

CHALMERS



Technology Carriers

The Role of Engineers in the
Expanding Swedish Shipbuilding System

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Göteborg, Sweden 2000



Thesis for the degree of Doctor of Philosophy

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Cover illustration: Producers meeting users – engineers at Götaverken meeting engineers representing the Royal Naval Material Administration, in connection with the building of the destroyer *Nordenskjöld* in 1927 – see also Section 5.6. (Photo: Varvshistoriska Föreningen)

Technology Carriers: The Role of Engineers in
the Expanding Swedish Shipbuilding System

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To Jan Hult and to the memory of my father, Roland Olsson; these are the two people who have done most to stimulate my interest in history.





Abstract

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This study analyses the process which shaped the role or function of college-trained engineers within a technological system or innovation system during the period from the start of the 20th century until the 1950s and 1960s. With a conceptual framework of sociotechnical systems and of engineers as a social group of technology carriers this process is studied in one particular system, namely the Swedish shipbuilding system.

The study deals with the temporal aspect of the engineers' ability to qualify as a social group of technology carriers, i.e. a group which has an interest in and the ability to bring forth, maintain and develop technological systems, addressing the different criteria of such an entity – it must have knowledge of and an interest in developing the system, be suitably organised and possess the necessary power or influence to realise its interest.

The main conclusion is that during the period from the early 20th century until the 1950s the engineers' ability to function as technology carriers increased as they became increasingly well organised and came to hold most leading positions within the system, one expression of which was their gaining of an informal monopoly of the position of managing director of the large shipyards. The engineers' role, however, was not formed in a vacuum. On the contrary, it was formed in interplay and conflict with other groups within the system, whose members possessed other kinds of knowledge, among them naval officers, sea captains, engine-room officers, economists and practically trained technologists.

With a systems approach to technology and innovation this study emphasises interaction between system components. As technology carriers the college-trained engineers formed important links between the different organisations of the system, representing producers as well as different kinds of users, organisations laying down rules and regulations and other supportive functions such as education and research.

Key words: history of technology, engineers, technological knowledge, engineering education, professional associations, industrial research, shipbuilding, technological systems, sociotechnical systems, systems of innovation, user–producer interaction, 20th century



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In 1988, as a first-year student at the Chalmers University of Technology, I took a course in the history of technology. The person responsible for the course was Jan Hult, and with his enthusiasm for the subject and his outstanding ability to bring the events of the past to life, he seized my interest from the start. A seed had been sown, and when a few years later I was ready to do my diploma thesis I contacted Jan. Being a student of naval architecture I decided on the history of engineers in Swedish shipbuilding as my subject, and eventually this also became the field of study for my doctoral dissertation.

When I became a doctoral student in 1992, the Centre for the History of Technology consisted of just three people, namely Jan, myself and, one day per week, Barbro Strömberg, our administrator. At first we had at our disposal one room in the Chalmers Library. The hallmarks of the Centre were the pioneering spirit and the pleasure of the search for knowledge. In later years it changed its name to the Department of History of Technology and Industry and the staff expanded, to a large extent due to Jan's untiring efforts. However, despite being busy both within and outside Chalmers he always had time to sit down and discuss my work when I needed to. His interest and never-failing enthusiasm have helped to make every working day an exciting adventure and I am deeply grateful.

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Danderyd, August 2000
Lars Olsson



1. Introduction

1.1 Background

During the 1990s politicians, industrialists and representatives of various organisations have all emphasised the need for more highly trained engineers as essential for the competitiveness of Swedish industry and for a future prosperous and ecologically durable society.¹ In debates on the need to train more engineers, there has also been discussion of the changing roles of engineers and of reforms in the system of higher technical education. In 1996 the government commissioned Linköping University to carry out the “NyIng” project, a study of the need for renewal of engineering education in Sweden.² One of the questions discussed within the project has been the future role of engineers: with the transformation from an industrial society into a service or information society it seems likely that engineers will fulfil new functions and therefore need to have a different education from that of today.³

Contemporary discussions indicate a conviction that college-trained engineers, i.e. engineers who have graduated from the universities of technology, have an important function in contributing to the competitiveness of Swedish industry and that they will become even more important in the future. To say anything about the future role of the engineer is, of course, very difficult if not impossible. The role of the engineer is not in any way predetermined but is formed in a complex process involving many other groups in society – the role should be seen as the result of interplay with these other groups and of interplay within the group of engineers themselves.

With the aim of producing a better understanding of such processes, I will study the forming of the *role* or the *function* (the two terms will be used synonymously) of the college-trained engineer in a period when Swedish society went through another transformation process, i.e. the transformation from a rural to an industrial society. Since a main feature of industrial society has been its large technological or industrial systems, it is vital to study what role engineers came to play in these expanding systems and how this role changed over time. My way of approaching the problem will be to study both the college-trained engineers’ efforts to reproduce and expand a system and the interplay between them and other groups concerned.

1 See for instance the Swedish prime minister Göran Persson’s article “Vi behöver fler ingenjörer”, *Ny Teknik*, 1997:23, 2, or the study of the Royal Swedish Academy of Engineering Sciences: *Ingenjörer för 2000-talet: En studie utförd av Ingenjörsvetenskapsakademien på uppdrag av Näringsdepartementet* (IVA-M 273, Stockholm, 1992), 81.

2 Ingemar Ingemarsson & Ingela Björck, eds., *Ny Ingenjörsutbildning*, NyIng slutrapport (Linköping, 1999).

3 See the various contributions to Ingela Björck, ed., *Vad är en ingenjör?*, NyIng (Linköping, 1998) and, in particular, the article by Bo Dahlbom, “Från ingenjör till itenjör”, 129–144.

I will concentrate on one particular industrial production system – the Swedish shipbuilding industry – and deal with its evolution mainly from the start of the 20th century until the 1950s and 1960s. The principal reason for this is that this was an important growth industry during the period. Internationally, in the early 20th century shipbuilding was among the prestigious edge technologies, perhaps comparable with information/communication technology or bio-technology in our own time. This was so, not least, as a result of the naval arms race between the great powers, which led to the rise of a powerful military-industrial complex in many countries.

During the period from the turn of the century until the 1960s, Swedish shipyards grew from mechanical engineering workshops, mainly building smaller vessels for the domestic market, into internationally competitive companies giving Sweden the rank of one of the leading shipbuilding nations of the world. At its peak in 1970, the Swedish shipbuilding industry accounted for 8 percent of the world's production of tonnage and employed some 50,000 people in its shipyards and subcontracting firms.

While in our own time we attribute great importance for economic growth to information technology and consequently emphasise the need for engineers with knowledge of this field, in the early 20th century shipbuilding seemed to offer great potential. Within a framework of great potential economic importance and rapid technological change, the range of action for different groups increased and it was in no way self-evident which groups would acquire what roles – there was an open and dynamic situation. The shipbuilding industry therefore constitutes a suitable field for studying the role of engineers, presenting patterns which go beyond this particular industry itself.

Apart from this primary motive, there is also another reason to study shipbuilding, and that is to fill a gap in the historical research on this industry. In the early 1980s historians with various specialities at the Göteborg University carried out a research project dealing with economic, social and political aspects of the industry. Since then others have also studied Swedish shipbuilding. With a few exceptions the research has mainly been restricted to the shipyards. Furthermore, technology and innovation have largely been neglected. Being the first to deal with engineers in Swedish shipbuilding and at the same time approaching the subject from a broader perspective, I hope to contribute to a better understanding of the dynamics of the industry.

The rest of this chapter will be organised as follows. First I will outline the conceptual framework with which I will translate the general issue of the engineers' role into questions that can be dealt with empirically. Then I will discuss earlier historical research on engineers, following this with a more detailed account of my questions and of the source material I have used. Finally, in Section 1.5, I will give a presentation of the layout of this book.

1.2 Conceptual framework

To come to grips with the issue of what role college-trained engineers play or what function they fulfil in industrial life, one starting point in the present study has been the technological systems approach developed by Thomas P. Hughes.⁴ Since engineers are engaged in the creation and maintenance of large systems rather than isolated artefacts, such an approach is essential. Furthermore, the concept of a *system*, with its broad holistic view of industrial growth processes, is more useful than that of a *branch of industry* in the kind of study carried out here.

A large technological or sociotechnical system is made up of various interacting components, all of which are necessary if the system is to function well. In his influential *Networks of Power* (1983) Hughes has investigated the growth of one particular kind of system, the electric light and power system – he deals with the evolution of the electricity systems in Chicago, London and Berlin between 1880 and 1930. The components of such a system are physical artefacts (turbogenerators, transformers, transmission lines, light bulbs etc.) as well as organisations (manufacturing firms, utility companies, investment banks), regulatory laws, engineering education, research programs etc. Each component interacts with other components to fulfil a system goal. If the characteristics of one component are changed, then other components have to change too in order for the system to function harmoniously.

Hughes' approach has particularly inspired scholars studying infrasystems, primarily grid-based or non-grid-based energy, communications or transportation systems. The concept of sociotechnical systems can, however, be used to analyse the rise and fall of a large production system, in my case Swedish shipbuilding.⁵ At a

4 For an account of the conceptual framework, see: Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, 1983); idem., "The Evolution of Large Technological Systems", in *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*, eds. Wiebe E. Bijker, Thomas P. Hughes & Trevor Pinch (Cambridge, MA, 1987). In *American Genesis: A Century of Invention and Technological Enthusiasm 1870–1970* (New York, 1989), Hughes extends his analysis to include not only electric light and power systems, but other systems as well, among them large-scale production systems. Further, in *Rescuing Prometheus* (New York, 1998), he deals with system building and massive research and development projects in the post-World War II period, mainly within the military-industrial-university complex of the United States.

5 Lars Olsson, *Engineers as System Builders: The Rise of Engineers to Executive Positions in Swedish Shipbuilding and the Industry's Emergence as a Large Technological System, 1890–1940* (Chalmers University of Technology, Department of History of Technology and Industry: Report 1995–2); idem., "System Builders, National Systems, and the Rise of the Swedish Shipbuilding Industry in the First Half of the 20th Century", *Polhem* 15 (1997), 250–281; idem., "Offshore som livboj: Varvskrisen och försöken till omorientering, 1974–1985", in *Den konstruerade världen: Tekniska system i historiskt perspektiv*, eds. Pär Blomkvist & Arne Kaijser (Stockholm, 1998), 205–229. Hughes deals mainly with electric light and power systems but he also discusses characteristics of other systems, e.g. production systems, see: Thomas P. Hughes, "Beyond the Economics of Technology: Summary Remarks 2", in *Economics of Technology*, ed. Ove Granstrand (Amsterdam, 1994), 432; idem., *American Genesis*, 184–226.

meso level this system was made up of numerous interacting components which contributed to its function, i.e. the design and construction of different kinds of ships.⁶ The components may be grouped into several categories:

- Producers of ships – the shipyards
- Users or customers – private shipping companies and the Swedish Navy
- Organisations laying down rules and regulations for the building of ships – classification societies and the National Ships' Inspectorate
- Educational and research institutions
- Professional and trade associations
- Suppliers – steel works, manufacturers of welding equipment, electric motors, paint, etc.
- Consultants

In my view, the great strength of the Hughesian systems approach is its emphasis on *interaction* between the components or actors of the system. It is these links, as channels of knowledge exchange between components, that are at the centre of my study. While not making use of Hughes' various conceptual tools such as reverse salients or technological style, an underlying idea is the view of shipbuilding as a sociotechnical system. One way in which this will be expressed is in the delimitation of my object of study.

Of course one might just speak of shipbuilding as a branch of industry but in this way it is easy to see the large manufacturing firms only and forget about other organisations – often less closely connected with the actual physical production process – dealing with, for instance, research or safety at sea. If instead we study shipbuilding as a production system it is possible to identify various interacting components which contribute to the harmonious function of the system.⁷ In dealing with shipbuilding in terms of a production system my study has many features in common with cluster or systems of innovation studies of other disciplines, as regards both the content of a system and the emphasis on flow of knowledge and interaction between actors within the system.⁸

6 For a discussion of a meso level in the study of economic transformation, see: Jan Glete, *Ägande och industriell omvandling: Ägargrupper, skogsindustri, verkstadsindustri 1850–1950* (Stockholm, 1987), 32 ff.; cf. Thomas J. Misa, "Retrieving Sociotechnical Change from Technological Determinism", in *Does Technology Drive History? The Dilemma of Technological Determinism*, eds. Merritt Roe Smith & Leo Marx (Cambridge, MA, 1994), 116–141.

7 The notion of a production system should not be interpreted as if I only deal with the production process – on the contrary, I include both product and process innovations.

8 A major source of inspiration in many cluster studies in the 1990s has been Michael E. Porter's *The Competitive Advantage of Nations* (New York, 1990). For an account of cluster analysis in Sweden and abroad, see: *Kluster och klusterpolitik*, NUTEK R 1998:29 (Stockholm, 1998), 11–44; *Klusteranalys och näringspolitik: Erfarenheter från Danmark, Finland, Holland och Norge*, NUTEK R 1995:12 (Stockholm, 1995); See also: Bo Carlsson, ed., *Technological Systems and Economic Performance: The Case of Factory Automation* (Dordrecht, 1995), 1–56; idem., ed., *Technological Systems and Industrial Dynamics* (Boston, 1997), 1–21; Charles Edquist, "Systems of Innovation Approaches – Their Emergence and Characteristics", in *Systems of Innovation: Technologies, Institutions and Organizations*, ed. Charles Edquist (London, 1997), 1–35.

The role Hughes attributes to engineers is dual and depends on their rank in the hierarchy of the systems. On the one hand we have those who do not hold top management positions, that is the great bulk of engineers, whom he refers to as system *tenders*. They are obviously part of the system and are mainly invisible in his analysis. On the other hand we have a much smaller group composed of engineers and others who have “risen from the ranks of system tenders into the heady atmosphere of system builders.”⁹ According to Hughes the system builders are the ones who invent and develop the components of the systems. He says that one of the “primary characteristics of a system builder is the ability to construct or to force unity from diversity, centralization in the face of pluralism, and coherence from chaos.”¹⁰ Another characteristic, according to Hughes, is that the system builder controls the system. While system builders could also be organisations, in his studies he has focused, to a large extent, on individuals.¹¹

The critics of Hughes’ model have to some extent focused on the “heroic” and “transcendent” system builders.¹² As several commentators have pointed out, this leads to an overemphasis on great men, heroes and winners, while at the same time neglecting other actors who have also had an impact on the shaping of new technology.¹³ These other actors may, for instance, be users of the systems’ products or services, or people who work at lower levels in the hierarchy of concerned companies or other organisations.

9 Hughes, *American Genesis*, 246.

10 Hughes, “The Evolution of Large Technological Systems”, 52; cf. idem, “The Electrification of America: The System Builders”, *Technology and Culture* 20 (1979).

11 Among these individuals are Thomas Edison, Samuel Insull, Henry Ford and Walther Rathenau, see: Hughes, *Networks of Power*; idem., “The Electrification of America”; idem., *American Genesis*; idem., “Walther Rathenau: ‘system builder’”, in *Ein Mann vieler Eigenschaften: Walther Rathenau und die Kultur der Moderne* (Berlin, 1990), 9–31. While still acknowledging the role of individuals, in *Rescuing Prometheus* Hughes has also emphasised the role of various organisations as system builders.

12 David A. Hounshell, “Hughesian History of Technology and Chandlerian Business History: Parallels, Departures, and Critics”, *History and Technology* 12 (1995), 215.

13 For instance, see: Jane Summerton, “Stora tekniska system: En introduktion till forskningsfältet”, in *Den konstruerade världen*, eds. Blomkvist & Kaijser, 34 f. and the literature cited there.

To present a better picture of how sociotechnical systems are constructed we should use a broader concept than that of system builders. While moving away from an approach with system builders in sole control, we must, on the other hand, keep in mind that all actors do not have an equal opportunity and ability to affect the course of events – some actors are more powerful than others and therefore exercise more influence on how our material world is formed.¹⁴

A fruitful way to approach the problem of the engineers' function in sociotechnical systems is to apply Henrik Björck's concept of "teknikbärande skikt" which here will be translated as a *social group of technology carriers*.¹⁵ The concept refers to a group which has an *interest* in and the *ability* to bring forth, maintain and develop technological systems.¹⁶ Björck argues that the importance of theoretically trained engineers in modern industrial society is mainly attributable to their role as "an indispensable part of the social group of technology carriers in this kind of society."¹⁷

The concept is an elaboration and widening of Charles Edquist's and Olle Edqvist's concept of *social carriers of techniques*. A social carrier is a "social entity which chooses and implements a certain technique."¹⁸ It may be either an individual or an organisation, such as a company or a government agency. The two authors prefer to use the expression techniques, rather than technology, since their analysis deals only with the transfer of physical artefacts.¹⁹ Furthermore, in their analysis they have chosen to concentrate on technology transfer not involving the development of new technology.²⁰

14 As regards interplay and conflicts between different groups in the shaping of new technology on a general level this study has been inspired by a social constructivist perspective. However, I agree with those critics who argue that the SCOT approach has largely neglected power relations between relevant social groups. On the contrary it is essential to study the relative power of the various actors or groups, see: Mikael Hård, "Beyond Harmony and Consensus: A Social Conflict Approach to Technology", *Science, Technology, & Human Values* 18 (1993), 415 f.; idem, *Machines are Frozen Spirit: The Scientification of Refrigeration and Brewing in the 19th Century – A Weberian Interpretation* (Frankfurt am Main, 1994), 70; Tage Alalehto, "Teknologi som sociologiskt studiefält – en diskussion om SCOT", *Polhem* 11 (1993), 247 ff.; Trevor Pinch, "The Social Construction of Technology: A Review", in *Technological Change: Methods and Themes in the History of Technology*, ed. Robert Fox (Amsterdam, 1996), 31 f.; cf. Trevor J. Pinch & Wiebe E. Bijker, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other", in *The Social Construction of Technological Systems*, eds. Bijker, Hughes & Pinch, 17–50; Wiebe E. Bijker, "The Social Construction of Bakelite: Toward a Theory of Invention", in *The Social Construction of Technological Systems*, eds. Bijker, Hughes & Pinch, 159–187.

15 Note that, in this study, the concept of a *social group* has a broader meaning than that of Wiebe E. Bijker and Trevor J. Pinch in their analysis of specific artifacts, cf. Pinch & Bijker, "The Social Construction of Facts and Artifacts", 30 ff.

16 Henrik Björck, "Bilder av maskiner och ingenjörskårens bildande: Tekniska tidskrifter och introduktion av ny teknik i Sverige, 1800–1870", *Polhem* 5 (1987), 296; See also: idem., *Teknisk idéhistoria* (Göteborg 1995), 24 ff.

17 Idem., *Teknisk idéhistoria*, 25.

18 Charles Edquist & Olle Edqvist, *Social Carriers of Techniques for Development* (Swedish Agency for Research Cooperation with Developing Countries, SAREC Report R3:1979, Stockholm, 1979), 31.

19 Ibid, 9.

20 The reason for this is that they study technology transfer to developing countries. Since only a minute part of global research and development is carried out in such countries, the choice between existing alternatives is of major importance.

Edquist and Edqvist suggest several criteria of a social carrier. First the social carrier must have *information* about the existence of the technique and *access* to it. Furthermore the carrier must have an *interest* in choosing and implementing the technique and have or be easily able to acquire *knowledge* of its operation. If the carrier is more than one person, they must be properly *organised*. Finally, it is essential for the carrier to have “the necessary social, economic and political *power* to materialize its interest.”²¹ With the authors’ strict definition, it is only if all the above conditions are fulfilled that a *potential* carrier becomes an actual social carrier of a technique. No implementation can take place without social carriers.

Henrik Björck discusses the merits of the concept of social carriers in a study of engineers and transfer of information through technical journals in the 19th century. Edquist and Edqvist have anticipated that their perspective could be broadened.²² According to Björck this would require a redefinition of the concept. However, from the point of view of the history of ideas he finds a more useful approach in the aforementioned concept of a *social group of technology carriers*. He acknowledges that, as an analytical tool, it is less precise than the social carrier concept, but argues that it is more useful since it can be used, among other things, to deal with the time-consuming adaptation and diffusion process.²³

By *ability* to bring forth and maintain technological systems Björck means possession by the engineers as a group of sufficient knowledge and influence to be able to function as technology carriers. Often influence followed as a result of their expert role. However, in cases when the engineers lacked the necessary economic or political power they needed to co-operate with other groups with whom they had common interests. Regarding the criterion of *interest*, Björck identifies, among the engineers, both an interest in the technology itself and an interest in raising the status of their profession or the position of the individual engineer.²⁴

While Edquist’s and Edqvist’s perspective may prove useful in micro level studies of technology transfer, I find Björck’s concept better suited for meso level studies of technological systems. This follows from the fact that even if we modify the former two authors’ concept to include technology, instead of technique, and its development, they have an actor-oriented perspective with emphasis on individual people’s or organisations’ role as social carriers, a perspective which to some extent corresponds to Hughes’ clearly identifiable system builders.²⁵ Björck’s looser concept, on the

21 Ibid., 31.

22 Ibid., 34. In another study, Charles Edquist has touched upon the issue of social carriers and the development of new technology, see: Charles Edquist, “Företag och fack som sociala bärare av teknik”, in *Det teknologiska uppvaknandet: En antologi om svensk forsknings- och teknologipolitik*, ed. Wilhelm Agrell (Stockholm, 1980), 58 ff.

23 Björck, “Bilder av maskiner”, 296 ff.; cf. idem., *Teknisk idéhistoria*, p. 24 and note 19, p. 243 f.

24 Idem., “Bilder av maskiner”, 298 and note 95, p. 309.

25 Even though Edquist and Edqvist introduce what they call a *combined* social carrier, i.e. “two or several [social] units that choose and implement the technique in combination,” they still focus on clearly identifiable individual people or organisations, see: Edquist & Edqvist, 33. Mikael Hård, who in his *Machines are Frozen Spirit* has suggested how the social carrier concept may be modified, also focuses on such individuals or organisations, see pages 69–80 and 171–178.

other hand, deals with a social group, whose members may be active in many different organisations within a system. As I see it, interaction between system components will to a large extent be channelled through the engineers. Hereby, they will form the links between the various components or organisations within a system, at least as regards sociotechnical knowledge.²⁶

Furthermore, the looseness in itself brings Björck's concept more into line with a contextualising and thus widening mode of writing the history of technology, and here we have a striking conformity with the systems approach.²⁷ In a review of *Networks of Power*, Barry Barnes labels Hughes' systems approach "extremely informal," being critical of the vague definition of the concept.²⁸ Still, he admits its merits: "The great merit of Hughes' 'systems' thinking is that it produces a marvellous sensitivity to *context*, and to that extent helps to liberate the historical imagination." Hughes himself says that the concept of technological system that he uses is "less elegant but more useful to the historian who copes with messy complexity than the system concepts used by engineers and many social scientists."²⁹ To me the sensitivity to context is essential.

In dealing with the role of college-trained engineers within an industrial system, I will examine to what extent these engineers collectively fulfilled the requirements of a social group of technology carriers. The temporal aspect is here of crucial importance since the extent to which the engineers met the different criteria is not constant over time – it changed as the engineers were confronted with other groups. While Björck has discussed the concept of a social group of technology carriers in an abstract way, I intend to apply it to a rich empirical material, basing the study on the criteria of knowledge, power and interest and of suitable organisation.

1.3 Previous research

Given the way I have framed my overall question the literature relevant to this study concerns both the Swedish shipbuilding system and college-trained engineers. With a few exceptions earlier research on engineers has not explicitly considered this occupational group's role in sociotechnical systems. After first dealing with the

²⁶ By sociotechnical knowledge I mean knowledge needed for system building, i.e. knowledge of the technical components of the system as well as of economics, marketing, labour relations, regulatory laws, politics etc.

²⁷ Björck himself acknowledges a kinship with the systems approach in this respect, see: Björck, *Teknisk idéhistoria*, note 19, p. 244.

²⁸ Book review by Barry Barnes of *Networks of Power* published in *Social Studies of Science* 14 (1984), 310 f.

²⁹ Hughes, "The Evolution of Large Technological Systems", note 1, 80 f.

literature on shipbuilding and systems I will then go on to discuss previous research on engineers, following the different criteria of a social carrier.

Earlier historical research on Swedish shipbuilding has not explicitly dealt with the industry as a system. However, some of the studies approach the subject in a somewhat similar way. Kent Olsson has discussed the expansion of the shipbuilding industry in terms of *development blocks*, a concept introduced by Erik Dahmén.³⁰ As Mats Fridlund has shown, Dahmén's conceptual framework very much resembles the systems approach developed by Thomas P. Hughes.³¹ Fridlund calls the approaches of Dahmén and Hughes "the twins of Schumpeter," since both emphasise the importance of individual entrepreneurs in industrial change. One difference is that while Dahmén's perspective is more oriented towards financial matters, that of Hughes is more concerned with engineering and the creation of new technology.

Kent Olsson uses the concept of a development block as a general interpretative framework in his studies, defining it as a "coherent economic unit with a dynamic relationship between different parts of the block."³² In the case of Gothenburg he identifies a *port block* composed of not only port facilities, shipping companies and shipyards, but also, in a broader perspective, the transportation system of the entire region and industries associated with the port and its trade.³³ However, in his studies of the shipyards he deals mainly with the interaction between the yards and the shipowners, paying less attention to the interaction with other parts of the block.³⁴ Olsson does not explicitly deal with the engineers' role in the industry – to the extent that members of this occupational group appear at all in his studies, they do so only because they have reached top management positions in the companies and consequently are of interest in their role as managers, not as engineers.

30 Kent Olsson, "Sjöfartens utvecklingsblock under yttre tryck – den svenska sjöfartssektorn under det andra världskriget", [Norwegian] *Sjöfartshistorisk Årbok* 1990, 190 ff.; cf. idem., *Från pansarbåtsvarv till tankfartygsvarv: De svenska storvarvens utveckling till exportindustri 1880–1936* (Göteborg, 1983), 43. In a similar way Håkon With Andersen deals with the development block or system of Norwegian shipping and shipbuilding, making a distinction between frontline firms, i.e. shipyards and shipowners, and supporting institutions such as brokers, insurance companies, classification societies, consultants and research organisations, see: Håkon With Andersen, "Producing producers: shippers, shipyards and the cooperative infrastructure of the Norwegian maritime complex since 1850", in *World of Possibilities: Flexibility and Mass Production in Western Industrialization*, eds. Charles F. Sabel & Jonathan Zeitlin (Cambridge, 1997), 461–500. Cf. idem., "Norsk skipsbyggingsindustri gjennom 100 år", in *Teknologi i virksomhet: Verkstedindustri i Norge etter 1840*, ed. Even Lange (Oslo, 1989), 93.

31 Mats Fridlund, "Schumpeters tvillingar: Utvecklingsblock och sociotekniska system i studiet av industriell förändring", *Polhem* 16 (1998), 27–47. For an account of the Dahménian conceptual framework, see the different contributions, by Dahmén and others, in the two volumes: Bo Carlsson & Rolf G. H. Henriksson, eds., *Development Blocks and Industrial Transformation: The Dahménian Approach to Economic Development* (Stockholm, 1991); Håkan Lindgren, ed., *Economic Dynamism in Honour of Erik Dahmén September 14, 1996* (Stockholm, 1996).

32 Kent Olsson, "Sjöfartens utvecklingsblock", 190.

33 Idem., *Göteborgs historia – Näringsliv och samhällsutveckling*, vol. 3: *Från industristad till tjänstestad 1920–1995* (Göteborg, 1996), 86.

34 Another study dealing with parts of the production system is Jan Kuuse's *Varven och underleverantörerna: Förändringar i fartygsbyggandets industriella länkeffekter* (Göteborg, 1983), which deals with the interaction between the shipyards and their subcontractors.

As mentioned above, on a more general level the Hughesian systems approach has attracted great attention among historians of technology, not least in Sweden.³⁵ The engineers' role in the systems has, however, not been of primary concern in this research. An exception is Eva Jakobsson's *Industrialisering av älvar*, which deals with the building of hydroelectric power plants in Sweden in the first two decades of the 20th century.³⁶ Here she combines Hughes' systems approach with Edqvist's and Edqvist's social carrier perspective. The way she does this is to make use of Hughes' concept of system builders, which, as pointed out above, is consistent with that of social carriers in its focus on individual actors. Consequently, emphasis is not on the engineers as a group but rather on some leading actors' role as system builders. Most of these system builders, however, were engineers. The closest she comes to the question of the impact of the engineers as a group upon developments in the system is her thesis that the system builders acted in line with a common "systems culture," which had originated in their common engineering education. A conclusion of her study is that as social carriers these system builders not only had knowledge of the technology and an interest in expanding the Swedish electric light and power system but also the necessary power to materialise their interest. As regards chronology it should be noted that the engineers came to have this influence in the first decades of the century.

Another study dealing with engineers in a sociotechnical system is Mats Fridlund's *Den gemensamma utvecklingen*. He investigates the long-term collaboration, named a "development pair," between the private electrotechnical company ASEA and the Swedish State Power Board, on the development of electric power technologies. This collaboration between a domestic producer and a large and demanding customer began in the early 20th century and Fridlund follows its evolution into the 1960s. A highly significant aspect of the collaboration was that engineers of the two organisations made up a strong social network, often having a common background and sharing the same set of values. Fridlund does not study the engineers as social carriers of technology – while acknowledging that large manufacturing firms in the field functioned as social carriers he emphasises ASEA's leading engineers' role as builders of development blocks and the role of the central actors of the Swedish State Power Board as system builders.³⁷

35 For an overview of Swedish research in this field, see: Blomkvist & Kaijser, eds., *Den konstruerade världen*.

36 Eva Jakobsson, *Industrialisering av älvar: Studier kring svensk vattenkraftsutbyggnad 1900–1918* (Göteborg, 1996).

37 Mats Fridlund, *Den gemensamma utvecklingen: Staten, storföretaget och samarbetet kring den svenska elkrafttekniken* (Stockholm, 1999), 19 f. & 30.

While there are no other studies, to my knowledge, dealing with technological systems and engineers as social carriers in combination, there exists a rich literature on different aspects of the Swedish engineer – in fact the subject of engineers and the engineering profession has constituted one of the major themes in Swedish research in the field of history of technology.³⁸ Relatively little attention has been paid, however, to the engineers' role in private industry. Instead much of the research on Swedish engineers deals with the academic and professional spheres, that is, engineers engaged in the educational system, technical research or professional societies.³⁹

To the present study it is of interest to discuss to what extent earlier research on Swedish engineers has dealt with the different criteria of a social carrier. I will begin with the criterion of the engineers' *power* or *influence* in industry and society.⁴⁰ One scholar who has addressed this subject is Rolf Torstendahl who has investigated the extent to which Swedish engineers acquired leading positions both in private business and in public service between 1860 and 1940.⁴¹ He speaks of the engineers' power as a knowledge-based power and argues that it found expression in giving engineers influence in several fields. One was the workshop floor, where engineers

38 Lars Olsson, "Teman och perspektiv i Polhem 1983–1996 och tidskriftens spegling av den svenska teknikhistoriska forskningen", in *Teknikens landskap: En teknikhistorisk antologi tillägnad Svante Lindqvist*, eds. Marika Hedin & Ulf Larsson (Stockholm, 1998), 341 f.

39 Nils Runeby, *Teknikerna, vetenskapen och kulturen: Ingenjörundervisning och ingenjörorganisationer i 1870-talets Sverige* (Uppsala, 1976); Rolf Torstendahl, *Teknologins nytta: Motiveringar för det svenska tekniska utbildningsväsendets framväxt framförda av riksdagsmän och utbildningsadministratörer 1810–1870* (Uppsala, 1975); Bo Sundin, *Ingenjörsvetenskapens tidevarv: Ingenjörsvetenskapsakademien, Pappersmasskontoret, Metallografiska institutet och den teknologiska forskningen i början av 1900-talet* (Umeå, 1981); Henrik Björck, *Teknikens art och teknikernas grad: Föreställningar om teknik, vetenskap och kultur speglade i debatterna kring en teknisk doktorsgrad, 1900–1927* (Stockholm, 1992); Svante Lindqvist, "Ideology and institutional structure: The historical origins of the present crisis in Swedish engineering schools", in "Universities and the sciences: Historical and contemporary perspectives", ed. Giuliano Pancaldi, special issue of the Bologna university journal *Alma Mater Studiorum* (1993), 181–199; Ulf Larsson, *Brobyggaren: Otto Linton, byggnadskonsten och dess professioner i Norden under första delen av 1900-talet* (Stockholm, 1997).

40 I have chosen to confine my discussion to a Swedish context. For comparative perspectives on the influence and prestige of engineers in various countries, see: Peter Meiksins & Chris Smith, eds., *Engineering Labour: Technical Workers in Comparative Perspective* (London, 1996); Göran Ahlström, *Engineers and Industrial Growth: Higher Technical Education and the Engineering Profession During the Nineteenth and Early Twentieth Centuries: France, Germany, Sweden and England* (London, 1982). See also the contributions (and especially the one by André Grelon, "The training and career structures of engineers in France, 1880–1939", pp. 42–64) to: Robert Fox & Anna Guagnini, eds., *Education, technology and industrial performance in Europe, 1850–1939* (Cambridge, 1993). For further discussion of the standing of engineers in industry and society in different countries, see also: (for the United States) Edwin T. Layton, jr., *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (1971; Baltimore, 1986); Terry S. Reynolds, "The Engineer in 20th-century America", in *The Engineer in America: A Historical Anthology from Technology and Culture*, ed. T. Reynolds (Chicago, 1991), 176 f.; (Germany) Kees Gispens, "Die deutsche Ingenieur elite, 1840–1930: Eine Analyse der Nachrufe", in *Ingenieure in Deutschland 1770–1990*, eds. Peter Lundgreen & André Grelon (Frankfurt, 1994), 221–241; (the Soviet Union) Loren R. Graham, *The Ghost of the Executed Engineer: Technology and the Fall of the Soviet Union* (Cambridge, MA, 1993).

41 Rolf Torstendahl, *Dispersion of Engineers in a Transitional Society: Swedish Technicians 1860–1940* (Uppsala, 1975); idem., "Ingenjörernas makt", in *Teknokrati, arbete, makt*, ed. Svante Beckman (Stockholm, 1990), 226 ff. See also: idem., "Engineers in industry, 1850–1910: Professional men and new bureaucrats. A comparative approach", in *Science, Technology and Society in the Time of Alfred Nobel*, eds. Carl Gustaf Bernhard; Elisabeth Crawford & Per Sörbom (Oxford, 1982), 253–270.

began replacing practically trained technologists as the leaders in the 1890s. From the same time onwards engineers also increased their influence in the field of design work. A third field where the college-trained engineers increased their influence was in management, not the least in manufacturing industry, gaining top executive positions. This latter power grew, according to Torstendahl, continuously from the 1890s until the 1940s, after which it stagnated. After 1970 it seems as if the pendulum has swung in the opposite direction and that the power of the engineers has decreased.

As regards the extent to which college-trained engineers gained top executive positions, Torstendahl has found that among those who graduated from the Royal Institute of Technology (KTH) between 1881 and 1910 and went into private industry, 28 percent had become business leaders by mid-career (15 years after graduation) and 40 percent late in their careers (30 years after graduation).⁴² The corresponding figures for the Chalmers Institute of Technology (Chalmers) are lower – 20 percent and 33 percent respectively. In other words, graduates of KTH were more successful in obtaining leading positions in private business. In the public sector the KTH engineers dominated the scene even more and were “virtually the only technicians who obtained the very high posts.”⁴³

Given their often influential position, Torstendahl does not go on to analyse what role the engineers played in private industry. Neither does he to any significant extent discuss how engineers competed for power with other professional groups, which possessed different kinds of knowledge. One scholar who to some extent has dealt with this question is Ulf Larsson, in his *Brobyggaren*, where he discusses competition between civil engineers and architects.⁴⁴

Another scholar addressing this theme is Conny Norling, who has dealt with competition for executive positions in Swedish industry between college-trained engineers and economists with a university-level education in economics and business administration.⁴⁵ Even though his reasoning is somewhat too far-reaching considering his empirical base, the study is of great fundamental interest. He argues that those who have power in an organisation are those who control what is considered to be the most critical resource. For a shift of power to take place, the organisation must be under pressure to change, which provokes a reaction where a new resource begins to be used or an old resource is reevaluated. In the next stage the resource becomes the source of power of a new group whose members have the specialist knowledge concerned.

In a historical perspective, Norling says, control of technology has often been a source of power. With the changeover from manual to industrial production both

⁴² Torstendahl, *Dispersion of Engineers*, 217.

⁴³ Ibid., 207.

⁴⁴ Larsson, *Brobyggaren*.

⁴⁵ Conny Norling, *Byråkrati och makt: Ingenjörer vs ekonomer* (Uppsala papers in economic history, Research report no 32, Uppsala, 1993).

factory owners and skilled workers could increase their influence at the expense of artisans. However, in the 20th century mass-production technology and new management ideals undermined the workers' influence while increasing the power of another group: the qualified engineers. Until the mid-1960s companies' major concern was to increase production, and therefore technology was the critical resource. High costs and increasing international competition from the late-1960s onwards, however, led to difficulties in Swedish industry. At this stage there was a gradual shift from a production-oriented thinking to an economic thinking. Norling argues that "the power of the economists grew as the uncertainty of the companies began increasingly to depend on economic factors, making skill in economics one of the industry's critical resources."⁴⁶ This of course did not mean that the engineers completely lost their power – technology is still a critical resource – but rather that they had to share the leading positions with the economists, whose knowledge has also become critical.⁴⁷

What is interesting is that Torstendahl, Norling, Jakobsson and Fridlund have all indicated that college-trained engineers gained increasing influence over different organisations within Swedish industrial life from the late 19th and early 20th century onwards. In this process the engineers often came to replace practically trained technologists in top executive positions. A little more than half a century later people with other educational backgrounds, not least college-trained economists, began to challenge the engineers in such positions. Norling dates this change to the 1960s and Torstendahl to 1970. Even if Fridlund does not explicitly address this theme, one can see signs of the same pattern, dating from the late 1950s, in his study. Due to the importance of the criterion of power in the technology carrier perspective, a more thorough analysis of the period in which engineers gained dominant positions in Swedish industry is needed.

Moving on to the criterion that a social carrier must have *knowledge* of a technology it is clear that internationally the nature of engineering knowledge has attracted great attention.⁴⁸ In Sweden, Boel Berner has addressed this theme. Her

46 Ibid., 52.

47 In the late 1990s, college-trained engineers (with a M.Sc. degree), as a group, still dominate in the position of managing director in large Swedish industrial companies, closely followed by college-trained economists, see: Erik Mellgren, "VD-skolan: KTH är porten till direktörsummet", *Ny Teknik*, 1997:12, 10 f. Cf. Sune Carlson, "Ett sekels industriledare", *Skandinaviska Enskilda Banken: Kvartalsskrift*, 67:2 (1986), 54 ff.; idem., *Företagsledning och företagsledare* (Stockholm, 1962).

48 There is an extensive literature on engineering (and technological) knowledge. Among the many works in this field we find: Walter G. Vincenti, *What Engineers Know and How They Know It: Analytical Studies from Aeronautical History* (Baltimore, 1990); Eugene S. Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA, 1992). For a discussion of the "technology as knowledge" theme in history of technology, for instance, see: Edwin Layton, "Mirror-Image Twins: The Communities of Science and Technology in 19th-Century America", *Technology and Culture* 12 (1971), 562–580; idem., "Technology as knowledge", *Technology and Culture* 15 (1974), 31–41; John M. Staudenmaier, *Technology's Storytellers: Reweaving the Human Fabric* (Cambridge, MA, 1985), 83–120.

emphasis has been on characteristic features of engineering knowledge and design work, discussing optimisation, systematic parameter variation and scale modelling.⁴⁹ On a micro level she discusses the engineers' workplace in industrial companies, with special emphasis on design work and work in the company's drawing department.⁵⁰ She has also discussed in detail what engineering students at KTH in the early 20th century learnt and how this knowledge helped to unite engineers as a group and laid the foundation for their future careers.⁵¹ This latter aspect is particularly important. In a technology carrier perspective it is important not only to consider the formal engineering education, but also the social training and the building of networks of contacts for the engineers' future careers, a point to which I will return in Chapter 3.

Regarding the criterion of *interest*, some scholars have discussed what interests engineers may have had in different issues. Beginning with Nils Runeby, much discussion has focused on the emergence of the engineering profession in the late 19th and early 20th century, and on the engineers' view of themselves, for instance as mediators in the struggle between capital and labour.⁵² Here, a professional interest can be identified. There are also studies of the engineers' interest in questions of rationalisation and their role as proponents of scientific management.⁵³ Both Runeby and Bosse Sundin have discussed the engineers' new role, in the early 20th century, as organisers in industrial companies.⁵⁴ Sundin has stressed the importance of certain accounting principles as tools in the management of the companies. Those who developed these and other methods for increasing efficiency were usually engineers.

49 Boel Berner, *Teknikens värld: Teknisk förändring och ingenjörsarbete i svensk industri* (Lund, 1981), 78–92; idem., "Experiment, teknikhistoria och ingenjörens födelse", *Dædalus: Tekniska Museets Årsbok 1982*, 39–52; idem., *Perpetuum mobile? Teknikens utmaningar och historiens gång* (Lund, 1999), 47–82. Another scholar who has discussed the engineers' knowledge and their calculating tools and methods is Jan Hult in his "Vad har hänt med räknestickan?: Ingenjörsarbete i förändring", in *I teknikens backspegel: Antologi i teknikhistoria*, ed. Bosse Sundin (Stockholm, 1987), 248–261. An account – unique in Swedish literature – of the nature of technical design work, based on an engineer's own experience, is given by Jonas Hesselman, who in the early 20th century was among the pioneers in developing diesel engine technology, see: Jonas Hesselman, *Teknik och tanke: Hur en motor kommer till* (Stockholm, 1948).

50 Berner, *Teknikens värld*, 141–183; cf. idem., "Engineering identity and economic change: Engineers in Swedish Society 1850–1990", *Polhem* 10 (1992), 131–160. Cf. idem., "Professional or Wage Worker? Engineers and Economic Transformation in Sweden", in *Engineering Labour: Technical Workers in Comparative Perspective*, eds. Peter Meiksins & Chris Smith (London, 1996), 168–195.

