? The theory that pointed to contaminated water pipes as the main cause of epidemics was supported by analysis carried out following the severe cholera epidemic in Hamburg in 1892. The practical result of this was that all drinking water would be effectively filtered in the water treatment process. Richert emphasised the importance of monitoring and using results from the non-engineering sciences (particularly the medical sector) and offered the cholera issue as an example. The epidemiological model used to explain it and the bacteriological theory contradicted each other. When it became possible to isolate the cholera bacteria and study its properties with the help of a microscope in a laboratory, it was the duty of hydraulic engineers to draw conclusions from this knowledge to guide them in their work.

Richert and his co-workers in the newly established consulting firm Richerts konstruktionsbyrå. Photo dated 1901.

Consultant and professor

In 1897 Richert left Gothenburg to work as a consulting engineer in Stockholm where he started a consulting firm called *J Gust Richerts konstruktionsbyrå för vattenbyggnader.* After a couple of years the name was changed to Aktiebolaget Vattenbyggnadsbyrån in which Richert and some of his colleagues were shareholders. *Vattenbyggnadsbyrån, VBB,* developed into a leading engineering consulting agency and was very active internationally (VBB is now part of the SWECO Group).

After moving to Stockholm Richert lectured for a while at Kungliga Tekniska Högskolan in civil engineering. In 1901 the university suggested upgrading the lectureship to Professor of Hydraulic Engineering. This was confirmed one year later by Royal decree. On 12 August 1903 Richert was awarded the chair, a position he would hold formally until 1906 but which he kept in practice until 1911.

In many of his writings – which totalled more than 300 – Richert deals with a number of strategically important areas of development in Sweden at that time: water supply and sewage treatment within the framework of a broad municipal engineering and municipal hygiene and sanitation perspective, hydropower and supply of energy. He also writes about various international assignments, such as canal projects in, for example, St. Petersburg as well as other international water supply and hydraulic engineering assignments. Richert's work includes numerous papers that confirm the breadth and importance of his work. Concrete ideas on district heating and more advanced traffic systems also appear in his papers. Stockholm and Gothenburg

experienced numerous problems as they grew into relatively large cities. Richert was interested in refrigeration. The fish and vegetable trades were able to function in the cities, but the meat trade faced problems. He created a concrete design for a modern slaughterhouse with refrigeration in which he applied his knowledge of bacterial contamination and the importance of good hygiene which he had gained during his studies and work with waste water and sewage treatment. His work during a relatively short period at Kungliga Tekniska Högskolan and at Vattenbyggnadsbyrån involved numerous important initiatives, characterised by his highly developed sense of the significance of engineering in urban development. Everyone who came into contact with Richert and his friendly and pleasant personality experienced his great ability to guide, teach and inspire, which was particularly beneficial to future hydraulic engineers. It is perhaps equally important to mention the importance of Richert's leadership and ability to establish strong relationships with colleagues who represented excellence in different engineering sciences.

Commitment to society

Richert's commitment to society was broad and extensive. He was not a scientist in the sense the term is used today. Kungliga Tekniska Högskolan did not introduce the opportunity for graduates with a Masters in Engineering to complete their doctorate after postgraduate research until the latter part of the 1920s. Richert was a scientist,

however, on the strength of his scientific and practical disposition; his approach was interdisciplinary and he also possessed social skills. This can be illustrated by a number of examples.

At a session of parliament (Riksdag) in 1907 Richert sat on the Stockholm bench next to bank director Knut Wallenberg. He was a city councillor in Stockholm for a while. During his time as a member of the Upper House of the Riksdag, Richert proposed two motions. The first dealt with easing the conditions for upper secondary school diplomas. Richert proposed that the final exams should be spread out over the four final terms in order to make the study process more effective. The motion was denied.