51 Boel Berner, *Sakernas tillstånd: Kön, klass, teknisk expertis* (Stockholm, 1996), 27–120.

52 See, for instance: Runeby, *Teknikerna, vetenskapen och kulturen*; Berner, *Teknikens värld*, 204–248; Sundin, *Ingenjörsvetenskapens tidevarv*, 61–97; Mikael Hård, *Ingenjören i slutet av 1800-talet* (Rapport 69, serie 2, Institutionen för Vetenskapsteori, Göteborgs universitet: Göteborg, 1981); idem., "Då ingenjörssrollen formades", *Polhem* 1:2 (1983), 26–32; Henrik Björck, "På de tillfälliga uppfinningarnas oroliga haf": Tekniska tidskrifter i Sverige 1800–1870", *Polhem* 4 (1986), 64–101; idem., "Bilder av maskiner", 295–301; Nils Runeby, "Större fart. Framåt: Kring en ingenjörns föreställningsvärld", in *I teknikens backspegel: Antologi i teknikhistoria*, ed. Bosse Sundin (Stockholm, 1987), 302–331.

53 Hans De Geer, *Rationaliseringsrörelsen i Sverige: Effektivitetsidéer och socialt ansvar under mellankrigstiden* (Stockholm, 1978). Cf. Berner, *Teknikens värld*, 184–203.

54 Nils Runeby, "Americanism, Taylorism and Social Integration: Action Programmes for Swedish Industry at the Beginning of the Twentieth Century", *Scandinavian Journal of History* 3 (1978), 21–46; idem., "Att organisera framtiden", in *Göteborgs-Emigranten* 6 (Göteborg, 1997), 220–228; Bosse Sundin, "Ingenjören som organisatör", *Polhem* 9 (1991), 360–386.

Finally, when it comes to the criterion that a social carrier has to be properly *organised*, there are studies of professional engineering associations and their role in shaping the engineering profession.⁵⁵ In dealing with engineers as technology carriers it is, however, of great importance also to study their role in the various organisations within a sociotechnical system, not the least in private companies, in which they spent most of their working lives. With the exception of Mats Fridlund's account of the electrotechnical industry mentioned above, this area has largely been neglected.

To sum up, earlier research on Swedish shipbuilding has not dealt with the industry as a sociotechnical system or explicitly dealt with the role of the engineers. Research on Swedish engineers has to a rather small extent dealt with the engineers' role in industrial systems and how this role has changed over time. Furthermore, the above mentioned studies, of the influence the engineers possessed, the knowledge they had, their interests in different questions and how they were organised, cover various fields of technology and industry, and extend over different periods of time. Consequently, the research can hardly be used to create an understanding of the engineers' role or function in technological systems – instead we need a comprehensive case study of a particular industrial system to shed light on this issue.

1.4 Issue and source material

The conceptual framework of a social group of technology carriers, combined with a systems approach to shipbuilding, forms the organising principle underlying this study. Given that it is reasonable to see engineers as a social group of technology carriers, my overall question is how the college-trained engineers' role as such a group changed over time. My approach to this question is to study the temporal aspect of their ability to function as technology carriers and discuss to what extent they fulfilled the requirement for knowledge of and interest in developing the system, being suitably organised and possessing the necessary power or influence to realise their interest. Since their role was not formed in a vacuum, an important objective is to identify other groups who also were part of the system and with whom the engineers interacted.

55 See for instance: Runeby, *Teknikerna, vetenskapen och kulturen*; Hård, *Ingenjören i slutet av 1800-talet*, 30 ff.; Svante Lindqvist, "Teknik, bildning och kultur: Den svenska ingenjörskårens förvandling", in *Bildningsgång: Natur och kultur 75 år* (Stockholm, 1997), 131–139. In her *Teknikens befäl: En etnologisk studie av teknikuppfattning och civilingenjörer* (Uppsala, 1999), pp. 39–52, Katarina Ek-Nilsson deals with one particular organisation, whose creation she views as a way of strengthening the engineering profession, namely the Swedish National Museum of Science and Technology in Stockholm. Cf idem., "Militär och museiman: Torsten Althin och skapandet av Tekniska museet", *Dædalus: Tekniska museets årsbok* 1998, 23–42.

Considering the power shifts between different groups in Swedish industry, three phases can loosely be identified: a first phase when practically trained technologists were the leaders of industrial companies, a second phase when college-trained engineers came to hold most of the leading positions in companies and other organisations and a third phase when college-trained economists became top executives. I have chosen to concentrate on the second phase and the transformation process beginning in the first phase. This means that I will cover the period from the early 20th century until the 1950s and 1960s, during which time the shipyards expanded. The third phase, although of great interest, will not be dealt with here but left for future research.

With the overall question being *changes* in the *role* of college-trained engineers this study does not deal with the question of how important the engineers were for the expansion of the shipbuilding system, compared with other groups. While an underlying assumption in the technology carrier perspective is that such a carrier is important for technical development and industrial growth, the concept does not have any explanatory power as regards the importance of technology carriers relative to other involved parties. This follows from the fact that the existence of a social group of technology carriers is a necessary but not sufficient condition for innovation and economic growth.

With the intention of dealing with, at a meso level, the changing role of engineers within a technological system, the source material I have used stems mainly from the interfaces between the engineers themselves and between the engineers and representatives of other groups. This means material related to meeting places or fora which span the entire system, and the material takes the form of minutes, correspondence, articles in technical journals etc.

There is a rich material from the engineers' associations, and the section for naval architecture of the Swedish Association of Engineers and Architects in particular. During the first decades of the 20th century the section published its minutes, the papers read at the meetings and the ensuing discussions, in the naval architecture issue of the technical journal *Teknisk tidskrift*. For the rest of the period archival material and articles in the journal gives a picture of the section's activities. As with all material of this kind, it is a weakness that not all engineers expressed their opinions; it was usually the leading engineers active in different parts of the system, or at least the most outspoken ones, who spoke at the meetings or who wrote articles in the journal. Nevertheless, the material represents a group much wider than a small number of heroic inventors or well-known managing directors.

Another reason not to draw too hasty conclusions when using this material is that the engineers may have kept certain information secret – for instance, an engineer at a private shipyard may have been forbidden to talk about a technical solution when competitors were present at a meeting, or a naval engineer employed by the Royal Naval Material Administration may not have wanted to present all the details on a new device in naval construction, fearing that the information eventually would reach foreign powers. Even though I have not found anything to indicate that this is so, the possibility cannot be ruled out. However, although I cannot offer specific

evidence, my impression is that secrecy was not very rigorous at the beginning of our period but that it increased with time. This may have been a result of increasing competition.

While the aspect of secrecy has an impact on the extent to which the professional societies could function as a forum for the exchange of knowledge, I have also studied these organisations in order to find out the engineers' interests. In this case it matters less if engineers omitted some information about what they were working on – the discussions clearly show that they had both a common and a conflicting interest in different questions.

In addition to the professional societies, there were also other organisations in which engineers played the leading part; these were the trade association the Swedish Shipbuilders' Association and the two research organisations, the Swedish State Shipbuilding Experimental Tank (SSPA) and the Swedish Shipbuilding Research Foundation (SSF). Correspondence and minutes of board meetings and working groups offer insight into developments in the organisations and the engineers' role.

Since this study is not a micro-level study of the engineers' work at the shipyards or elsewhere, the archives of such organisations have not been used to any significant extent. In order to find out who held the leading positions in the different organisations I have used earlier historical literature, archival material and engineering directories.

To reconstruct the careers of the engineers I have used various bibliographical directories. Up until about 1930 the careers of those who had graduated from Chalmers and KTH are well documented but it has also been possible to find some information for the following decades. The main sources for the earlier part of the period have been, for Chalmers, Gösta Bodman's *Chalmers Tekniska Institut: Matrikel 1829–1929* and, for KTH, Govert Indebetou's and Erik Hylander's *Svenska Teknologföreningen 1861–1936: Biografier*. These directories have then been supplemented with additional biographical information – see the directories listed under References.

At an early stage in my work I became aware of the fact that the archives of the shipyards contain very little on engineers and their professional life, with the exception of those few engineers who became top executives, whose correspondence and other documents usually have been preserved. Neither have, with a few notable exceptions, engineers to any significant extent written down memories of their life and work. Their reluctance to commit themselves in print has led scholars aptly to describe them as “papyrophobic.”⁵⁶ This may have the effect that the picture presented in this study neglects important aspects of the formation of their role. On the other hand, the problem is probably more acute at a micro level than in a study conducted at a meso level.

⁵⁶ Berner, *Teknikens värld*, note 2, p. 275.

1.5 The layout of the study

The study is organised into two parts. While Part I deals with some of the criteria of a technology carrier it also fills the function of presenting a background to the engineers' working lives within the shipbuilding system. In this, its coverage and claims differ somewhat from those of Part II, particularly Chapter 5, which deals thoroughly with the dispersion and influence of college-trained engineers in the system during the period.

The content of the individual chapters is arranged as follows. Chapter 2 gives an account of the evolution of the shipbuilding system, emphasising the more important system components. While giving the reader a view of the structural context in which the engineers carried out their life work, it also fills the function of presenting earlier research on the history of Swedish shipbuilding.

The object of Chapter 3 is to give a picture of the engineers' knowledge which constituted the key to their careers. The expert knowledge was a result both of the theoretical education gained at the Chalmers Institute of Technology or the Royal Institute of Technology, and of practical training, including work abroad after graduation. I shall focus especially on those who graduated in naval architecture. They were not the only engineers who came to work in the shipbuilding system during the period studied; mechanical engineers were also represented. Naval architects, however, made up the large majority of college-trained engineers employed there, which justifies a special focus on this group.

In Chapter 4, I discuss one aspect of how the engineers were organised to function as a social group of technology carriers – their membership in professional associations. Within these associations, engineers working in different parts of the system got to know each other and exchanged experiences. The associations therefore filled an important function in transferring knowledge, and in creating and upholding networks among the actors of the system. Apart from the organisational aspect, Chapter 4 will also deal with the criterion of interest.

The discussions at the meetings of the engineering associations offer valuable insight into what interests the engineers may have had in different issues. The criterion that a social carrier must have an interest in developing or implementing a certain technology must also apply to a social group of technology carriers. It is, however, reasonable to assume that within such a larger group of individuals both common and conflicting interests are represented. Therefore it is important to study what issues the engineers agreed on and what they did not. For the concept of a social group of technology carriers to be viable, it has to be possible to identify an overall common interest among the engineers; even if they had very different opinions on certain matters they must have been in agreement on a more general level.

I have chosen to pay special attention to two issues discussed among the engineers. The first is an ongoing discussion in the first decade of the 20th century of what could be done to raise the Swedish shipbuilding industry from a period of decline.

Since engineers would eventually be the ones to lead the companies as these evolved into internationally competitive shipyards, it is valuable to study the engineers' opinions of what was wrong and what could be done about it. In addition, these discussions reveal the engineers' opinions on and interests in a wide range of related questions. The second issue which I study is the introduction of welding and prefabrication from the 1930s onwards. This new technology came to have a major impact on the production process and it also led to changes in the design of the ships. Consequently, it is of interest to study how engineers representing different organisations in the system viewed the new technology. While these two cases discuss the criterion of interests, it should be noted that discussions of the engineers' interests also appear in the other chapters.

A second aspect of how the engineers were organised to function as a social group of technology carriers is their work in the companies and other organisations of the system. Chapter 5 begins with a statistical account of the dispersion of naval architects into different parts of the shipbuilding system. The aim here is to present a picture of where the engineers came to work and therefore it is sufficient only to cover the careers of those who graduated before 1930. Then follows a more detailed discussion of engineers in different categories of organisations throughout the entire period studied. As we shall see, engineers came to work not only for the *producers* of ships but also for the *users*, for organisations setting up *rules and regulations* and in other *supporting functions* of the larger production system. The main purpose of Chapter 5 is to discuss the engineers' power or influence in these organisations.

Finally, Chapter 6 deals with the engineers as proponents of technical-scientific research in the shipbuilding system. This is a case study of how engineers functioned as a social group of technology carriers, discussing the different criteria of knowledge, interest, power and degree of organisation. The chapter also highlights a new role of the engineers from the 1940s onwards – that of researchers. The focus will be on the establishment of two research organisations: the Swedish State Shipbuilding Experimental Tank, which began operation in 1940, and the Swedish Shipbuilding Research Foundation, established in 1955. I will also discuss the research work carried out and the organisations' role as meeting places for engineers from different parts of the industry.

While each chapter ends with a conclusion, in Chapter 7 I will gather the threads of the study and discuss the wider implications of the findings.

As mentioned the study deals mainly with the period from the early 20th century until the 1950s and 1960s, during which time the Swedish shipbuilding industry expanded. On some occasions, however, earlier and later periods are also referred to, mainly in tables, in order to elucidate important changes over time.

Finally, some terminological questions have to be clarified. As indicated, when speaking of an *engineer* or a *college-trained engineer* in this text I mean a person with a university-level degree in engineering (in Swedish: "civilingenjör"). For the period studied, this means a graduate of the Chalmers Institute of Technology (Chalmers) in Gothenburg or the Royal Institute of Technology (KTH) in Stockholm or

someone with an equivalent foreign qualification.⁵⁷ Until 1937, only KTH was formally of university status. Since the education given in the upper division of Chalmers was of almost equal standing to that at KTH, however, graduates of both these schools will be considered as having a college education in engineering.

A *naval architect* was an engineer who had graduated in naval architecture from Chalmers or KTH. The term should not be confused with a *naval engineer* (in Swedish: “mariningenjör”) which means an engineer, usually trained in naval architecture, who worked for the Royal Naval Material Administration or at the Navy yards, and thus belonged to the Corps of Naval Engineers. The equivalent term in Great Britain and the United States was naval constructor.⁵⁸

To make a distinction between college-trained engineers and “engineers” without such an educational background I will use the term *technologist*, to mean someone who has practical technical experience and sometimes also a basic technical education.

⁵⁷ Both engineering schools have had different names over the years. From 1829–1881 Chalmers was called Chalmersska Slöjdskolan, from 1881–1914 Chalmers Tekniska Läroanstalt, from 1914–1937 Chalmers Tekniska Institut and after 1937 Chalmers Tekniska Högskola. In English I have chosen to call the school Chalmers School of Arts and Crafts for the period 1829–1881, Chalmers Institute of Technology 1881–1937 and Chalmers University of Technology after 1937. KTH was called Teknologiska Institutet (TI) between 1827 and 1876 and Kungl. Tekniska Högskolan from 1877. The names in English are the Technological Institute and the Royal Institute of Technology.

⁵⁸ Larrie Ferreiro, “Genius and Engineering: The Naval Constructors of France, Great Britain, and the United States”, *Naval Engineers Journal*, September 1998, 99. Note that nowadays, the Americans use the term “naval architect” instead of “naval constructor” for a designer of warships.

2. The Expansion of Swedish Shipbuilding

Most of the large internationally competitive shipyards in Sweden which built merchant vessels for the seven seas emerged as such during World War I and in the following two decades.¹ Their roots, however, can be traced to the 19th century. In the period from the mid-19th century until 1920, Sweden underwent a transformation from an agricultural to an industrialised country. Two important features of the Swedish economy were the export of timber and, from the 1880s onwards, of iron ore. The period between 1870 and the turn of the century saw the founding of several mechanical engineering companies, which during the 20th century have made up the backbone of Swedish industry. These companies specialised in a particular type of product or group of products, and therefore quickly became dependent on export to foreign markets due to the smallness of the domestic market.

Industrialisation brought an increased need for transportation, both within the country and to other countries. Several steam-shipping companies were founded in Sweden in the second half of the 19th century. They often bought second-hand steamships from Britain to be used as tramps. The increasing export of iron ore offered an opportunity for Swedish shipowners to earn money and from the 1890s onwards such shipping became of great importance.

In response to the need of the growing export-oriented engineering industry for new markets, regular Swedish shipping services to distant parts of the world were established in the first decade of the 20th century. Before that time goods usually had to be shipped to the major ports of Europe and transferred to the ships of foreign lines. In 1904 the shipping company Transatlantic opened a line to South Africa and the Johnson shipping company a line to South America. The former company also started a line to Australia in 1907, the year in which the Swedish East Asia Company, partly owned by the Broström shipping group, was established. Other Broström-controlled lines were the Swedish Orient Line, to the Eastern Mediterranean, and the Swedish America Mexico Line, both of which were started in 1911, and the Swedish American Line, started in 1914.

¹ This section on the expansion of the Swedish shipbuilding system is based on earlier historical research in the field, especially Kent Olsson's *Från pansarbåtsvarv till tankfartygsvarv: De svenska storvarvens utveckling till exportindustri 1880–1936* (Göteborg, 1983). Cf. idem., "Det varvsindustriella genombrottet i Sverige under mellankrigstiden", *Unda Maris* 1975–1982, 51–98. For an overview of the literature on Swedish shipbuilding, see the bibliography: Rune Olsson, *Varvsbibliografi: Litteratur om och kring de svenska stålskeppsvarven*, ed. Lars Olsson (Chalmers tekniska högskola, Institutionen för teknik- och industrihistoria, Rapport: 1997–2).

2.1 The private shipyards

The expansion of the Swedish shipping business constituted a potential market for a prosperous Swedish shipbuilding system. Of course, the fact that a country had a large merchant fleet did not necessarily have to mean that it would also develop a great shipbuilding industry; Norway, in the inter-war years, is a good example of this.

During the 19th century, steam and iron, and eventually steel, gradually replaced sail and wood. From the 1860s onwards, Britain established itself as the leading shipbuilding nation of the world, a position it would hold for almost a hundred years. In Sweden, the once-flourishing yards which built wooden ships did not usually have the resources to change over to iron or steel shipbuilding, and went out of business towards the end of the century.² Instead it was mechanical engineering workshops, founded in the 19th century, that took over the role of shipbuilders, the more important being:

Motala Werkstad in Motala (founded in 1822)
Kockums Mekaniska Werkstad in Malmö (1840)
Keillers Werkstad in Gothenburg (1841; later called Göteborgs Mekaniska Werkstad and, after 1916, Götaverken)
Lindholmens Varf in Gothenburg (1845)
Eriksbergs Mekaniska Verkstad in Gothenburg (1853)
Finnboda Varf in Stockholm (1874)

The ships built by the Swedish engineering workshops in the final decades of the century were usually small. Two exceptions were vessels built for the Swedish Navy and oil tankers. In the 1880s, the Lindholmen shipyard, until World War I the largest shipyard in the country, had begun building tankers for the Nobel oil company in Russia.³ Eventually other shipyards (Finnboda and Kockum) also came to build tankers for the Russian market. After the turn of the century, however, that market disappeared, as the Russians developed the facilities to build tankers in their own country.

In the first decade of the 20th century the yards or engineering workshops did not usually have the capacity to build large ocean-going merchant vessels. Instead, the repair department made up the profitable part of the business. Since repair work was not spread evenly over the year the companies saw the building of new ships primarily as what has descriptively been called a “work accumulator” to keep the

² For an extensive account of Swedish shipbuilding during the 19th century, see: Sven A. Björkenstam, *Svenskt skeppsbyggeri under 1800-talet: Marknad och produktion* (Göteborg, 1989).

³ Johannes Rosengren, “Tankfartygsbyggeri i Sverige under 50 år”, in *Chalmers Tekniska Institut: Minnesskrift 1829–1929*, ed. Gösta Bodman (Göteborg, 1929), 493–542.

workforce occupied.⁴ Skilled workers were the company's most valuable resource and if they were laid off when there was no repair work, there was a risk that they might not come back when needed. If, on the other hand, they were working on a new ship they could easily be transferred to the repair department when a ship came in for repair. As a result it was almost impossible to compete in price with ships built at modern specialised shipyards in Britain. In order to build new ships profitably the Swedish shipyards would have to be enlarged and completely reorganised. If workers were to specialise in certain kinds of job, as they did in Britain, in order to increase productivity, the shipyard had to be large enough to accommodate several ships, at different stages in the building process, at the same time.

One company of particular interest here is Göteborgs Mekaniska Werkstad, later known as Götaverken. In the early 20th century it was an engineering workshop producing a wide range of items, including railway carriages, bridges, iron bedsteads, steam engines and ships. Shipbuilding made up only a smaller and less profitable part of the business. In 1906, the top management of Lindholmen had been dismissed following a change of ownership of that company. In their subsequent search for employment, the former Lindholmen managers formed a consortium, including bank and textile business interests, which took over Göteborgs Mekaniska Verkstad.

In the period up to World War I, they transformed the company into a specialised shipyard, discontinuing the manufacture of most other products. For instance, in 1911 the company sold its rolling stock division. To begin with, a new engine shop and foundry were built. Then followed enlargement or new construction of building berths, cranes, a plate shop, quays, a pier, railway sidings etc. The economic climate of the first years was difficult and it was not until after 1912 that the market began to improve. Since the capital investment was made during a period of recession, the company got good value for its money.

Swedish shipowners at the turn of the century had ordered most of their ocean-going ships from Britain. When World War I broke out in 1914, shipowners first played a waiting game but after a while they began to realise that it was going to be a long war and orders for new ships were signed. Since they could no longer order ships from Britain – the British needed the building capacity themselves – they had to place the orders with Swedish shipyards. The resulting boom in the shipbuilding business encouraged many shipyards to expand. But the war brought higher costs for labour and materials, and the yards that had recently been established or enlarged found themselves in serious difficulties in the depression of the early 1920s.⁵

While the war contributed to the rise of the shipyards, there was another factor which was of great importance in the long-term evolution of Swedish shipbuilding: the production of diesel engines. Originally created in the 1890s the diesel engine was quickly adapted to many fields. There were, however, certain problems in using it to power ships: the engines had to be very large and they also had to be reversible.

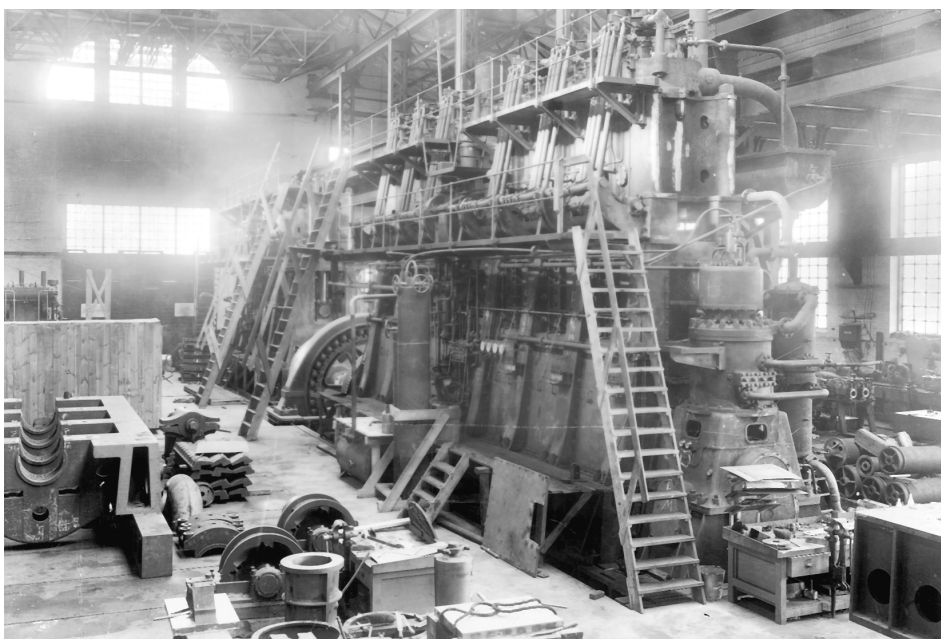
4 Kent Olsson, *Från pansarbåtsvarv*, 53 ff.

5 Ibid., 81–88 & 147–188.

In 1912 the Danish shipyard Burmeister & Wain delivered the merchant ship *Selandia*, which was equipped with two diesel engines of the yard's own manufacture. Shipowners were impressed with the new technology, which offered many advantages compared with steam: it meant lower operating costs even if it was more expensive to buy in the first place, the ship could have a larger operational range, the fuel could be stored in the double bottom, and the engine did not require as much space or weigh as much as a steam engine with its boilers.

Despite being the leading shipbuilding nation, Britain was lagging in the development of marine diesel engines. British energy technology was based on coal and this represented a vested interest that prevented the new technology of diesel engines from being developed there.⁶ The British were also, to a large extent, building ocean liners and warships, and these required steam turbines in order to produce the necessary motive power. Instead, the greatest interest in developing diesel technology was to be found in Germany, Scandinavia and Russia.

In 1915 Götaverken signed a contract to manufacture the Burmeister & Wain diesel engine under licence. Götaverken had already had an order from the Nobel oil company in Russia for a large diesel-engined tanker in 1913. The tanker was equipped with two engines manufactured by Atlas Diesel in Stockholm. Götaver-



Manufacture of diesel engines at Götaverken in the 1910s. From the mid-1920s the production of diesel-engined oil tankers, particularly for Norwegian shipowners, became something of a speciality of the major Swedish shipyards. (Photo: Varvshistoriska Föreningen)

⁶ Ibid., 61 ff.

ken could have chosen to buy all its future engines from a subcontractor, but instead decided that the company should produce the engines itself.

The earlier investment in a new engine shop had given Götaverken a large engine-building capacity, which was a major reason for Götaverken's becoming the leading shipyard in the country.⁷ The first ship with Götaverken-built diesel engines was *Bullaren*, for the shipping company Transatlantic, which was delivered in 1918. After 1921 the shipyard produced no large steamships at all.

In 1916 Götaverken obtained a large order for eighteen ore carriers for the Swedish mining company Grängesberg, of which eleven were actually built. This order helped Götaverken through the depression of the early 1920s. Other customers were Swedish shipping lines, which ordered motor ships. After 1925 Norwegian shipowners began to order oil tankers on a large scale. With its entry into the Norwegian market, Götaverken took a step of the greatest importance to the company as well as to the Swedish shipbuilding system: selling diesel-engined oil tankers to Norwegian shipowners became a speciality of the Swedish shipyards. While the period between the two World Wars was characterised by falling prices, economic stagnation, unemployment, protectionism and overcapacity in the global shipbuilding market, the oil business was expanding rapidly, and Götaverken, and eventually other Swedish shipyards, became part of this sector of the economy. Until the 1970s the Norwegians would remain among the company's most important customers.

While Götaverken, in the inter-war years, totally dominated the large-merchant-vessel sector of the Swedish shipbuilding system, other shipyards gradually came to challenge the company's position. In the 1920s and 1930s the two shipyards of Eriksberg in Gothenburg and Kockum in Malmö followed the successful lead of Götaverken and began to produce diesel engines. In fact they copied Götaverken's concept both as regards the product and the market, as they too came to build oil tankers for Norwegian shipowners. As we shall see below, in the late 1930s and the 1940s, Eriksberg and Kockum expanded further and transformed their plants to allow the introduction of welding and prefabrication in the building of ships. This technological transformation constituted a major change in the production system.

In sharp contrast to the diesel-engine producing shipyards stand those yards that kept on producing steamships during the interwar years. They had to rely on a shrinking market and went into a phase of decline. A notable example was Lindholmen, which in the 1930s had become a place for the scrapping of vessels. The company was, however, later financially reconstructed and again became a major shipyard, even though never as large as Götaverken, Eriksberg, Kockum and Uddevallavarvet, the latter founded in 1946.

7 Kent Olsson, "Det varvsindustriella genombrottet", 73.

2.2 The role of the Swedish state

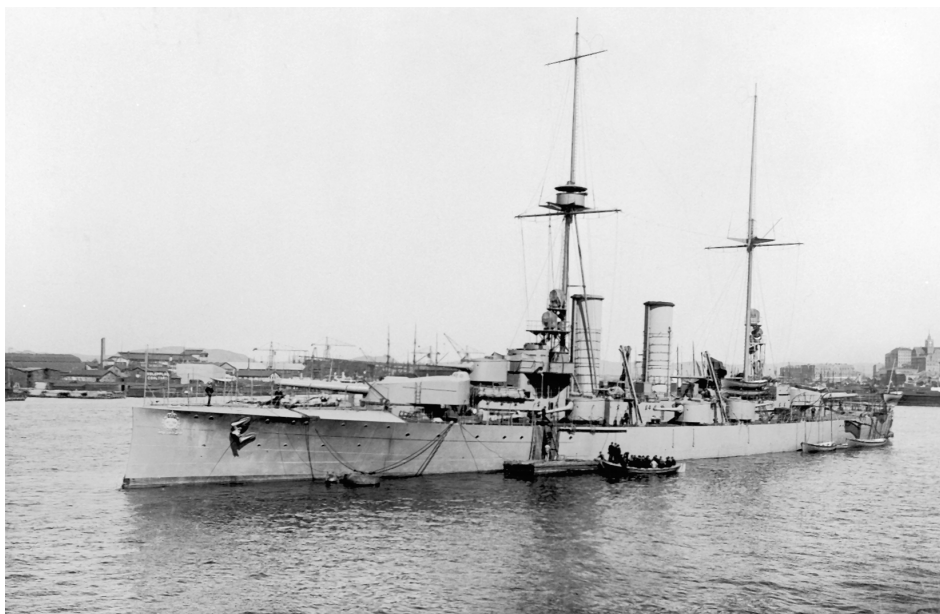
While shipowners, especially Norwegian ones, were the private shipyards' most important customers, the Swedish Navy must not be forgotten. During certain periods the building of naval vessels was of great importance to Swedish shipyards. The 19th century had witnessed a radical change in the design of warships – I will deal with this change more thoroughly in Section 5.6. In an international perspective, the period from the 1880s until World War I was characterised by an intense naval armaments race and naval technology represented the leading edge of the great powers' technical development with the battleships as the superweapons of the time. An extensive military-industrial complex evolved around the building of increasingly powerful warships, most notably in Great Britain but later in other countries too, not least in Germany and the United States.⁸

In the Swedish case it is clear that the building of warships was especially important to the shipyards in the 1890s and early 20th century.⁹ Those yards which were doing most work for the Royal Naval Material Administration at that time were Lindholmen in Gothenburg, Finnboda in Stockholm and Kockum in Malmö. Under its new management Götaverken became a new producer of naval vessels after 1906. First the company built a few torpedo boats and a destroyer but with the signing of the contract for the *Sverige* in 1912 Götaverken became responsible for a very large project. In fact, at that time no single shipyard in the country had the capacity to build the entire ship, at least not in the stipulated time of three years, and therefore the major shipyards had to divide the order between them. Götaverken built the hull and co-ordinated the work, while Kockum built the turbines. Other companies involved were Lindholmen, Bergsund, Atlas Diesel and Bofors, the latter supplying the artillery. For Götaverken the building of the *Sverige* generated the resources needed to enlarge the production facilities and also brought valuable experience.¹⁰ When the Naval Material Administration some years later ordered two sister ships to the *Sverige*, the *Drottning Victoria* and the *Gustaf V*, Götaverken and Kockum were capable of building one ship each.

8 William H. McNeill, *The Pursuit of Power: Technology, Armed Force, and Society since A.D. 1000* (Oxford, 1983), 262–306; Sidney Pollard & Paul Robertson, *The British Shipbuilding Industry, 1870–1914* (Cambridge, MA, 1979), 201–222; Thomas R. Heinrich, *Ships for the Seven Seas: Philadelphia Shipbuilding in the Age of Industrial Capitalism* (Baltimore, 1997), 99–121. On the issue of battleships as the early 20th century's superweapons, see: Robert L. O'Connell, *Sacred Vessels: The Cult of the Battleship and the Rise of the U.S. Navy* (Boulder, 1991).

9 Kent Olsson, *Från pansarbåtsvarv*, 44; idem., "En tung verkstadsindustri i omvandling under skilda konjunkturer: Finnboda Varf 1900–1940", *Föreningen Stockholms Företagsminnen: Årsmeddelande* 1981, 20 ff. For a list of naval vessels built at the private Swedish shipyards in the late 19th century and the first half of the 20th century, see: Gustaf Halldin, ed., *Svenskt skeppsbyggeri: En översikt av utvecklingen genom tiderna* (Malmö, 1963), 277, 334 & 391 f.

10 In his memoirs, written in the late 1930s, Hugo Hammar (managing director of Götaverken from 1910) emphasises the importance of the building of the ships in the *Sverige*-series in the expansion of Götaverken and Kockum, see: Hugo Hammar, *Minnen III: I den svenska sjöfartsnärings tjänst*, ed. Lars Olsson (Göteborg, 1994), 120 ff.



The Sverige in Gothenburg Harbour in 1917. The ship was the first in a series of three and served in the Swedish navy until the late 1940s (Photo: Varvshistoriska Föreningen)

After World War I, the relative importance of naval building decreased. Internationally, the 1920s was a period of naval disarmament and Sweden was also affected by this trend. In the 1930s, the building of warships became somewhat more important to the shipyards. Naval orders, however, were far from sufficient to counterbalance recessions, a function which would have been of value to the shipyards.¹¹ During World War II, the building of warships became a valuable substitute for the building of oil tankers for Norwegian shipowners, a market which disappeared as a result of the war.¹² The larger part of the contracts for surface ships went to Götaverken and Eriksberg while Kockum mainly built submarines.¹³ The two large cruisers which Götaverken and Eriksberg built were not delivered until after the war.

11 Kent Olsson, *Från pansarbåtsvarv*, 232 ff.

12 Idem., "Sjöfartens utvecklingsblock under yttre tryck – den svenska sjöfartssektorn under det andra världskriget", [Norwegian] *Sjöfartshistorisk Årbok* 1990, 212 f.

13 Folke Wedin, *Amiralitetskollegiets historia*, vol. V, 1920–1968 (Stockholm, 1983), 79–91; On the building of submarines, see also: Gustaf Halldin, ed., *Från Hajen 1904 till Hajen 1954: Minnesskrift till ubåtsvapnets femtioårsjubileum* (Malmö, 1954).

In the 1950s, too, some shipyards built larger warships – destroyers – but in the 1960s work for the Naval Material Administration began to become increasingly scarce, mainly due to the Navy's new policy of using smaller vessels.¹⁴ After that time, naval building at the large private shipyards was mainly restricted to the building of submarines at Kockum.¹⁵

While the building of naval vessels was one way in which the government could support and stimulate the growth of the shipbuilding system, it was not the only way. In other countries governments had actively supported shipbuilding with subsidies. As we shall see in Section 4.2, in the years just before World War I Swedish shipbuilders urged such state intervention, but without success. This did not mean, however, that the Swedish government did not do anything for the country's shipyards. One kind of support which should not be forgotten was education, which found expression in the training of naval architects at Chalmers and KTH.¹⁶ From the late 1930s the government also supported shipbuilding by establishing an experimental tank and in the following decades state funding of research in the field increased in scope.

2.3 New production technology

A major change in the way ships were produced came about with the introduction of welding and prefabrication. Electric welding was used, mainly in repair work, at the Swedish shipyards from the early 20th century onwards. Use of the technology was facilitated by the establishment of the Gothenburg-based company *Elektriska Svetsnings Aktiebolaget* (ESAB) in 1904, which manufactured equipment for electric welding.¹⁷ During the first 25 years of ESAB's existence the use of electric welding in the building of new ships increased only slowly. The conservatism of the classification societies is often given as the reason for this.¹⁸

On the international scene, however, things were happening. Both in America and Europe electric welding was increasingly employed in shipbuilding in the 1920s and 1930s. This applied particularly to naval vessels, since the Washington arms

14 With this change the navy yard in Karlskrona (again, after roughly a hundred years) became the principal builder of ships for the Naval Material Administration, see: Erik Norberg, "Från marinverkstäder till aktiebolag 1945–1992", in *Karlskronavarvets historia, del 2, 1866–1992*, ed. E. Norberg (Karlskrona, 1993), 163–192.

15 Wedin, *Amiralitetskollegiets historia*, vol. V, 173 ff.

16 The government also supported industry, for instance, by improving the infrastructure (transport, communication, electric power etc.). For a discussion of the importance of government intervention in different countries, not the least as regards education and research, see: Ian Inkster, *Science and Technology in History: An Approach to Industrial Development* (Basingstoke, 1991), 89–130.

17 *Elektriska Svetsnings-Aktiebolaget 1904–1929* (Göteborg, 1929); Bertil Lundberg, *Maskinhistorik 1904–1990* (Göteborg, 1992); "The Birth of the Welded Ship", 100 A1: *The Magazine of Lloyd's Register of Shipping*, March 1976, 12–18.

18 Thommy Svensson, *Från ackord till månadslön: En studie av lönepolitiken, fackföreningarna och rationaliseringarna inom svensk varvsindustri under 1900-talet* (Göteborg, 1983), 235.

reduction agreement of 1922, and, for the Germans, the Treaty of Versailles, placed restrictions on their weight.¹⁹ While the potential gain of an all-welded merchant ship was lower weight and the ability to carry a greater payload, in the case of warships the gain was the ability to carry more arms with the same displacement. For the navies, the use of welding was of course facilitated by the fact that they did not have to worry about what the classification societies thought of the new technology.

The great breakthrough of electric welding came during World War II, when American shipyards began to mass-produce standardised all-welded merchant vessels. As had also been the case during World War I, in 1941 the United States entered a war without having a sufficiently large merchant marine. The authorities launched an enormous shipbuilding programme and by the end of 1942 the Americans were building ships faster than the Germans could sink them. This was made possible by the opening of a large number of new shipyards, all concentrating on the production of one or a few standard types of vessels, the "Liberty ship" being the best known.²⁰

Speed of production was of crucial importance. It was accomplished thanks to the use of welding, prefabrication of large sections, which permitted an increase in the number of workers operating on each ship without overcrowding the workplace, standardisation of components, division of labour and learning-curve benefits, since identical ships were built over and over again. For every round of ships being built, the production time decreased until ships were being turned out after 17 days on the ways, followed by some 10 days of outfitting before delivery. This was the fastest rate which could be maintained continuously, but as a publicity stunt one Liberty ship, the *Robert E. Peary*, was launched after just four days and 15 hours on the ways.

The idea of putting ships together in large sections was not new: American yards were already practising this method around the turn of the century and it had come into extensive use in the country's large shipbuilding programme during World War I.²¹ At that time riveting was the principal way of fastening plates and profiles together. The assembling of large sections was a prerequisite for fast ship production. The material was prefabricated by bridge builders and structural steel manufacturers throughout the United States and then transported to the coast with the many new shipyards essentially functioning as assembly plants.

19 Karl Ringdahl, "Svetsningen och klassificeringssällskapen", *Teknisk tidskrift: Skeppsbyggnadskonst*, April 15, 1933, 24; idem., "Skeppsvetsningens utveckling och svetsvarvets tillkomst", *Svetsen: Organ för Svetstekniska Föreningen*, 9:1 (1950), 3–12; Svensson, *Från ackord till månadslön*, 235–252; Kent Olsson, "Sjöfartens utvecklingsblock", 224 ff.; Yukiko Fukasaku, *Technology and Industrial Development in Pre-War Japan: Mitsubishi Nagasaki Shipyard 1884-1934* (London, 1992), 126.

20 The most comprehensive account of shipbuilding in the U.S. during World War II is Frederic C. Lane's *Ships for Victory: A History of Shipbuilding Under the U.S. Maritime Commission in World War II* (Baltimore, 1951). Other studies dealing with the subject are: F. G. Fassett, jr., ed., *The Shipbuilding Business in the United States of America*, I–II (New York, 1948); John G. Bunker, *Liberty Ships: The Ugly Ducklings of World War II* (Annapolis, 1972, reprint 1991); Mark S. Foster, *Henry J. Kaiser: Builder in the Modern American West* (Austin, 1989); Charles Wollenberg, *Marinship at War: Shipbuilding and Social Change in Wartime Sausalito* (Berkeley, CA, 1990); Gunnar Dahllöf, *Teknikkriget som förändrade världen* (Stockholm, 1985).

21 *50 Years New York Shipbuilding Corporation* (Camden, NJ, 1949), 14 f.; Heinrich, *Ships for the Seven Seas*, 130–140 & 173–189.

When prefabrication again came to be extensively used, during World War II, most of the steel fabrication took place within the shipyards. Now, however, the method offered another important advantage, viz. that welding was most efficient when carried out horizontally. Further, automatic welding machines required the plates to be in horizontal positions. This was easy to arrange if sections were erected on the ground. Electric welding was also more easily disrupted by wet weather, but with prefabrication much work could be done indoors and therefore production could go on regardless of the weather. Clearly, from the 1930s onwards welding and prefabrication came to evolve hand in hand.

The experience of the United States during World War II came to have a great impact on shipbuilding in many countries.²² These included Sweden, but nevertheless one should not overestimate the influence of American shipbuilding practice on Swedish shipyards. The trend towards welding and prefabrication had in fact been well under way by the late 1930s.

The two shipyards which pioneered the use of welding in Sweden were Kockum and Eriksberg. This was made easier by the welding regulations issued by the classification societies Germanischer Lloyd in 1931 and Lloyd's Register in 1932.²³ In the latter year Kockum built a small oil tanker, *Brännaren*, for the Naval Material Administration and then used welding for decks, bulkheads, alternative ribs in the shell plating, etc. In the building of a series of submarines between 1932 and 1936, the shipyard did a lot of welding in order to save weight. In the latter half of the 1930s, Kockum built several oil tankers where welding gradually replaced riveting, oil tankers being the type of ship considered most suited for the new technology. Table 2.1 shows the increasing use of welding in different types of tankers delivered by the shipyard between 1936 and 1940.

Table 2.1 The proportion of welding used in the building of different types of oil tankers at Kockum, 1936–1940

<i>Basilea</i> -type	32 %
<i>Sveadrott</i> -type	83 %
<i>Braconda</i> -type	97 %
<i>B. P. Newton</i> -type	98 %

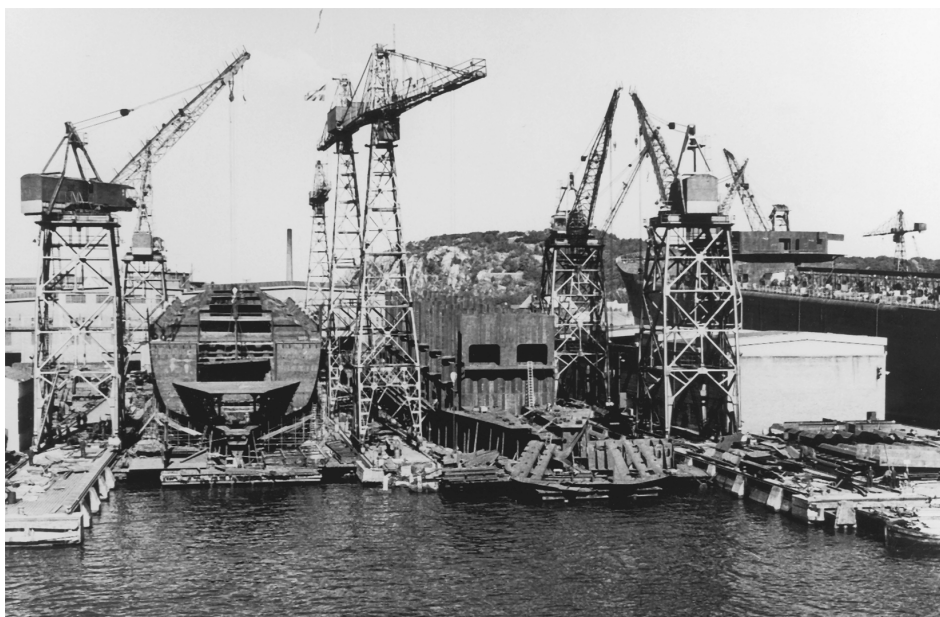
Source: Söderlund, "Konstruktion och praktiskt utförande av svetsade fartyg", 108.

22 Håkon With Andersen, *Fra det britiske til det amerikanske produksjonsideal: Forandringen av teknologi og arbeid ved Aker mek. Verksted og i norsk skipsbyggingsindustri 1935 – 1970* (Trondheim, 1989), 232–238.

23 C. E. von Seth, ed., *Kockums Mekaniska Verkstads AB. Malmö, 1840–1940* (Malmö, 1940), 341 ff.; Kurt Söderlund, "Konstruktion och praktiskt utförande av svetsade fartyg: 1. Konstruktioner", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, December 21, 1940, 108.

Kockum built its welded ships in the late 1930s in the traditional way, erecting the hull plate by plate on the berth.²⁴ Eriksberg, on the other hand, was the first Swedish shipyard to make extensive use of the method of prefabrication of large sections. Beginning in 1940, the management enlarged and reorganised the yard to accommodate the new technology; in fact a new shipyard grew up adjacent to the old plant. By 1948 the transformation was complete.²⁵ The shipyard now had three new large berths, a new plate shop and welding shop, and cranes each capable of lifting sections of 20 to 30 tonnes. One result of the conversion of the yard was a decrease in building time on the berths from six to three months.

After the war, Kockum, too, expanded and renewed its plant to facilitate prefabrication.²⁶ There was no adjacent land on which the shipyard could be extended, and new land had to be reclaimed from the sea. The work of building up the former seabed and erecting new berths, workshops etc. took place between 1945 and 1948.



Gothenburg shipbuilding in the late 1950s. Welding and prefabrication required powerful cranes. To the left is the ore carrier Alvafors, under construction at Götaverken for the shipping branch of the mining company Grängesberg. (Photo: Varvshistoriska Föreningen)

²⁴ Kent Olsson, "Sjöfartens utvecklingsblock", 225.

²⁵ Ture Rinman, *Eriksbergs Mekaniska Verkstad 1853–1953: Ett sekel av arbete och inspiration* (Göteborg, 1953), 42 ff.

²⁶ Kurt Söderlund, "Kockums verkstad", *Teknisk tidskrift*, October 22, 1949, 751–757; Cyril Carleson & Wiking Ljunggren, *Kockums Mekaniska Verkstads AB, Malmö: Utvidgning och modernisering av anläggningarna 1945–1948* (Stockholm, 1949).

Götaverken also introduced welding and prefabrication from the 1940s. The new technology and the increasing sizes of ships, however, called for enlargements of the yard. With its location in the port of Gothenburg the company had very little space for radical reshaping of its plant. The Arendal shipyard, which began production in 1963, became the company's answer to the new production technology.²⁷ This was an entirely new yard built on virgin land just outside the city. Here ships were built using methods not earlier tried out anywhere in the world.

Somewhat simplified, the Arendal concept involved moving steel material through the factory in a straight flow, while it was transformed from plates and profiles into sections. Two dry docks extended into the large assembly shop where the prefabricated sections were put together. As soon as a 14-metre length of the ship was completed, it was pushed out through the dock by large jacks, and work started on the next 14 metres. In this way a nearly completed ship grew out of the building, almost as "one squeezes toothpaste out of a tube."²⁸ As a result almost all the work could be performed indoors and production no longer depended on weather conditions, something that was important in a country in Northern Europe. In a way the production process of the shipyard resembled the assembly line principles of other industries.²⁹

2.4 The post-World War II period

In the post-World War II era, oil consumption steadily increased in the Western world, with a consequent large demand for oil tankers, which was especially profitable to the Swedish shipyards. In contrast to Great Britain, with its labour-intensive

27 Svensson, *Från ackord till månadslön*, 329 f.; Kent Olsson, "Assar Gabrielssons utredning om Arendalsvarvet – framtagandet av ett ekonomiskt beslutsunderlag i slutet av 1950-talet", *Unda Maris* 1997, 63–91; Arne Söderbom, *Förändringsförloppet i ett storföretag: En studie om strategiskt handlande, strategifaser och företagsmyter* (Göteborg, 1995), 91–129.

28 Svensson, *Från ackord till månadslön*, 330.

29 In an article on the competitiveness of Swedish shipbuilding, written in 1961, the naval architect Nils Svensson (technical manager of Götaverken and the "father" of the Arendal yard) said that in the design of the new yard, people at Götaverken had learnt from the latest developments in production technology. In his own words, they "tried to apply an assembly-line principle, if it is possible to speak in such terms when it comes to so big a product as a ship"; Nils Svensson, "Svenskt skeppsbyggeri – en konkurrenskraftig industri?", *Teknisk tidskrift*, 1961, 1124. The new shipyard, which began production in 1963, attracted attention all around the world and shipbuilders, politicians and others came to see it. In foreign journals and newspapers, enthusiastic articles spoke of "the world's most modern shipyard", "a revolution in shipbuilding", "Arendal, the shipyard of tomorrow – today" and "Ship construction... into the 21st century"; "Skeppsbyggeri år 2000", *Skeppsbyggaren* 1963:3, 18 f. One journalist wrote that "this is a shipyard that most certainly will be imitated in many countries." In a book entitled *Ships*, published in 1965 and written by two Americans, Edward Lewis (research professor of naval architecture) and Robert O'Brien (journalist), the Arendal yard was given a chapter of its own headlined: "Ships on the Assembly Line." The authors called Nils Svensson "shipbuilding's Henry Ford" and stated that he had "pioneered the adaptation of automobile assembly-line techniques to the shipbuilding process"; Edward V. Lewis & Robert O'Brien, *Ships* (New York, 1965), 19.

craft-oriented shipbuilding industry, countries such as Sweden, France and Japan developed capital-intensive shipyards.³⁰

In the Swedish case, the shipyards became more and more mechanised. Management and trade unions co-operated in rationalising the production process, an expression of the "Swedish model" based on a belief in a common interest in productivity gains.³¹ One reason for this consensus was that the economy was growing and that there was a surplus to distribute. A large part of the gain in productivity was used to raise the workers' wages. Another reason can be found in the fact that Sweden had strong and centralised national unions and a Social Democratic government which gave high priority to raising the standard of living through increased industrial production, which would follow from new technology and peace on the labour market. Managers and owners of private companies, fearing communism, chose to co-operate with the more moderate sections of the Social Democrats. These factors gave the Swedish shipyards a specific national style, characterised by a high capital-labour ratio and a high labour productivity.³² The similarities between the major Swedish yards are striking. They all developed into highly mechanised ship-manufacturing plants specialising in the production of series of standardised oil tankers or ore carriers.

While the 1950s had been a period of prosperity and a golden age for Swedish shipbuilding, the 1960s were a time of intensifying competition and, in many countries, increased government subsidies.³³ Japan expanded its shipbuilding industry and acquired larger and larger shares of the market, thanks in part to lower wages, state support and generous terms of credit. In Europe, Sweden seemed to be the only country which could stand up to the "Japanese attack." Nevertheless, the Swedish shipyards were put under pressure by the generous credits which Japanese firms offered shipowners. Later, Swedish shipyards also made great losses on foreign exchange transactions.

In the wake of the war between the Arab States and Israel in October 1973 came the first oil crisis, which resulted in a decreasing need for oil transport. Since the global fleet of oil tankers had expanded rapidly during the preceding years, there was suddenly a large surplus of ships, a surplus that would last for nearly 15 years. Due to their concentration on the building of tankers, Swedish shipyards were particularly hard hit and the government eventually took them all over.

Under state ownership, the shipyards were to be restructured with the aim of reinvigorating some of the companies by providing alternative production while

30 Edward H. Lorenz, *Economic Decline in Britain: The Shipbuilding Industry, 1890–1970* (Oxford, 1991), 72–91.

31 Svensson, *Från ackord till månadslön*, 307 ff. Two other studies dealing with the shipyard workers and their unions are Bo Stråth's *Varvsarbetare i två varvsstäder: En historisk studie av verkstadsklubbarna vid varven i Göteborg och Malmö* (Göteborg, 1982) and Magnus Wikdahl's *Varvets tid: Arbetarliv och kulturell förändring i en skeppsbyggerstad* (Stockholm, 1992).

32 William F. Beazer; William A. Cox & Curtis A. Harvey, *U.S. Shipbuilding in the 1970s* (Lexington, MA, 1972), 4–15. Cf. Svensson, *Från ackord till månadslön*, 293 ff.

33 Kent Olsson, "Big Business in Sweden: The Golden Age of the Great Swedish Shipyards, 1945–1974", *Scandinavian Economic History Review* 43 (1995), 310–338. Cf. Jan Bohlin, *Svensk varvsindustri 1920–1975: Lönsamhet, finansiering och arbetsmarknad* (Göteborg, 1989), 38–60.

closing down others. Even though some yards were able to keep on producing ships, or managed to change their production to offshore rigs, in the long run they could not stay in business and by the end of the 1980s all of the major Swedish shipyards had closed down.³⁴

2.5 Concluding remarks

This chapter, which is based on earlier historical research, has given an overview of developments in Swedish shipbuilding during the period. I have chosen to emphasise some of the more important organisations or components which made up this production system, both producers and users of ships. I have also outlined the major changes in shipbuilding technology during the period.

In the next chapter I will turn my attention to the engineers, beginning with their theoretical and practical training.

³⁴ For an account of the crisis in Swedish shipbuilding and how different parts of the sociotechnical system reacted to the changing conditions, see: Lars Olsson, "Offshore som livboj: Varvskrisen och försöken till omorientering, 1974–1985", in *Den konstruerade världen: Tekniska system i historiskt perspektiv*, eds. Pär Blomkvist & Arne Kaijser (Stockholm, 1998), 205–229.

3. Engineers and Their Education

In this chapter I shall study the starting point of the engineers' careers: their theoretical education and their practical engineering training abroad. As mentioned above, I will concentrate on those who graduated in naval architecture. Before entering into a discussion of engineers in Swedish shipbuilding, some general patterns regarding the establishment of engineering education and the professional situation of engineers will be outlined.

3.1 Engineers in industrial society

In many European countries, schools offering technical education were founded in the early 19th century. Sweden was no exception; in 1827 *Teknologiska Institutet* (the Technological Institute) was founded in Stockholm and in 1829 *Chalmersska Slöjdskolan* (the Chalmers School of Arts and Crafts) opened in Gothenburg. There were also other and earlier schools specialising in mining, civil engineering etc.¹

As time went by, the content of the education became increasingly theoretical. The model for higher technical education in Sweden in the latter half of the 19th century was that of the German Technische Hochschulen. In 1876 the Technological Institute acquired university status and was renamed *Kungl. Tekniska Högskolan* (the Royal Institute of Technology; henceforth abbreviated KTH, the initials of its Swedish name). The Chalmers School of Arts and Crafts, eventually renamed the Chalmers Institute of Technology, had been divided into two divisions in the 1850s, an upper and a lower. The education provided in the upper division was of a standard almost equal to that of KTH, but Chalmers as a whole came to be a school of intermediate rank between KTH and the technical upper secondary schools established in the mid-19th century.² It was not until 1937 that Chalmers formally became a university of technology.³

In the mid-19th century there was no obvious demand for theoretically trained engineers, whom many industrialists considered to be overqualified for practical

1 For instance: the School of Artillery at Marieberg (1818) and the Falun School of Mining (1822), see: Ragnar Widegren, "Militär och civil ingenjörsutbildning i Sverige under 1800-talet", in *Fortifikationen 350 år 1635–1985*, ed. Bertil Runnberg (Stockholm, 1986), 161–184; E. Börje Bergsman, *Fahlu Bergsskola 1819–1868: Sveriges första civila tekniska högskola* (Falun, 1985).

2 Göran Ahlström, *Engineers and Industrial Growth: Higher Technical Education and the Engineering Profession During the Nineteenth and Early Twentieth Centuries: France, Germany, Sweden and England* (London, 1982), 35 f.

3 Henrik Björck at the Department of Technology and Society at Chalmers University of Technology is working on a study of the school's transformation into a university of technology.

work on the workshop floor but still not competent to hold leading positions in business. Among many managers there was a reluctance to employ such engineers. The leaders of industrial companies and ironworks were usually merchants, lawyers, military officers or practically trained technologists.⁴

The professional situation of engineers began to change during the second half of the 19th century. There was an increasing demand for theoretically trained engineers at ironworks when ingot steel processes were introduced and at the same time plants were reorganised in larger units.⁵ The government became a major employer of engineers. When the Technological Institute acquired university status in 1876 it was partly because the government wanted academically trained engineers for the building of the national infrastructure. Since the 1860s a growing number of engineers had been employed in the building and maintenance of railways, telegraph systems, municipal water and sewage systems and gasworks.⁶

Another step in the strengthening of the engineers' position in society was the founding of professional associations. In 1887, three engineering associations, established in the 1860s and 1870s, amalgamated as *Svenska Teknologföreningen* (the Swedish Association of Engineers and Architects; abbreviated STF) which became the national professional organisation of engineers. Both engineers and prominent business leaders without an engineering education were eligible for membership.⁷ The association published a technical journal, *Teknisk tidskrift*, and functioned as a discussion forum both in technical and professional matters. Concerning their professional status it was often argued that engineers were entitled to leading positions in governmental agencies and private industry by virtue of their scientific training. Many engineers complained that their "expert knowledge" was not given a proper place in decision-making. Engineers found themselves fighting against the "rule of the lawyers," but while they criticised the old elite they were anxious to gain the social recognition bestowed by becoming part of it.⁸

In earlier historical research on Swedish engineers of the late 19th and early 20th century, two ideals have been identified.⁹ On the one hand there was the "traditional" engineer, often a civil servant, a man devoted to technology and science. As a scientist he was supposed to be impartial in the growing struggle between labour and

4 Torsten Gårdlund, *Industrialismens samhälle* (Stockholm, 1942), 221 f.; Boel Berner, *Teknikens värld: Teknisk förändring och ingenjörsarbete i svensk industri* (Lund, 1981), 122.

5 Gårdlund, 222.

6 Nils Runeby, *Teknikerna, vetenskapen och kulturen: Ingenjörundervisning och ingenjörorganisationer i 1870-talets Sverige* (Uppsala, 1976); cf. Berner, *Teknikens värld*, 122 f.

7 Compare with Edwin Layton's discussion on the balance between professionalism and business in engineering societies in the United States in the late 19th and early 20th century, see his *The Revolt of the Engineers: Social Responsibility and the American Engineering Profession* (1971; Baltimore, 1986), 25–52.

8 Runeby, *Teknikerna, vetenskapen och kulturen*, 180; cf. Berner, *Teknikens värld*, 204 ff.

9 Nils Runeby, "Americanism, Taylorism and Social Integration: Action Programmes for Swedish Industry at the Beginning of the Twentieth Century", *Scandinavian Journal of History* 3 (1978), 27–46; Berner, *Teknikens värld*, 204 ff.; Bo Sundin, *Ingenjörsvetenskapens tidevarv: Ingenjörsvetenskapsakademin, Pappersmasssekontoret, Metallografiska institutet och den teknologiska forskningen i början av 1900-talet* (Umeå, 1981), 63 ff.; Mikael Hård, "Då ingenjörrollen formades", *Polhem* 1:2 (1983), 26–32.

capital and therefore to act as a mediator. The “modern” engineer, on the other hand, was the leader of a private company. In the class struggle he was aligned with capital. In addition to having technical knowledge, the “modern” engineer needed to have a knowledge of economics, management and foreign languages in order to be able to lead a company.

In the late 19th and early 20th centuries many companies were founded which specialised in manufacturing one particular type of product, for instance, Separator, ASEA and SKF. With a large proportion of the products being exported, these companies faced growing competition in the world market. Engineers with a higher technical education came to be considered those best suited for the task of leading these companies. Courses in economics, some argued, had to be included in the curriculum of engineering schools. The proponents of the traditional engineering ideal, on the other hand, argued that the curriculum had to be purely technical.

The struggle between the two ideals also concerned the issue of membership of the Swedish Association of Engineers and Architects. Supporters of the traditional ideal wanted to restrict membership to practising engineers and technologists, whereas their modern opponents also wished to include industrial leaders, whether their main activity was technical or commercial. One result of this conflict was the founding in 1910 of *Sveriges Industriförbund* (the Federation of Swedish Industries) to safeguard industrial interests. During the decade which followed, the conflict subsided as Taylorism, or scientific management, became known in Sweden. With scientific management, which formed a synthesis of organisation, economy, science and technology, it was possible to reconcile the differences between the two ideals.¹⁰

Hand in hand with the introduction of mass production into many branches of Swedish industry in the interwar years, engineers found new roles as organisers and carriers of scientific management.¹¹ In the first decade of the century there had been a widespread belief among industrialists and others that Swedish industry was inefficient.¹² A solution to this would be to adopt more efficient American practices. An important source of inspiration was Frederick W. Taylor, whose ideas on scientific management were spreading in Sweden from the early 1910s onwards. As Nils Runeby states, even if one should not overestimate the influence of the Taylor movement on Swedish industry, “theories closely connected with its main proposals, as well as revised forms of its ideas, have been vitally important for modern conceptions of management and industrial relations.”¹³ In Sweden the ideas were originally referred to as scientific management or Taylorism, but from the 1920s

10 Sundin, *Ingenjörsvetenskapens tidevarv*, 63–97; idem, *Den kupade handen: Historien om människan och tekniken* (Stockholm, 1991), 243–267.

11 Idem., “Ingenjören som organisatör”, *Polhem* 9 (1991), 360–386; Hans De Geer, *Rationaliseringsrörelsen i Sverige: Effektivitetsidéer och socialt ansvar under mellankrigstiden* (Stockholm, 1978), 181; Berner, *Teknikens värld*, 124 ff.

12 Runeby, “Americanism, Taylorism and Social Integration”, 22.

13 Ibid., 34.

“rationalisation” became the generic term for efforts to increase efficiency. Ulf Olsson calls rationalisation a “key concept of the period.”¹⁴ A wish to make production more efficient had always been an essential feature of industrial activity but during the interwar years the striving for rationalisation attained a hitherto unimagined intensity, which Olsson attributes to the long-lasting and fierce competition created by two severe depressions and an unusually slow rate of growth throughout the industrial world generally.

The principal proponents of the new ideas were engineers, active in organisations such as *Ingenjörsvetenskapsakademien* (the Royal Swedish Academy of Engineering Sciences, abbreviated IVA) or the consultant firm *Industribyrån*, established by the Federation of Swedish Industries, and within industrial companies.¹⁵ For their new duties, some of the proponents argued, engineers had to have theoretical training in economics and the organisation of work. KTH began to offer courses in industrial economics in the early 1910s with Erik A. Forsberg as a teacher. Forsberg, one of the strongest advocates of scientific management, was chief engineer at AB Separator, a company producing, among other things, cream separators, where he tried to apply the new principles in production, one result of which was a well publicised conflict with the workers at Olofström in 1915.¹⁶ He held the position at KTH until 1928, when Tarras Sällfors replaced him. During the 1930s the subject field attracted increasing attention among students, as is reflected in a growing number of diploma theses.¹⁷ In 1940 Sällfors became the school’s first professor of industrial economy and management.

The engineers clearly saw themselves as those best suited for the task of rationalising and organising production. As Sällfors put it in 1935, in the past it had been common for college-trained engineers to be:

largely employed in drawing office work and other duties in connection with the constructive designing of the products. Operations in the works had in many, perhaps in most, cases been entrusted to engineers with a less comprehensive training [...] With the arrival of the new industrial era, however, it became apparent that engineers trained to university standard were better equipped than their colleagues from less advanced technical schools to take responsibility for the running of the works and other engineering duties in industrial companies.¹⁸

One expression of the engineer’s interest in questions of rationalisation was the establishment of a separate section for industrial management and economics by the Swedish Association of Engineers and Architects (STF) in 1931. In contrast to most other sections, the section for industrial management addressed itself to all

14 Ulf Olsson, “LM Ericsson och trettioårsdepressionen”, in Artur Attman & Ulf Olsson, *LM Ericsson 100 år*, vol. II, *Räddning återuppbyggnad världsföretag 1932–1976* (Örebro, 1976), 83.

15 De Geer, 239 f.

16 Alf Johansson, *Arbetarrörelsen och taylorismen: Olofström 1895–1925: En studie av verkstadsindustrin och arbetets organisering* (Lund, 1990), 67–79.

17 De Geer, 169.

18 Quoted in: Berner, *Teknikens värld*, 127.

STF members regardless of the branch of industry in which they worked. That many engineers were interested in such matters is indicated by the rapid increase in membership of the new section; in 1931 it had 108 members while in 1939 the number was 922, which represented 23 percent of STF's total membership.¹⁹

The key to the engineers' future advancement into different positions in industry was their education. This does not mean that the theoretical training they acquired was the only thing that counted. Other aspects of the learning period have also to be considered, such as practical experience and the establishment of personal contact with other engineering students and with older engineers active in the field.

In her study *Sakernas tillstånd*, Boel Berner considers technical expertise and what the students gained from their studies at KTH or Chalmers in the early 20th century. The education was intended to train future industrial leaders. During the years at KTH or Chalmers the students received training in both theoretical and practical aspects of their profession and in behavioural skills, giving them a mixture of "competence and authority." The sense of social community among them played a double role: it "gave cultural training in male, middle-class ways, and a network of social contacts for future professional life."²⁰ This last aspect was not the least important. Furthermore, the theoretical training gave the engineers a common language which united the group. According to Berner, knowledge "united the alumni of the school in a spirit of fraternity around technical models and theories that they alone understood. With the aid of the models, the formulae and the conventions of drawing they could always communicate with each other after their time at the school, wherever and on whatever they were working."²¹

Berner states that engineering students at KTH or Chalmers, at least until the 1930s, usually had a middle or upper class background. Moreover, with a few rare exceptions, they were all men. That the group of engineers was from the outset quite homogeneous naturally helped to form an affinity. After graduation the social solidarity of the engineers was reinforced in the professional associations.

The total number of engineers in Sweden increased considerably during the period: at the turn of the century there had been some 2000 college-trained engineers in the country, a figure which by the late 1930s had risen to 7000. The post-World War II expansion of Swedish industry led to an increased need for engineers. Many parties warned of the harm that a shortage of engineers would do to Swedish industry. In a period when the educational system in general expanded rapidly, there was substantial expansion of technical education at all levels. In the 1960s and 1970s three new universities of technology were established in different parts of the country. In the early 1990s Sweden had some 50,000 college-trained engineers.²²

19 De Geer, 196.

20 Boel Berner, *Sakernas tillstånd: Kön, klass, teknisk expertis* (Stockholm, 1996), 118.

21 Ibid., 56.

22 Boel Berner, "Engineering identity and economic change: Engineers in Swedish Society 1850–1990", *Polhem* 10 (1992), 138–147.

To sum up, from the mid-19th century onwards the engineers established themselves as a strong professional group and increasingly they came to influence developments in Swedish industry. We shall now turn our attention to the field of shipbuilding.

3.2 Education of naval architects

In the 17th century the Swedish Navy had had to recruit its master shipwrights from abroad, first mainly from Holland and then, after the middle of the century, from England. These men treated their knowledge of naval architecture as private property and passed it on from father to son as a family secret. For instance, the Sheldon family worked as master shipwrights or had other leading positions at the Royal Navy Yard in Karlskrona, in southeast Sweden, for four generations.

To “nationalise” the knowledge, the Navy built up collections of models and drawings, and encouraged projects intended to develop theoretical methods of ship design.²³ This step was taken because if shipbuilding theory could be developed and printed in books it would be easier for the Navy to control the education.

The way to study naval architecture in the 18th century was to be an apprentice to a master shipwright. From 1761 apprentices could obtain theoretical training at the cadet school in Karlskrona. However, it was not until the early 19th century that the training of naval architects for the Navy became more organised, with syllabuses and examination requirements. In 1804 a school was established, *Informationskontoret* (the Information Office), in which those who were to become members of the Construction Corps of the Navy received both theoretical and practical training.²⁴

The first civil school in Sweden to train naval architects, for private, as well as naval, shipyards, *Skeppsbyggeri-institutet* (the Institute of Naval Architecture), was founded in 1843. It was located near the navy yard in Karlskrona, and the instructors belonged to the Construction Corps of the Navy. Both theoretical study and practical work at the shipyard were geared to the building of wooden ships. As ships came increasingly to be built of iron, Gothenburg grew as a shipbuilding centre, and the institute moved to that city in 1870. The reorganised institute, *Skeppsbyggeriskolan* (the School of Naval Architecture) became a division of the School of Nautical

23 Jan Glete, “Örlogsflottorna som stora tekniska system: Några långa perspektiv”, *Polhem* 9 (1991), 67 f.; idem., “Teknikhistoriska synpunkter på några äldre fartygsmodeller”, *Sjöhistorisk årsbok 1988–1989*, 66–77. See also: idem., “Arvet från flottans modellkammare”, *Sjöhistorisk årsbok 1990–1991*, 9–44. For an account of design work in the 17th and 18th centuries, see: David McGee, “From Craftsmanship to Draftsmanship: Naval Architecture and the Three Traditions of Early Modern Design”, *Technology and Culture* 40 (1999), 209–236. Cf. James Pritchard, “From Shipwright to Naval Constructor: The Professionalization of 18th-Century French Naval Shipbuilders”, *Technology and Culture* 28 (1987), 1–25.

24 Gustaf Holmberg, “Svenska flottans fartygstyper och fartygsbyggen”, in *Svenskt skeppsbyggeri: En översikt av utvecklingen genom tiderna*, ed. Gustaf Halldin (Malmö, 1963), 180 ff.; Wilhelm Sjöstrand, *Kadettskolan i Karlskrona 1756–1792* (Karlskrona, 1937).

Studies, an arrangement which lasted for seventeen years.²⁵ The education concentrated purely on ship design and construction and years of practical training were considered more important than theoretical knowledge.

In 1887 the school merged with Chalmers, which meant that the curriculum for naval architects was broadened to place greater emphasis on mathematics and physics, an emphasis shared by the Institute's mechanical engineering, civil engineering and chemical engineering curricula. In addition, the period of study was increased from two to three years, a requirement which applied until 1906, when it was extended to three and a half years. To be admitted to the naval architecture education one had to have nine months of practical experience in shipyards in Sweden or abroad. During their time at Chalmers, the young men had to use the summers to gain further shipyard experience; to graduate they needed a total of 18 months of practical training. From 1906 onwards the students also had the option of staying on for an additional term to do a degree project.

From the 1870s, KTH in Stockholm offered a course in "steam ship design."²⁶ In the mid-1890s the lecturer Fredrik Lilliehöök expanded the scope of the subject field, but it was not until 1898 that a department of naval architecture was established within KTH's school of mechanical engineering.²⁷

One important task of the department was to train those who were to become naval engineers. As will be discussed in Section 5.6, when the Corps of Naval Engineers was established in 1868, the directions stipulated that the young men had to graduate from the Technological Institute (eventually renamed KTH) and then study naval architecture elsewhere before they could enter the Corps. After 1898, however, KTH offered a full course of training in naval architecture, so future naval engineers could acquire their entire theoretical training there. In the first years of the new century about half of all graduates went to work for the Navy.

The period of study in naval architecture at KTH became a compulsory four years, and twelve months of practical experience was required before graduation. Taken together, this meant a total of five years of training, which was the same total time as at Chalmers with its three and a half years of study and one and a half years of practical work.

In 1906 the government appointed a commission to examine higher technical education in Sweden and two years later it delivered a report. The essential result of

25 On the history of the Institute of Naval Architecture in Karlskrona and the School of Naval Architecture in Gothenburg, see: Gustaf Witting, "Skeppsbyggeriinstitutet i Karlskrona 1843–70", in *Svenskt skeppsbyggeri*, ed. Halldin, 279–283; *Chalmersska Institutet 1829–1904* (Göteborg, 1907), 143–159; Axel S. Blomgren, "Navigationsskolan i Göteborg", in *Navigationsskolornas historia*, ed. Olof Traung (Göteborg, 1941), 256 ff.

26 Pontus Henriques, *Skildringar ur Kungl. Tekniska Högskolans historia*, vol. II (Stockholm, 1927), 2 f. & 24 f.

27 Ibid., 248 f.

the work was that in due course KTH acquired new, larger buildings with laboratories and that the number of professorships increased at KTH and Chalmers. The outcome as far as naval architecture was concerned was that in 1912 the lectureships at the two schools were upgraded to professorships. Naval architecture at KTH also separated from the school of mechanical engineering. At KTH, two positions as associate professor were added; one in hydromechanics and one in shipyard installations. A further result of the commission was that the department at KTH was provided with a smaller experimental tank for ship models, which was ready for operation in the early 1920s.

When Lilliehöök retired in 1925, the vacancy was not filled. This was because the teaching staff at KTH initiated a revision of the curriculum with a view to giving the theoretical aspects of the subject a more prominent position. It was suggested that the chair of naval architecture be replaced with one of hydromechanics, while putting matters of design, which had earlier formed a considerable part of the subject field, under an associate professor. It took some time to deal with these proposals, not the least because the director-general of naval construction opposed the change.²⁸ The question was not resolved until 1941 when a chair of hydromechanics was finally established and the more practical aspects of naval architecture became the responsibility of an associate professor. Between 1925 and 1941 the two associate professors, H. F. Nordström and Nils Ljungzell, had shared responsibility for the education. In 1955 naval architecture again became a professorship.

In 1941 KTH's school of naval architecture changed its name to the school of aeronautical engineering and naval architecture.²⁹ The first courses in aeronautical engineering had been offered at KTH in the early 1920s and since then the subject field had expanded. A professorship of 'aeronautical engineering' was established in 1928 and one of 'aircraft structural analysis and design' followed in 1949. During the 1920s and 1930s the courses had been open to students of both naval architecture and mechanical engineering. From 1942, however, only students at the new combined school could study aeronautical subjects.

At Chalmers there was one chair of naval architecture until 1941 when it was replaced by two: a chair of 'practical shipbuilding' and a chair of 'theoretical shipbuilding', i.e. hydromechanics. In 1948 a chair of marine engines came into existence. During the entire period there were also positions as associate professors to cover various aspects of naval architecture.

For a long time the number of students of naval architecture was higher at KTH than at Chalmers. Until the 1930s, Chalmers awarded degrees to an average of three naval architects each year while KTH produced twice as many.³⁰ From the 1940s onwards the number of students increased considerably at both schools, with an

28 Parliamentary documents (Riksdagstryck): Kungl. Maj:ts proposition Nr. 1 (1929), åttonde huvudtiteln, Tekniska högskolan [127]: Professur i skeppsteori samt professur i skeppsbyggnad vid tekniska högskolan, 331–340.

29 Torsten Althin, *KTH 1912–62: Kungl. Tekniska Högskolan i Stockholm under 50 år* (Stockholm, 1970), 115 f.

30 Redogörelse för Chalmers Tekniska Läröanstalts/Instituts verksamhet, (Göteborg 1900–1936); Govert Indebetou & Erik Hylander, eds., *Svenska Teknologföreningen 1861–1936: Biografier*, vol. II (Stockholm, 1937), 1401–1511.

annual output of between 15 and 30 engineers. At KTH, however, the majority of the graduates had followed the aeronautical curriculum, which meant that Chalmers now trained the largest number of naval architects.

At times there was heated debate on the question of concentrating all training of naval architects in one school. This discussion went on from the 1910s onwards and was not resolved until 1969, when both educational programmes were instead absorbed by the respective colleges' schools of mechanical engineering. The question arose, for instance, in connection with the consideration of the future status of Chalmers in the interwar years: the commission of 1919 wanted to preserve both colleges' departments of naval architecture, while the commissions of 1929 and 1934 favoured concentrating the education at Chalmers.³¹ The issue came up again in the 1950s and in the 1960s.³²

The major argument discontinuing one of the programmes seems to have been that the number of students was small and therefore, in the long run, the government would not be willing to pay for two departments. Although most parties concerned wished to preserve both programmes, if this was economically feasible, advocates of the two schools argued that their own programme should be the preferred choice if one had to be sacrificed.

Those who wanted to close down the department at KTH and keep the education at Chalmers were mainly politicians or representatives of the private shipyards, the latter often former Chalmers graduates. Their main argument was that it was important for the education to be offered in Gothenburg since the city constituted the country's leading shipbuilding district. Here the students, and also the lecturers, could study the practical work of the shipyards, daily and at close quarters, something that was of vital importance. In a discussion arranged by the Royal Academy of Engineering Sciences in 1935, the Chalmers professor Anders Lindblad said that "[t]his background of vital, active shipbuilding is an invaluable teaching asset. It arouses a lively interest in and enthusiasm for the studies which cannot be given to the students in any other way."³³ Another argument in favour of Chalmers was that its department of naval architecture had so far been highly successful, as shown by, for example, the fact that a majority of the leading men at the private shipyards were Chalmers graduates.

The supporters of KTH were mainly representatives of the Corps of Naval Engineers, privately employed engineers in the Stockholm area and, maybe not

31 Betänkande II, avgivet av 1919 års sakkunniga för Chalmersska Institutets omorganisation: Omorganisation av Chalmers Tekniska Instituts högre avdelning till teknisk högskola och dess lägre avdelning till tekniskt gymnasium (Stockholm, 1922), 46 f.; Betänkande och förslag angående omorganisation av Chalmers tekniska instituts högre avdelning till en teknisk högskola m. m. (unpublished, 1935).

32 "Både 'Teknis' och Chalmers behövs", *Svensk Sjöfartstidning* 1953:49, 36 f.; "UKÄ-utredning önskar ändrad S-utbildning", *Teknisk tidskrift* 1967:24, 615.

33 Minutes of a meeting of IVA on February 4, 1935: "Protokoll fört vid sammankomst på Ingenjörsvetenskapsakademiens lokal den 4 februari 1935 för överläggning rörande den högre tekniska undervisningens inom skeppsbyggnadsfacket ordnade med hänsyn till de två utbildningsanstalterna tekniska högskolan och Chalmers tekniska institut"; Handlingar ang. omorganisation av skeppsbyggeriavdelningen: Chalmers University of Technology (GLA).

surprisingly, the teaching staff of KTH. Most of these engineers were KTH graduates. They argued that it was not at all necessary to locate a school of naval architecture in close proximity to the shipyards. In parliament in 1936 the KTH professor Carl Forssell said that talk of the fertile influence that a maritime city had on tuition was a “romantic fantasy” and he dismissed such arguments as “poetic ideas.”³⁴ In reality, what counted was that the students acquired a deep theoretical foundation and then KTH was the best choice. As the naval engineer Thore Knös put it in 1920, arguing in favour of the KTH alternative, “shipbuilding is after all no more than applied mathematics and physics.”³⁵ In any case, the students would not have time to visit the shipyards during the term, and even if they had, they might not be welcome since the shipyards would not like to have a lot of people running around the yard. Instead the students would have ample opportunity to learn the practical aspects of their profession during the summer and then the location of the school would not matter. Another argument which the supporters of KTH put forward was that it was wrong to close down the department in Stockholm, which had both a suitable laboratory in its towing tank, and a large and annually growing number of students, while keeping the department at Chalmers, which had only very few students. It would be much more expensive to concentrate the education on Chalmers since, in that case, new buildings with laboratories would have to be erected. At the same time the tank at KTH would be redundant.

There were also arguments in favour of keeping both departments of naval architecture. One was that the two programmes had differing fields of specialisation. The 1919 expert opinions suggested that the education at Chalmers should not deal in depth with marine engines but should instead concentrate on “shipbuilding proper” which meant the design of the hull and the choice of the most suitable machinery for economic operation. With this differentiation it would be possible to “arrange instruction so as to form a natural complement to the instruction given in the corresponding department at KTH in Stockholm, where there are and will continue to be better facilities for a deeper study of marine engine design.”³⁶

That Chalmers should concentrate on the training of “shipbuilders proper” and KTH on engineers with deeper knowledge of marine engines became a governing principle, at least until World War II.³⁷ Another differentiation which came about from the 1930s onwards was that the school of naval architecture at KTH came also to include the study of aeronautical engineering, a combination which never was established at Chalmers.

34 Parliamentary documents (Riksdagstryck): Riksdagens protokoll, Första kammaren, April 29, 1936, 12 f.; see also: Riksdagens protokoll, Andra kammaren, April 29, 1936, 64 ff.

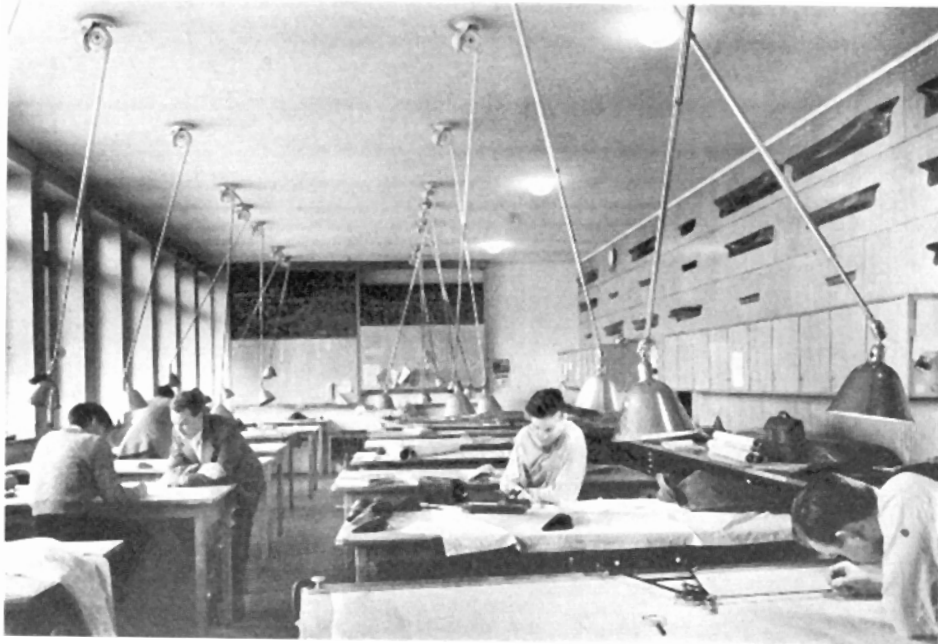
35 Thore Knös, “Är det lämpligt att inskränka eller borttaga fackskolan för skeppsbyggeri vid Kungl. Tekniska Högskolan?”, *Teknisk tidskrift: Skeppsbyggnadskonst*, September 29, 1920, 123; see also: “Orätt angripa Tekn. högskolan”, *Aftonbladet*, January 28, 1929.

36 Betänkande II, avgivet av 1919 års sakkunniga för Chalmersska Institutets omorganisation (Stockholm, 1922), 46.

37 Parliamentary documents (Riksdagstryck): Kungl. Maj:ts proposition Nr. 135 (1936), angående Chalmers tekniska institut m. m., 36 f.; SOU 1943:34 Betänkande med utredning och förslag angående den högre tekniska undervisningen, 175 f., 206.

As things turned out, both Chalmers and KTH were able to keep their programmes in naval architecture. That the programme at KTH survived probably owed much to the fact that representatives of the Swedish Navy and the Naval Material Administration argued strongly for its continued existence in order to secure the supply of naval engineers.³⁸ From the 1940s onwards, of course, there was another strong argument in that there were many advantages in co-ordinating the study of naval architecture and of aeronautical engineering.³⁹

After this account of organisational changes we shall take a closer look at the naval architecture students and the content of their theoretical training. If we study these students between 1890 and 1930 we find that they, like other categories of engineering students, had a middle or upper class background.⁴⁰ To some extent there was a difference between Chalmers and KTH in that the latter had a larger proportion of people from the upper class, with a few members of the aristocracy. The difference, however, was not very great: most students belonged to the middle class. At KTH roughly one-third of the students had been born in Stockholm while the rest came



Naval architecture students in their drawing room at Chalmers in the 1940s or early 1950s. Here the future engineers both received their theoretical training and established social networks. Note the half-models on the wall to the right, which students of the late 19th century had built as a part of their training. (Photo in Chalmers Tekniska Högskola 1829-1954, p. 30)

38 For instance, see: Bengt Kjellén, "Behöver vi skeppsteknisk forskning?", *Teknisk tidskrift*, 1971:4, 31.

39 SOU 1943:34, 175 f., 206.

40 Gösta Bodman, *Chalmers Tekniska Institut: Matrikel 1829-1929* (Göteborg, 1929); Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vols. I-II.

from other parts of the country. Of those studying at Chalmers even fewer were of local origin: less than 20 percent came from Gothenburg. Among the students' fathers we find artisans, tradesmen, civil servants, physicians, factory owners, teachers, clergymen and lawyers. Some ten to twenty percent of the students had fathers who were engineers. The fathers of the Chalmers students were more likely than those of the KTH students to have worked in the maritime sector, where they would mainly have been sea captains or naval architects. KTH on the other hand shows a larger number of military officers among the fathers. Some ten percent of the Chalmers students' fathers were farmers; at KTH only one student had such a background but a few had fathers who were landowners. Finally, we find that virtually none of the students of the two schools were of working-class background.

We might ask what kind of knowledge those who studied naval architecture at Chalmers or KTH acquired. At the turn of the century, the first-year students at the two schools followed the same curriculum as other categories of engineering students, i.e. they studied mathematics, physics, chemistry, geometry and drawing.⁴¹ During the second year, too, the curriculum very much resembled that of the other educational programmes, especially that of mechanical engineering. This meant that the naval architecture students studied mathematics, engineering mechanics, engine design, building design, geodesy etc. Only at Chalmers did the second-year students begin studying different aspects of naval architecture, something that probably followed from the fact that the length of the degree course there was only three years. While the last year at Chalmers was dominated by theoretical and practical aspects of naval architecture, during the third and fourth year at KTH the students, in addition to naval architecture, spent considerable time learning how to design steam engines, turbines, pumps etc.