The second motion at the 1908 session proposed the creation of a Ministry of Transport and Communications – Motion No. 27 to the Upper House by Mr. Richert, concerning a letter to H.M. the King requesting a committee to consider the proposal in question on the creation of a ministry of transport, communications and public works. This issue had been raised back in 1857. Initially the motion was set aside and subsequently denied in the 1860 session. The same motion was proposed again in 1874 and 1877, but was again denied both times. Richert conducted a thorough analysis and pointed out that we were living in a time when transport communications were becoming more and more important. He also stated that most countries in the world had placed traffic issues high up on their agendas. Issues were coming up at the time for which only twenty years previously it would have been impossible to find a solution

from a technical and economical perspective. He also pointed out that the network of public highways was in such bad shape that it was becoming more expensive or simply impossible for the roads to be used by the traffic they were intended for. He referred to the expansion of the railway and the ongoing process of electrification, navigational development relating to the canal projects and the regulation of seas and rivers, the increasing scope of activity in the ports, the telephone system which was taking over from the telegraph in Sweden and which may have been the finest in the world – *"The people of the world are coming in closer and closer contact with one another, while we are the country that remains in 'splendid isolation'."*

Richert concluded his long summary of the situation in Sweden by posing the following question: *Can we afford a new ministry?* And he answered it himself: *We can no longer afford to be without a ministry of transport and communications!* The motion led to a decision by The Parliament to ask if H.M. the King was willing to consider the appropriate measures to meet the need for a more uniform treatment of the issue of communications and public works. Sweden was thus ultimately also provided with a ministry of transportation and communication.

At a meeting of Svenska Teknologföreningen (Swedish association of technologists) in 1918 Richert held an opening speech on the issue of a central heating plant, which had been raised by the Stockholm City Council in 1909. A study had shed light on Stockholm's fuel requirement and the issue of constructing a municipal central heating plant. It was expressed as follows:

Just as the city has handled the production and distribution of drinking water, gas and electricity, the city can also handle the production and distribution of heat to surpass by far what is currently provided through the gas mains system. Wood, coke, peat, briquettes and paraffin as fuel would no longer be necessary, nor would the space needed to store them. The city would be the supplier of all the heating a household needs.

Hugo Theorell conducted a study on central heating plants for the production and delivery of heat to residential areas. He pointed out that in Germany and America plants of this kind exist where heat was transported over significant distances, as far as 2 km from the source to the location where the heat was being used. In America the pipes were insulated and placed in the ground. The systems were fitted with the requisite shut-off and expansion devices. The City Council was hesitant but stated that if a private company was willing to construct a central heating plant at its own risk for a certain district or building complex, the city would grant a permit. The central heating plant issue was raised in connection with a full study of the heating and power issue and its many aspects. The study, which was exemplary in all respects, is summarised in a printed work entitled *Gas-, och Värme- och kraftverk i Norrköping* (Gas, heating and power stations in Norrköping), which was presented by the municipal commercial development director consul Arthur Hultqvist. The proposal described a central steam turbine plant, partly to generate electricity and partly to sell steam to industrial plants. In a new study Hultqvist proposed that the city's energy requirement could be met by

a central heating plant constructed in such a way that both power and heat could be produced by burning gas. This proposal attracted a lot of attention and was supported by Richert, among others, who emphasised the fact that the future development of the Stockholm gas and electric works should follow the concepts in the Norrköping study.

Richert's life work was celebrated by his friend, colleague and doctor of geology, Gerard De Geer when Richert was awarded an honorary doctorate by Stockholm University:

"He led the work of men
and harnessed the enormous power of the rivers
and the clear water in the springs
for the benefit of everyone"

Hansen and Richert – Members of IVA

After the end of WWI a bill was introduced in the Swedish Parliament for measures to promote a systematic energy and fuel policy. The National Board of Trade (Kommerskollegium) was charged with investigating the issue with Axel F. Enström at the helm. Enström believed, however, that a central institution with a broader engineering sciences mandate was needed; an institution that would focus on more than just energy and fuel issues. After the issue had been studied for a couple of years, during which time Richert chaired an advisory committee, the Parliament and the Government decided to form a Swedish engineering sciences academy, the Royal Swedish Academy of Engineering Sciences, IVA.

The Government appointed the Academy's first 40 members and this exclusive group included both Hansen and Richert. The Government also appointed Richert as Vice Chairman of IVA. He took up this post at the fully-fledged Academy's first meeting.

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IVA-M 408 • ISSN 1102-8254 • ISBN 978-91-7082-810-2