If we move forward in time, to the early 1960s, we find that the overall structure of the curriculum was roughly the same as at the turn of the century. Much of the content had, however, changed.⁴² The period of study at both schools was now four years and the students had to do a degree project. There had been changes in the content of the courses and many new courses had been added in response to the use of new technology: for instance, it was now vital for a naval architecture student to learn about electric welding.

In addition to the introduction of new technology, the resources to which the departments had access had influenced the content of the education. For instance, the establishment in the early 1940s of the Swedish State Shipbuilding Experimental Tank, which was located next door to the department of naval architecture at

41 *Kongl. Tekniska Högskolan i Stockholm: Program för läsåret 1900–1901* (Stockholm, 1900), 22 ff.; *Program för Chalmers Tekniska Läranstalt 1900* (Göteborg, 1900), 37 f.

42 *Läro- och timplaner för läsåret 1962–1963 vid Kongl. Tekniska Högskolan i Stockholm* (Stockholm, 1962), 13 ff.; *Chalmers Tekniska Högskola: Program och studiehandbok 1962–1963* (Göteborg, 1962), 81–89. On the trend towards a more theoretical content in Swedish higher technical education during the period, see: Arne Kaijser, "Ingenjörer i takt med tiden?", in *Vad är en ingenjör?*, ed. Ingela Björck (Linköping, 1998), 40.

Chalmers, had led to a new course there on model-testing.⁴³ Of course, not all new courses were a result of technical change: at both Chalmers and KTH the naval architecture students, like other categories of engineering students, had to take certain courses on economics and management.

On some of the naval architecture courses people at the shipyards functioned as teachers. Moreover, at both Chalmers and KTH visiting lecturers from industry frequently addressed students on recent developments in the field, for instance on welding in the 1940s. Those who visited Chalmers were usually active in the Gothenburg area while there was a close co-operation between the department at KTH and Kockum in Malmö.⁴⁴

When the newly graduated engineers left the engineering schools they had both a solid theoretical education and some practical experience from the workshop floor. What they usually lacked was experience of working as engineers. Those who graduated in the earlier part of the period covered in this study often gained this experience abroad. In fact, such foreign experience became something of an extension of the training at Chalmers or KTH.

3.3 Foreign experience

As we shall see, a majority of the Swedish naval architects who graduated in the late 19th century and in the first three decades of the 20th century went abroad for a few years after graduation.⁴⁵ One major reason for doing this was that it was difficult to get qualified jobs in Sweden. The fact that the engineers' area of expertise is inter-

43 For a more detailed account of new courses at Chalmers and KTH until the 1960s, see: Lars Olsson, *Utbildning av skeppsbyggnadsingenjörer i Sverige ca. 1500–1970* (Chalmers Tekniska Högskola, Centrum för teknikhistoria, Rapport: 1991–1), 33–55.

44 Gustav Hössjer, "Chalmers utveckling omkring och efter 100-årsjubileet 1929", in *Chalmers Tekniska Högskola 1829–1954: Minnesskrift utgiven till högskolans 125-årsjubileum* (Göteborg, 1954), 29 f.; Olle Härlin, "Minnen och funderingar kring förhistorien till Lunds tekniska högskola", in *Jubileumsskrift Skånska Ingenjörsklubben 1887–1987* (Malmö, 1987), 101.

45 This subsection on foreign experience is based on: Lars Olsson, "To See How Things Were Done in a Big Way": Swedish Naval Architects in the United States, 1890–1915", which first appeared in *Technology and Culture*, Volume 39, Issue 3, July, 1998, 434–456, published by the Johns Hopkins University Press. Copyright © (1998) The Society for the History of Technology. For an account of earlier studies of Swedish engineers working in the United States and of the impact of ideas from America upon Swedish industry, see: Lars Olsson, "Amerikaemigration och återvändande svenska ingenjörer, 1890–1930", in *Göteborgs-Emigranten* 6 (Göteborg, 1997), 229–243. Especially, see: Sten Carlsson, *Swedes in North America 1638–1988: Technical, Cultural, and Political Achievements* (Stockholm, 1988), 58–66; idem., "Swedish Engineers in Chicago", in *Swedish-American Life in Chicago: Cultural and Urban Aspects of an Immigrant People, 1850–1930*, eds. Philip J. Anderson & Dag Blanck (Uppsala, 1991), 181–192; Hans Lindblad, "Impulser som förändrade Sverige", in Ingvar Henricson & Hans Lindblad, *Tur och retur Amerika: Utvandrare som förändrade Sverige* (Stockholm, 1995), 193–276. A recent study dealing with Swedish electrotechnical engineers who in the early 20th century went to the United States on study trips or to work is Mats Fridlund's *Den gemensamma utvecklingen: Staten, storföretaget och samarbetet kring den svenska elkrafttekniken* (Stockholm, 1999), 36 f., 50 f., 64 ff., 74 f.; cf. Jan Glete, *ASEA under hundra år 1883–1983: En studie i ett storföretags organisatoriska, tekniska och ekonomiska utveckling* (Västerås, 1983).

national naturally facilitated their travels.⁴⁶ Furthermore, the opportunity to go abroad and acquire knowledge of large-scale shipbuilding and the latest developments in the field must have been very attractive to the engineers, especially at a time when the Swedish shipyards were still small.

The naval architects from Chalmers were the ones most eager to go abroad on study tours or to work; some 70 percent of those who graduated between 1888 and 1927 did so. The countries most commonly visited were the United States, Germany and Britain, but naval architects also went to Russia, Denmark, Ireland, Holland, Italy and France.⁴⁷ Some of the graduates were from Norway and Finland, and they eventually returned to their own countries.

Since Britain was the leading shipbuilding nation of the world, one might expect naval architects to have gone there to find a job. However, the statistics tell another story. The single country most commonly chosen was the United States. As many as 48 percent of all naval architects who graduated from Chalmers between 1888 and 1927 worked there at some time or another; if those who only went there on study tours are included, the percentage of naval architecture graduates with experience in the United States rises to 55 percent. On average they worked in the United States for four years.⁴⁸ Some 25 percent of those who went there stayed in the country permanently.

Table 3.1 shows the proportion of Chalmers-trained naval architects who worked in the United States, grouped in ten-year intervals by year of graduation. As the table indicates, naval architects who graduated in the years just before and after the turn of the century went abroad in the greatest proportions; after that the percentage decreased. This decrease was especially striking after 1920. By then, many naval architects could find jobs in the Swedish shipbuilding system after graduation.

Table 3.1 The proportion of graduates in naval architecture from Chalmers who worked in the United States

Year of graduation	1888–1897	1898–1907	1908–1917	1918–1927
Total	20	39	26	35
To the USA	8	25	12	13
% to the USA	40 %	64 %	46 %	37 %

Source: Lars Olsson, "To See How Things Were Done", 437 ff.

46 Gudmund Stang, *The Dispersion of Scandinavian Engineers, 1870–1930, and the Concept of an Atlantic System* (Senter for teknologi og samfunn, universitetet i Trondheim, working paper no. 3/89), 25; Stang argues that engineers "are a geographically eminently mobile social category" and that "the market for their specialist competence has since the mid-19th century been more or less world wide. The barriers which hinder other migrant groups are less evident."

47 Many naval architects went to more than one country. A few went to other parts of the world: among them Oscar Medelius who graduated from Chalmers in 1888 and spent some years in Peru before coming to the United States, see: Elisabet Hammar, "Oscar Medelius, varvschef på Götaverken: En skeppsbyggares väg till sitt yrke", *Unda Maris* 1965–1966, 27–44.

48 The average of four years refers to those who stayed in the country for less than ten years. Those who stayed longer usually settled for good.

Comparison with corresponding figures for other countries underscores the tendency of Chalmers graduates to prefer the United States when looking abroad for employment or experience. About 21 percent of the naval architects worked in Germany at some time, spending on average two and a half years there, and study tours were also common. Of the thirteen who graduated between 1894 and 1899, as many as eleven went to Germany. The total proportion of naval architects visiting the country during the period 1888–1927 was about 35 percent.

Only 12 percent of the graduates worked in Great Britain, and they also spent on average two and a half years there. Counting those who visited on study tours, the proportion of graduates opting for Great Britain was 21 percent.

How do the numbers of Chalmers naval architecture graduates travelling to foreign countries compare with the numbers of other engineering graduates who went abroad? On the whole, the percentages are higher among the naval architects. The proportion of all Chalmers engineering students going abroad tended to increase from the 1830s to the 1870s, after which it decreased somewhat – see Table 3.2. The proportion of all Chalmers graduates who went to America was on average 6 percent until the 1870s, when it rose to 17 percent. Peaks were reached in the 1880s, 1900s and 1920s, when the number exceeded 25 percent.

Table 3.2 The proportions of graduates from the Chalmers Institute of Technology (by decade of graduation) who went abroad and who went to the United States

	1830s	1840s	1850s	1860s	1870s	1880s	1890s	1900s	1910s	1920s
Abroad	18 %	21 %	21 %	40 %	56 %	48 %	47 %	45 %	36 %	36 %
To USA	5 %	3 %	7 %	9 %	17 %	26 %	18 %	26 %	21 %	27 %

Source: Bodman, "Ett och annat ur Chalmersmatrikeln", 197–206.

The above figures show that the proportion who went abroad and to the United States was substantially higher among the naval architects than among other categories of Chalmers engineers. The proportion was also higher than among the naval architects from KTH.

During the period 1900 to 1929 some 56 percent of naval architecture graduates from KTH went abroad, on study tours or to work, for some time. As was the case with Chalmers graduates, the United States was the most popular country to work in, some 27 percent of those from KTH did so while 18 percent worked in Germany and 12 percent in Britain. The future naval engineers had to acquire a few years of shipyard experience before entering the Corps and were therefore especially eager to go abroad. Among these engineers Germany and the United States were the most frequent destinations, being equally often visited. Many went to both countries.

Considering that Britain dominated world shipbuilding, one might have expected Swedish engineers to have gone there in larger numbers to learn of the latest developments in the field. An interesting question is therefore why they chose above all to go to America. The reasons were many and individual, but the experiences of Hugo Hammar, later managing director of Götaverken (see Section 5.2), provide a useful illustration; he was in many respects typical of young Swedish engineers, especially naval architects, of his generation.

When Hammar graduated from Chalmers in 1888 he could find no work in Sweden, where the shipyards were small and the need for theoretically trained engineers was limited. He found work at Palmers Iron and Shipbuilding in England, where his job was to check measurements on vessels already completed and compare them with the original drawings for discrepancies. As a young, newly graduated naval architect, Hammar was not satisfied with this kind of routine work. He wanted a position that would enable him to create something new.⁴⁹

In the autumn of 1890 he crossed the Atlantic to Boston, where a job awaited him at Harrison Loring, helping to build cruisers for the U.S. Navy. The position gave Hammar responsibility and the opportunity to use his own initiative, which was an important factor in his decision to go to America. That it paid six times what he had been getting at Palmers also played a big part in inducing him seek his fortune in the new world.⁵⁰

Hammar recorded another reason for his move in his memoirs: "Even as a little boy I used to stand on the heaths of Öland [Ölands Alvar], yearningly looking westward. In that direction lay the great, promising new world, America, where so many people from Öland had gone to seek their fortune and had been successful. There would surely be room for me too."⁵¹ The passage refers to the great emigration of Swedes to America in the latter half of the 19th century. Although some Swedes had emigrated to America earlier, it was not until the years of famine in 1867–1868 that the first mass emigration from Sweden began. After a lull in the mid-1870s, a second, even bigger wave of emigrants left the country between 1879 and 1893. From 1851 to 1924, no fewer than 1.1 million people emigrated from Sweden. In 1910, 665,000 native Swedes were living in the United States; with their children they numbered about 1.4 million. The population of Sweden was then about 5.5 million; in other words, one-fifth of all Swedes lived in the United States.⁵²

As a child Hammar must have seen many people pack up and leave. Öland was one of the provinces of Sweden that lost the greatest proportion of their inhabitants through emigration.⁵³ From the port of Kalmar, on the east coast of Sweden, where Hammar attended school between 1875 and 1883, many emigrants embarked on

49 Hugo Hammar, *Minnen I: Från Ölands Alvar till livets* (Stockholm, 1937), 253–255.

50 Ibid., 271; In idem., *Minnen II: Som emigrant i U.S.A.* (Stockholm, 1938), page 11, Hammar reveals that he did not see himself just as an ordinary emigrant but as a "skilled engineer, who was now to reap the fruit of his years in college."

51 Idem., *Minnen II*, 11.

52 Lars Ljungmark, *Den stora utvandringen: Svensk emigration till USA 1840–1925* (Stockholm, 1965), 26.

53 Ibid., 68; Margot Höjfors Hong, *Ölänningar över haven: Utvandring från Öland 1840–1930 – bakgrund, förlopp, effekter* (Uppsala, 1986).

ships that took them to Germany and on to America.⁵⁴ From this perspective the emigration of Swedish engineers may be viewed as part of a greater emigration of Swedish people to America.

Another factor, however, and maybe the most important one, encouraged Swedish engineers to go to the United States. These technologically astute men increasingly saw that country as a leading industrial nation. Sweden was a late industrialiser – the large-scale transformation of Sweden from an agrarian into an industrial country mainly occurred after 1870.⁵⁵ The earlier stages of industrialisation in Sweden, however, had slowly begun before that time. For instance, several mechanical engineering companies had been founded in the first half of the 19th century. During this period, the main technological inspiration came from Britain, “the workshop of the world.”⁵⁶ Towards the end of the century, however, when Germany and the United States began to challenge Britain’s role as the leading industrial nation, interest in these two countries grew among Swedish engineers.

In the 1860s Swedish technologists introduced the American system of manufacturing, characterised by mechanisation and the production of interchangeable parts, into the operations of Swedish arms manufacturers, but American ideas were slow to migrate from these arms-manufacturing companies to other engineering workshops.⁵⁷ The American influence grew when Swedish engineers visited America on study tours during later decades.⁵⁸ The 1876 World Fair in Philadelphia attracted particular attention. Before then, most of reports on American technology published in Sweden were based on second-hand material from Britain or Germany but in that year many Swedes reported directly from the exhibition.⁵⁹

Some of those who travelled from Sweden to the United States in the late 19th century were funded by the Swedish government. They reported on what they had seen and learnt, and some of their reports have been preserved.⁶⁰ The view of America which they present stressed its openness, youth, enterprise, the new ideas of the country and the practicality of the Americans themselves. Because of the shortage

54 It should be noted that most Swedish emigrants bound for the United States travelled from Gothenburg on the west coast via England.

55 For instance, see: Lennart Jörberg, “Några tillväxtfaktorer i 1800-talets svenska industriella utveckling”, in *Kring industrialismens genombrott i Sverige*, ed. Ragnhild Lundström (Stockholm, 1966), 13–47. Göran Ahlström argues that the industrialisation of Sweden was already well under way by the 1850s, see his *Technological Development and Industrial Exhibitions 1850–1914: Sweden In An International Perspective* (Lund, 1996). For an account of the technological change of the period, in a Swedish context, see: Jan Hult, “Bondeland blir industriland”, in *Svensk teknikhistoria*, ed. Sven Rydberg (Hedemora, 1989), 230–268.

56 Geoffrey D. Gooch, *Teknikimporten från Storbritannien 1825–1850: En studie av Göta Kanals och Motala Verkstads betydelse som förindustriella teknikimportörer* (Linköping, 1991).

57 Gårdlund, 244 f.; For a description of the evolution of the expression “the American System of Manufactures”, see David A. Hounshell, *From the American System to Mass Production, 1800–1932: The Development of Manufacturing Technology in the United States* (Baltimore, 1984), 331 ff.

58 Gårdlund, 245.

59 Ingrid Jansson, *Svensk rapportering av amerikansk teknologi på världsutställningen i Philadelphia 1876* (Royal Institute of Technology, Rapport TRITA-HOT-2006, Stockholm, 1980).

60 Maja Hagerman, *Berättelser från utlandet: Svenska tekniker och arbetare på studieresor i Europa och Amerika under 1800-talets senare hälft* (Royal Institute of Technology, Rapport TRITA-HOT-2008, Stockholm, 1981).

of skilled workers in the newer nation, wages remained high. Employers had to increase productivity by the division of labour and the use of specialised machine tools.⁶¹ Machines in turn facilitated the fast, cheap production of merchandise of consistent quality.⁶² Of course, not everything was good about America: the “go ahead” spirit and an overemphasis on the maxim “time is money,” said to be the reason for the success of America’s industry, could also lead to sloppy workmanship and unscrupulous exploitation.⁶³

To judge from contemporary articles in the Swedish technical journal *Teknisk tidskrift*, by the end of the 19th century the United States was the acknowledged leader in mechanical engineering and many other fields of technology. In 1890, a writer in the journal described America as “in the vanguard of all progress.”⁶⁴

Thomas P. Hughes has argued that in the decades around the turn of the century “the United States became not only the most inventive nation, but also the world’s industrial leader, thereby surpassing the United Kingdom, whose leaders had long belittled the industry and technology of its former colony.”⁶⁵ The former colony overtook the former coloniser in coal production between 1895 and 1900, in pig-iron and steel production between 1885 and 1890, and in heavy chemicals between 1900 and 1913. The United States also led the world in electric light and power technology. The image of the United States as the leading industrial nation was reinforced after World War I, when many Europeans saw Taylorism and Fordism as the keys to economic development and the cures for social unrest. As Hughes writes, many German engineers, journalists, and others “voyaged to the New World in order to see the future.”⁶⁶

The growing interest of Swedish engineers in the new industrial power across the Atlantic is indicated by the proportion of those going abroad who went to America (see Figure 3.1). On average about 25 percent of all Chalmers graduates between 1830 and 1879 who went abroad visited the United States. In the 1880s, the figure rose to 54 percent. Except for a dip in the 1890s, the proportion kept on rising. Among those who graduated in the 1920s and went abroad, as many as 75 percent went to America.

61 On the scarcity of labour and the use of labour-saving methods in American industry, see Hounshell, *From the American System*, and H. J. Habakkuk, *American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions* (Cambridge, 1967).

62 Hagerman, 21.

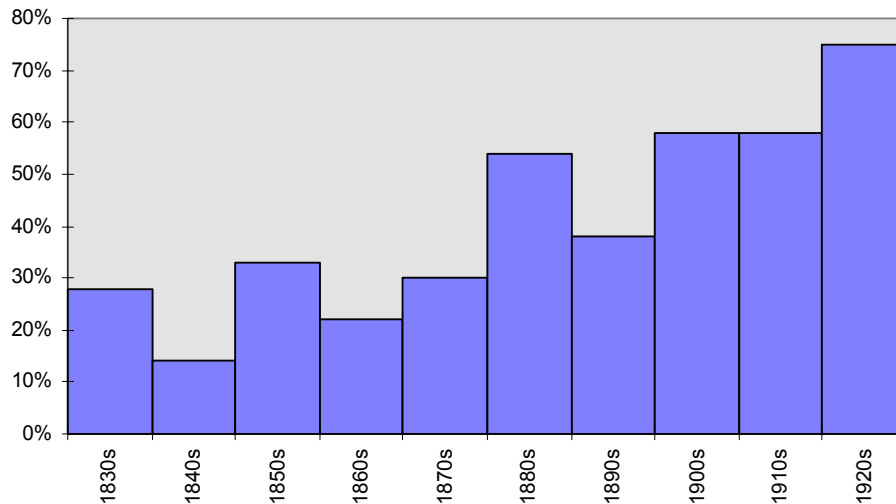
63 Ibid., 24 f.

64 Quoted in Marie-Louise Bowallius, *Den förändrade synen på amerikansk teknologi: Rapportering och värdering av amerikansk teknologi i Teknisk Tidskrift 1870–1893* (Royal Institute of Technology, Rapport TRITA-HOT-2005, Stockholm, 1980), 24. On the picture of America given by Swedish technical journals in the period 1800–1870, see Henrik Björck, “‘På de tillfälliga uppfinningarnas oroliga haf’: Tekniska tidskrifter i Sverige 1800–1870”, *Polhem* 4 (1986), 78–101.

65 Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm 1870–1970* (New York, 1989), 15.

66 Ibid., 290.

Figure 3.1 Proportion of Chalmers graduates going abroad who went to the United States, by decade of graduation



Source: Bodman, "Ett och annat ur Chalmersmatrikeln", 197 ff.

Further indications that many Swedish engineers at the turn of the century saw the United States as a leading industrial nation come from James E. Brittain's biography of Ernst F. W. Alexanderson (1878–1975). Alexanderson graduated from KTH in Stockholm in 1900 and emigrated to America a year later. He is best known as an inventor in the fields of radio, power transmission, electric railways, television, radar, and other technologies. According to Brittain, around the turn of the century, the United States had become "a virtual mecca for Swedish engineering students." Long afterward, he says, Alexanderson recalled that "the glamour of America had been almost constantly present in the minds of his fellow engineering students. His college song had described the wonders of California, he recollected, but Schenectady had been the attraction for electrical engineering students, even though they hadn't known how to pronounce it."⁶⁷ When Alexanderson arrived at General Electric in Schenectady, some twenty-five former classmates were already working there. In Alexanderson's own words, young Swedes had "naturally, wanted to see how things were done in a big way in America."⁶⁸

⁶⁷ James E. Brittain, *Alexanderson: Pioneer in American Electrical Engineering* (Baltimore, 1992), 1.

⁶⁸ Quoted in Brittain, p. 8; In *Dispersion of Scandinavian Engineers*, p. 40, Gudmund Stang explains the dispersal of engineers as, among other things, a "result of the wish to see and experience best practice."

What did the Swedes learn during their years abroad? First, of course, they gained experience of doing, to some extent, what they had learnt in the school of naval architecture – making drawings, designing different types of ships etc. Another kind of experience, which was probably more important, was knowledge of production technology and work organisation. In America and elsewhere they could see the organisational principles applied in the running of large yards, not only in the workshops and on the berths, but also in the drawing offices and the stores. An expanding Swedish shipbuilding industry would face a problem similar to that encountered in the United States – a difficulty in securing sufficient numbers of skilled workers.⁶⁹ To deal with that problem, knowledge of American production technology – such as mechanised handling, the templet system etc. – was valuable. Even if such production methods not always could be transplanted in their original form to Swedish conditions, the industry could selectively adopt the best ideas from abroad.

Apart from issues of production technology, Swedish engineers who advanced to positions of greater responsibility at foreign shipyards might also have gained experience of business methods and in the organisation of large corporations. For instance, some accounting principles later used at Götaverken were imported from American shipyards by one of these returning engineers, Ernst A. Hedén.⁷⁰

One example of knowledge gained in America by Swedish naval architects concerned the building of warships. After the Civil War, the U.S. Navy had entered a period of stagnation. While the navies of the European powers went through a period of rapid technological change in the 1860s and 1870s, the U.S. Navy bided their time. By the 1880s, however, Americans began to grow alarmed by the naval arms race, driven by the rising tides of European nationalism and imperial expansion. Concerned to defend its coast and its overseas trade, the United States initiated a large naval construction programme and, between the mid-1880s and the turn of the century, had many steel warships built. In contrast to the earlier tradition of building warships in navy yards, this “new navy” was built at private shipyards. The boost to the shipbuilding industry was immense and since there were not enough naval architects in the country, the American shipyards had to import engineers from Europe, among them many from Sweden. The experience that these people gained was of great importance when they returned home, since many Swedish shipyards were engaged in the building of warships for the Swedish navy in the period from the 1890s to the early 1920s.⁷¹

69 Ernst A. Hedén, “System, såsom en faktor i verkstadsdrift”, *Teknisk tidskrift: Allmänna afdelningen*, April 18, 1908, 91; On the importance of ideas from the United States, see also interview with Hedén, “Dir. Hedén ny chef för Götaverken”, *Nya Dagligt Allehanda*, June 3, 1938.

70 Kent Olsson, *Från pansarbåtsvarv till tankfartygsvarv: De svenska storvarvens utveckling till exportindustri 1880–1936* (Göteborg, 1983), 344.

71 See for instance: Hugo Hammar, *Minnen III: I den svenska sjöfartsnärings tjänst*, ed. Lars Olsson (Göteborg, 1994), 94; Ann-Marie Sälde, “Albin Pontino: En Götaverkeningenjör för 80 år sedan”, *VARV: Varvshistoriska Föreningen i Göteborg Årsskrift* 1997, 2 f.

It is clear that the foreign experience of Swedish naval architects was considered of value to Swedish shipbuilding. In 1901 the Swedish National Board of Trade, which gave grants to engineers for study tours to foreign countries, argued that it was time to increase the funds for naval architects who wanted to go abroad.⁷² Many Swedish engineers were already working at shipyards in Europe and America, and the Board was happy to encourage the practice. The reason given was that if the Swedish shipyards were ever to expand it would be easy to induce these engineers to return home, so the supply of experienced naval architects would be secured. And they would bring with them the latest developments in shipbuilding.

For the individual engineers, foreign experience seems to have been a qualification for a leading position. Of those engineers and technologists, of all categories, who had graduated from Chalmers, KTH or technical upper secondary schools between 1881 and 1910, and who later became executives in manufacturing industry, 24 percent had been abroad during the first years after graduation.⁷³ Rolf Torstendahl speaks of the time abroad as a non-theoretical “leadership education” and says that “foreign experience was highly regarded for business leaders in Sweden around the turn of the century.”⁷⁴ With regard to leaders of industrial companies generally (not only engineers), in 1880 as many as 42 percent had worked abroad early in their careers.⁷⁵ In 1930 this figure had risen to 46 percent whereas fifty years later, in 1980, it was only 21 percent.

3.4 Concluding remarks

In this chapter we have discussed the theoretical and practical training which prepared naval architects for working in the Swedish shipbuilding system. As technology carriers they came to have both basic engineering knowledge, gained at Chalmers or KTH, and first-hand knowledge of the most modern large-scale technology of the day, which they learnt about in the major shipbuilding nations. The United States was of particular importance in this regard until the 1920s. The largest proportion of Swedish naval architects went there and on average they stayed there for longer periods than they did in Germany and Britain.

Here we have also seen examples of the engineers’ interests. On the individual level several reasons for wanting to go abroad after graduation were identified, such as high earnings or the opportunity to become a more competent engineer and

⁷² “Svenska skeppsbyggeriets höjande”, *Teknisk tidskrift: Allmänna afdelningen*, November 30, 1901, 333 f.

⁷³ Rolf Torstendahl, *Dispersion of Engineers in a Transitional Society: Swedish Technicians 1860–1940* (Uppsala, 1975), 245 f.

⁷⁴ *Ibid.*, 252

⁷⁵ Sune Carlsson, “Ett sekels industriledare”, *Skandinaviska Enskilda Banken: Kvartalsskrift*, 67:2 (1986), 60 f.

learn of the latest developments in the field. We have also seen an example of conflicting interests between Chalmers and KTH graduates. The rivalry between the two groups found expression in the debates over resources to the two naval architecture departments and the question of concentrating the education on one school. Having touched upon the question of the interest of engineers as technology carriers, the subsequent chapters will address this subject in more detail.

As well as purely formal education and ability in the different technical aspects of design work, which the engineers learnt during the first years after graduation, it is also important to stress other less visible, but nonetheless vitally important, effects of their training. One such result was that the students, during their study time and often also when they worked abroad for a few years, formed networks of contacts among themselves. This was facilitated by the fact that they usually had similar middle-class backgrounds. Being graduates of KTH and Chalmers also was important for eventually becoming members of the engineering associations, in which they expanded their networks further and were able to exchange knowledge and experience with engineers from various parts of the shipbuilding system.

In the next two chapters we shall follow the engineers as they became active in the Swedish system of shipbuilding. While Chapter 5 deals with the organisations for which they worked, Chapter 4 will discuss the role of professional associations within the system.

4. Engineers and Their Associations

In this chapter we shall deal with the professional associations in which the engineers were active. After a brief survey of the various associations forming part of the shipbuilding system, I will concentrate on two of them: *Svenska Teknologföreningen* (the Swedish Association of Engineers and Architects; abbreviated STF) and *Tekniska Samfundet i Göteborg* (the Gothenburg Technical Society; abbreviated TSG). The former was the national meeting place of Swedish engineers while at the same time the concentration of its activities in Stockholm to some extent gave it a local character. The Gothenburg Technical Society, on the other hand, was a local association in the country's leading shipbuilding region and its members were mainly active there. Furthermore, by studying two issues which the engineers discussed at the meetings of these associations we will see what occupied their attention and what common or conflicting interests they had in different fields.

In what way were professional associations of value to Swedish industry? What actually went on within them? In his account of STF, Sven A. Hansson, chief editor of *Teknisk tidskrift* from 1942 to 1953, asks whether the association played any role in the development of technology in Sweden. He finds the answer to be "yes" and says that its importance lay in "the training that it gave the engineers by means of the papers and the discussions, the courses, the journal. The engineers were then in the happy position of being able in their daily work to contribute to the advance of technology and commerce."¹ In STF's premises the members met and had a chance to learn of each other's experiences and knowledge. Hansson has given a vivid description of these meetings:

The club life for which the Association's premises gave the opportunity and the occasion went on largely in connection with the Association's, and especially the sections', meetings. The older members were less interested in the lectures than in the dinner and the conviviality, when they had the chance both to discuss matters of mutual importance and to amuse themselves as engineers did. The younger ones had more use of the lectures for the sake of their own education – and they listened, fascinated, when the great eagles stretched their wings – or their claws.²

The exchange of knowledge and experience, however, was not the only function of STF. It was an exclusive association into which one was elected and the role it played in creating and upholding influential social networks was probably equally important. Hansson goes to say:

¹ Sven A. Hansson, *Svenska Teknologföreningen: De andra femtio åren 1911–1961* (Stockholm, 1981), 7 f.

² *Ibid.*, 84.

On the other hand it was in the course of the convivial activities that the young engineers got the chance to meet the older ones in a less hierarchic setting than that characteristic of their everyday employment. The engineering temperament saw to it that protocol was dispensed with so that personal relationships could develop naturally. When on such an occasion one of the older members condescended to drop the formalities with a younger one this was an acknowledgement and a favour which was of more importance in everyday life than we can today imagine.³

Of course, the engineering associations filled many other functions too. One was in establishing the engineering profession as such, and so to speak making the engineers a professional group in the first place. In this process not only the associations played a role but the technical journals too, and *Teknisk tidskrift*, issued by STF, in particular.⁴ Representing the engineers as a group, the professional societies also functioned as bodies of expert knowledge which the government could draw upon and as lobbying groups, giving the engineers the opportunity to express their interests.

4.1 Professional associations for naval architects

In many countries, separate professional associations for naval architects had been established in the second half of the 19th century. Some of the more important ones were the Institution of Naval Architects (established in Great Britain in 1860), the North East Coast Institution of Engineers and Shipbuilders (Great Britain; 1884), l' Association Technique Maritime (France; 1888), the Society of Naval Architects and Marine Engineers (the United States; 1893), and die Schiffbautechnische Gesellschaft (Germany; 1899).⁵

In Sweden, the naval architects did not establish their own professional association. Instead a section for naval architecture was established within STF in 1904. The Association already had sections for mechanical engineering, electrical engineering, building construction, civil engineering, chemical engineering and mining and metallurgy (all established in 1888), and engineering education (1892).⁶ The tendency to set up different sections can also be found on the local level. As we shall see, the Gothenburg Technical Society was reorganised with separate sections for different

3 Ibid.

4 Cf. Henrik Björck, "Bilder av maskiner och ingenjörskårens bildande: Tekniska tidskrifter och introduktion av ny teknik i Sverige, 1800–1870", *Polhem* 5 (1987), 299 f.

5 Robert Angus Buchanan, *The Engineers: A History of the Engineering Profession in Britain, 1750–1914* (London, 1989), 91 ff., 137. See also: Joe F. Clarke, *Building Ships on the North East Coast: A Labour of Love, Risk and Pain, Part 2 c 1914 – c 1980* (Tyne & Wear, 1997), 124; William H. Thiesen, "A Tale of Two Shipbuilding Societies: The Influence of Construction Materials on Nineteenth-Century Shipbuilding", *The Log of Mystic Seaport* 48 (1995), 2–10.

6 *Svenska Teknologföreningen 1861–1911* (Stockholm, 1912), 152–160.

branches of industry in 1908 and a section for mechanical engineering and naval architecture came into existence.

Of course, there were local technical societies in other parts of the country too. Many engineers who worked at the Kockum shipyard in Malmö were members of *Skånska Ingenjörsklubben* (the Scanian Engineers' Club), which was established in 1887. Naval architecture, however, seems to have been weakly represented there during most of the period studied: only in 1952 did the club first set up a special committee for naval architecture (special committees had existed in other fields since 1908) and not until 1965 were sections for the different fields of technology established, among them a section for naval architecture.⁷

Another association in the field was *Sveriges Varvsindustriförening* (the Swedish Shipbuilders' Association), established in 1918. This was a trade organisation for the Swedish shipyards, represented by their managing directors. As we shall see in Section 5.2, these men were usually college-trained engineers and the Association became a meeting place for the exchange of experience and knowledge, as well as a powerful co-ordinating body among the otherwise competing shipyards.

The establishment of the organisation was an outcome of the expansion of the Swedish shipyards during World War I and the difficulty of obtaining sufficient quantities of material from foreign suppliers; the supply of material was an issue in which the shipyards had a common interest.⁸ After the end of the war, when the supply of material was no longer a major problem, other questions of common interest attracted attention. The Association became engaged in work to create standards for components of ships, such as anchors, rudders, pumps, gearboxes and boilers. The meetings of the Association also considered such matters as common tariffs for docking of ships, liability for damage to vessels while under repair, effects of the introduction of the eight-hour working day, duty-free import of shipbuilding materials, and reorganisation of the naval architecture degree courses at KTH. During the depression of the early 1930s the Association tried to persuade the government to have new naval vessels built at the private shipyards. In the latter half of the decade the Association examined the possibility of establishing a new Scandinavian steelworks to produce material for the shipyards. During World War II steel materials again became a serious problem. Sweden and Germany signed an agreement whereby Germany was to buy iron ore in exchange for other products, among them steel. The Swedish Shipbuilders' Association was given the task of sharing out, among its members, the volume of material available for shipbuilding, allotting material to the

7 On the establishment of sections within the club, see: Fritz Montén, "Skånska ingenjörsklubben", *Teknisk tidskrift*, May 23, 1931, 279; *Skånska Ingenjörsklubben 1887–1962* (Malmö, 1962), 7; Sten Almqvist, "SIK:s programverksamhet 1962–1987, en tillbakablick", in *Jubileumsskrift Skånska Ingenjörsklubben 1887–1987* (Malmö, 1987), 139; For an account of the club's earlier history, see: Fritz Montén, "Skånska ingenjörsklubben 1887–1937", in *Skånska Ingenjörsklubben 1887–1937* (Malmö, 1938), 3–29.

8 "Sveriges Varvsindustriförening", *Verkstäderna*, 39:11 (November 1943), 261 f. On the issues dealt with by the Association, see: Minutes, 1918–1940: Swedish Shipbuilders' Association (CKG).

shipyards in proportion to their output in the last three years before the outbreak of the war.⁹

The statutes stated that the aim of the Association was to watch over the common interests of the shipyards except in “matters of engineering science and labour questions.”¹⁰ It is reasonable to assume that the founding fathers considered such issues well handled by existing organisations: regarding questions of labour the Swedish Employers' Confederation and the Metal Trades Employers' Association, and regarding technical-scientific questions the naval architecture section of STF.

The associations mentioned were the more important ones but there were others, too, which brought together naval architects, for instance *Svetstekniska föreningen* (the Association of Welding Technology). This association was established in Stockholm in December 1941 with the aim of bringing together engineers and technologists interested in the application of welding to different fields.¹¹ In October 1942 a Gothenburg branch of the Association was founded and eventually local branches were established in various other parts of the country. While at the start the Association had had a total of some 60 members, by September 1942 there were 217 members and in December 1951 – ten years after the founding of the Association – some 1,270 members.¹² In addition to meetings, from 1942 onwards the Association issued a journal, *Svetsen*. Clearly, a minority of the Association's members worked in the shipbuilding system but many prominent naval architects were members and the use of electric welding in shipbuilding often attracted attention at the meetings and in the journal.

Occasionally there were also conferences in the field of naval architecture. Another kind of organisation, which fulfilled similar functions to the engineering associations in exchanging knowledge and upholding networks between engineers working in various parts of the shipbuilding system, was the research institutes, and their boards and working groups in particular. These organisations, which will be dealt with in Chapter 6, became important in the 1940s and 1950s. Here we shall begin with the associations of the early 20th century, that is STF and TSG.

9 Karl Erik Jacobson, “Materialanskaffning under kriget”, in *Götaverken* 10 (1947), 22 f.

10 Minutes, October 26, 1918: Swedish Shipbuilders' Association (CKG).

11 “Ny svetsteknisk sammanslutning”, *Svetsaren: Svetstidning utgiven av Elektriska Svetsningsaktiebolaget*, No. 30, 1942, 843 f.

12 *Svetsen: Organ för Svetstekniska Föreningen*, 1942–1952. Like the total membership, the membership of the Gothenburg branch increased rapidly – by the end of World War II there were 96 members and in 1951 some 170 members.

The Swedish Association of Engineers and Architects

STF's section for naval architecture came into existence on the initiative of a number of engineers residing in Stockholm. Among the founding fathers were Wilhelm Hök, Nils G. Nilsson and Axel Lindblad. As we shall see in Chapter 5, each of the two last-named eventually became head of the National Ships' Inspectorate.

Wilhelm Hök (1858–1933), who was a prominent figure in Swedish shipbuilding in the first two decades of the century, came to play a vital role in the creation of a professional association for naval architects. He had graduated in mechanical engineering from KTH in 1880. After working at shipyards in Sweden he went to Paris, where he studied at l'École d'application du Génie Maritime for a year. Between 1884 and 1901, he worked at various shipyards in Britain and during this period he was also an active member of the North East Coast Institution of Engineers and Shipbuilders and of the Institution of Naval Architects, publishing several articles in their *Transactions*. When he returned to Sweden, he first became technical manager at a small shipyard in Stockholm and later a consultant and a ship surveyor. Between 1911 and 1922 he was managing director of Lindholmen in Gothenburg. Possessing a deep understanding of both practical and theoretical aspects of naval architecture, he was called as an expert by various government commissions, for example the Safety at Sea Commission.¹³

The planned Swedish association came to be modelled on British lines, not least as a result of Hök's own experiences.¹⁴ Since the establishment of a separate society would have been too expensive, the initiators found the best solution to be to create a section for naval architecture within STF. A letter was sent to interested parties and obtained 38 signatures. The question was raised at a STF meeting in April, 1904 but was adjourned for STF to examine more detailed proposals. Those eager to start a naval architecture section therefore called a meeting in the middle of May, at which rules of procedure, drawn up by Hök, were adopted and an interim committee, with Hök as chairman, was appointed. The other members of this committee were Ivar Engström (chief naval engineer), Ferdinand Flodman (engineer at a small private shipyard), Albert Isakson (surveyor for Lloyd's Register), Fredrik Lilliehöök (lecturer in naval architecture at KTH), Oscar Nycander (consultant engineer and managing director of a minor steam shipping company) and the above-mentioned Axel Lindblad.

At a full meeting of STF, a few days later, it was decided that the new section should be established and in late September STF's board finally approved the rules of procedure. Initially the section for naval architecture had 58 members, of whom 35 resided in Stockholm, 19 in the rest of Sweden and four abroad.

¹³ Govert Indebetou & Erik Hylander, eds., *Svenska Teknologföreningen 1861–1936: Biografier*, vol. II (Stockholm, 1937), 219; regarding Hök's technical-scientific work, see the obituary by Hugo Hammar in *Teknisk tidskrift: Skeppsbyggnadskonst*, April 21, 1934, 27 f.

¹⁴ *Teknisk tidskrift: Allmänna afdelningen*, October 8, 1904, 367 ff. & December 31, 1904, 465; see also W. Hök, "Om det svenska skeppsbyggeriets utveckling under 25-årsperioden 1904–1929", *Teknisk tidskrift: Skeppsbyggnadskonst*, April 20, 1929, 29 ff.

The section held its inaugural meeting in late September 1904. With one exception, the board came to be composed of the same people as the interim committee (the lecturer in naval architecture at Chalmers, Henrik Lindfors, replaced Oscar Nycander).

Hök, who was appointed chairman, gave a speech on the aims and policy of the section for naval architecture. He began by stressing that “we should *never* forget, that we are an engineering association – not a political or economic organisation.”¹⁵ The section should not allow itself to become involved in political matters but only in purely technical or technical-economic ones. He acknowledged that many questions had both political and technical dimensions and as a result should not be dealt with. As an example he mentioned the issue of state control of safety at sea, a question which was often discussed at this time by *Sveriges Allmänna Sjöfartsförening* (the Swedish General Shipping Association). Since this question was “at the same time of political, economic and technical importance,” in his opinion the section should not “deal with this question as it stands, because it is not purely technical.” When the politicians had made their decisions, for instance to establish state control of ships, the section would be able to deal with the technical aspects and suggest solutions. The section should furthermore actively encourage the government to use it as an advisory body when “matters of public interest and of a purely technical nature are being considered and investigated.”

An important aim of the section was to inform the members of the latest developments in naval architecture. This was, according to Hök, of particular importance in Sweden where the literature in the field was so “deplorably scanty.”¹⁶ He mentioned that many young engineers went abroad, funded by the government, but complained that they usually kept their experiences to themselves. The section could remedy this unsatisfactory state of affairs by keeping an eye on them and see to it that after returning home they informed the section of what they had learnt. In this way the whole country might benefit from their findings.

Another way in which the section could make valuable contributions to Swedish shipbuilding was, said to Hök, in dealing with theoretical aspects of naval architecture. While some problems had been solved, many remained, not least in hydromechanics. He assured his audience that those members of the section whose “inclinations are in a mathematical direction have an infinitude of suitable subjects to choose for treatment.” While papers on practical issues would after a few years have lost their topicality, the mathematical-theoretical works would have “a permanent value at all times.” What was more, he emphasised, no other problems in the field offered better opportunities for the section’s “younger members to distinguish themselves, while their proficiency in mathematics was still undiminished.”¹⁷

15 W. Hök, “I hvilken riktning bör Afdelningens verksamhet ledas och utvecklas?”, *Teknisk tidskrift: Allmänna afdelningen*, October 8, 1904, 368.

16 Ibid., 369.

17 Ibid.

When it came to the more practical aspects of naval architecture the section should be open to influences from many parties in the field. Hök argued that members of the section should not keep themselves to themselves at meetings, but should listen to shipowners, underwriters, master mariners and others, since engineers active at the shipyards had “an endless amount to learn from these men.” He went on to say: “there is nothing more valuable to an engineer than to hear what those people who spend their daily lives in them think of his creations. These are the men who are in a position, if they wish, to point out to us the mistakes that we have made in our designs, so that we can avoid them next time.”

Hök ended his address by saying that there was an enormous amount of work to be done and concluded, “let us get down to work with intelligence and energy, so that our country may, within a limited time, attain the same high standing in both practical and theoretical shipbuilding as the two great industrial nations [...] of Britain and Germany.”

The talk of having shipowners, sea captains, naval officers and others present at the meeting was not just empty words. At the very next meeting, in December 1904, the board members of several nautical associations were invited and many showed up. In the years that followed, the section often held its meetings jointly with the Swedish General Shipping Association. It seems likely that Hök had something to do with this arrangement since he was also on the board of that organisation – he was in fact a member of its board from 1903 to 1933.¹⁸

From 1906 onwards the section acquired its own voice in *Skeppsbyggnadskonst* (“Naval Architecture”), the naval architecture issue of *Teknisk tidskrift*. At first *Skeppsbyggnadskonst* came out six times per year, a figure which rose in 1919 to twelve. Axel Lindblad became the first editor and continued in that capacity until 1911. The main purpose of the publication was to print both papers read at the section’s meetings and the ensuing discussions. The journal, however, came also to contain the section’s minutes of meetings and annual reports, statistics of shipbuilding activities in Sweden and abroad, travel reports, announcements and book reviews. With time the records of discussions were more seldom published and eventually publication almost ceased. During the 1930s there were an increasing number of articles on aeronautical engineering and from 1936 onwards the publication was renamed *Skeppsbyggnadskonst och flygteknik* (“Naval Architecture and Aeronautical Engineering”). The publication existed until 1943 when *Teknisk tidskrift* as a whole became a single technical journal without separate supplements for STF’s different sections.¹⁹

By September 1905, the section for naval architecture had 122 members, of whom seventy resided in Stockholm, twelve in Gothenburg, three in Malmö, twenty-six in other parts of Sweden and eleven abroad.²⁰ Of these members half worked at

18 On the presence of representatives of different nautical associations at the meetings of the section for naval architecture, see: proceedings of meetings published in *Teknisk tidskrift*, from 1905 onwards; see also: N. G. Nilsson & Axel Lindblad, “Olika ångfartygstyper inom handelsflottorna”, *Teknisk tidskrift: Allmänna afdelningen*, May 13, 1905, 232.

19 *Teknisk tidskrift: Skeppsbyggnadskonst*, 1906–1935; *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, 1936–1942.

20 “Medl. förteckning för afdelningen för skeppsbyggnadskonst sept. 1905”, Section for naval architecture: STF (RA).

shipyards or workshops, a quarter were naval engineers, 9 percent worked as consultants and the rest were surveyors, teachers etc. The total number of members then increased steadily until the early 1950s, when it exceeded 500.

The composition of the membership during the period studied is shown in Table 4.1. Note that only those members who actually worked in the shipbuilding system are included. They are grouped by type of employer – shipyards, shipping companies, the Navy, i.e. the Naval Material Administration or the navy yards, consultant firms, educational institutions, research organisations, classification societies, the National Board of Trade (including tonnage surveying and the National Ships' Inspectorate), maritime insurance companies and other organisations, for instance suppliers.

Table 4.1 The number of members of the section for naval architecture who worked in the shipbuilding system, 1910–1960

	1910	1920	1930	1940	1950	1960
Shipyards	29	31	28	33	49	136
Shipping companies	3	5	5	9	15	27
Navy	39	45	50	55	84	102
Consultant firms	10	11	6	5	4	10
Education	2	7	4	8	6	7
Research	-	-	-	-	5	13
Classification	3	5	4	4	3	8
Ships' Inspectorate & tonnage surveyors	3	6	4	6	11	20
Maritime insurance	-	-	1	2	2	4
Others (maritime)	8	7	26	33	27	26
Total (maritime)	97	117	128	155	206	353

Source: Svenska Teknologföreningen: Ledamotsförteckning 1910–1950; Sveriges civilingenjörer, bergsingenjörer och arkitekter 1961; Additional information has been obtained from various biographical directories.

The main point of the table is that it indicates the section's role as a meeting place for engineers from most parts of the system, even if some categories of members are more numerous than others. As can be seen, those working for the Navy, mainly naval engineers, made up the largest individual group – only in 1960 did the number of engineers at the shipyards (136) outnumber those in the Navy (102). The naval engineers were usually very active members, reading papers on both military and civil aspects of shipbuilding, taking part in the discussions and functioning as board members, programme organisers etc.²¹

If we turn to the second largest group of members, that is those who worked at the private shipyards, they represented shipyards of all sizes. As time went by,

²¹ See annual reports of STF's section for naval architecture; published between 1905 and 1942 in *Teknisk tidskrift*; thereafter (until 1957) in the archives of STF (RA).

however, engineers of the larger companies came to dominate. For most of the period Kockum shows the highest number of members among its personnel.

The sharp increase in some categories of members after World War II is striking, especially in those working at shipping companies, for classification societies or the Ships' Inspectorate, and in those working full-time as researchers – before 1940 there was very little research in the field. One group of members of the section whose proportion decreased are the consultants: whereas in 1910 they made up 10 percent of the members in maritime occupations, in 1960 they constituted only 3 percent.

It should be noted that those working in the shipbuilding system were not the only members of the section. In 1910 they accounted for some 75 percent of the total number of the section's members while the rest worked in other branches of industry. As time went by the proportion of "maritime members" decreased to roughly half. That so many engineers active in other industries were members of the section might have been due to the fact that many of the naval architecture graduates from KTH, who became members of the section, spent most of their careers outside the shipbuilding system.

Of the non-maritime members it was mainly the aeronautical engineers who came to influence the section's direction. From the 1930s onwards the numbers of engineers in that field increased and by 1960 they constituted a quarter of all the section's members. The first paper dealing with aeroplanes appeared as early as 1910 but it was not until the 1930s that the subject appeared more regularly. As was mentioned above, in 1936 the naval architecture supplement of *Teknisk tidskrift* changed its name to include aeronautical engineering. At a meeting in late November 1943 the section decided to change its rules to give the aeronautical engineers more influence in the section.²² In addition to reserving more places on the board for representatives of aviation, it was decided that there should be a special aeronautical engineering editor in *Teknisk tidskrift*. Finally, the section changed its name to the section for naval architecture and aeronautical engineering. This may be seen as part of a larger process, which two years earlier had found another expression in the change of name and direction of the school of naval architecture at KTH.

The Gothenburg Technical Society

The Gothenburg Technical Society (TSG) was founded in 1882 as a sub-section of the Association of Arts and Crafts in Gothenburg. Initially TSG was mainly concerned with municipal engineering and building design.²³ The first statutes stated that to

²² Minutes, November 29, 1943, section for naval architecture: STF (RA).

²³ Gösta Bodman, "Tekniska Samfundet i Göteborg: Historik 1882–1932", in *Tekniska Samfundet i Göteborg 1882–1932: Minnesskrift*, ed. G. Bodman (Göteborg, 1932), 18 ff.; See also: Richard Ekstrand, "Historik öfver Teknisk Samfundets verksamhet 1882–1907", in *Tekniska Samfundet i Göteborg 1882–1907* (Göteborg, 1907), 5 f.

become a member, one had to be a member of the Association and be a person who “has been practically engaged in one of the branches of the art of building or possessed the interest or the expert knowledge which can be considered useful to the society in its common aspirations.”²⁴ In 1889 TSG broke away from the Association of Arts and Crafts and became a separate organisation. At the same time, the requirement for membership of the Association and for competence in building engineering was done away with. Instead it was prescribed that to be elected as a member one had to be practically engaged in “some engineering activity” or otherwise able to contribute something of value to TSG.²⁵

Like STF, TSG met regularly to listen to speeches and to discuss technical matters. It also arranged study visits, field trips and exhibitions. From 1889 onwards TSG published its transactions, *Tekniska Samfundets Handlingar*, which contained papers on different matters and, from 1893, also the minutes from the TSG meetings.

In 1906 the civil engineer Anders Atterberg suggested that the other technical societies in Gothenburg should be amalgamated with TSG.²⁶ At the same time, within TSG there should be special sections for the different fields of technology. After nearly two years of deliberations TSG was reorganised, with the result that as from January 1908 there were four sections: one for civil engineering, one for electrical engineering, one for building design and construction, and one for mechanical engineering and naval architecture. Later on two other sections were added: one for chemical engineering in 1914 and one for heating and sanitary engineering in 1918.

As we saw earlier, STF's section for naval architecture was concerned only with shipbuilding, and from the 1930s also aeronautical engineering, despite the fact that many of its members worked in other industries. The corresponding section in Gothenburg dealt, as its name indicates, with both mechanical engineering and naval architecture. Those working in the maritime field constituted a minority of the Gothenburg section's members during the period; in 1920 and 1930 they made up a little less than a quarter of the members while in 1910, 1940, 1950 and 1960 they were somewhat more than one-third of the total.²⁷ Of course, the others did not make up a homogeneous group, but many of them worked for the city's large engineering companies, most notably the Swedish manufacturer of ball bearings, Svenska Kullagerfabriken (SKF).

The reorganisation of TSG in sections in 1908 led to a dramatic increase in the number of meetings held.²⁸ This change is clearly shown in the number of papers on maritime matters. While in the first 25 years of TSG's existence, between 1882 and 1907, there had only been 15 papers in this field, during the next 25 years there were as many as 52. In the following quarter of a century the level of activity was even

²⁴ Bodman, “Tekniska Samfundet”, 26.

²⁵ Ibid., 27.

²⁶ Ibid., 21, 28 ff, 35 f.

²⁷ Directories of the members of TSG published in *Tekniska Samfundets Handlingar*, 1910–1960.

²⁸ Bodman, “Tekniska Samfundet”, 22.



The leading men of Gothenburg shipbuilding, gathered at TSG to celebrate Professor Henrik Lindfors' 70th birthday in 1920. The picture is interesting since it points to the function of TSG and its section for mechanical engineering and naval architecture as a meeting place for engineers from various parts of the system – of the men in the photo six worked at shipyards (another one had done so for many years but left for another mechanical engineering firm), two for classification societies, two as consultants, one for a shipping company, one for a supplier firm, and one as a local inspector. In addition to Lindfors, who had retired, there were also one lecturer and two professors from Chalmers present, one of whom was the rector of the school. The persons are, in the front row from the left: Johannes Rosengren, (second person unknown), Frantz Hinke, Henrik Lindfors, Hugo Hammar, Wilhelm Lager and Hjalmar Fries; back row from the left: Ernst A. Hedén, Knut Bildt, Oscar Medelius, Hilding Schalin, Hugo Grauers, Erik Smitt, N. O. Nilsson, Ernst Almqvist, Lennart Runhagen, Oscar Kjellberg, Gunnar Engberg and Alf Palmqvist. (Photo: Varvshistoriska Föreningen)

higher: between 1933 and 1958 there were more than 75 papers dealing with ship-ping and shipbuilding.

During the entire period studied here the section for mechanical engineering and naval architecture was the largest section within TSG. This is hardly surprising considering the industrial structure of the Gothenburg region. In 1908 the section had a total of 127 members, a figure which increased to some 290 in 1917. Then it dropped somewhat during the inter-war years before again increasing from the late 1930s onwards, reaching 460 in 1950.

It may be of interest to compare the composition of members with that of STF's section for naval architecture. Table 4.2 shows the members of the Gothenburg section who worked in the shipbuilding system. It should be noted that in contrast to the STF, whose members were mainly college-trained engineers, TSG had many members without such an education. Therefore, the figures refer both to engineers and to people with other backgrounds.

Table 4.2 Members of the section for mechanical engineering and naval architecture who worked in the shipbuilding system, 1910–1960

	1910	1920	1930	1940 ²⁹	1950	1960
Shipyards	38	30	19	43	83	115
Shipping companies	1	4	3	9	15	32
Navy	1	1	1	2	3	3
Consultant firms	5	5	5	9	8	7
Education	2	5	1	3	13	7
Research	-	-	-	-	5	8
Classification	3	9	4	5	9	20
Ships' Inspectorate & tonnage surveyors	-	2	3	2	3	5
Maritime insurance	-	1	2	4	3	5
Others (maritime)	4	2	2	17	14	17
Total (maritime)	54	59	40	94	156	219

Source: *Directories of TSG members published in Tekniska Samfundets Handlingar, 1910–60.*

Comparison of Table 4.2 and the corresponding one for STF shows that in Gothenburg the employees of the shipyards dominate, while only a few members worked for the Navy. Except for 1910, those working for the private shipyards made up roughly half of all “maritime members.” Only a few of these worked at shipyards outside the city. No other company had so many members among its staff as Göta-verken, which reflects the fact that the company, at least until World War II, was the biggest shipyard in the country. Leading engineers at Göta-verken were often on the governing board of both the section and TSG as a whole, among them Hugo Hammar, Ernst A. Hedén, Hugo Heyman, Oscar Medelius, Nils O. Nilsson, Ernst Almqvist, Folke Seldén and Allan Borgström.³⁰

The section in Gothenburg shows a similar trend to that of STF's section, as regards the number of members who worked for shipping companies, as surveyors or as researchers. Having been rather few in the early period, there was a sharp increase in members belonging to these three categories after World War II and then to the shipping company group in particular. This in its turn improved the TSG section's role as a meeting place between the producer side and the user side within the shipbuilding system.

²⁹ The figures for 1940 refer to TSG as a whole since the directory's account of the section for mechanical engineering and naval architecture is incomplete.

³⁰ Bodman, “Tekniska Samfundet”, 48–64

Subjects discussed at the meetings

The subjects dealt with by the members of the two professional associations at their meetings are a matter of great relevance to this study. What attracted their attention? We shall now consider the contents of the papers presented from the turn of the century until the 1960s.

In STF's section for naval architecture we find, maybe not surprisingly, that the papers usually reflect those topics in the field which were generally attracting the greatest attention in Sweden and abroad at the time.³¹ For instance, in the first twenty years of the century, the gradual changeover from steam engines to turbines or diesel engines was under way and the two new forms of motive power were much discussed. During World War I, certain aspects of the shortage of materials were debated, for instance domestic production of various articles, and the replacement of steel with other materials, such as concrete, in the construction of hulls. Papers on oil tankers in 1929 and 1932 reflect the growing importance of this type of ship to Swedish shipbuilding. Often the papers dealt with recently delivered ships. Regarding naval vessels it was common for the ships to become the subject of discussion while still at the planning stage. The fact that there were so many naval engineers among the section's members does not mean that the military aspects of naval architecture dominated. On the contrary, problems concerning merchant ships occupied the great bulk of the papers. Of course, many technical problems could have both civil and military applications.

Apart from papers dealing with specific technologies there were also those dealing with more general questions in the maritime field, for instance safety at sea, technical education, or Swedish merchant shipping.

One interesting question is whether any differences are discernible in the contents of the papers of the Stockholm-based national section for naval architecture and the local Gothenburg-based section. It turns out that despite the difference in the composition of the occupations of the members, the content of the papers was very similar. One explanation for this is that the same people often read the same papers at meetings of both organisations in order to reach a larger interested audience. For instance, despite the fact that only very few of the Gothenburg section's members worked for the Navy, there were several papers on warships, since naval engineers of the Naval Material Administration travelled to Gothenburg to address TSG.

As with the section in Stockholm, in Gothenburg we usually find papers on topical matters, whether they concerned diesel engines in the early 1910s or the growing

31 On topics discussed at the engineers' meetings, see: annual reports, minutes of the meetings, papers etc. of STF's section for naval architecture; until the early 1940s most of the material was published in *Teknisk tidskrift*; for the period thereafter, see the archives of STF (RA).

size of oil tankers in the late 1950s.³² Another common feature was that a large majority of the papers during the period studied dealt with the design of different types of ships or their component parts.

Eventually a change came about in that applied research increasingly attracted the engineers' attention. As we shall see in Chapter 6, the establishment of a Swedish experimental tank for testing ship models was occasionally discussed at the meetings of STF from 1908 onwards. In the 1920s, H.F. Nordström presented the results of his work at the small KTH tank at several meetings. However, it was not until the 1930s that research was brought up more regularly at meetings in both Stockholm and Gothenburg. One thing that contributed to the interest in this topic was of course the establishment of the Swedish State Shipbuilding Experimental Tank. The government decided in 1936 that it should be built and it began operation in 1940. From that time on, engineers employed at the Tank often presented their research at the meetings of the two technical associations. This meant that theoretical aspects of naval architecture more often came to the attention of the engineers. It should be noted, however, that the research focused on the design of ships rather than on their production.

As regards both STF's and TSG's sections for naval architecture it should be emphasised that the large majority of the papers during the period concerned the product itself, the ship, or component parts of it. The production process, on the other hand, was only rarely of primary concern. However, from the 1930s onwards production methods of the shipyards more often became a subject for discussion. This was mainly a result of the introduction of welding and prefabrication, which would eventually lead to a radical change in the work process.

The rest of this chapter will be devoted to two of the subjects which attracted the engineers' attention. The account does not claim to give a comprehensive picture of what the engineers discussed during this period. Nor is this necessary for our purpose, which is to study what interest the engineers may have had in various issues and to what extent they agreed or expressed differing opinions.

4.2 How to revive the industry

A recurring problem which, from the turn of the century until World War I, particularly concerned the engineers was what they found to be the low standing of the Swedish shipbuilding industry and what could be done in order to improve it. The general view among the engineers was that in the past Sweden had had a flourishing shipbuilding industry, which had been able to produce ships for the nation's

³² On what the engineers discussed at their meetings, see: annual reports, minutes of the meetings, papers etc. of TSG's section for mechanical engineering and naval architecture in *Tekniska Samfundets Handlingar/Förhandlingar*, 1908–1966; Bodman, "Tekniska Samfundet", 186 ff.; Minutes, 1908–1965, section for mechanical engineering and naval architecture: TSG (GLA).

merchant fleet. In an article in 1909 Hugo Hammar at Götaverken wrote that “Since time immemorial shipbuilding has been a Swedish skill, highly respected and esteemed by Sweden’s rulers and people.”³³ The glorious past, however, stood in sharp contrast to the present. Towards the end of the 19th century, the shipyards had failed to keep up with developments abroad and the engineers now spoke of shipbuilding as “in a state of stagnation” and a “moribund industry.”

This ongoing debate, conducted both at the meetings of STF’s section for naval architecture and in articles in the journal *Teknisk tidskrift*, is of fundamental interest since it reveals the engineers’ views on a number of issues, such as themselves, the Swedish worker, the labour unions, the nation etc. Therefore we shall follow it in detail.

There were many suggestions as to why the industry had fallen into decay, for instance the government’s action in the customs question of 1888, the fact that Swedish shipowners had preferred to buy their ships, often second-hand tonnage, abroad and the lack of investment capital in Sweden. However, the main focus of the discussions was on what could be done to revitalise the shipyards and what factors might be an obstruction to this endeavour.

One factor discussed was Sweden’s geographical location; some engineers stated that a disadvantage of the Swedish shipyards was the climate, with its cold winters, snow and darkness. Others did not find this argument convincing. At a meeting in 1906, the two main speakers Nils G. Nilsson and Axel Lindblad had compiled statistics which showed that, with the exception of the northern parts of the country, Sweden had roughly the same temperature as Norway, Denmark and the Baltic Coast regions of Germany.³⁴ Others emphasised that while the weather conditions presented difficulties to shipyards on the east coast, conditions on the west coast were fully satisfactory.

All the engineers seem to have agreed that one thing that could facilitate the growth of the industry was the high standard of the Swedish engineer. In 1902 Fredrik Lilliehöök stated that “we have capable engineers, both within the country and in employment abroad, where they occupy quite prominent positions in shipbuilding.”³⁵ Others who joined in the praise included Albert Isakson, who stated in 1910 that “ever since the days of Chapman and John Erikson [sic], Swedish naval architects and engineers have been in the leading rank of the world’s shipbuilders.”³⁶

At another meeting in 1906, Hugo Hammar said that he had heard people say that staff of drawing offices in Sweden were inferior to those abroad, something he

33 Hugo Hammar, “Skeppsbyggeriet”, *Teknisk tidskrift: Allmänna afdelningen*, special issue March 1909, 12.

34 N. G. Nilsson & Axel Lindblad, “Svensk skeppsbyggeristatistik”, *Teknisk tidskrift: Skeppsbyggnadskonst*, June 9, 1906, 48.

35 Fredrik Lilliehöök, “Om svenska sjöfartsnärings och skeppsbyggeriets höjande”, *Teknisk tidskrift: Mekanik och elektroteknik*, April 12, 1902, 61.

36 Albert Isakson, “Anförande vid mötets öppnande”, *Teknisk tidskrift: Skeppsbyggnadskonst*, July 20, 1910, 55. In the original, the last seven words of the quotation are printed in italics.

repudiated. On the contrary, from his experience both in Sweden and abroad he concluded that “nowhere is there done so much and such really good work per individual as in those Swedish drawing offices that I have had the pleasure of getting to know.”³⁷ He went on to say: “in design we are quite on the same level as, if not superior to, the foreigners [...] in addition the Swede is both bold and original in his designs,” of which he found proof in the icebreakers, oil tankers, passenger ships and naval vessels constructed in the country. Swedes, however, had one bad point and that was their weakness for everything of foreign origin. On the other hand, this had the advantage that Swedish engineers closely followed the latest developments abroad.

The view of Swedish people generally, which is discernible in the debate, was that they had an innate aptitude for the mechanical. This belief was a widespread one in Sweden at this time.³⁸ In 1908, Ernst A. Hedén at Götaverken wrote that with its “natural riches and its population endowed with a pronounced mechanical aptitude our country is excellently suited to nurture a flourishing industry within its borders.”³⁹ He went on to say that “the mechanical talent of our people, which is our great strength, is at the same time a weakness, for it makes us inclined to underestimate the commercial and human factors that are necessary in successful work in that many a time we seek only to create a technically first-rate product, without devoting enough thought to how to do this with a minimum of labour and at minimum cost.” During his years abroad, mainly in the United States, he had found that Swedes – himself included – did not have much to learn as regards the technical but were weak on such matters as the “organisation and systematisation of labour and work.” Hedén was not the only engineer to emphasise the Swedes’ lack of business awareness.⁴⁰

Some engineers maintained that a major reason why Swedish shipyards were unable to compete with foreign establishments was that Swedish workers were less efficient than those of other countries. Furthermore, the labour unions had a damaging influence, demanding unjustifiably high wages and in encouraging the workers to “do as little useful work as possible.”⁴¹

The workers also rejected the new methods of work that were needed to increase productivity, some argued. Thore Thelander, chief draughtsman of Bergsunds Mechaniska verkstad, maintained that the Swedish workers’ reluctance to learn new methods stemmed from their belief that they were superior to workers abroad. He

37 Hammar’s comment in the discussion following: Nilsson & Lindblad, “Svensk skeppsbyggeristatistik”, 56.

38 Cf. Gunnar Eriksson, *Kartläggarna: Naturvetenskapens tillväxt och tillämpningar i det industriella genombrottets Sverige 1870–1914* (Umeå, 1978), 201.

39 Ernst A. Hedén, “System, såsom en faktor i verkstadsdrift”, *Teknisk tidskrift: Allmänna afdelningen*, April 18, 1908, 90.

40 See, for instance: Lilliehöök, “Om svenska sjöfartsnäringsens”, 65.

41 Discussion following: Nilsson & Lindblad, “Svensk skeppsbyggeristatistik”, 54. In the original, a part of the quotation is printed in italics.

said that the workers had inherited from their fathers a delusion that “no workmanship in the world can match the Swedish, and that for Swedish workmanship and Swedish material no price can be too high.”⁴²

Those who blamed the workers and their organisations did not go unopposed: there were also engineers who defended the workers. One of them was Hugo Hammar, who said in 1906 that if the labour situation was as bad as some engineers had tried to assert then Swedish shipbuilding was doomed to destruction. He, however, was glad to inform the members that he was of a different opinion. With the exception of a few “bad eggs,” he had found the workers to be “alert and attentive, and just as interested in the progress of our industry as perhaps anyone in this circle.”⁴³ When he had been negotiating with representatives of the labour unions he had met with an understanding attitude and despite these people’s pronouncements in the press, they showed a great interest in the success of the industry.

One view heard at the meetings was that Swedish-built ships, especially naval vessels, were of a quality that gave an important competitive advantage. Hugo Lilliehöök, director-general of naval construction, asserted in 1906 that “the products of our workshops are generally of a quality that can compare with any foreign make, and in the building of naval vessels in particular I have every reason to confirm that our workshops measure up well for skill. So well, even, as in many respects to surpass workshops abroad.”⁴⁴ The skill which naval orders helped to develop in the work force would also benefit the building of merchant vessels, he thought.

Albert Isakson objected to this latter view and argued that the quality of the workmanship required in naval vessels was so much higher than for ordinary merchant ships that it was inappropriate to use the same workers. He said that “if people who are used to building cruisers and torpedo boats are told to build a freighter, they will bring the habits and techniques from their previous work and they will press, rivet and caulk in the same way here as on the cruiser *Fylgia* and others.”⁴⁵ From an economic point of view, “top skills are the enemy of good skills” since merchant ships would become too expensive. Therefore only very few shipyards in the country should be allowed to build naval vessels.

One question which attracted particular attention among the engineers was that of specialisation. As we saw earlier, around the turn of the century shipbuilding was only one part of the production of the workshops. The diversified production appealed to both the workers and the owners of the companies, the former because it gave them greater freedom in their work and the latter because it meant that the company always had some product which gave a profit.⁴⁶ Many engineers, however, were less enthusiastic. As things turned out, it was under the leadership of engineers that a transformation of the engineering workshops into specialised shipyards

42 Lilliehöök, “Om svenska sjöfartsnäringens”, (discussion), 66.

43 Nilsson & Lindblad, “Svensk skeppsbyggeristatistik”, (discussion), 56.

44 Ibid., 50; see also page 57.

45 Ibid., 51 f.

46 Kent Olsson, “Det varvsindustriella genombröttet i Sverige under mellankrigstiden”, *Unda Maris* 1975–82, 65.

eventually took place. Therefore, it is of particular interest here to follow the discussions on this issue at a time when the transformation had not yet occurred.

Specialisation was considered at two levels. The first was the abandonment of other lines of business to concentrate on the building and repair of ships. The second was concentration of production on certain types of vessels, for instance oil tankers. In specialisation many engineers saw a chance to lower production costs and thereby make the companies competitive on the international market. The way to accomplish this was by increasing the volume of production. As Fredrik Lilliehöök put it in 1902, "a modern shipyard must be fully employed all year round and therefore have several vessels at different stages of construction at the same time, because only then can the work be done rationally on an industrial basis and the cost of building be substantially reduced."⁴⁷ In this way workers could carry out the same kinds of tasks over and over again and become very good at them.

At a meeting in 1909, Thore Thelander commented upon the lack of specialisation and said that "when he's first bending frames, then shell-plating, then being a riveter, it is impossible for a workman to develop such specialised skills as he can if he does the same thing for a longer period."⁴⁸ He attributed the success of some yards, mainly in Germany, Norway and Denmark, to the fact that "they have reached the point of being able to train specialists in every field."

Something that probably stimulated the engineers' interest in the issue of specialisation was their foreign experience. Abroad, especially in the United States, Germany and Britain, they had seen how large specialised shipyards were organised and run. Of course they were also aware of a trend towards specialisation in other branches of Swedish industry and in the mechanical engineering industry in particular. In 1909, Hugo Hammar wrote that "the need for specialisation which is noted everywhere in mechanical engineering, is more acute than ever in the shipyard."⁴⁹ He was at this time chief engineer at Götaverken and within a year he would succeed the managing director Sven Almqvist. The process of transforming the company was under way and soon other parts of its diversified production would be sold off or closed down. For instance, in 1911 the railway carriage division, which had made up a large part of the company's total production, was sold.

In his memoirs Hammar later recalled these days: "Imagine a naval architect, who is specially trained to build ships, and then put to work on the production of hundreds of different items. In most branches of industry at the turn of the century there emerged specialised manufacturers, and their managers were superior to the shipbuilder, not only in the manufacture of a particular product but also in marke-

47 Lilliehöök, "Om svenska sjöfartsnäringens", 61.

48 Nilsson & Lindblad, "Svensk skeppsbyggeristatistik", (discussion), 51 f.; cf. Thelander's comments in the discussion following: Fredrik Lilliehöök, "Några meddelanden rörande iakttagelser inom skeppsbyggnadskonsten från en studiefärd i Tyskland", *Teknisk tidskrift: Allmänna afdelningen*, January 14, 1905, 20.

49 Hammar, "Skeppsbyggeriet", 13.

ting it.”⁵⁰ After giving an account of the problems he had encountered in designing and selling iron bedsteads, which was another of the company’s products, he concluded “we had to wind up one business after another to concentrate on the only thing I could build and sell, namely ships.”

Of course, it was not always easy to know what types of ships to concentrate on. In 1906 Hammar stated that it would be a great advantage if the shipyards could specialise to the point of building only a certain type of ship. He went on to say that “we all recognise this, but which type one should make the object of one’s specialisation is the question that is so difficult to answer and until we have succeeded in answering it we must take what the market offers.”⁵¹

After this discussion of the engineers’ opinions on different questions we might ask what measures they took collectively within the section for naval architecture to promote Swedish shipbuilding. To start with, the very founding of the section could be seen as a contribution to the development of the industry.

In his opening address to the first regular meeting in December 1904, the chairman Wilhelm Hök noted with satisfaction that Sweden now had an organised meeting place for naval architects. For the first time ever, he said, “Swedish engineers, who are actual practitioners of perhaps the most fascinating of the many branches of engineering science, namely the art of shipbuilding” had gathered to discuss technical matters.⁵² So far the section for naval architecture could only boast some one hundred members but these would make a difference in the future: “we are intrepidly filled with desire to do our best for the advancement of shipbuilding in our country and we are full of the hope of better and brighter times for it.” In the second half of the 19th century similar associations had been established in Britain, France and Germany and these had, according to Hök, undoubtedly contributed to the high standing of shipbuilding there. He concluded: “may we through our association seek to raise our domestic industry to the same level as that occupied by shipbuilding in other countries.”

One of the section’s actions was to demand state support in the form of shipbuilding subsidies. The issue came up at a meeting in 1909 and a committee was appointed to draw up recommendations.⁵³ In an international perspective these were hard years for shipyards and in many countries governments took measures to support their shipbuilding industries. The deliberations of the committee resulted in a communication which the government referred to the National Board of Trade. When World War I broke out the efforts had not yet led anywhere and with the resulting

50 Idem., *Minnen III: I den svenska sjöfartsnärings tjänst*, ed. Lars Olsson (Göteborg, 1994), 21.

51 Hammar’s comment in the discussion following: Fredrik Lilliehöök, “Hvad bör göras för höjandet af vårt skeppsbyggeri?”, *Teknisk tidskrift: Skeppsbyggnadskonst*, June 9, 1906, 64.

52 “Svenska Teknologföreningens afdelning för skeppsbyggnadskonst: Ordinarie höstsammanträdet 1904”, *Teknisk tidskrift: Allmänna afdelningen*, December 31, 1904, 465.

53 Dan Broström, “Rederirörelsen och skeppsbyggnadsindustrien”, *Teknisk tidskrift: Skeppsbyggnadskonst*, June 19, 1909, 49–57; On the further treatment of the question, see: Albert Isakson, “Frågan om skeppsbyggnadspremier inför 1911 års riksdag”, *Teknisk tidskrift: Skeppsbyggnadskonst*, May 31, 1911, 64–81; Kent Olsson, *Från pansarbåtsvarv till tankfartygsvarv: De svenska storvarvens utveckling till exportindustri 1880–1936* (Göteborg, 1983), 45 ff.

boom in Swedish shipbuilding there was no longer any need for state support. As Fredrik Wiking, managing director of a shipyard in Stockholm, put it in a discussion in 1915: "Conditions are now such that we are managing splendidly."⁵⁴

As we have seen, the engineers who made their voices heard at the meetings of the section for naval architecture held widely varying opinions on what was causing the decline of the industry and what should be done about it. They all agreed, however, that a thriving Swedish shipbuilding industry, which could build large vessels for the country's merchant fleet, had to be created. Why was that so important to them? What were their interests in this issue? Without trying to give a comprehensive answer, I will discuss some factors which were of importance.

To begin with, a vital shipbuilding industry would give the engineers improved career opportunities. They would have better chances of gaining influential positions at the shipyards, and therefore higher earnings. That the engineers had a personal financial interest in the question is clearly indicated in an article in *Teknisk tidskrift* in 1906. No author is given but it was probably written by someone on the board of the section, most likely Axel Lindblad who was both secretary and editor of the naval architecture issue of the journal. The article began by stressing that the purpose of the section was to work for "the development and vigour of our entire shipbuilding industry," which would give the profession prestige and importance and make it "an honour to the individual to belong to it."⁵⁵ The expansion of the industry would also make it possible for energetic and talented engineers to "win the financial advantages with which such an intricate and demanding profession as that of the naval architect ought to furnish its practitioners."

Of course, financial motives were not the only ones. Another was that engineers took a great passion in the actual process of creating new technology – that they often had an interest in the technology itself and enjoyed experimenting or "tinkering" with it. Several historians have touched upon this theme. Eugene S. Ferguson argues that the enthusiasm of engineers for what they do is an important factor in their productivity. He maintains that "[t]he passion of a technologist who is pursuing a technical problem is just as real as that of a composer who tries to capture on paper the fugitive tune in his head. The technologist can and does become emotionally involved in his production."⁵⁶

54 Discussion following the paper by: Ivar Engström, "Kan svenskt skeppsbyggeri fylla de kraf, som efter världskrigets slut säkerligen ställas på detsamma?", *Teknisk tidskrift: Skeppsbyggnadskonst*, December 29, 1915, 64.

55 "Afdelningen för skeppsbyggnadskonst", *Teknisk tidskrift: Skeppsbyggnadskonst*, December 29, 1906, 85.

56 Eugene S. Ferguson, "The American-ness of American Technology", *Technology and Culture* 20 (1979), 9; cf. idem., "Toward a Discipline of the History of Technology", *Technology and Culture* 15 (1974), 21. Other studies addressing the theme are: Henrik Björck, "Bilder av maskiner och ingenjörskårens bildande: Tekniska tidskrifter och introduktion av ny teknik i Sverige, 1800–1870", *Polhem* 5 (1987), note 95, p. 309; Bosse Sundin, *Den kupade handen: Historien om människan och tekniken* (Stockholm, 1991), 272; see also idem., "Den hängivne amatören", *Lychnos* 1994, 115–125; Per Wisselgren, "Homo ludens på verkstadsgolvet: Ett humanistiskt perspektiv på skogsbrukets mekanisering", *Polhem* 13 (1995), 407 ff.; Ulf Mellström, "Teknologi och maskinitet: Män och deras maskiner", in *Från symaskin till cyborg: Genus, teknik och social förändring*, eds. Elisabeth Sundin & Boel Berner (Stockholm, 1996), 127–134; Ulf Mellström, *Män och deras maskiner* (Nora, 1999), 45–55; Boel Berner, *Perpetuum mobile? Teknikens utmaningar och historiens gång* (Lund, 1999), 162 ff.; Samuel C. Florman, *The Existential Pleasures of Engineering* (New York, 1976). Cf. Ronny Ambjörnsson, *Mansmyter: James Bond, Don Juan, Tarzan och andra grabbar* (Stockholm, 1999), 149 f.

In the case of Swedish shipbuilding it is clear that whether this kind of passionate and creative engineering work concerned the design of hulls, engines or entire shipyard plants, resources were needed and an expanding industry would facilitate this.

A personal portrait from Götaverken may serve to illustrate that interest in the technology itself can be a vital incentive for engineers to work prodigiously. John Olsson, later known as “Motor-Olle,” graduated in mechanical engineering from Chalmers in 1912 and then started work in the bridge-building department at Götaverken. When, in 1915, the company acquired the right to manufacture the Burmeister & Wain diesel engines under license, Olsson moved to the engine-testing staff. For the rest of his career he worked in the engine department. From 1936 he led the work on a single-acting two-stroke diesel engine of Götaverken’s own design, which would eventually lead to the termination of the licence agreement with the Danish shipyard. In the 1960s, his wife recalled that her husband had been totally devoted to his task, working both Sundays and nights, and bringing work home in the evenings. After dinner, she said, he would first go out for a walk. When he returned he “wanted coffee, but he hardly gave himself time to drink it” before it was time to start working again. She continued:

Then he would carry his big drawing board into our bedroom and put it on his bed and draw up a chair and start working. Now and again he would pop out to the kitchen and pour himself a cup of cold coffee from a large kettle that I always had to keep full. But he wouldn’t let me go out; he didn’t want to be alone. That was how it went on, day after day, for long periods. And he used to think aloud. His work took all his strength, it was his only interest, his hobby, and his happiness.⁵⁷

So far we have only encountered personal reasons for wanting an expansion of the Swedish shipbuilding system but discussions among the engineers indicate that there were also other and less personal ones involved. In the early 20th century Swedish society, like that of other industrial countries, was permeated by patriotic ideals. In contrast to the nationalism of earlier periods, which had been militaristic in character, with the emphasis on the heroic kings and military victories of the past, the new nationalism sought to revive Sweden’s “greatness and fame” by peaceful competition in industrial production.⁵⁸ Many people thought that nations had to fight to uphold

57 Quoted in: Ture Rinman, *The Story of an Engine: 25th Anniversary of the Götaverken Diesel Engine* (Göteborg, 1964), 43; On John Olsson’s role in the design of Götaverken’s diesel engines, see also: *Götaverken 125 år*, 81.

58 Staffan Björck, *Heidenstam och sekelskiftets Sverige: Studier i hans nationella och sociala författarskap* (Stockholm, 1946); Bo Jonsson, *Staten och malmfältet: En studie i svensk malmfältspolitik omkring sekelskiftet* (Stockholm, 1969), 350 ff.; Sverker Sörlin, *Framtidslandet: Debatten om Norrland och naturresurserna under det industriella genombrottet* (Stockholm, 1988), 97; Henrik Björck, *Teknikens art och teknikernas grad: Föreställningar om teknik, vetenskap och kultur speglade i debatterna kring en teknisk doktorsgrad, 1900–1927* (Stockholm, 1992), 36 ff. See also: Mats Fridlund, “De nationalistiska systemen: Konstruktion av teknik och svenskhet kring sekelskiftet 1900”, in *Den konstruerade världen: Tekniska system i historiskt perspektiv*, eds. Pär Blomkvist & Arne Kaijser (Stockholm, 1998), 77; idem., *Den gemensamma utvecklingen: Staten, storföretaget och samarbetet kring den svenska elkrafttekniken* (Stockholm, 1999), pp. 40–60 in particular. On the building of hydro-electric power plants in the early 20th century, seen in a patriotic context, see: Staffan Hansson, *Porjus: En vision för industriell utveckling i övre Norrland* (Luleå, 1994), 19 f.; Eva Jakobsson, *Industrialisering av älvar: Studier kring svensk vattenkraftutbyggnad 1900–1918* (Göteborg, 1996), 80.

their position in “the struggle for existence.” Frequent world fairs in Europe and the United States enabled the latest products from different countries to be compared.⁵⁹ The degree of a country’s industrialisation was to a large extent seen as reflecting its level of civilisation.⁶⁰

The nationalism of the era might be seen as an expression of a consensus ideology intended to divert the increasing antagonism between the working class and the capitalists that had resulted from the process of industrialisation.⁶¹ In line with this reasoning Gunnar Eriksson argues that: “the factory worker could, in his poverty, still be offered the privilege of feeling like a Swede, his insignificant status in the hierarchy of the classes could be compensated through his greatness in that of the nations.”⁶² Everybody, worker and capitalist alike, was to have a common stake in the growth of Swedish industry.

Patriotic strains are frequently evident in contemporary comments by people in Swedish shipping and shipbuilding with slogans such as “Swedish cargo on Swedish keels.”⁶³ In discussions among the engineers the issue of keen international competition and “the struggle for existence” is ever present.

At a meeting in 1905, Nils G. Nilsson and Axel Lindblad emphasised that shipping, due to its international character, was particularly vulnerable, saying “transport across the oceans between countries, by virtue of its offering free waterways, open to all, gives the greatest opportunity for peaceful competition, and is therefore the branch of industry in which competition between nations is most effective.”⁶⁴ This vulnerability would also affect the shipyards since Swedish shipowners would be their main customers.

In his opening address at a meeting in 1910, Albert Isakson, then chairman of the section, drew a comparison between German naval officers and Swedish shipbuilders. He stated that when German officers got together on festive occasions on board their new battleships, they toasted the day they would meet the British Navy in single combat, a day which they all longed for. Isakson continued that “We Swedish shipbuilders also have a single combat ahead, in which we must conquer or go under. Not a bloody one, but a contest in the field of industry and intelligence, a *day of*

59 Eugene S. Ferguson, “Expositions of Technology, 1851–1900”, in *Technology in Western Civilization*, vol. I, eds. Melvin Kranzberg & Carroll W. Pursell, jr. (Oxford, 1967), 706–726; Anders Ekström, *Den utställda världen: Stockholmsutställningen 1897 och 1800-talets världsutställningar* (Stockholm, 1994), 57 ff.; cf. Svante Lindqvist, “An Olympic Stadium of Technology: Deutsches Museum and Sweden’s Tekniska Museet”, *History and Technology* 10 (1993), 37–54; On the question of Sweden’s ranking among the industrial nations, see: Ahlström, *Technological Development*, 44 ff.

60 Cf. Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca, 1989).

61 Jan Larsson, “En ny nationell effektivitet. Några perspektiv på svensk historia 1895–1920”, in *Teori- och metodproblem i modern svensk historieforskning*, ed. Klas Åmark (Stockholm, 1981), 210 ff.

62 Eriksson, *Kartläggarna*, 202.

63 *Teknisk tidskrift* and (from 1906) its section for naval architecture *Skeppsbyggnadskonst*, 1902–1915; *Sveriges Allmänna Sjöfartsförenings Tidskrift*, 1903–1914; Herbert Jacobsson in the introduction to the anniversary issue: “Inledning”, in *Hugo Hammar 1864 4/3 1939*, ed. Olof Traung (Göteborg, 1939).

64 Nilsson & Lindblad, “Olika ångfartygstyper”, 217.

untiring labour, in which we hope once more to gain for ourselves and our beloved country the lost 'place in the sun' that we once successfully claimed."⁶⁵

One person who often spoke in terms of "the struggle for existence" was Hugo Hammar. At a meeting in 1918 he outlined why shipyards faced stiffer competition than other industries. He stated that "in no branch of industry is foreign competition so keenly felt as in shipbuilding in that its products move by themselves from the place where they are cheapest manufactured to the most appropriate market and when moving generally get paid instead of paying to be transported."⁶⁶ Hammar added that "the ship, which has to pay interest in general world competition must not be burdened with a higher acquisition cost than its competitors and thus cannot be protected with customs duties."

Some engineers maintained that Sweden had to have a shipbuilding industry, not least in case war broke out; if that happened it was vital to have shipyards along the coasts and "a corps of engineers and workmen practiced in naval shipbuilding."⁶⁷ Moreover, at times of war the country had to a large extent to be self-sufficient, as became clear to many people during World War I. At a meeting in 1915, Ernst A. Hedén stated "The world war now in progress has to a very high degree brought us to see the necessity of purposefully working in every respect and in every field to free ourselves from dependence on other countries."⁶⁸ This was especially true in the field of technology and industry, he argued: "industry is not only of increasing significance in peacetime, but this war has also made it clear that the importance of native industry in times of strife is comparatively much greater than previously suspected." Therefore it was important for everybody "to work with greater vigour and purpose for the development and independence of Swedish industry, making full use of the land's own resources" and in their work to try to put into practice the slogan "Sweden for the Swedes."⁶⁹

We might ask if the engineers really believed in the patriotic arguments or if they just used them in pursuit of other goals. Jan Glete observes that in the first half of the 20th century Swedish industrial companies came to be seen as highly prestigious symbols of the nation. He speaks of a "national engineering spirit," by which he means that engineers and business leaders were driven by more than concern for their own companies alone. He maintains: "The safeguarding of the national technology and the ambition to develop it further were strong forces in Swedish

65 Albert Isakson, "Anförande vid mötets öppnande", 56.

66 Hugo Hammar & Edwin Fornander, "Den motsedda utvecklingen af Sveriges skeppsbyggnadsindustri och möjligheten att fylla där af skapadt behof af järn och stål genom inhemsk produktion", *Teknisk tidskrift: Kemi och bergsvetenskap*, June 26, 1918, 73.

67 Nilsson & Lindblad, "Svensk skeppsbyggeristatistik", (discussion), 53; Cf. Allan Boo's comment in the discussion following: Engström, "Kan svenskt skeppsbyggeri", 65.

68 Ernst A. Hedén, "Beräkning af det svenska skeppsbyggeriets behof af materialier och utrustningsartiklar med tanke på desammas framställning inom landet", *Teknisk tidskrift: Skeppsbyggnadskonst*, December 29, 1915, 66.

69 Ibid., 66, 69.

industrial life.”⁷⁰ Gunnar Eriksson shares this point of view and says that the nationalism of the era “was undoubtedly not merely a superficial phenomenon, a suitable adornment for speeches at formal openings and for innumerable toasts at banquets. It involved a new awareness of our country’s intrinsic resources and potential, it expressed a growing feeling of vigour and the attainability of riches.”⁷¹

It is of course difficult to say what the engineers in the shipbuilding system really thought. Possibly, there were those who may have used the national argument for other purposes. On the other hand we have reason to believe, as argued by Glete and Eriksson, that many engineers were driven by a patriotic wish to improve the conditions of the Swedish people.⁷² A frequent theme of the engineers’ comments is a recognition of the country’s potential. As Hedén wrote in 1908, he was convinced that “with our far from impoverished land and its fundamentally sound population we can well look forward to a future as a major industrial power.”⁷³

Having dealt with opinions and interests revealed in the early 20th century discussions on the revival of the shipbuilding industry, the rest of this chapter will be devoted to the engineers’ discussions on a subject of a more technical nature, viz. the discussions from the late 1930s until 1950 on new production technology.

4.3 Welding and prefabrication

As mentioned earlier, from the 1930s onwards the production process at the shipyards began increasingly to be discussed at the meetings of the two engineering associations. The immediate reason was that welding had now begun to cause major changes in the way ships were built. Seen in a broader perspective, the introduction of welding and prefabrication was the shipyards’ answer to rationalisation and the application of scientific management in other industries.

By the end of the 1930s engineers at the shipyards usually acknowledged the many advantages of welded ships. There were however differing opinions on how to organise the building process. At a meeting of TSG’s section for mechanical engineering and naval architecture in October 1939, Pontus Forssell, a welding engineer at Eriksberg, presented a paper on the subject.⁷⁴ He saw as the major reason for the rapid recent increase in the use of welding the fact that good, easily welded thick-coated electrodes could now be purchased at reasonable prices. It was easier to do good work with thick-coated than with thin-coated or bare electrodes, which meant

⁷⁰ Jan Glete, *Storföretag i starkström: Ett svenskt industriföretags omvärldsrelationer* (Västerås, 1984), 69. Cf. Fridlund, *Den gemensamma utvecklingen*.

⁷¹ Eriksson, *Kartläggarna*, 201.

⁷² Jacobsson, “Inledning”.

⁷³ Hedén, “System, såsom en faktor”, 92.

⁷⁴ Pontus Forssell, “Om bågsvetsning på fartyg”, *Svetsaren*, January 1940, 461–47.

that a competent welder could be trained more quickly. Forssell went on to say that nowadays the quality of welded joints was fully satisfactory and the problem was rather how to weld plates and frame members together efficiently. Even if it was possible to weld at any angle, it was best to do it in a horizontal position, which meant that units should be welded together on the ground and then added to the hull.⁷⁵ What determined the size of the sections was the capacity of the cranes available, and unfortunately Swedish shipyards were not particularly well equipped in that respect.

At a meeting of STF's section for naval architecture in June 1940, Robert Fredrikson, shipyard engineer, i.e. head of the production plant, at Kockum, expressed a somewhat different view of the need to prefabricate sections on the ground. In the technical literature he had often encountered the idea that for it to be economic to build welded ships, the shipyards had to have cranes with a capacity of thirty to fifty tonnes, while ordinary Swedish cranes only could handle three to five tonnes. He had also met the opinion that it was necessary to "collect large units on the ground and there weld them together while turning them around so as to facilitate only horizontal welding."⁷⁶ He refused to accept this and said that experience at Kockum showed that it was "quite unnecessary" to rebuild the shipyard to facilitate such a method of production. For many hull components, welding was "actually becoming both cheaper and better when done on the vessel itself than when the components are collected and welded in the workshop and then brought on board." Even if it was sometimes more costly to carry out welding work on the berths, the additional cost was not enough to justify a complete conversion of the shipyard, and the capital expenditure this would involve. He concluded by saying: "in our view, big cranes are not a condition for building welded vessels economically."

At the time Fredrikson presented his paper, World War II was in progress, which made it more difficult to follow the latest developments in the field abroad. As mentioned earlier, the United States was then leading the way in developing welding and prefabrication. What did Swedish engineers know about wartime shipbuilding in the United States? Very few had a chance to travel there themselves, but some information reached Sweden through foreign technical journals. This information was later published in Swedish newspapers and journals and therefore brought to the attention of the public as well as of engineers in the shipbuilding system. Between 1941 and 1945 *Teknisk tidskrift* had several articles on how the American shipyards "mass-produced" standardised ships.⁷⁷ The accounts came from journals such as *Motor Ship*, *Marine Engineering*, *Shipbuilder* and *Shipbuilding and Shipping Record*. What the Swedish articles seized on was among other things the extensive use of

⁷⁵ Ibid. – see photos 20 and 21 on page 472 f.

⁷⁶ Robert Fredriksson, "Konstruktion och praktiskt utförande av svetsade fartyg: 2. Praktiskt utförande", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, January 18, 1941, 1.

⁷⁷ *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, 1941–1943; *Teknisk tidskrift*, 1944–1945; There were also articles on the subject in other journals during this period, for instance in *Verkstäderna: Organ för Sveriges Verkstadsförening* and *Svetsaren: Svetsstidning utgiven av Elektriska Svetsningsaktiebolaget*.

welding, the shape of the prefabricated sections, the lifting capacity of the cranes, the flow of material and the training of welders. The articles were profusely illustrated with photos and drawings showing both the production process and the design of the ships.

A few Swedes did have the chance to make study trips abroad during the war. One engineer to visit the United States was Hilding Törnebohm, a director of the Swedish ball-bearing company SKF. In March 1944 he visited Henry Kaiser's shipyards at Richmond, near San Francisco. On returning home he told both Hugo Hammar and Ernst A. Hedén what he had seen. Törnebohm said that he did not get the impression that "Kaiser's yard involved anything revolutionary of a kind that could be useful in peacetime, for the waste of labour was evident" and with his own eyes he had seen how many "idle and underemployed workmen there were."⁷⁸ He was, however, impressed with the organisation and the material-handling system and concluded: "the Americans are surely, whatever one may say, masters at solving transport problems."

Törnebohm's statement about the American shipyards is interesting since to some extent it summarises what many people in Swedish shipping and shipbuilding thought about the American mass production of ships. As news of the extensive building programme reached Sweden, questions began to be asked about what would happen after the war: would American shipyards, with their large production capacity, knock out other countries' shipbuilding industries, or would the many standard ships built during the war flood the market and depress the demand for vessels for a long time to come?

Several engineers expressed little alarm and indicated that they faced the future with confidence. The low speed and simple design of the standard ships would not appeal to shipowners who wanted ships to their own specifications and for particular routes.⁷⁹ Moreover, American shipyards had been designed for building ships fast, and the cost had been of less concern. The plants, however, were not suited for peacetime production when economic operation became a priority.⁸⁰ Consequently, shipbuilding in the United States would not become a serious threat to the Swedish shipbuilding industry.

⁷⁸ Letter from Hilding Törnebohm to Hugo Hammar, September 8, 1944: Hugo Hammar's archives (SMG).

⁷⁹ Rolf Sörman, "Framtidsproblem inom sjöfart och skeppsbyggeri", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, June 19, 1943, 54; Hugo Heyman, "Svensk varvsindustri och efterkrigsårens problem", in *Morgondagens teknik: Aktuella problem och framtidsperspektiv inom teknik och ingenjörsvetenskap* (Stockholm, 1945), 88 ff.; Allan Borgström, "Det svenska skeppsbyggeriets framtidsutsikter", in *Götaverken* No 10 (1947), 17 ff.

⁸⁰ Kent Olsson, "Sjöfartens utvecklingsblock under yttre tryck – den svenska sjöfartssektorn under det andra världskriget", [Norwegian] *Sjöfartshistorisk Årbok* 1990, 236; "Skeppsbyggeri på löpande band", *Verkstäderna* 39:6 (1943), 146; Draft of a speech by Hugo Hammar, "Svensk varvsindustri, dess utveckling och aktuella problem", presented at a lecture in Gothenburg in October 1944: Hugo Hammar's archives (SMG).

After the war many Swedes in shipbuilding, as in numerous other fields of technology and industry, crossed the Atlantic to study the latest technological developments.⁸¹ As well as sending engineers to study advances in welding, machine tools etc. and bring that knowledge back home, some Swedish shipyards also bought equipment in the United States. The most extreme manifestation of this technology transfer to Sweden was when the shipowner Gustaf Thordén bought an entire shipyard in America, dismantled it and shipped it to Uddevalla on the west coast of Sweden.⁸² The shipyard, which had been located in Providence, Rhode Island, was one of the many that had produced "Liberty ships" during the war. In the decades after World War II, the new Uddevalla shipyard became one of the largest in the country.

Impressed by the developments in the United States but confident of the Swedish shipyards' own abilities, many engineers after the war argued enthusiastically in favour of the new production technology. One of them was Nils Eckerbom. He had graduated in naval architecture from Chalmers in 1939 and worked at Kockum until 1946 when he became shipyard engineer at Eriksberg, the yard which was leading the way in prefabrication.⁸³

At a joint meeting of the Association of Welding Technology and TSG in November 1947, Eckerbom gave an account of a study trip to Britain six months earlier. He began by stressing the attention commanded by developments across the Atlantic: "From innumerable lectures and newspaper reports we have learnt of the enormous progress made in America during the war years in welding and shipbuilding technology."⁸⁴ There was no doubt that these new methods had had a great impact on shipbuilding practice. Many people, however, had questioned whether the methods could be transplanted to older shipyards.

In order to shed light on this issue he had chosen to go to Britain to see to what extent the new technology had been adopted by "the English and Scottish shipbuilders so known for their conservatism." He went on to say that his first impression of the British shipyards was rather depressing: as a whole the situation there resembled that of Sweden some ten to fifteen years earlier. However, there were exceptions, and the study trip had not been in vain; "Many novelties from the

81 Göran Måhlén, "Några rön från amerikanska varv", in *Götaverken*, No. 10 (1947), 24 ff.; John Wennerlund, "Intryck från Amerika", in *Götaverken*, No. 10 (1947), 40 ff.; Bo Ek, "Sektionsbygge av fartyg", *Teknisk tidskrift*, August 21, 1948, 513 ff.

82 Gustaf B. Thordén, *Alla mina skepp* (Göteborg, 1962), 97 ff.; Jan Hermansson, *Uddevallavarvet: Historien om 40 år i skeppsbyggnadens tjänst* (Uddevalla, 1994).

83 *Vem är det 1969* (Stockholm, 1968), 208.

84 Nils Eckerbom, "Intryck från studieresa till engelska och skotska varv våren 1947", unpublished travel report, Göteborg 1947, 1 (CTHB).

American building of warships have been transplanted to the well-tilled British soil and been able to take root.”⁸⁵ Several shipyards had successfully started welding and also bought many new machines from the United States. He had studied the use of automatic welding machines, where the British had developed a model of their own which was not as sensitive to wet weather as the American Unionmelt machine. This, of course, was important, given the British climate. Some shipyards had also built separate welding shops to facilitate prefabrication of sections indoors.

Eckerbom also commented on the British yards' approach to planning. Some of them had developed planning systems which had worked well and helped to rationalise the production process. He acknowledged the importance of planning but argued that it should not be carried too far: “Exaggerated and unrealistic planning easily results in laborious organisation, which can cause chaos after even minor disruptions.”⁸⁶

In a 1949 article Eckerbom described the production process in a modern shipyard laid out for the building of sections, illustrating his description with photos from Eriksberg. He began by giving an account of the expansion of Swedish shipbuilding during the last 30 years and argued that while output had grown fivefold, productivity had doubled. The increase in productivity was due to the introduction of new work methods and more efficient machines. He attached particular importance to electric welding and oxyacetylene cutting and maintained that the “latest link in this chain of rationalisation is sectional building.”⁸⁷ The advantages of prefabrication were obvious, he argued, in that work could be carried out under more favourable conditions, often even indoors, which meant that production was no longer dependent on the weather. Furthermore, the building of large units on the ground meant that welding work could be done more efficiently: “The financial and qualitative advantage of a horizontal position is greater in the case of welding than of riveting.” For example, it became possible to use automatic welding machines, whose speed had considerably increased productivity. All the new methods and devices had resulted in reduced times on the ways: at Eriksberg it had been possible to cut the building time at the berths from six months to three.

At the same time, said Eckerbom, the new methods brought better working conditions. One example of this was the fact that since work could be carried out in a horizontal position indoors it was less of a physical strain. Another aspect was that prefabrication made it possible to hire a larger number of less qualified workers. Whether he saw a chance here to reduce labour costs is not clear from the article. What he emphasised was that the professional requirements could be lowered, which meant that the time required to train new workers was shortened. This was important,

⁸⁵ Ibid., 5.

⁸⁶ Ibid., 9.

⁸⁷ Nils Eckerbom, “Sektionsbyggeri”, *Svensk Sjöfartstidning: Årsnummer*, 1949, 47.

he argued, since one of the major difficulties facing the shipyards at this time was a shortage of skilled workers.

The method of prefabrication implies specialisation. By dividing the work force into groups by section, with, for example, one group always working on plating sections, another on deck sections, and so on, the skills required in each group are reduced. In this way new labour can naturally become productive sooner.⁸⁸

A prerequisite for the use of prefabrication was that the shipyards were equipped with cranes and other handling equipment of sufficient capacity, he argued. The cranes had to be able to lift sections weighing 35 to 40 tonnes each. For production to flow smoothly, the sections had to be completed in the right order, which called for detailed planning.

Another advocate of the new technology was Karl Ringdahl. He had graduated in naval architecture from KTH in 1929, been in the United States for a few years and from 1932 worked for ESAB. In 1943 he came to the company's Stockholm branch and from 1945 he was as a specialist instructor in welding at KTH.⁸⁹ At a meeting of STF's section for naval architecture in December 1948, he discussed how a modern shipyard geared to the use of welding and prefabrication had to be laid out.⁹⁰ He argued that a shipyard which had been well suited for the production of riveted ships would be more or less hopeless for welding. The new shipyards needed very large storage areas, welding shops and buffer stocks, powerful cranes and other new equipment. To facilitate a straight and smooth flow of material the ideal welding shipyard should have a short waterfront and stretch a long way back from the shore. For older yards the opposite often was the case. Sometimes, it was not possible, for topographical reasons, to build a new shipyard of the necessary depth, but a yard with a U-shaped or L-shaped material flow was almost as good, since the number of transfers would be the same.

While it was easy to design a rational layout when a new welding shipyard was to be established, it was often very difficult to transform older yards into effective production plants. This problem was of great importance since shipbuilders in Europe, unlike those of the United States during the war, could not usually build new shipyards on virgin soil. Ringdahl therefore devoted the rest of his paper to a presentation of guidelines on how management could make improvements to their existing yards, with special emphasis on the dimensioning of different production and storage areas.

⁸⁸ Ibid., 49.

⁸⁹ Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 1210 f.; "Specialläraren i svetsteknik vid Kungl. Tekniska Högskolan utsedd", *Svetsaren*, May 1945, 64.

⁹⁰ Karl A. Ringdahl, "Om svetsvarvets arealbehov", *Svetsaren* 14:1 (1949), 1–19; For an account of the discussion which followed the paper, see the minutes from the meeting of the section for naval architecture and aeronautical engineering, December 8, 1948: Svenska teknologföreningen (RA); cf. idem., "Dimensioning the Standard Shipyard for Welding Production", *Svetsaren* 16:1 (1951), 23 ff.

Another person to discuss the merits of welding was Gerhard Berntson, chief engineer at Öresundsvarvet. He had graduated as a naval architect from Chalmers in 1925 and worked at Lindholmen from 1927 until 1944. In June 1948 he read a paper on the planning of shipyards to STF's section for naval architecture. He said that "the last decade has seen a veritable rush of rationalisation in the shipyards," something that was due to both favourable market conditions and the introduction of welding.⁹¹ However, as certain parts of the production process became more efficient, inefficiency in other parts became more visible: "As far as the plate shop is concerned, the fact is that the more the processing of the material is simplified by welding, the more important handling has become, because it has come to account for a higher proportion of the manufacturing costs." Berntson estimated that some 75 percent of the work on the steel, from the time it arrived at the shipyard until it was in place on the hull, consisted in transporting it. This also included moving plates into position so that they could be worked in machines. The remaining 25 percent went on the actual working of the material. He maintained that even a "relatively small reduction in handling costs means, therefore, large savings in labour costs and can justify considerable expenditure on improving efficiency. Low handling costs and short travelling times in the course of the work must be the prime objective when planning shipyard installations. This is [...] the basis of all the planning."

Above we have seen examples of how some engineers at the private shipyards gained knowledge from abroad of the new technology of welding and prefabrication. Furthermore, their positive attitude to welding as a production method has been indicated. What remains to be dealt with here is the engineer's opinions of the product itself, i.e. the welded ship – in fact, a prerequisite for the transformation of the shipyards was that shipbuilders, shipowners, representatives of classification societies and others gained confidence in such ships.

By 1950, welding had become established at the shipyards and prefabrication was spreading rapidly. But there was also an anxiety that the change might have gone too far, a fear that mounted with several failures of welded ships built at American shipyards during the war. Cracks had appeared in these ships. In a riveted ship a crack would stop when it reached the end of a plate or the hole of a rivet, but in welded ships it could continue all the way through the hull. Among the more spectacular accidents were some where large ships split into two halves. In addition to the issue of the reliability of welded joints, there were other questions, such as whether welded ships were more difficult to repair.

⁹¹ Gerhard Berntson, "Planering av varvsanläggningar", *Teknisk tidskrift*, November 20, 1948, 753.

The uncertainty was expressed at a meeting of engineers arranged by ESAB in 1950 with the title "Has recent experience confirmed that all-welded ships are the ships of the future?"⁹² There were five introductory speakers, representing different parts of the shipbuilding system, and in their comments it is possible to identify two sets of interests: those of the producers and those of the users.

The former, emphasising all the merits of welding, were mainly represented by Per Stenberg, chief engineer at Kockum. He began by stressing that "from the point of view purely of design, a welded steel construction offers greater scope for effective use of the material than any other method of assembly can give."⁹³ Therefore, the all-welded ship ought to be the ship of the future. That many people still doubted this was a result of the serious cracks that had developed in many ships built during the war. However, one had to accept that new technology had its teething troubles: "The welded vessel is in a great many ways a different species from the riveted one, and one cannot expect even the most skilled designer to be able to go over from one method of assembly to another without any mistakes at all." The pressures of the war, with demands for an ever-increasing pace of production, had added to these difficulties. On the other hand, with time, shipbuilders had learnt to avoid many faulty designs.

Stenberg went on to say that he had heard people stating that "repair of damage to all-welded vessels would be exceptionally difficult to carry out, require longer than similar jobs on riveted vessels and also contain a certain feeling of uncertainty concerning the quality of the repair work."⁹⁴ In his work at Kockum he had had a chance to compare damage to welded ships with damage to riveted ships of the same type and size. The comparison was to the advantage of welding, not least because the welded ship could withstand considerable deformation without springing leaks. This saved money since the shipowner did not have to take immediate action to unload the cargo in the nearest port but could let the ship continue to its destination. The fact that the cost of repairing a welded ship might be somewhat higher than that of repairing a riveted ship was therefore of minor significance. After discussing the importance of using steel of suitable quality, he enthusiastically concluded that "welding and the execution of designs that are technically correct from a welding point of view contain so much that is sound and genuine, that progress will inexorably continue as it has hitherto."⁹⁵

Two spokesmen for the user side were the engineer David Lindahl, technical manager of the shipping company Transatlantic, and Allan Zander, an engineer working for the maritime insurance company, *Sveriges Ångfartygs Assuransförening* (the Swedish Steamship Assurance Club). They both acknowledged that welding offered many advantages but argued that there were also disadvantages.

92 "Har senare års erfarenheter bekräftat, att helsvetsade fartyg är framtidens fartyg?", *Svetsaren* 15:2–3 (1950), 31–74.

93 Ibid., 32; For a biographical note on Per Stenberg, see: "Sjösäker doktor hos Kockums", *Ny Teknik* 1968:5, 12 f.

94 "Har senare års erfarenheter", 35.

95 Ibid., 43.

Lindahl said that even if the difficulties involved in repair work would not be “exceptionally great,” as Stenberg had heard people predict, there would indeed be difficulties.⁹⁶ He mentioned that when a riveted ship had suffered bottom damage in the form of buckling it was only necessary to take the plates apart, straighten them and put them back again. In a welded ship, on the other hand, the only way to remove the plate was to cut it off with flame cutters which meant that it would be too small to put back again and would have to be replaced with a new one. With this in mind his company had chosen to have its ships’ bottom plating riveted while welding was used extensively in the rest of the hull. Lindahl concluded that the question of whether all-welded ships were the ships of the future could not be answered with a simple “yes” or “no.” The advantages and disadvantages of the new technology had to be weighed against each other. In his opinion the best result would be achieved if some parts were welded, while others were joined by riveting.

Allan Zander argued that the major drawback with welded ships was the risk of crack formation. Even if engineers gradually learnt how to design certain parts of the ship in order to avoid crack initiation the ship would still be very sensitive to faults: “this sensitivity to the slightest design or production fault seems to me to be a definite weakness in the welded vessel. For certain shortcomings in these respects can surely never be avoided.”⁹⁷ In his opinion it was important to find steel material which was less sensitive to cracking. Also a certain amount of riveting should be retained, so that the riveted joints would function as “crack-arresters,” preventing the crack from spreading. On the question of repair costs, Zander argued that it was often more expensive to repair a welded ship than a riveted one. It also took longer, which meant that the shipowner lost freight revenue. He was also critical of Stenberg’s comparison of welded and riveted ships, since every accident was unique. It was risky to base an opinion on only a few events, not the least in an economic respect, since “the course of events and other circumstances of different wrecks are very seldom fully comparable.”⁹⁸

Zander ended his contribution by saying that despite the objections to welding which he had presented he was “firmly convinced that we are moving towards increased use of welding in shipbuilding” and that “a return to a predominance of riveting is inconceivable.”⁹⁹ As an insurance man, however, he emphasised the importance of not proceeding too fast in the application of the new technology and of showing some caution, for instance in keeping some riveted joints on board and not “going to extremes to save weight.”¹⁰⁰

To conclude, we have found that engineers working in the shipbuilding system differed in their opinions on welding. Those working at the shipyards were quick to come out in favour of welding, while engineers working for other organisations were

⁹⁶ Ibid., 58 ff.

⁹⁷ Ibid., 67.

⁹⁸ Ibid., 68.

⁹⁹ Ibid., 70.

¹⁰⁰ Ibid., 71.

apparently less enthusiastic about the new technology. While disagreeing on the extent to which welding should be used, however, they all seem to have agreed that welding was a good thing and belonged to the future.

We might ask what interest the engineers working at the shipyards had in welding and prefabrication. The authors of the articles above consistently show a strongly production-oriented thinking. Of course, they also emphasised aspects such as financial considerations and the advantages of reducing the need for highly skilled workers. But the key was the production process: that material flowed efficiently through the plant, that production could go on regardless of the weather, that the shipyards were able to employ enough workers and so forth. It should be noted that from the end of World War II until the late 1950s it was a seller's market and the golden age of Swedish shipyards. This situation was not unique to shipbuilding. After the war, when much of Europe lay in ruins, Sweden's industry was intact and "could sell everything it could produce." The critical problem was how to increase production.

4.4 Concluding remarks

In this chapter we have studied how engineers were organised in professional societies both on a national and on a local level. Within the Swedish Association of Engineers and Architects and the Gothenburg Technical Society, engineers met with colleagues from various parts of the shipbuilding system, listened to speeches, discussed the issues of the day, and socialised. At the meetings of the Swedish Shipbuilders' Association the leading engineers of the system met and discussed the industry's problems. The associations functioned both as forum for the exchange of *knowledge* and *experience* between the engineers and as channels for establishing and maintaining influential personal *networks*.

As regards the flow of knowledge between the members, the discussions concerned various topical matters of naval architecture. While the question in the early 19th century of how to revive the industry offered a picture of discussions on a more general level, the account of the engineers' opinions of welding and prefabrication gave an illustration of the more technical discussions.

Following the discussions at the meetings, this chapter has also considered what *interest* the engineers as a group may have had in different questions. In the debate on how to revitalise the industry in the early 20th century we found both personal interests and a broader national interest. Within the larger group of engineers in the field, however, there were often sharp differences of opinion, whether they concerned the quality of Swedish labour or the extent to which the shipyards should introduce prefabrication.

On many questions engineers' opinions divided according to the organisational context, that is according to who employed them. Here, we can identify a *producer interest* and a *user interest*. While engineers at the shipyards saw welding as superior to riveting, engineers representing shipping and maritime insurance saw to their organisations' interests and argued that some riveting should be retained in order to facilitate repair and to minimise the risk of failure. As we shall see in the next chapter, a similar dividing line between a producer and a user interest was present in the relationship between engineers working for private shipyards and naval engineers representing the Naval Material Administration.

Despite all these differences, however, it must be emphasised that on the whole there was a broad consensus among the engineers who expressed their opinions at the meetings: they all wanted a flourishing shipbuilding industry within the nation's borders; they saw specialisation as essential in order to arrest the decline of the industry; whether they represented shipping companies or shipbuilders they acknowledged that welding was here to stay. The members of the group also often expressed great confidence, not least in emphasising that one of the major competitive advantages of the shipbuilding industry was the high quality of Swedish engineers.

After having followed the engineers through their initial theoretical and practical training, and studied their activities within professional associations, it is now time to see where in the Swedish shipbuilding system they came to work and what positions they gained there.

5. Engineers in the Swedish Shipbuilding System

For the engineers in their role as a social group of technology carriers the companies and other organisations in which they did their daily work offered the resources necessary to influence the shaping of the system. As we shall see in this chapter, engineers came to work not only at the shipyards but in most other parts of Swedish shipbuilding as well.

Viewing the industry as a sociotechnical system, with all its components contributing to its functioning, several categories of organisations can be identified: producers (the shipyards), organisations laying down rules and regulations for the building of ships (the National Ships' Inspectorate and the classification societies), users or customers (shipping companies and the Naval Material Administration), and other supportive functions (technical colleges, research institutes, etc.). The extent to which engineers came to work for these organisations will be discussed in this order. It is also of interest here to study the different positions within the hierarchy of the organisations that the engineers acquired, what influence they gained and on what grounds they were able to reach these positions.

For an overview of the engineers' presence in the system we shall begin with a statistical account of the dispersion of naval architects. Then, in Sections 5.2 to 5.8, the different categories of organisations will be examined in detail.

5.1 Dispersion of naval architects

The aim of this section is to indicate what kind of organisations the engineers came to work for, rather than to give a complete picture of their dispersion in the shipbuilding system throughout the period. Consequently, I have chosen to include only those who graduated from the school of naval architecture at Chalmers between 1888 and 1927, the first forty years of the school's existence, and at KTH between 1900 and 1929, the first thirty years.¹

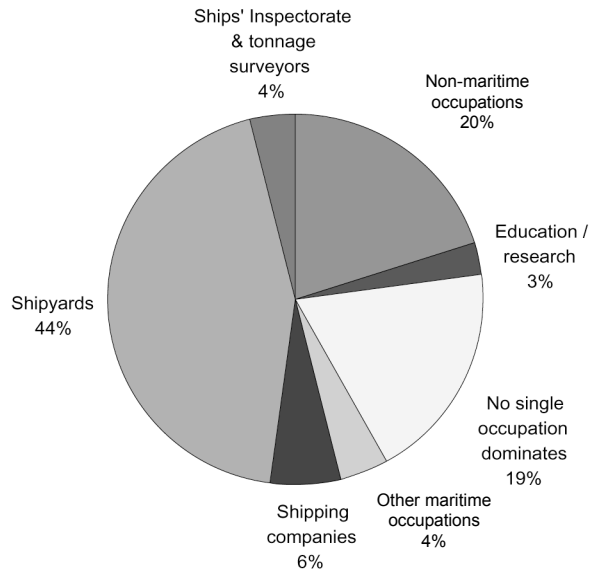
¹ The names of the Chalmers naval architecture graduates are in the annual reports of the Chalmers Institute of Technology (published under different titles over the years). The directory of Chalmers graduates between 1829 and 1929, *Chalmers Tekniska Institut: Matrikel 1829–1929* (Göteborg, 1929), edited by Gösta Bodman, has information on the individual careers of the naval architects. On the careers of the naval architecture graduates from KTH, see Govert Indebetou & Erik Hylander, eds., *Svenska teknologföreningen 1861–1936: Biografier*, vols. I–II (Stockholm, 1937). Details of the careers of those who graduated in the 1910s and 1920s are necessarily incomplete as the information in the two directories only covers the period before their publication in 1929 and 1937. For Chalmers additional information has been obtained from the annual directory of *Chalmersska Ingenjörsföreningen* (the Chalmers Alumni Association) and for KTH from the annual directory of the Swedish Association of Engineers and Architects. For both schools, further

Chalmers graduates 1888–1927

Figure 5.1 below shows the dispersion of graduates in naval architecture from Chalmers into different categories of organisations within the field as well as the proportion working outside the field. The figure illustrates the different categories of organisations in which they spent the greater part of their careers, that is twenty years or more. Foreign experience is also included. The men listed under the title 'No single occupation dominates' are those who did not work for twenty years in any single category – maybe they died young or worked, for instance, fifteen years at shipyards, fifteen years for shipping companies and ten years as consultants. 'Non-maritime occupations' are those outside the production system of shipbuilding. The title 'Other maritime occupations' includes people working for the Navy, i.e. the Naval Material Administration or the Navy yards, suppliers or maritime insurance companies, or as consultants. Table 5.1 shows the proportion of those who graduated between 1888 and 1927 who at some time in their careers worked for certain kinds of organisations within the shipbuilding system.

information has been obtained from various sources, such as biographical reference books (see the list of literature), notes in journals etc. As a result I have been able to reconstruct the careers of 98 percent of the naval architects from Chalmers and 86 percent from KTH, which is an adequate basis for the conclusions drawn here. On the reliability and usefulness of Bodman, Indebetou & Hylander, and other biographical registers as material for statistical investigations, see: Rolf Torstendahl, *Dispersion of Engineers in a Transitional Society: Swedish Technicians 1860–1940* (Uppsala, 1975), 46–84.

Figure 5.1 The dispersion of graduates in naval architecture from Chalmers between 1888 and 1927 into different parts of the shipbuilding system (as regards the greater part of their careers)



Sources: Bodman, Chalmers Tekniska Institut: Matrikel; the annual directory of the Chalmers Alumni Association; additional biographical directories.

Table 5.1 The proportion of graduates in naval architecture from Chalmers between 1888 and 1927 who at some time during their careers, after graduation, worked in certain organisations within the shipbuilding system

Shipyards	90 %
Shipping companies	15 %
Consultant firms	15 %
Education	13 %
Ships' Inspectorate & tonnage surveyors	10 %
Navy	6 %
Classification societies	5 %
Maritime insurance	1 %

Sources: Bodman, Chalmers Tekniska Institut: Matrikel; the annual directory of the Chalmers Alumni Association; additional biographical directories.

The most common workplaces of the naval architects from Chalmers were the private shipyards – 44 percent worked there for the greater part of their careers and as many as 90 percent worked there for some time after graduation. Most of the engineers worked at the larger shipyards – Götaaverken, Kockum, Lindholmen, Eriksberg, Finnboda and Öresundsvarvet – but several also found employment at medium-sized and small yards.

Some of the naval architects worked for the shipyards' customers – shipping companies or the Navy. The proportion who spent the greater part of their careers working for shipping companies was 6 percent. If all who worked there at one time or another are counted the proportion rises to 15 percent. As will be discussed in Section 5.5 most of these engineers came to work in the companies' technical departments. In contrast to the KTH engineers rather few Chalmers graduates came to work for the Naval Material Administration or at the navy yards, only one person working there for the greater part of his career and 6 percent at some time during their careers.

As can be seen in Figure 5.1, 3 percent spent the greater part of their working lives as teachers or researchers. The proportion rises to 13 percent if all who taught at some time are counted. This group was composed both of those who had teaching as their full-time occupation and of engineers, working in different parts of the system, who taught as a job on the side. The schools where naval architects taught were Chalmers, schools of nautical studies in Gothenburg, Malmö and Härnösand, and various vocational schools, among them the Gothenburg School of Arts and Crafts.

Only two men worked as consultants for more than twenty years – in Figure 5.1 they are listed under other maritime occupations. However, many more – 15 percent – worked as consultants for some time. Often the consultants also worked as surveyors for the classification societies. While 5 percent worked full-time at some time or another for the classification societies, the total number of graduates who worked for these organisations was therefore higher.

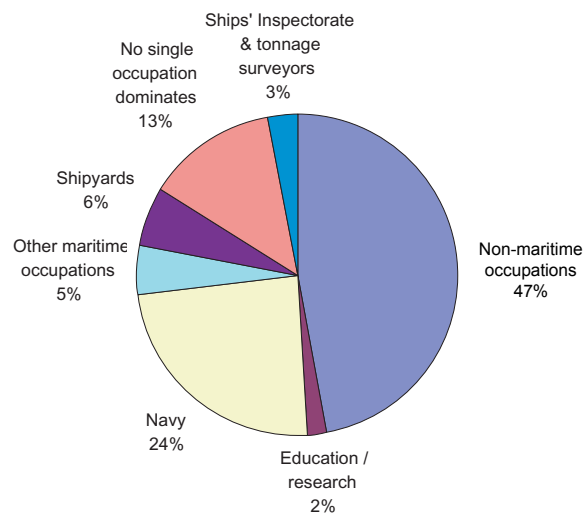
In addition to engineers working for classification societies there is one other group who were engaged in regulatory activity with regard to the building of safe and seaworthy ships – those who worked as government inspectors, both locally and centrally at the Ships' Inspectorate of the Swedish National Board of Trade. As can be seen above, 4 percent worked in this field for most of their careers and 10 percent did so at some time. Included in this group are also those who worked on tonnage measurement.

Some 20 percent of the naval architects spent the greater part of their careers working outside the field of shipping and shipbuilding. These were often employed in the metalworking and engineering industries.

KTH graduates 1900–1929

As may be seen in Figure 5.2 the dispersion of naval architects graduating from KTH shows a different pattern from that of Chalmers graduates. The most marked differences are in the numbers of people working for the Navy, at private shipyards and outside the maritime field. The title 'Other maritime occupations' covers people working as consultants or working for shipping companies, maritime insurance companies, classification societies etc.

Figure 5.2 The dispersion of graduates in naval architecture from KTH between 1900 and 1927 into different parts of the shipbuilding system (as regards the greater part of their careers)



Sources: *Indebetou & Hylander, eds., Svenska Teknologföreningen; additional biographical directories.*

Table 5.2 The proportion of graduates in naval architecture from KTH between 1888 and 1927 who at some time during their careers, after graduation, worked in certain organisations within the shipbuilding system

Shipyards	68 %
Navy	47 %
Education	20 %
Shipping companies	8 %
Ships' Inspectorate & tonnage surveyors	6 %
Consultant firms	4 %
Classification societies	3 %
Maritime insurance	2 %

Sources: *Indebetou & Hylander, eds., Svenska Teknologföreningen; additional biographical directories.*

A large proportion of the naval architecture graduates from KTH came to work for the Navy, which meant working for the Royal Naval Material Administration or at the navy yards. The majority of these engineers belonged to the Corps of Naval Engineers. The figure shows that 24 percent of the graduates spent the greater part of their careers working for the Navy. If all who at some time during their careers worked there are counted the proportion rises to 47 percent.

In sharp contrast to the graduates of Chalmers, among those who graduated in naval architecture from KTH only 6 percent spent the greater part of their careers working at the private shipyards. Approximately two-thirds of all graduates worked there at some time – this figure also includes the future naval engineers who, after they had left KTH, had to work for some years at shipyards, in Sweden or abroad, to qualify for admission to the Corps of Naval Engineers.

As many as 47 percent of the graduates worked most of their careers outside the shipbuilding system. They found their way into both the public sector and private industry. Among those who took jobs in private industry, the greatest proportion worked in companies producing pumps, diesel engines, cars, railway equipment, ball bearings, etc.

About 20 percent of the graduates worked in the civilian public sector, for instance for the Ships' Inspectorate of the National Board of Trade, the Swedish Patent and Registration Office, the State Railways, the Telecommunications Administration and as teachers in various schools. As with the Chalmers engineers, among the naval architecture graduates from KTH who became teachers we find both those who worked full-time as teachers and those who taught as a second job. They taught at KTH, Chalmers, schools of nautical studies in Stockholm, Gothenburg, Malmö and Härnösand, various vocational schools and military schools such as the Royal Naval College and the Royal Naval Staff College. At the latter two schools members of the Corps of Naval Engineers were employed as teachers. Some 20 percent of the

naval architecture graduates taught at some time during their lives and 2 percent did so for more than 20 years.

A few of the KTH engineers worked at one time or another for other organisations in the shipbuilding system – 8 percent for shipping companies, 4 percent as consultants, 2 percent for maritime insurance companies and 3 percent for classification societies. Of the graduates, 3 percent worked at the Ships' Inspectorate or as tonnage surveyors within the National Board of Trade for more than 20 years while 6 percent worked there some time in their careers.

To conclude, the most striking difference between the Chalmers and the KTH graduates was that the former came to dominate in the production category, that is the shipyards, while the latter completely dominated in one of the user organisations – the Naval Material Administration. It should also be noted that a large proportion of the naval architects from KTH spent their working lives in other industries.

5.2 Private shipyards

The private shipyards were large units, which were the dominating components of the production system. This, together with the number of naval architects who came to work for the shipyards for some time, or even the larger part of their careers, makes it natural to begin our examination of the engineers' positions within the system here.

Until the 1920s, newly graduated engineers often worked at foreign shipyards before taking employment in the Swedish shipbuilding system. After returning to Sweden and working there for a few years, many of them rose to leading positions at the shipyards. The nature of "the leading positions" differed between the companies, not least depending of the size of the company, but some common features can be identified (the following refers primarily to the interwar period).²

At the larger shipyards the top executives were an engineering manager and a commercial manager, of whom one was the managing director. Götaverken, for its part, had a chief manager who was above both such managers and was managing director. At medium-sized and small yards, one person usually held both the positions of engineering and commercial manager and was the managing director of the company. At the next level in the hierarchy we find positions such as chief draughtsman and shipyard engineer. The larger shipyards often had one chief draughtsman for the ship department and one for the engine department.³ While the chief

² For information on the different management positions at the shipyards and who held them, see: "Chefsplatser vid varven", *Teknisk tidskrift: Skeppsbyggnadskonst*, February 26, 1919; "Varv och verkstäder", published annually in *Teknisk tidskrift: Skeppsbyggnadskonst*, 1922–1941.

³ A detailed account of work at the drawing offices at Götaverken (in the early 1970s; the situation, however, was to a large extent the same for earlier periods) is presented in: Edgar Nilsson & Jan Nilsson, *Varvet: Samverkan i arbetslivet* (Stockholm, 1975), 14–65.

draughtsman headed the work at the drawing offices, the shipyard engineer was head of the production plant. The people with the above-mentioned leading positions often also held the title of chief engineer.

From our perspective the interesting question is to what extent college-trained engineers obtained the leading positions at the shipyards. Earlier, technologists with a shorter technical education, for instance people who had acquired their theoretical training at technical upper secondary schools and had worked for a long time in the field, had been the ones who advanced to the leading positions. However, the period from the turn of the century until about World War II was a transitional time when such posts increasingly came to be held by college-trained engineers. The process started earlier at some shipyards than at others. For instance, at Götaverken most top and middle management positions were held by graduate engineers by 1910.⁴ At Kockum, on the other hand, non-college trained technologists held several middle management positions, such as chief draughtsman, well into the 1930s and 1940s.⁵ At other large or medium-sized shipyards there was a gradual change, with engineers replacing technologists in leading positions mainly during the 1920s and 1930s. Of course, it was not necessarily an irreversible process. Even when engineers had held certain positions it was still possible for people who had worked their way up to acquire these jobs. However, as time went by this became less common.⁶

How influential did the engineers become? Were they powerful enough to be rightfully called a social group of technology carriers? As an indicator of their influence I have chosen to study the extent to which they acquired the very top position in their companies, i.e. that of managing director. As we shall see, they did so to a large extent.

Managing directors of the large shipyards

In this section we shall consider the extent to which engineers rose to top executive positions at the major Swedish shipyards. Table 5.3 contains a list of all the managing directors of the six major shipyards, extended beyond the strict time limits of this study in order to make changes over time more visible. Those classified as technologists are those who had practical technical experience and usually also some kind of shorter theoretical training in engineering. Naval architect – Nav.arch. – means a person who had a university-level engineering education in naval architec-

4 Note that the meaning of the term "middle management" used in this text differs from the one suggested by Alfred Chandler, see: Alfred D. Chandler, jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA, 1977), 381–414.

5 C. E. von Seth, ed., *Kockums Mekaniska Verkstads AB. Malmö, 1840–1940* (Malmö, 1940), 518–525.

6 Ibid.; "Varv och verkstäder", *Teknisk tidskrift: Skeppsbyggnadskonst*, 1922–1941; Gösta Kaudern, "Varvens behov av civilingenjörer och önskvärda kvalifikationer", unpublished manuscript, Malmö 1955, 5; "Nils Svenssons ämnesordnade handlingar": Götaverken (CKG); "Förändringar i styrelse och ledning", *Skeppsbyggaren* 1957:2, 4 f.; "Utnämningar", *Skeppsbyggaren* 1964:3, 14 f.

ture from Chalmers or KTH. School and year of graduation are shown in brackets. Mechanical, chemical and mining/metallurgical engineers are presented in the same manner. The classification “economist” refers to a person with practical experience, and sometimes also a shorter theoretical education, in economics and commerce. Those labelled economists with a university-level education are those who had graduated from a school of economics and business administration. Those managing directors who only supervised the closing down of the shipyards in the 1970s and 1980s are not included in the table.

Table 5.3 Managing directors of the five major shipyards in the 19th and 20th centuries⁷

Eriksberg	
1853–1904, David W. Flobeck	Technologist
1904–1917, Erik Flobeck	Technologist
1917–1948, Gunnar Engberg	Technologist (see comments below)
1948–1961, Erik Häggström	Nav. arch. (Chalmers, 1919)
1961–1971, Sven Häggqvist	Economist
1971–1974, Bengt Eneroth	Economist, univ. level (1941)
1975, Per Alsén	Nav. arch. (KTH, 1940)
Götaverken	
1841–1867, Alexander Keiller	Technologist
1867–1906, James Keiller	Technologist
1906–1910, Sven Almqvist	Technologist
1910–1938, Hugo Hammar	Nav. arch. (Chalmers, 1888)
1938–1944, Ernst A. Hedén	Nav. arch. (Chalmers, 1898)
1944–1946, Hugo Heyman	Mech. eng. (Chalmers, 1909)
1947–1957, Karl Erik Jacobson	Economist
1957–1964, Hilding Nielsen	Nav. arch. (KTH, 1923)
1964–1970, Nils Svensson	Nav. arch. (Chalmers, 1931)
1971, Ivar Nordén	Nav. arch. (Chalmers, 1942)
1971–1976, Hans Laurin	Economist, univ. level (1952)
1976–1978, Erland Wessberg	Technologist
1978–1988, Rolf Bergstrand	Nav. arch (Chalmers, 1959)
Kockum	
1840–1866, Frans H. Kockum	Merchant
1866–1873, Gottfried Kockum	Technologist
1873–1883, Balthasar Münter	Technologist
1883–1904, Hjalmar Wessberg	Technologist

⁷ Note that for the 19th century, titles other than managing director were usually used to describe the top executive position.

1904–1936, Georg Ahlrot
 1936–1940, Frans H. Kockum
 1940–1958, Gösta Lundeqvist
 1958–1968, Nils Holmström
 1968–1978, Nils-Hugo Hallenborg
 1978–1979, Olafur Sigurdsson
 1979–1980, Christian Christiansson
 1981–1982, Ebbe Krook
 1982–1986, Göran Herslow

Nav. arch. (Chalmers, 1889)
 Foreign higher technical education
 Nav. arch. (KTH, 1915)
 Lawyer
 Economist, univ. level (1944)
 Nav. arch. (KTH, 1939)
 Economist, univ. level (1955)
 Economist, univ. level (1964)
 Economist, univ. level (1960)

Lindholmen

1845–1859, Theodor W. Tranchell
 1859–1885, Carl E. Norrman
 1885–1892, Emil Telander
 1892–1906, Sven Almqvist
 1906–1911, Johan Sjöholm
 1911–1922, Wilhelm Hök
 1922–1923, Pehr Perno
 1923–1926, Andreas Ljungman
 1927–1931, Erik W. Sundblad
 1931–1935, Oscar E. Johansson
 1935–1943, Hilding Nielsen
 1943–1954, Erik Larsson
 1954–1966, Gustaf Löwenhielm
 1966–1968, Nils Eckerbom
 1968–1970, Carl-Eric Carlson

Merchant
 Technologist
 Technologist
 Technologist
 Technologist
 Mech. eng. (KTH, 1880)
 Mech. eng. (KTH, 1898)
 Mech. eng. (KTH, 1894)
 Military officer
 Technologist
 Nav. arch. (KTH, 1923)
 Nav. arch. (Chalmers, 1921)
 Nav. arch. (KTH, 1928)
 Nav. arch. (Chalmers, 1939)
 Nav. arch. (Chalmers, 1947)

Uddevallavarvet

1946–1950, Erik Norberg
 1950–1951, Gustaf Thordén
 1951–1952, Olof Sahlin
 1953–1958, Helge Hagelin
 1958–1959, Josef Anér
 1959–1964, Tore Segerdahl
 1964–1975, Johan Schreil
 1975–1985, Ingvar Trogen

Nav. arch. (Chalmers, 1926)
 Shipowner, owner of the shipyard
 Mining/metallurgy (KTH, 1916)
 Nav. arch. (Chalmers, 1930)
 Economist
 Nav. arch. (Chalmers, 1923)
 Nav. arch. (KTH, 1941)
 Economist, univ. level (1951)

Öresundsvarvet

1915–1916, Arthur Du Rietz
 1916–1920, Carl Fritsch
 1920–1923, Franz Werner
 1923–1931, Johan Tygård
 1931–1944, Carl Ridell

Shipowner
 Shipbroker
 Foreign higher technical education
 Technologist
 Nav. arch. (Chalmers, 1899)

1944–1953, Hilding Nielsen	Nav. arch. (KTH, 1923)
1954–1965, Bertil Karlbom	Nav. arch. (Chalmers, 1926)
1965–1967, Gerhard Berntson ⁸	Nav. arch. (Chalmers, 1925)
1969–1970, Ivar Nordén	Nav. arch. (Chalmers, 1942)
1970–1972, Stig Isak Andersson	Mech. eng. (Chalmers, 1948)
1972–1980, Hans G. Forsberg	Chemical eng. (KTH, 1956) & Economist, univ. level (1960)

Sources: *Rinman*, Eriksbergs, 7–45; *Beckholmen*, Torpet; *Av bestående värde*, 32; *von Seth*, Kockums, 518; *Lindholmens varv*, 17–174; *Varvsbilder*, 125; *Svensk Sjöfartstidning*; *Svenska Varv AB: Årsredovisning*, (1977–86); *Berglund & Grönfors*, Handelshögskolan i Göteborg, 637–678; *Bodman*, Chalmers Tekniska Institut: Matrikel; *Chalmersska Ingenjörssällskapets Katalog 1946–1995*; *Harnesk*, Vem är vem i Stor-Stockholm; *Indebetou & Hylander*, eds., *Svenska Teknologföreningen*; *Pravitz*, Vem är vem inom handel och industri?; *Vem är det? (1917–1987)*; *Sveriges civilingenjörer, bergsingenjörer och arkitekter 1961*.

There is a clear pattern among the managing directors of the shipyards. The older companies – Eriksberg, Götaverken, Kockum and Lindholmen – were founded and also for many years, until the decade preceding World War I, led by people with a practical and often also a shorter theoretical technical education. From that time on, college-educated engineers entered the scene as managing directors and, with a few exceptions, they enjoyed a near monopoly of that position for about half a century.⁹ Most of these engineers had studied naval architecture at Chalmers or at KTH.

Eriksberg may seem to be an exception to this pattern but in fact its managing director between 1917 and 1948, Gunnar Engberg, had a background very similar to that of the other engineers. He graduated from the Norrköping technical upper secondary school in 1901 and then worked for two years at different engineering workshops in Sweden while also going to sea for some time. During the school year 1903–04 he took certain parts of the naval architecture degree programme at Chalmers and left the school with the highest average grade of all naval architecture students that year.¹⁰ Like the naval architects of his generation, after graduation from Chalmers he went to Britain, Germany and the United States. In the latter country he worked at some of the largest shipyards. It would therefore actually be more appropriate to place Engberg in the group of college-trained engineers than in the group of technologists.

Regarding Lindholmen, the company had, until 1935, managing directors who were not naval architecture graduates. This was probably due to the fact that Lindholmen and the engineering workshop Motala Verkstad were amalgamated between

⁸ Gerhard Berntson was yard manager; Nils Svensson, who was Götaverken's general manager, was formally managing director of Öresundsvarvet between 1965 and 1969.

⁹ The only major exception is K. E. Jacobson, who was managing director at Götaverken between 1947 and 1957. He had studied economics and worked at Götaverken since 1918.

¹⁰ Material on admission and grades: Betygs- och tentamensuppgifter 1903/04 & ansökningshandlingar: Chalmers University of Technology (GLA).

1920 and 1935 – from 1922 the head office was located in Motala – and that shipbuilding was only one activity among others. Two of Lindholmen's top executives during this period were, however, actually highly qualified naval architects. Wilhelm Hök, who was managing director between 1911 and 1922, had graduated as a mechanical engineer in 1880. After graduation he studied naval architecture in France and worked at shipyards in Britain before returning to work in the Swedish shipbuilding system (see also Section 4.1). Pehr Perno, managing director between 1922 and 1923, had worked as a naval engineer for some ten years when he became chief engineer at Motala Verkstad in 1913. As well as these two Erik Sundblad also had experience in the field of naval architecture, being a naval officer who had worked at the Naval Material Administration's torpedo department. He had also completed some studies in the subject at KTH between 1908 and 1910, although not a full degree programme. Andreas Ljungman and Oscar Johansson, on the other hand, had their backgrounds in the mechanical engineering industry. After the mid-1930s, when Lindholmen was separated from Motala Verkstad, naval architects became managing directors of the company.¹¹

Of the six shipyards, two were founded in the 20th century. Öresundsvarvet, founded in 1915, follows the above pattern but with naval architects as executives from the early 1930s onwards. Uddevallavarvet, which was founded in 1946, had college-trained engineers as managing directors from the start except for a short period, seven months, in the early 1950s when the shipowner and owner of the yard, Gustaf Thordén, was himself managing director. When Uddevallavarvet was in financial difficulties in the late 1950s, Josef Anér, who was an economist without shipbuilding experience, functioned as managing director for a transitional period.¹²

From the late 1950s until the 1970s the engineers' monopoly-like position as top executives was broken. At this time non-engineers, mainly economists, became managing directors – at Kockum in 1958, Eriksberg in 1961, Lindholmen in 1970 through the merger with Eriksberg, Götaverken in 1971 and Uddevallavarvet in 1975. Öresundsvarvet might appear to be an exception but its managing director between 1972 and 1980, Hans G. Forsberg, had both a higher technical education and a university-level education in economics and business administration. During the crisis of the 1970s and 1980s, when the shipyards were closing down one after another, there is no clear pattern in the educational background of the executives: they were economists as well as engineers.

We might ask why college-trained engineers replaced technologists as managing directors in the first decades of the 20th century and about half a century later were themselves replaced by economists. As mentioned in the Introduction, Conny Norling has suggested a framework for studying power shifts between professional groups in industrial life, with emphasis on how different kinds of knowledge may at different times be seen as critical resources, giving power to their carriers. In the present study I will not deal with the process whereby engineers were replaced by economists

¹¹ *Lindholmens varv 1845–1945* (Göteborg, 1947), 249–296; Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vols. I–II; Gunnar Pravitz, ed., *Vem är vem inom handel och industri?* (Stockholm, 1944).

¹² Josef Anér, *Magistern blev affärsman* (Stockholm, 1961).

as managing directors. It should, however, be pointed out that this is an important question for future historical research.

With the concept of critical resources I will touch upon the issue of why engineers became managing directors in the first place. What did they have that the technologists lacked? To shed some light on this issue it is appropriate to study, in detail, the careers of those engineers who became top executives in the early 20th century. The purpose is not to find any definite answer to the question above but rather to present some factors that might have been of importance. We shall start with Hugo Hammar, who became managing director of Götaverken.

The new business leaders

Hugo Hammar (1864–1947) was born on Öland, an island off the east coast of Sweden, as the seventh of twelve children.¹³ His father was a civil servant who had studied at the universities of Lund and Uppsala. After finishing secondary school in 1883, the young Hammar worked for two years as an apprentice plater at Kockum in Malmö. In September 1885 he was admitted to the School of Naval Architecture, then a part of the School of Nautical Studies in Gothenburg. For two years he studied mathematics, physics, ship design, etc. In 1887 the school merged with the Chalmers Institute of Technology. The naval architecture students who were going to graduate that year, among them Hammar, were offered the opportunity to study for an additional year at Chalmers. Then, in the spring of 1888, he graduated as the very first Chalmers engineer in naval architecture.

In the summer of 1887 Hammar had been on a study tour to shipyards in France and Britain. After graduating in 1888 he could not find work in Sweden and so went to England, where he first worked as a plater at Wigham Richardson, Wallsend. After a while he obtained a job as a draughtsman at Palmers Iron & Shipbuilding Co., Jarrow-on-Tyne. In October 1890 Hammar left England to go to America, not least because he wanted greater responsibility. He arrived in Boston and stayed there for six months at Harrison Loring, who at the time were building cruisers for the U.S. Navy. In May 1891 he left for Philadelphia to work at William Cramp & Sons, one of the leading shipyards in the country. By August the same year he was moving again, this time to New York, where he found employment in the construction department of the New York Navy Yard and stayed until March 1896. Then he went to work at the Newport News Shipbuilding and Dry Dock Company in Virginia.

In September 1896 Sven Almqvist, the managing director of the Lindholmen Shipyard in Gothenburg, wrote to Hammar offering him a job, since the company needed an engineer with experience of building warships. He accepted the offer and

13 Hugo Hammar, *Minnen I: Från Ölands Alvar till livets* (Stockholm, 1937); idem., *Minnen II: Som emigrant i U. S. A.* (Stockholm, 1938); idem., *Minnen III: I den svenska sjöfartsnärings tjänst*, ed. Lars Olsson (Göteborg, 1994); Sven Ohlson, "Hammar, Hugo Gilius Eugen", in *Svenskt biografiskt lexikon*, vol. 18 (Stockholm, 1969–1971); *Svenska män och kvinnor*; Magnus Fahl, *Göteborgs stadsfullmäktige 1863–1962, II: Biografisk matrikel* (Göteborg, 1963); Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vol. I, 284 f.; Bodman, *Matrikel 1829–1929*; "Hugo Hammar 1864–1947: Ur Föreningens '1864 års män' arkiv", unpublished manuscript: Hugo Hammar's archives (SMG).

returned to Sweden. From 1896 Hammar worked at Lindholmen as chief engineer, being involved in the building of both merchant vessels and warships. Following a change of ownership of the company in 1906, Hammar and Almqvist left Lindholmen and formed a consortium which took over Göteborgs Mekaniska Verkstad – the company later changed its name to Götaverken.

As we saw in Chapter 2, in the period up to the outbreak of World War I, the management transformed the company from an engineering works into a shipyard specialised in the building and repairing of ships, mainly merchant vessels. Important steps in Götaverken's subsequent evolution into the leading shipyard in the country were the decision to manufacture Burmeister & Wain diesel engines under licence in 1915, the building of eleven ore carriers for the mining company Grängesberg and, not least, the production of oil tankers for Norwegian shipowners from the mid-1920s onwards.

In 1910, when Almqvist retired, Hammar became the managing director of the company, a position he held until 1938. During these years he actively promoted Swedish shipbuilding in various ways. During World War I, for example, he was engaged in questions of supply of foreign steel material to the Swedish shipyards, and in the 1930s he was the driving force behind the establishment of the Swedish State Shipbuilding Experimental Tank.

Like many other industrial leaders, Hammar was a member of the boards of a large number of companies, organisations and professional associations, among them: ESAB, Nydquist & Holm, the Swedish Shipbuilders' Association, the Federation of Swedish Industries, the Metal Trades Employers' Association, the Swedish Employers' Confederation, the General Export Association of Sweden, the Swedish Committee of Lloyd's Register of Shipping, the Swedish Association of Engineers and Architects, the Gothenburg Technical Society, the Gothenburg Maritime Museum and the Royal Gothenburg Yacht Club. This gave valuable contact with representatives of other parts of the shipbuilding system, as well as with leaders of other branches of business.¹⁴ Hammar, who was an active lobbyist in parliament, was also a member of the Gothenburg City Council from 1914 to 1919. Moreover, he took a great interest in education, being a member of the boards of directors of Chalmers between 1921 and 1942, and the School of Nautical Studies in Gothenburg between 1914 and 1943.

An indication of the great prestige which Hammar, as a prominent business leader, enjoyed in Swedish industry and society was that he was several times called upon as an expert by various government commissions, which are very influential in Swedish political life. Furthermore, he himself was a member of committees and commissions examining, for example: the modernisation and enlargement of the Navy Yard in Karlskrona (1914 and 1916–1917), the naval base in Stockholm (1917

¹⁴ For an account of some of the more important nodes in Hammar's social network, see: Lars Olsson, *Engineers as System Builders: The Rise of Engineers to Executive Positions in Swedish Shipbuilding and the Industry's Emergence as a Large Technological System, 1890–1940* (Chalmers University of Technology, Department of History of Technology and Industry: Report 1995–2), 87–94.

and 1930), industrial democracy (1920), and the elevation of the Chalmers Institute of Technology to the rank of a technical university (1934).¹⁵

Hammar's career shares many common features with the careers of the other leading engineers at the shipyards, not least as regards education, foreign experience and membership of professional associations. If we compare Hammar with other top executives of the pre-World War II period, a general pattern as regards the backgrounds and careers is discernible. We may consider the careers of Georg Ahlrot (managing director of Kockum between 1904 and 1936), Gunnar Engberg (managing director of Eriksberg 1917–48), Ernst A. Hedén (deputy managing director of Göta-averken 1912–38, managing director 1938–44) and Wilhelm Hök (managing director of Lindholmen 1911–22).¹⁶ Hedén is included although he did not become a managing director until 1938 because, as deputy managing director of Göta-averken, he probably



Engineers as business leaders at Göta-averken in the interwar years. Three managers, who all were college-trained engineers, negotiate with three representatives of the workers; from the left: Hilding Hedenskoug (production engineer), Ernst A. Hedén (deputy managing director) and Hugo Hammar (managing director). (Photo: Varvshistoriska Föreningen)

¹⁵ Ibid., 90 f.

¹⁶ On the careers of these four, see: Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vol. I; Bodman, *Chalmers Tekniska Institut: Matrikel*; *Svenskt biografiskt lexikon*; *Svenska män och kvinnor*.

had at least as much influence on developments in the shipbuilding system as the managing directors of the other three shipyards.

The first column in Table 5.4 shows when the engineers were born and died, when they became managing director (MD) or deputy managing director (DMD), and the age at which they reached that position. Under “theoretical training” we find school and year of graduation (ÉPM – École polytechnique du génie maritime, Paris; TES – “teknisk elementarskola,” that is a technical upper secondary school). The last column shows the Swedish professional associations of which the engineers were members, with the year of admission; the abbreviations stand for: TSG – Tekniska Samfundet i Göteborg (the Gothenburg Technical Society), STF – Svenska Teknologföreningen (the Swedish Association of Engineers and Architects), SIK – Skånska Ingenjörsklubben (the Scanian Engineers’ Club).

Table 5.4 The new generation of managing directors at Kockum, Eriksberg, Göta-verken and Lindholmen in the early 20th century

	father's occupation	theoretical training	foreign experience	membership
Georg Ahlrot (1865–1944) MD 1904 (age 39)	clergyman	Chalmers 1889	Germany 10 years	SIK 1904 STF 1903
Gunnar Engberg (1884–1967) MD 1917 (age 33)	customs officer	Norrköp. TES 1901 Chalmers 1903–04/ not full programme	USA 3 years	TSG 1908 STF 1911
Hugo Hammar (1864–1947) MD 1910 (age 46)	civil servant	Chalmers 1888	Gt. Britain 2 years USA 6 years	TSG 1897 STF 1904
Ernst A. Hedén (1878–1944) DMD 1912 (age 34)	consul	Chalmers 1898	Germany 2 years USA 5 years	TSG 1907 STF 1914
Wilhelm Hök (1858–1933) MD 1911 (age 53)	district police superintendent	KTH 1880 ÉPM 1882–83	France 1 year Gt. Britain 17 years	TSG 1919 STF 1877

Source: Bodman, “Tekniska Samfundet”, 230–243; Indebetou & Hylander, eds., Svenska Teknologföreningen, 219, 284 f., 291, 557, 738; Skånska Ingenjörsklubbens ledamöter, 10.

Like Hammar, the other four engineers all came from small towns or rural areas and all had a middle-class background, their fathers being white-collar workers. After graduation from Chalmers or KTH they worked abroad, in Germany, the United States or Britain, for some years. Then they returned home and immediately acquired middle-management positions at the shipyards, for instance, as chief engineer or

shipyard engineer. Eventually they became managers and oversaw their companies' evolution into major internationally competitive shipyards. As managing directors they were members of several trade and employers' associations. They were also members of the boards of directors of different companies, schools etc. Like Hammar, Hedén was a member of the Gothenburg City Council, and Ahlrot was a member of the Malmö City Council. Being engineers interested in technology, they all were members of engineering associations and were frequent speakers and active members of these various boards and committees.¹⁷

We might ask in what way the careers of these engineers differed from those of their predecessors. A survey of the careers of the men who held the top executive positions at the four shipyards Eriksberg, Göteborgs Mek. Verkstad (Götaverken), Kockum and Lindholmen, before Engberg, Hammar, Ahlroth and Hök, shows that two based their position on proprietary interest (Erik Flobeck and Johan Sjöholm) while the other two were employed managing directors (Sven Almqvist and Hjalmar Wessberg).

Erik Flobeck (1873–1917) succeeded his father as the leader of Eriksberg in 1904 and held that position until 1917. Unfortunately it has proved impossible to ascertain his educational background. It is, however, clear that he had not graduated from Chalmers or KTH, and there are no indications that he had studied abroad. On the contrary, in 1893 he moved to Norrköping, which suggests that he studied at the technical upper secondary school there.¹⁸ What we know for sure is that from 1895 onwards he held a position as an engineer at Eriksberg.

The managing director of Lindholmen between 1906 and 1911, Johan Sjöholm (1851–1918), had graduated from the Malmö technical upper secondary school in 1869 and then worked at Swedish and foreign engineering workshops until 1874.¹⁹ After some years as works manager at Kristinehamns Mek. Verkstad, Sjöholm moved to Gothenburg where he and Henrik Lindfors, who eventually became professor of naval architecture at Chalmers, founded an engineering workshop in 1879. In 1906 the City of Gothenburg needed the land on which the workshop was located for enlargement of the port. With the money Sjöholm received for the estate, he was able to gain control over Lindholmen, holding the position as its managing director until 1911.

Two *employed* managing directors were Sven Almqvist and Hjalmar Wessberg. Sven Almqvist (1840–1931), managing director of Lindholmen between 1892 and 1906, and of Götaverken between 1906 and 1910, had studied at the Stockholm

17 Compare with Henry Nielsen's and Birgitte Wistoft's discussion of social networks among influential engineers and industrialists in late 19th and early 20th century Denmark: Henry Nielsen & Birgitte Wistoft, "Painting Technological Progress: P. S. Krøyer's The Industrialists", *Technology and Culture* 39 (1998), 408–433; idem., *Industriens Mænd: Et Krøyer maleris tilblivelse og industrihistoriske betydning* (Aarhus, 1996).

18 According to the parish registration for Lundby parish, where the Eriksberg shipyard was located, Erik Flobeck moved to Norrköping on February 24, 1893, "In- och utflyttningslängder", 1885–1894: Lundby Parish (GLA). Unfortunately, there is no directory of graduates from the Norrköping technical upper secondary school, see: Torstendahl, *Dispersion of Engineers*, 47.

19 Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vol. I, 143 f.; Fritz Schéel, "Från sekelskiftet till andra världskriget", in *Lindholmens varv 1845–1945* (Göteborg, 1947), 217 f.

School of Arts and Crafts in 1854–55 and then taken certain courses at the Technological Institute the following year.²⁰ After working as a bricklayer in the summer of 1856 he began what was probably the best practical engineering training of the day, with a Swedish Ironmasters' Association scholarship at Motala Verkstad. The training lasted for several years; first he worked four and a half years in the workshops and the foundry and then seven years in the drawing office. In 1869 he became a designer at the Lindholmen shipyard, which was then a part of the Motala Verkstad group. He stayed there until 1877, when he returned to Motala as chief engineer, a position he held for 15 years.

Hjalmar Wessberg (1845–1904), managing director of Kockum between 1883 and 1904, had graduated from Norrköping technical upper secondary school in 1865 and then worked within the Motala Verkstad group, eventually in leading positions, until 1882.

Table 5.5 shows the four men who were the managing directors of Lindholmen, Eriksberg, Götaverken and Kockum at the turn of the 20th century. The abbreviations stand for: SthlmS – Stockholms Slöjdskola (the Stockholm School of Arts and Crafts), TI – Teknologiska Institutet (the Technological Institute), TES – teknisk elementarskola (technical upper secondary school), TSG – Tekniska Samfundet i Göteborg (the Gothenburg Technical Society), STF – Svenska Teknologföreningen (the Swedish Association of Engineers and Architects), SIK – Skånska Ingenjörsklubben (the Scanian Engineers' Club).

Table 5.5 The earlier group of managing directors of the four shipyards Lindholmen, Götaverken, Eriksberg and Kockum in the late 19th and early 20th centuries

	father's occupation	theoretical training	foreign experience	membership
Sven Almqvist (1840–1931) MD 1892 (age 52)	factory owner	SthlmS 1854–55 TI 1855–56/ not full programme	no	TSG 1892
Erik Flobeck (1873–1917) MD 1904 (age 31)	factory owner	–	no	TSG 1902 STF 1911
Johan Sjöholm (1851–1918) MD 1906 (age 55)	blacksmith	Malmö TES 1869	abroad 4 years	TSG 1885 STF 1909
Hjalmar Wessberg (1845–1904) MD 1883 (age 38)	district court judge	Norrköp. TES 1865	no	SIK 1887 STF 1888

Source: Harald Almqvist, "Sven Almqvist 1860–1910, 5–89; Bodman, "Tekniska Samfundet", 231–254; *Indebetou & Hylander, eds*, Svenska Teknologföreningen, 99, 143 f., 428; Skånska Ingenjörsklubben 1887–1937, 19.

²⁰ Harald Almqvist, "Sven Almqvist 1860–1910: Ett halvsekel i skeppsbyggeriets tjänst", *Unda Maris* 1967–1968, 5–89; idem., "Lindholmen – Motala", *Unda Maris* 1975–1982, 7–36.

The careers of Almqvist, Flobeck, Sjöholm and Wessberg show a somewhat different pattern from that of the college-trained engineers. The three that we know about all had some kind of theoretical technical training. The practical training, however, was of crucial importance for reaching the top; they had begun their careers on the workshop floor and then worked their way up. Another difference was their lack of foreign experience – only Sjöholm had worked abroad. Wessberg and Almqvist had only been abroad on shorter sales or study trips, mainly to Russia, and they did so only after they had gained leading positions within the companies they worked for. This stands in sharp contrast to the college-trained engineers, who went abroad early in their careers, to gain experience, and who went to the leading industrial countries.

A further difference concerns membership of professional associations. While the engineers had usually become members before reaching top executive positions, the technologists of the earlier period more often became members after they had become managing directors. A reason for their failure to become members earlier, at least of the Swedish Association of Engineers and Architects, may be that without having graduated from KTH or Chalmers, one had to have gained a leading position in Swedish industrial life to be elected. The point here, however, is that membership is therefore unlikely to have played any role in their advancement. In the case of the college-trained engineers, on the other hand, who usually became members several years before becoming managing directors, membership could have helped them to rise in the ranks, both as a result of the knowledge they gained at the meetings and in the journal, and through the making of contacts with other people in the system.

This discussion suggests that the most striking aspects of the critical resource, which the graduate engineers may have had and which the non-graduates lacked, were the quality and scope of their college education in engineering, including the more informal aspects such as early on becoming part of influential social networks, and their foreign experience.

Regarding the importance of foreign experience, it is difficult to find any qualitative sources supporting the argument that it was crucial to the engineers' careers. An exception is a statement of Hugo Hammar. In the late 1930s, looking back over his life, he emphasised the importance of ideas from abroad and the United States in particular, brought home by Swedish engineers. Knowledge and ideas from other countries had become of great importance, both to the returning engineers personally and to the organisations they worked for; Hammar stated that many large Swedish industrial companies "have as their driving forces and in many cases their heads men who in one way or another have received impulses out there, which have led them themselves and the industry for which they work to the very foremost rank."²¹

²¹ Hammar, *Minnen II*, 79.

The power of the employed managing directors

The next question, having found that engineers became managing directors of the shipyards, is to evaluate how influential they really were in that capacity. It is of interest here to find out whether they were free to develop their companies as they pleased or whether there were others, such as strong owners, who took the major decisions. Before dealing with these questions there is reason briefly to reflect upon the subject of how influential managing directors were in Swedish industry generally.

Jan Glete argues that the power of the employed managing directors in Swedish industry reached its peak in the first half of the 20th century. In the absence of strong owners the management dominated the majority of the larger companies. "The power over the industrialised Sweden that grew up in the early twentieth century lay to a large extent with the independent and vigorous business leaders who knew new industrial technology, new forms of organisation of large-scale enterprises and new forms of industrial marketing."²²

Glete attributes the influential position of the employed managers to the status of engineers and business organisers in industrial society. "Shareholders, banks and leading sectors of society saw the successful leaders of industrial companies as key persons in the increase of wealth and dividends."²³ In the period after the 1950s, however, the power of the managing directors decreased somewhat as strong owners gained control of an increasing proportion of industrial companies.

Returning to Swedish shipbuilding we shall begin by studying conditions at Göta-averken. This company clearly represents the tradition of powerful employed managing directors described above. In 1916 the shipowner Dan Broström bought the majority holding in Göta-averken, a year after buying another shipyard, Eriksberg. Until his death in 1925 he contributed the necessary capital for enlargement of the shipyard. He was also chairman of the board of the company from 1917 onwards. The management was, however, given a large degree of freedom and Broström did not change the established long-term policy.²⁴

Some years after his death the heirs needed money to consolidate the shipping concern and decided to sell the shares in Göta-averken. In 1931, the Göta-averken board, led by Hugo Hammar, bought the majority of the shares through a holding company, Förvaltnings AB Gilius – Gilius was Hammar's middle name. Those who were given opportunity to buy shares in Gilius were the management and certain departmental heads at Göta-averken, shareholders in Tirfing, which was the parent company of the Broström shipping group, and other "close friends of Göta-averken." A clause in the articles of the company provided that if shares were to be sold, for

²² Jan Glete, *Nätverk i näringslivet: Ägande och industriell omvandling i det mogna industrisamhället 1920–1990* (Stockholm, 1994), 294.

²³ Ibid., 295.

²⁴ *Göta-averken*, No. 1 (1924), 3 ff.; *Göta-averken*, No. 7 (1938), 2 f.; Kent Olsson, *Från pansarbåtsvarv*, 381 f.

instance if a shareholder died, they had first to be offered to the other shareholders. As time went by and new people acquired leading positions in the company, they too were offered the opportunity to buy shares.²⁵ In this way, the already strong position of the Götaverken management became entrenched. The holding company retained a controlling interest in Götaverken until 1971 when the Salén shipping group took over the shipyard.

Regarding the other shipyards, it is difficult to evaluate the power of the employed managing directors, but it is reasonable to assume that they had less influence than their counterparts at Götaverken. At Kockum, the owning family had a strong position and in the 1920s and 1930s Frans H. Kockum held top executive positions – he was deputy managing director between 1919 and 1936, and managing director 1936–40.²⁶ Even though he represented the family it should be noted that he too was a college-trained engineer, having graduated from the Technische Hochschule in Darmstadt, Germany, in 1902. The Broström group owned Eriksberg while from 1941 onwards Lindholmen belonged to the Johnson shipping and industrial group. Unfortunately there exists no study of the extent to which the owners were engaged in the operation of these two shipyards. At Uddevallavarvet, the owner Gustaf Thordén himself took an active part in the running of the yard, reducing the influence of the managing director, from the start in 1946 until 1959, when he lost control of the company.²⁷ From 1940 onwards Götaverken owned Öresundsvarvet, creating a situation there similar to that at Götaverken.

The above suggests that the managing directors had a very strong position at some private shipyards while a less strong one at others. However, it must be emphasised that the material on this issue is limited and that more research would be needed to deal with the question of influence.

Competition between Chalmers and KTH graduates

It may be of interest to reflect upon how the engineers themselves saw the fact that they acquired top positions at the shipyards. Comments from the first half of the 20th century indicate that they found such a state of affairs quite natural.²⁸ Something that occasionally attracted the naval architects' attention was that Chalmers-trained engineers seemed to be more successful in gaining leading positions than those from KTH. That this was the case is indicated in Table 5.3. As we saw earlier, engineers from KTH generally became managing directors of other Swedish industrial

25 Minutes, board and shareholders' meetings, 1931–1954: Holding Company Förvaltnings AB Gilius (CKG).

26 Jan Glete, *Ägande och industriell omvandling: Ägargrupper, skogsindustri, verkstadsindustri 1850–1950* (Stockholm, 1987), 263; von Seth, *Kockums*, 164–189.

27 Gustaf B. Thordén, *Alla mina skepp* (Göteborg, 1962).

28 See for instance: Hugo Hammar, "Ingenjörsutbildningen", *Tekniska Samfundets Handlingar* (Göteborg, 1929), 8 f.

companies more often than engineers from Chalmers. However, for some reason the conditions in shipbuilding differed from that pattern.

In a discussion at STF's section for naval architecture in April 1916, dealing with naval architecture education at KTH, Albert Isakson, who was the representative of Lloyd's Register in Stockholm and an active member of the section, touched upon this issue. He argued that the reason why naval architects from Chalmers "have been able to assert themselves better in competition even if they may in one or two respects have been inferior on the theoretical side to their rivals from the Royal Institute [i.e. KTH]" was that they had received more practical training.²⁹ Whereas 18 months of shipyard practice was required for graduation from Chalmers only 12 months was required at KTH. Isakson listed the leaders of 13 shipyards and found that the majority had been trained at Chalmers. Having himself graduated from KTH in 1877, he said: "This is hardly flattering to us Institute-engineers [KTH graduates], since the task of the Institute is usually considered to be, among other things, that of educating the leading men of the Swedish industry."

Acknowledging the importance of practical experience, another speaker at the meeting, Thore Thelander, who had graduated from KTH in 1879, added that a further reason why Chalmers engineers were more successful than their KTH rivals in reaching top positions in the major shipyards in Gothenburg was local patriotism.

Another time when the careers of the Chalmers and KTH graduates were compared was when the issue of granting Chalmers the rank of a university was being investigated by an expert commission in 1929. Now the relative success of the former Chalmers students became an argument for concentrating all higher education in naval architecture in Sweden on Gothenburg, despite the fact that every year KTH turned out larger numbers of naval architects. The experts had found that the Chalmers graduates were in leading positions, both at the very top and at slightly lower levels, in most private shipyards. A count of the number of engineers employed in leading positions at these yards showed that 46 had graduated from Chalmers and only 13 from KTH.³⁰

The work of the 1929 commission was never completed, due to the crisis of the early 1930s. However, in 1934 a new commission was appointed to investigate Chalmers' future status, to which I shall return in Chapter 6. In its report, delivered in November 1935, the experts built on the material of the earlier commission. The 1935 report does not suggest why the naval architects from Chalmers more often gained leading positions in private industry. A closer look at the work of the commission reveals, however, that the matter of practical training was considered.

²⁹ See the contributions of Isakson to the debate following the reading of the paper: "Förslag till program för undervisning i skeppsbyggnadslära vid Kungl. Tekniska Högskolan, afgifvet af vid höstmötet 1915 tillsatta kommitterande", *Teknisk tidskrift: Skeppsbyggnadskonst*, May 31, 1916, 25 ff. As early as 1906, Isakson had pointed to the fact that Chalmers-trained engineers acquired leading positions in Swedish shipbuilding more often than those from KTH and that this, to a large extent, was a result of the length of practical experience required in order to graduate: Albert Isakson, "Reservation beträffande svaret å fråga N:o 7. till det af Svenska Teknologföreningens Andra Sektion afgifna yttrandet i fråga om ordnandet af den högre tekniska undervisningen", in *Betänkande och förslag till ordnandet af den högre tekniska undervisningen i riket*, II. Bilagor (Stockholm, 1908), 75–81.

³⁰ Quoted in: *Betänkande och förslag angående omorganisation av Chalmers tekniska instituts högre avdelning till en teknisk högskola m. m.* (unpublished 1935), 56.

In a letter to Edvard Björnsson, a member of the commission, the rector of Chalmers, Sven Hultin, argued that the requirement for practical experience was a determining factor. Not only did Chalmers require an extra six months of practical work but it all had to relate to the actual production of ships, which was not the case at KTH. Moreover, to be admitted to Chalmers one had to have worked for nine months, while no practical experience was needed for admission to KTH. Hultin stated that: "After the length of shipbuilding practice that we require, a trained engineer will not lightly leave the field to which he has devoted so much work. Such a love of the profession cannot be counted on to the same extent in a Stockholm engineer if his practical work has involved only a short period of shipyard work."³¹ This was, he argued, the reason why the "small" department of naval architecture at Chalmers had "provided the country with three-quarters of its leading naval architects."

Obviously, he meant that with a smaller overall number of graduates from KTH coming to work in the private shipyards there would be a smaller number who reached top executive positions. As mentioned in Chapter 3, there was a difference between Chalmers and KTH as regards the content of their programs in naval architecture. It seems likely that the concentration on marine engines at KTH made its graduates more interested in looking for employment opportunities in companies such as Atlas Diesel than at the shipyards. We should also remember that a great proportion of the KTH graduates worked for the Royal Naval Material Administration and as civil servants.

To conclude, during the period from the early 20th century until World War II, the group of college-trained engineers gained an influential position within the category of producers. They did so by acquiring both middle and top management positions at the private shipyards. The next category of organisations within the Swedish shipbuilding system which will be dealt with are the organisations which had a decisive influence upon rules and regulations.

³¹ Copy of letter from Sven Hultin to Edvard Björnsson (the letter is undated but was probably written in March or April 1935), "Handlingar ang. omorganisation av skeppsbyggeriavdelningen", Chalmers University of Technology (GLA).

5.3 The National Ships' Inspectorate

The work of engineers employed at the shipyards has, naturally, been carried out within the framework of rules and regulations on ship design. The organisations responsible for setting these rules have been both the independent classification societies and government agencies. The former will be discussed in the next section; here we shall study the efforts to establish state control of safety at sea in Sweden and the engineers' role in these events.

In an international perspective the second half of the 19th century was a period of increasing activity in the field of legislation to protect seafarers. In Britain, for example, many measures were taken.³² By the 1840s and 1850s the country had laws and regulations in the field. In the early 1870s the British member of parliament Samuel Plimsoll drew attention to the problem of overloading of ships. He argued that ships should have a load line, that is a mark showing the minimum freeboard permitted at full load. With the Merchant Shipping Act of 1876 Britain adopted a voluntary load line which in 1890 became compulsory for ships of more than 80 tons. In 1906 the British parliament decided that these requirements should also embrace foreign ships which visited the country's ports. This forced countries which had not yet introduced similar regulations to do so.

Early Swedish efforts to improve safety at sea included the organisation in 1841 of schools of navigation run by the state, the adoption of regulations on the qualifications required of ships' officers in 1842 and the advent of building requirements for steam passenger ships in 1849.³³ In addition to regulations on building and use, the Merchant Shipping Act of 1864 stipulated that steam passenger ships had to undergo inspections every year. For this purpose local inspectors were appointed who came under the county administrative boards.

In 19th century legislation, the master of the vessel alone was held responsible for safety on board, even though the Merchant Shipping Act of 1891 gave the shipowners a limited liability – the shipowner could only be held responsible if he had deliberately forced the captain to do something that might threaten safety. State control of safety at sea was mainly retrospective in character, i.e. it was concerned with the aftermath of accidents in conducting maritime inquiries and apportioning liability. The agency which carried out these tasks was the Swedish National Board of Trade. After the turn of the century, the issue of legislation to protect seafarers was increasingly debated in parliament. These efforts were inspired both by efforts in Swedish industry

32 Håkon With Andersen & John Peter Collett, *Anchor and Balance: Det norske Veritas 1864–1989* (Oslo, 1989), 69 ff.; Anders Anderson, "Skeppsmätning och fribord", in *Svenskt skeppsbyggeri: En översikt av utvecklingen genom tiderna*, ed. Gustaf Halldin (Malmö, 1963), 414 ff.

33 Axel S. Blomgren, "Navigationsundervisningen 1841–1941", in *Navigationskolornas historia*, ed. Olof Traung (Göteborg, 1941), 101–111.

to make the working environment safer generally and by legislation in other European countries to improve safety at sea.³⁴ The existing state control, which embraced passenger ships only, had to be extended, people argued, to include cargo ships. It was mainly liberals and socialists who demanded that government should play a more active role in protecting seamen.

Establishing state control of safety at sea

In 1906 Arvid Lindman's conservative government appointed the Safety at Sea Commission, to overhaul the Maritime Code. This commission was only one of several reforming commissions set up by Lindman's government.³⁵ It was composed of representatives of shipowners, seamen and technical expertise.³⁶ Some of the members were also members of the Swedish parliament. The commission delivered two reports: in 1909 one on salvage equipment and in 1910 a very extensive report on amendments to the maritime code, ordinances on seaworthiness and laws on the inspection of vessels.³⁷

In response to demands that government should do more for the safety of seafarers and legislate to prevent accidents, the commission suggested that the inspection system should be expanded.³⁸ Seaworthiness inspections and surveys should be carried out by local inspectors. To lead and supervise the activities of the local inspectors a central Ships' Inspectorate should be established. This agency would also have the important duty of monitoring technological developments in the field. The commission stated that the Ships' Inspectorate should be under the umbrella of the National Board of Trade, which was a logical step as the Board already dealt

34 Hjalmar Sellberg, *Staten och arbetarskyddet 1850–1919: En studie i svensk socialpolitik* (Uppsala, 1950), 266–277. It should be noted that some engineers came to be the driving force behind the Swedish industrial safety movement in the first decades of the 20th century and among these engineers we find Hugo Hammar at Götaverken, see: Bill Sund, *The Safety Movement: En historisk analys av den svenska modellens amerikanska rötter* (Stockholm, 1993). On efforts to make the working environment safer at Swedish shipyards and the Finnboda yard in particular, see: Ken Bjerregaard, *Varvet vid Saltsjön: Om arbetarskyddet på Finnboda Varf 1930–1981* (Stockholm, 1993).

35 Hans Meijer, *Kommittépolitik och kommittéarbete: Det statliga kommittéväsendets utvecklingslinjer 1905–1954 samt nuvarande funktion och arbetsformer* (Lund, 1956), 8 ff.

36 The members of the committee were: August Wall, chairman (county governor), Knut G. Bjarke (sea captain and nautical adviser of the Swedish National Board of Trade), Hjalmar Blomberg (shipowner), Dan Broström (shipowner and member of parliament), O. Gummeson (representative of the engine room officers), Wilhelm Hök (consultant engineer), August Lillienau (insurance company manager), Charles Lindley (transport workers' union representative and member of parliament), and Carl J. Ödman (shipowner).

37 *Sjöfartssäkerhetskommitténs betänkande I: Förslag till förordning angående båtar och andra bärgningsredskap, som fartyg skall medföra jämte motiv* (Stockholm, 1909); *Sjöfartssäkerhetskommitténs betänkande II: Förslag till ändringar i sjölagen, Förordning om hvad i vissa afseenden skall iaktagas beträffande fartygssjövårdighet, utrustning och lastning, Lag om tillsyn å fartyg* (Stockholm, 1911).

38 *Sjöfartssäkerhetskommitténs betänkande II*, 76–92 & 195–225; see also Parliamentary documents (Riksdagstryck): Kungl. Maj:ts proposition Nr. 122 (1914), angående anordnande av utvidgad statskontroll å fartygs sjövårdighet m.m., 23–41.

with many issues connected with shipping.³⁹ As mentioned above, the Board was responsible for retrospective control. From 1902 it kept the register of ships. In 1909, the Board employed one inspector of ships' salvage equipment who in the following year, when new rules for load lines came into force, also became responsible for ensuring that these were correctly applied. Furthermore, the Board had until 1877 been the authority supervising the schools of navigation, which it became again in 1920.⁴⁰

After further investigation and submissions from various authorities and organisations the question of greater state control of the seaworthiness of vessels was finally considered by parliament in 1914. The person responsible for dealing with it was the Minister of Finance, Axel Vennersten, who took over with the change of government in February of that year from his predecessor at the ministry. For the most part the draft bill implemented the recommendations of the Safety at Sea Commission. Much impetus had been given to the demand for reform by the Titanic disaster of 1912; the trend towards increased state control was international.⁴¹

One question which attracted considerable attention in the bill was that of the qualifications to be required of the inspectors, both the local ones and those working for the central supervisory authority.⁴² The Safety at Sea Commission had emphasised that the local inspectors must have sufficient knowledge and experience of both naval architecture and marine engines "to be able to carry out their duties expertly."⁴³ In the course of the deliberations various ships' officers' organisations expressed a somewhat divergent opinion, arguing that every district should have two inspectors, one of whom ought to have held a master's certificate and captained a merchant vessel.

Vennersten found this argument convincing and suggested that there should be two categories of inspector, a senior and an assistant. The senior inspector, who would be the one to carry out seaworthiness and passenger vessel inspections, should be a man with a higher technical education. The assistant inspector should be experienced in nautical matters and marine engines and would assist his senior colleague and, under the latter's supervision, himself carry out inspections with regard to the maintenance and loading of vessels and the conditions of the crew. Only in exceptional circumstances would the assistant inspector be empowered to prohibit the use of a ship, for example in case of immediate danger where there was no time to contact his superior. Otherwise an order prohibiting use of the vessel could be issued only by the senior inspector or the central authority.

39 *Sjöfartssäkerhetskommitténs betänkande II*, 197 f.

40 Sven Gerentz, *Kommerskollegium och näringslivet 1651–1951* (Stockholm, 1951), 352–369.

41 Sellberg, 273.

42 Kungl. Maj:ts proposition Nr. 122 (1914), 26–60.

43 *Sjöfartssäkerhetskommitténs betänkande II*, 225; see also: Kungl. Maj:ts proposition Nr. 122 (1914), 26.

Vennersten argued that the senior inspectors and a few highly qualified assistant inspectors, who were to be stationed in Stockholm, Gothenburg and Malmö, should ideally be required to have graduated in naval architecture from KTH or Chalmers, and to have studied steam engines. They should also have had substantial practical experience in the field. The assistant inspectors should have obtained a master's or an engine-room officer's certificate and have been to sea for a substantial period of time. However, in cases when it proved difficult to find people possessing exactly these qualifications and where there were applicants who were known to be competent, then "it should be possible, at least to a certain extent, to waive the purely formal requirements."⁴⁴

The Safety at Sea Commission had suggested that the central organisation, the Ships' Inspectorate, be headed by "a man with a knowledge of shipping and a familiarity with the requirements of maritime affairs" which meant a nautically trained person, that is a sea captain.⁴⁵ At his side, he should have two assistants, one "possessing the highest possible technical qualifications in shipbuilding and marine engineering," the other a person suitable for administrative duties.⁴⁶

One of the members of the commission was Wilhelm Hök, who at that time was a consultant engineer and, as we saw in Section 4.1, was one of the founders of STF's section for naval architecture. He had reservations and expressed an opinion dissenting from that of some of the other members on the question on who should head the new organisation. He argued that if the local inspectors had to be engineers, then the director of the national authority ought also to be an engineer. Of course it was good to have a person thoroughly versed in conditions in shipping, but more important, the director had to have the relevant "engineering training and experience."⁴⁷ Without this qualification he would not himself be "competent to judge what is required in different cases from the point of view of safety or to lead the investigations which needed to be carried out or the action which needed to be taken with a view to ensuring the safety of the vessel." That the Ships' Inspectorate should be headed by an engineer was particularly clear, said Hök, when it was borne in mind that the matters were essentially of an international character and required continuous negotiation and communication with other countries on questions which required a "purely technical opinion." Since the director of the Ships' Inspectorate would represent Sweden in many international contexts he ought to "be fully competent to assess what each question is about in order to safeguard our country's interests." In further support of his argument he mentioned that the large classification societies, which performed similar tasks to the suggested Ships' Inspectorate, were headed by men trained in naval architecture.

That Hök, who himself was an engineer, argued that the head of the central authority should be an engineer is, perhaps, not surprising. However, he found sup-

44 Kungl. Maj:ts proposition Nr. 122 (1914), 32.

45 *Sjöfartssäkerhetskommitténs betänkande II*, 198 f.

46 *Ibid.*, 199.

47 *Ibid.*, 333.

port for his objections among those members of the Safety at Sea Commission who represented the crews: O. Gummesson, who represented the engine-room officers, and Charles Lindley, who represented the seamen. Between 1904 and 1941 Lindley was also a member of the Swedish parliament.

In his history of the Swedish engine-room officers' association Anders Söre argues that Hök, Gummesson and Lindley shared a common disinclination to put a former sea captain in charge of the new organisation since he might not be impartial but favour the interests of the shipowners. This suspicion is discernible in the last paragraph of Hök's reservation, where he wrote that, with the qualifications that the Safety at Sea Commission had suggested, "it is not impossible that a person whose main interest is not consistent with the aims of the Ships' Inspectorate – the maintenance of safety at sea – may take charge of the inspection of ships in Sweden."⁴⁸ Söre says that during the committee work the sea captain Knut Bjarke, who was the nautical adviser of the Swedish National Board of Trade, had proved to be "the most conservative and intractable of all the members of the commission when it came to prescribing rules which really gave crews some protection with regard to safety at sea."⁴⁹ Together with the shipowner Carl Ödman he had been the one to urge most strongly that the director should be a former shipmaster. According to Söre, the three who expressed reservations feared that "the future head of the Ships' Inspectorate would be a colleague of the same mind as Bjarke."

Lindley was also critical of the Board of Trade as the agency responsible for matters of safety, as emerges in a parliamentary motion in 1914 where he stated: "We are all too well aware of the great influence of capital, particularly within [...] the Board of Trade, which has the particular task of upholding its interests."⁵⁰

The engineers' interest in the issue of safety at sea

We may ask how the crews' representatives viewed the engineers. Since the two supported Hök's reservation they obviously preferred an engineer to a master mariner as director of the Ships' Inspectorate. As members of the commission, Lindley and Gummesson had had a chance to hear the views of engineers and other groups on safety when questionnaires were sent to the organisations concerned.

How STF's section for naval architecture should answer this questionnaire had been discussed at a meeting in December 1907.⁵¹ Both Lindley and Gummesson were present. While the latter said little, Lindley was irate. He had read a draft of the section's proposed reply and was upset since, as he interpreted it, the engineers seemed satisfied with the present situation and did not appear to want any detailed

⁴⁸ Ibid., 334.

⁴⁹ Anders Söre, *SMBF: Från Machinistsamfundet 1848 till Svenska Maskinförbundet 1951* (Göteborg, 1951), 550.

⁵⁰ Parliamentary documents (Riksdagstryck): Motioner i Första kammaren 1914, Nr. 85, 2 f.

⁵¹ "Förslag till svarsskrivelse å 1906 års sjöfartskommittés frågeformulär A" (and the following discussion), *Teknisk tidskrift: Skeppsbyggnadskonst*, February 29, 1908, 11–26.

building rules. The reason was, he thought, that the engineers “have an interest in experimenting as they feel inclined, and therefore regard every detailed instruction as an obstacle to their activity.”⁵²

To some extent he was right – most of the engineers saw a danger in having too many building regulations. Of course there had to be some regulations, mainly of a more general nature, governing hulls, equipment and boilers. To prescribe every technical detail by law, however, would be bad for the industry, not least because it would inhibit technical development, some engineers thought. Hugo Hammar said that “[i]f you inflate the cost of shipping with a load of regulations you will drive it away and there will be nothing to legislate about. We engineers are wary of legal enactments because we have found that they delay construction, and prevent and obstruct all progress.”⁵³

In an impassioned speech Lindley tried to persuade the assembled engineers to change certain passages in their submission. He referred to earlier studies, which showed that some 40 to 50 percent of all who became seamen were “condemned to a violent death.” Were not these figures sufficiently astounding, he asked, for the engineers to reconsider their standpoint and “forego their own interest in being allowed to experiment.” The reason why he protested so strongly against the engineers’ submission and their pronouncements emerges from one of his comments. He underscored that the prestige that the engineers and their Association enjoyed in the community was such that their answers could be used against the interest he represented. He said that “the document that the gentlemen have produced is a document from a body which has authority, and this will be used against us, who want to see the matter satisfactorily dealt with. While this document stayed within the Safety at Sea Commission, it did not matter. But once it is printed and appears in the general press, it is our duty to protest. There are things said here that must not go unchallenged.”

To several questions, e.g. those dealing with the crews’ quarters, the section had answered “none,” which meant that they, from a technical point of view, did not have any opinion. As we saw earlier, the engineers were anxious that the section should deal only with “purely technical problems,” and not express opinions on social or political issues. Lindley, however, could not agree that some problems were technical and others political. He interpreted the answer “none” in the draft of the official reply to mean that the engineers did not want any regulations and he found this to be “a definite stance, taken by the Association, directly against what all people demand of society by way of protection of life and health.”⁵⁴ Lindley complained: “I do not understand the esteemed engineers and they do not understand me.”⁵⁵ Towards the end of the discussion, however, he realised what the engineers meant and that they were not hostile to regulations as such but that they themselves wanted

⁵² Ibid., 15.

⁵³ Ibid., 16.

⁵⁴ Ibid., 26.

⁵⁵ Ibid., 20.

to deal solely with what they saw as technical matters. In that case, the only problem was that others who read the submission might also misinterpret its message and use it against the seamen. Therefore, he argued, it was important that the fact that only technical aspects had been considered was made clear in the replies to the Safety at Sea Commission, a plea with which a majority of the engineers agreed and which was duly acted upon.

One engineer, Thore Thelander, however thought it superfluous. He said that as the Commission had “addressed its questions to a technical body, then it will receive a reply from a technical viewpoint and no other. It is in the nature of things, and the replies have to be given from a technical viewpoint.”⁵⁶ Lindley concluded by stressing that it “is good for the Association itself not to appear in a false light, for it to be emphasised that only the technical aspects have been considered and nothing at all which may hinder the adoption of necessary rules of safety.”

This discussion shows that the engineers were anxious only to pronounce on matters on which they considered themselves to be the experts, i.e. the “purely technical” ones. They seem also to have agreed that lines could and should be drawn between technical and other questions, something that a non-engineer such as Lindley had difficulty accepting. From his perspective, the engineers’ major interest was to “experiment” with technology. While this of course could be dangerous for seamen, an engineer would probably be a better choice as director of the new supervisory authority than a sea captain who gave priority to the shipowners’ interests.

Engineers as directors of the Inspectorate

To return to parliament's consideration of the question of the Ships' Inspectorate in 1914, in the bill Vennersten went along with Hök's reservation. The fact that Vennersten himself was an engineer – he had studied chemical engineering in Germany in the 1880s – may have been relevant to his position on this issue. By 1914 he was also a member of STF.⁵⁷ Clearly, there were strong links between STF and the political leadership of the country.

Vennersten noted that due to the “wide variety of extensive and responsible duties” that would be dealt with by the new organisation, its personnel needed to be highly qualified and have both theoretical knowledge and practical experience.⁵⁸ They also had to have a good knowledge of conditions overseas. He emphasised that the director must be a college-trained engineer with substantial practical experience. As his subordinates he should have two inspectors, one with an engineering education, a senior inspector, and one with nautical training, an assistant inspector. In suggesting that the senior inspector, too, who ranked as second in the

⁵⁶ Ibid., 26.

⁵⁷ Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vol. I, 279.

⁵⁸ Kungl. Maj:ts proposition Nr. 122 (1914), 55.

hierarchy, must be a college-trained engineer, Vennersten in fact went one step further than Hök in giving engineers influence over the organisation.

On the question of remuneration, Vennersten emphasised that to be able to hire qualified personnel one had to pay quite high salaries. This was especially true of the director of the Ships' Inspectorate, who should not only have the technical knowledge but also, for his frequent contacts with authorities and organisations abroad, "representative qualities and a good knowledge of languages."⁵⁹ He should therefore be given a salary only slightly lower than that of the assistant secretaries in the Board of Trade. That he could not be given an equal salary, despite having a job of equal responsibility, followed from the fact that the Ships' Inspectorate was not to become a department of its own but a section of the foreign department. With a salary equal to that of the other assistant secretaries he would be paid as much as his superior, which Vennersten found illogical.

Regarding the salaries of the two subordinate inspectors, Vennersten stated that in principle the nautically trained assistant inspector could be given an equal salary to that of the senior inspector. However, he saw compelling reasons for giving the inspector who was an engineer a higher salary. First, he argued, as "ships are developing at present the assessment of matters of safety at sea from the point of view of naval architecture and marine engineering will be much more demanding than the duties with which the nautical expert will be entrusted."⁶⁰ Secondly, he stated that it was usually more expensive to hire a person with an engineering education. He therefore suggested that the senior inspector should be given a salary which was some 40 percent higher than that of the assistant.

Parliament accepted the proposal in the same year and directions for the Ships' Inspectorate came into force in January 1915.⁶¹ The directions stated that both the director, designated chief inspector, and the senior inspector must be naval architecture graduates from KTH or Chalmers, or have corresponding knowledge, and have practical experience in the field. The assistant inspector on the other hand had to have passed a master's examination and have spent a considerable time at sea. Table 5.6 shows the educational backgrounds of the directors of the Ships' Inspectorate.

Table 5.6 Directors of the Ships' Inspectorate, 1915–1969

1915–1929, Nils G. Nilsson	Mech. eng. (KTH, 1896)
1929–1936, Axel Lindblad	Nav. arch. (KTH, 1900)
1936–1954, Hjalmar Sjöholm	Nav. arch. (Chalmers, 1912)
1954–1969, Lennart Borg	Nav. arch. (Chalmers, 1939)

Source: Gerentz, *Kommerskollegium*, 366 ff.; *Indebetou & Hylander*, eds., *Svenska Teknologföreningen; Vem är det 1957 & 1975*.

⁵⁹ Ibid., 57.

⁶⁰ Ibid., 58.

⁶¹ Official Series of Laws of Sweden (*Svensk Författningssamling*): SFS 1914, Nr. 493, instruktion för fartygsinspektionens chefsmyndighet, 1739 ff..

The first director was Nils G. Nilsson (1872–1944). He had graduated in mechanical engineering with naval architecture from KTH in 1896.⁶² Between then and 1914 he gained substantial experience relevant to his later career, working as assistant tonnage surveyor in Stockholm and assistant surveyor for the classification society Lloyd's Register. In 1909 he also became inspector of salvage equipment and in 1910 of load lines at the Swedish National Board of Trade. Nilsson had been one of the founders of STF's section for naval architecture and as a member he gave talks and also took part in the activities of the section in various other ways. As will be discussed in the chapter on industrial research, in the late 1910s and early 1920s he was an active advocate of a Swedish research institute in maritime engineering. Later he also wrote textbooks in naval architecture and was involved in work on the standardisation of shipbuilding material.

As newly appointed director Nilsson's first task was to organise the work of the new body and carry on the efforts to prepare building regulations with detailed directions for the safety of the vessels, work which had already begun in the autumn of 1914. To begin with, transitional provisions applied. By the summer of 1915 the Inspectorate's activities were in full swing.⁶³ The building regulations attracted various criticisms as time went by, and after some ten years they were revised.

Nilsson presented proposed new regulations at a meeting of STF's section for naval architecture in April 1925. The need for a revision, he said, was evident from the fact that over 5000 exemptions had been granted over the last ten years. The main purpose of the revision had been to make the regulations less rigid. This meant modifications making the rules less stringent with regard to small vessels, changing and relaxing certain requirements so as not to put the Swedish shipowner at a disadvantage relative to foreign competitors, making the regulations clearer and, in a few cases, introducing new provisions.

A change of major importance concerned ships classified by the international classification societies. From 1915 onwards, ships built according to the rules of the classification societies had been exempted from the Inspectorate's control, unless the Inspectorate's regulations contained stricter directions. In the revised version this reservation had been removed, much to the satisfaction of the shipowners. Nilsson said that the experience of the years that had elapsed had shown "the regulations of the approved classification institutions in the area concerned to be fully satisfactory, which can surely in any case be considered obvious."⁶⁴ To have to consider two sets of rules had been shown to be inappropriate. Overall, the directions in the new building rules had "in all essentials been brought in line with the corresponding provisions of the classification institutions."

62 Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 414; Allan Boo, "Nils Gustaf Nilsson", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 2, 1915.

63 Nils G. Nilsson, "Några riktlinjer för den nya fartygsinspektionen", *Teknisk tidskrift: Skeppsbyggnadskonst*, December 30, 1914; Boo, "Nils Gustaf Nilsson".

64 Nils G. Nilsson, "Den föreslagna nya fartygsbyggnadsförordningen", *Teknisk tidskrift: Skeppsbyggnadskonst*, December 19, 1925, 85 ff. & April 17, 1926, 33 ff.

The assembled engineers expressed their approval of the new building regulations. Wilhelm Hök said that during the time he was a member of the Safety at Sea Commission he had hoped that the regulations and detailed provisions would acquire the form they had now assumed. "Even then," he went on, "I worked persistently to ensure that rules and regulations would be given, if I may so express it, a certain flexibility, as they now have."⁶⁵ Hök had had a chance to look at the new proposals and had found that "by and large all that I considered bad in the old regulations is now gone." He therefore took the opportunity to congratulate Nilsson on his excellent work, and went on to say "we can now confidently leave matters of the safety of our vessels in the hands of the Ships' Inspectorate, as it now appears to possess the necessary experience and to be as enlightened as any inspectorate really can and should be." Other engineers, among them Ernst A. Hedén at Götaverken, agreed with Hök.

The Ships' Inspectorate had become a department of its own when the National Board of Trade was reorganised in 1920. Since it had a supplementary budget within the Board of Trade, Nilsson came to have the title acting assistant secretary instead of that of his colleagues at the other departments who bore the title head of division (*kommerseråd*).⁶⁶ This state of affairs lasted until 1929 when the Inspectorate was formally placed on the same footing as other departments.⁶⁷ At the same time Nilsson left his position to become chief tonnage surveyor.

He was succeeded by Axel Lindblad, who had worked for the Board of Trade since 1914, first as senior inspector and after 1921 as chief tonnage surveyor. Before joining the Board, Lindblad, who graduated in naval architecture at KTH in 1900, had worked both at shipyards and for a shipping company. As mentioned above Lindblad, together with Nilsson and Hök, had started STF's section for naval architecture and between 1906 and 1911 he had been editor of the naval architecture issue of *Teknisk tidskrift*.⁶⁸

When Lindblad died in 1936, Hjalmar Sjöholm replaced him. After graduation from Chalmers in 1912 Sjöholm had worked for some years at shipyards in Sweden and abroad. Between 1918 and 1924 he was a local ship inspector in Gothenburg and after that senior inspector at the Board of Trade until 1936. In addition to this latter employment he was also a surveyor for the classification society Det norske Veritas.⁶⁹

Sjöholm retired in 1954 and Lennart Borg became the new director of the Ships' Inspectorate. Like the three who held the position before him he had substantial

⁶⁵ Ibid., 35.

⁶⁶ Official Series of Laws of Sweden (Svensk Författningssamling): SFS 1919, Nr. 891, instruktion för Kungl. Maj:ts och rikets kommerskollegium, 2908.

⁶⁷ Official Series of Laws of Sweden (Svensk Författningssamling): SFS 1929, Nr. 222, instruktion för kommerskollegium, 450.

⁶⁸ Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 503.

⁶⁹ Ibid., 874 f.

experience as a ship surveyor. He had graduated from Chalmers in 1939 and then worked at shipyards some years before becoming a local ship inspector, which he remained until he took up the post of director of the Ships' Inspectorate.⁷⁰

As we can see, those who became directors of the Inspectorate had worked for a long time within the organisation or on similar duties. In acquiring the leading positions in the governmental agency responsible for the safety at sea, engineers gained influence over the rules which prescribed how ships should be designed. As the discussion in 1925 indicates, the revision which was carried out in the 1920s met the engineers' interest in not having excessively detailed rules and regulations, thereby giving the designers at the shipyards a larger degree of freedom in their work, at least regarding smaller vessels.

Despite the influential position of engineers within the National Ships' Inspectorate we must not jump to conclusions regarding their ability to shape the rules governing design of new maritime technology. Of greater importance in this regard were the international classification societies, and as we shall see in the next section, here Swedish engineers had relatively little chance to influence the building rules.

5.4 Classification societies

Together with the Ships' Inspectorate the classification societies were the bodies who laid down rules and regulations for the building of merchant vessels. These independent organisations issued detailed and extensive instructions regarding the design of the hull, the machinery, outfitting, quality of material etc. which had to be fulfilled for a ship to receive a certain classification.⁷¹ In theory, it was of course up to a shipowner whether he wanted his ship classified or not, but since it might be impossible or at least very expensive to insure the ship and difficult to find anyone who wanted to send his cargo with it, if it was not classified, most large ocean-going vessels were. That the society had granted a ship the highest class was a guarantee to a maritime insurance company, which could insure both the ship and its cargo without taking too large a risk. This in turn meant that premiums could be kept to a reasonable level. Details of all classified vessels and their condition were published in annual registers.

⁷⁰ *Vem är vem i Stor-Stockholm*, ed. Paul Harnesk (Stockholm, 1962), 188.

⁷¹ Ture Rinman, *Handelsflotta och sjöfart: Sverige på världshaven* (Malmö, 1956), 574 ff.; Karl-Gustav Lind, *Fartygslära* (Hermods skola; Malmö, 1977), 56 f.

In order to retain its “class,” a ship had to undergo regular inspections. Annually, the societies’ surveyors checked the hull, boilers and other pressure vessels, cargo hatches, capstans, safety devices and other components. Every fourth year they carried out more extensive inspections where many components were dismantled to check them for wear and rust. To do all this work the societies had surveyors in most of the world’s ports and shipbuilding districts.

The actual form taken by work on classification in conjunction with the building of vessels changed little during the period studied. At a meeting of the section for naval architecture in 1914, the managing director of the shipping branch of the Grängesberg mining company, Per A. Welin, gave a description of the building of a new ship and the classification society’s role in this process. Even if the account gives a somewhat idealised picture of the process, it is instructive:

So when a vessel is going to be built “to class,” the procedure is, as is well known, as follows. The shipping line and the shipbuilder agree on the size, type, draught etc. of the vessel, after which the master shipwright produces drawings and submits them to the shipowner. After this, special drawings are prepared, copies of which are sent to the classification society, which checks that the dimensions are correct and that the necessary strength is provided, etc. The master shipwright then orders the material accordingly, but not a piece gets into the vessel without the society’s experts first checking its strength. The classification society is responsible for this and the gentlemen may be certain that if the material is not of the correct dimensions or does not pass the strength tests to which it is subjected, it is instantly rejected. This happens over and over again [...] Then the experts watch the construction process every day, and when everything is ready and the vessel is to go to sea, certificates are issued for anchors, chains, mooring equipment etc., which have been tested in the meantime for the class. But even then the classification society follows unceasingly the vessel’s progress over the seas and intervenes at once if there is cause.⁷²

The oldest and largest society was Lloyd’s Register of Shipping, originally established in London in 1760 but reorganised in 1834. Other classification societies were the Bureau Veritas (France; established in 1828), the American Bureau of Shipping (USA; 1862), Det norske Veritas (Norway; 1864), Germanischer Lloyd (Germany; 1867) and the British Corporation (Great Britain; 1890, in 1949 it amalgamated with Lloyd’s Register).

⁷² P. A. Welin, “Om några påvisbara olägenheter, som synas vidlåta Kungl. Maj:ts nådiga proposition till riksdagen angående anordnande af utvidgad statskontroll å fartygs sjövärdighet m. m.”, *Teknisk tidskrift: Skeppsbyggnadskonst*, January 14, 1914, 32.

Classification in Sweden

The two societies of greatest importance to Swedish shipbuilding were Lloyd's Register and Det norske Veritas, the latter mainly due to the fact that Swedish shipyards built numerous ships for Norwegian shipowners.⁷³ Lloyd's Register for its part was the dominant society among Swedish shipowners and it had the National Board of Trade's authorisation to issue international certificates of freeboard for Swedish ships. In the late 19th century, Lloyd's Register's only representatives in Sweden were so called "non-exclusive surveyors." Non-exclusive meant that they were free to carry out work for other organisations too. In 1900 the society opened an office in Gothenburg and Viggo C. Bülow became its first permanently appointed surveyor in Sweden – an exclusive surveyor. Born in Denmark in 1871, he had been at sea for some ten years before he obtained an engine-room officer's certificate in London in 1900. While in practice he was the head of the office from the beginning, it was not until 1920 that he formally acquired the title Principal Surveyor for Sweden.⁷⁴

From the early 20th century onwards the staff at the Gothenburg office grew as the Swedish shipbuilding system expanded; during World War I there were five surveyors, in 1947 the number had risen to 21 and in 1954 to 36.⁷⁵ In this latter year as much as 84 percent of Swedish registered tonnage was classified by Lloyd's Register.

The surveyors were both college-trained engineers, usually naval architects, and people with other backgrounds, including former seamen. If we study the surveyors employed by Lloyd's Register in Sweden from the early 20th century until 1960 we find that while several came from Great Britain, the large majority were Swedes. However, the proportion of foreigners increased in the 1950s.⁷⁶ Those who became heads of the Swedish organisation were foreigners: Bülow, who was Danish, was the Principal Surveyor until 1937 and the men who held the position after him were engineers from Britain.

⁷³ The most comprehensive account of Det norske Veritas' history is: Håkon With Andersen & John Peter Collett, *Anchor and Balance: Det norske Veritas 1864–1989* (Oslo, 1989). Another recent account, with a focus on the work of the surveyors and the society's activities in Sweden is: Hans E. Klev, *Min norske Veritas historie: En beretning om et klassifikasjonsselskap* (Göteborg, 1993).

⁷⁴ Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 386; "Lloyds Registers representation i Sverige: Tjugufem år sedan sällskapet öppnade eget kontor i Göteborg", *Göteborgs Handels- och Sjöfartstidning*, May 8, 1925, 16.

⁷⁵ "Lloyd's Register of Shipping", in *Stor-Göteborg / Great-Gothenburg* (Göteborg, 1957), 316 f.

⁷⁶ "List of Swedish Surveyors of Lloyd's Register 1900–1960", compiled by Lloyd's Register of Shipping, London, 1998: in the author's possession.

Rules and regulations

The detailed building rules of the classification societies, of course, considerably restricted the engineers' ability to develop new technology as they saw fit. This was a difficulty that was accentuated in Sweden by the fact that the rules were drawn up in the countries of the societies concerned, i.e. a long way from the Swedish shipbuilders.

In an article written in 1930, Hjalmar Hylander asked "Who is really the builder of our merchant and passenger vessels from the point of view of the steel hull – the naval architect or the classification society?" Hylander had graduated in naval architecture from Chalmers in 1901 and then worked at shipyards in the United States, Russia, and Finland until he returned to Sweden in 1918.⁷⁷ The question had come to his mind while looking back on his years in Finland, when he:

without being bound by any regulations or ordinances designed a lot of small or medium-sized vessels of various categories and often of considerable speed, where the dimensions of the material were determined from the resources of our own intelligence or in accordance with time-honoured practice, applying the principle of saving weight as far as possible without taking risks. There was a touch of artistry, of creativity, in such work. The industry's attack on the problems has robbed, not shipbuilding, but the naval architect, of much of this creative artistry. Everything has been tabulated and formalised. You "look in the rules."⁷⁸

The quotation clearly points to the engineer's interest in and passion for creating new technology, comparing the naval architect to the creative artist. Hylander went on to say that not only had the solving of many design problems been transferred from shipyards and consultants to the classification societies, but also since these latter were foreign establishments, a valuable source of knowledge had become less accessible to Swedish engineers. Therefore, he argued, young engineers should be encouraged to take employment with the societies for some time in order to learn different practical aspects of ship design and construction.

A chance for Swedish shipbuilders and shipowners, at least to some extent, to influence the making of rules and regulations came with the establishment of the Swedish Committee of Lloyd's Register in 1920. Similar national committees were established in the United States and France a little earlier, and in Holland, Japan and Denmark soon afterwards. The purpose was both to facilitate collaboration between local parties and the head office in London, and to strengthen the society's position in these countries.⁷⁹

⁷⁷ Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 525.

⁷⁸ Hjalmar Hylander, "Industrien och skeppsbyggnadsundervisningen III", *Verkstäderna: Organ för Sveriges Verkstadsförening*, February 1931, 36.

⁷⁹ George Blake, *Lloyd's Register of Shipping 1760–1960* (Sussex, 1960), 139.

The Swedish committee was from the start composed of six representatives of shipowners, three representatives of shipyards, two representatives of maritime insurance companies and one representative of the steel industry. The shipowner Dan Broström became chairman, a position he held until his death in 1925 when Hugo Hammar succeeded him. It is interesting to note that Hammar attributed great importance to this position: in a letter in 1935 to the treasurer of STF, Reinhold Naucclér, Hammar described the chairmanship as “the finest position I have today, from an international point of view.”⁸⁰ After fourteen years with an engineer as chairman, the committee acquired a shipowner chairman in Gunnar Carlsson in 1939.



Hugo Hammar's copy of the 1923 edition of Rules and Regulations of Lloyd's Register of Shipping, with his name in gold lettering. Hammar had been a member of the society's Swedish Committee since its inception in 1920 and in 1925 he became its chairman. (Photo: Jan-Olof Yxell)

⁸⁰ Copy of letter from Hugo Hammar to Reinhold Naucclér, December 30, 1935: Hugo Hammar's archives, (GLA).

The establishment of the national committee meant that people in the Swedish shipping and shipbuilding community had a chance both to comment on planned changes and additions to the regulations, and to come up with suggestions of their own concerning questions of particular interest to Sweden. As time went by the committee found an audience for several of its ideas, for instance the introduction of measurements in millimetres in the rules applied in Scandinavian countries and the publication of rules for ice-strengthened ships.⁸¹ Other suggestions that the Swedish committee conveyed to the headquarters in London concerned diesel engines, oil tankers, ore carriers and electrical welding. – all fields where Swedish shipyards enjoyed a prominent position. Furthermore, on the Swedish committee's initiative, Lloyd's Register opened an office in Helsingborg in Southern Sweden.

Probably more important to the Swedish shipyards than the possibility of influencing the rules and regulations was the fact that Lloyd's Register, in connection with the setting up of the Swedish Committee, placed an expert from London, H. J. Thomson, at the Gothenburg office. Earlier, all drawings had to be sent to England before the building of a ship could begin, which was time-consuming and increased the costs.⁸² Thomson's task became to examine and approve the drawings on site. Only when the design differed substantially from ordinary ships did the drawings have to be sent to England. This of course saved time but his presence also proved to be of value to the people at the shipyards since they could now discuss constructional details face to face with a representative of the London office.⁸³

The conclusion to be drawn from the above is that Swedish engineers could only to a limited extent influence the rules of regulations which governed the design of the ships. This, of course, to some extent restricted their ability to function as a social group of technology carriers.

5.5 Shipping companies

So far we have looked at organisations producing ships and organisations laying down rules and regulations on how ships should be constructed. The next category to be dealt with is the customers of the shipyards. These were mainly the shipowners and the Swedish Navy, the latter represented by the Royal Naval Material Administration. In this section I shall discuss the extent to which engineers came to work for shipping companies, while the next section will be devoted to the Navy.

81 See summaries of the minutes of the meetings of Lloyd's Registers' Swedish Committee, published in *Teknisk tidskrift: Skeppsbyggnadskonst*, 1920–1939.

82 On practical problems in connection with classification work see Hugo Hammar's contribution to the discussion following the paper: N. G. Nilsson & Axel Lindblad, "Svensk skeppsbyggeristatistik", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 9, 1906, 56.

83 Summary of the minutes of the meeting of Lloyd's Registers' Swedish Committee on May 11, 1920, published in *Teknisk tidskrift: Skeppsbyggnadskonst*, July 28, 1920, 107; "Lloyds Registers representation i Sverige: Tjugufem år", 16; "Vårt skeppsbyggeri i kraftig utveckling: Lloyds Register ökar sin tekniska personal i Sverige", *Göteborgs Handels- och Sjöfartstidning*, June 23, 1927, 16.

Those steam shipping companies that came into existence in the period between 1860 and 1910 were usually founded by merchants or former sea captains. When these men retired they were replaced by people with a mercantile rather than a technical training. This was probably considered natural, since the main task of a shipowner is to earn money by transporting goods and by buying and selling ships. There were exceptions, most notably Rolf Sörman, who graduated as a naval architect from Chalmers in 1912, worked as technical manager in the Transatlantic shipping group for many years and, from the late 1920s onwards, was managing director of various shipping companies within the group. That he gained top executive positions, however, probably owed more to the fact that his aunt was the widow of the shipowner Wilhelm Lundgren, the founder of Transatlantic, than to the fact that he was an engineer.⁸⁴

With the expansion of the business in the 20th century and with the introduction of new technology, most larger companies set up inspection departments or technical departments. One such concern was the Broström group in Gothenburg. The company was founded in the mid-1860s by Axel Broström. Like other Swedish steam ship companies of the late 19th century its fleet came to be made up mainly of second-hand tonnage bought in Britain.⁸⁵ In 1905 Dan Broström succeeded his father and under the son's leadership the concern expanded considerably. Among other things Dan Broström established shipping lines to East Asia and North America. As mentioned above, in the 1910s he also bought the majority holdings in the two shipyards Eriksberg and Götaverken.

In 1915 he established the Broström Lines Agency in Stockholm.⁸⁶ As the name indicates, this was originally intended to function as the group's agency on the east coast. Within a year, however, it was reorganised and a head office of the Lines Agency was established in Gothenburg with Filip Lindahl as managing director. Lindahl, who had earlier been an engine-room officer had been the company's inspector since 1902.⁸⁷ The Lines Agency's main responsibility became to handle certain tasks where the different companies of the shipping concern had a common interest, such as the building of new ships, inspection, coal and oil supplies, general supplies and recruitment of personnel.

When new ships were to be built, the staff of the Lines Agency's design department drew up tendering documents on the basis of the company's experience and requirements.⁸⁸ The specifications were sent to different shipyards and when these

⁸⁴ See preface and page 122 in: Olof Traung, *Kapten Lundgren: En skeppsredares historia* (Göteborg, 1944).

⁸⁵ Axel Ramm, "Axel Ludvig Broström" & "Daniel (Dan) Broström", in *Svenskt biografiskt lexikon*, vol. 6 (Stockholm, 1925), 456–468; Olof Traung, *Dan Broström: En sjöfartsman* (Göteborg, 1948).

⁸⁶ *AB Broströms Linjeagentur 1915–1955* (Göteborg, 1955), 3 ff.

⁸⁷ Arthur Attman, "Dan Broström", in *From Lake and River to Distant Oceans: Broströms 1865–1965*, ed. Algot Mattsson (Göteborg, 1965), 74 f.

⁸⁸ *AB Broströms Linjeagentur*, 6 ff.; On the shipping companies', and especially their technical managers', influence on the design of the ships, see: Hans Åkerlind, *Fartygsarkitektur i Sverige 1935–1995: Från estetisk guldålder till renodlad rationalism* (Umeå, 1998).

submitted tenders, the Lines Agency's engineers checked them and made a recommendation to the shipowner. After a contract had been signed, the Lines Agency worked in close co-operation with the shipyard, working out detailed building specifications and checking class and working drawings. During the building process the company had inspectors present at the shipyard. This continued until the ship had undergone all tests in connection with the trial trip and the technical manager could inform the shipowner that the ship fulfilled all the requirements of the contract and was therefore ready for delivery.

Another important task of the Lines Agency was inspection of the ships of the Broström fleet.⁸⁹ This was intended to ensure that the ships were kept in good technical condition to avoid costly delays. The inspector was responsible for both emergency repairs and scheduled maintenance, classification work and modifications to be carried out at the shipyards. If a ship became unseaworthy the inspector immediately had to go and examine it anywhere in the world to form an idea of the damage.

Engineers in the technical departments

The Broström shipping concern was not the only one to set up a technical department: most other large shipping companies did so in the first decades of the century. These departments employed both seamen and engineers. The technical managers of some of the firms and their educational backgrounds are listed below. The companies, which in the mid-1950s were the five largest shipping groups in the country, are listed in order of their total tonnage of ships, Broströms being the leading one.

Table 5.7 Technical managers of the five largest shipping companies

Broströms

1916–1934, Filip Lindahl	Engine-room officer
1934–1965, Eric Th. Christiansson	Nav. arch. (Chalmers, 1923)
1965–1977, Gösta Kaudern	Nav. arch. (KTH, 1938)

Transrederierna

1914–1933, Rolf Sörman	Nav. arch. (Chalmers, 1912)
1933–1958, David Lindahl ⁹⁰	Mech. eng. (Chalmers, 1916)
1959–1978, Lennart Ericsson	Nav. arch. (Chalmers, 1944)
1978–1990, Per Fagerlund	Nav. arch. (Chalmers, 1969)

⁸⁹ AB Broströms Linjeagentur, 10 ff.

⁹⁰ From the mid-1950s until 1958 Lindahl had leave of absence and Magnus Andersson occupied the position. Andersson had obtained his engine-room officer's certificate in 1915 and worked in the Transatlantic shipping concern since 1916, first at sea and then from 1932 as an inspector in the technical department.

Trafik AB Grängesberg-Oxelösund

1912–1945, Wilhelm Lundbohm	Engine-room officer
1945–1957, Ture Berglund	Technologist
1958–1978, Hugo Ekwall	Nav. arch. (Chalmers, 1942)

Rederi AB Nordstjärnan

1920–1944, Axel J. Kromnow	Engine-room officer
1944–1964, Robert Fredriksson	Nav. arch. (Chalmers, 1922)
1964–1966, Nils Eckerbom	Nav. arch. (Chalmers, 1939)
1966–1970, Per-Erik Peterson	Nav. arch. (Chalmers, 1947)
1970–1985, Carl-Erik Carlson	Nav. arch. (Chalmers, 1947)

Svearederierna

1915–1937, Frans C. D. Friberg	Sea captain
1937–1965, Erik Bernelius	Nav. arch. (KTH, 1923)
1965–1967, Torsten Blixt	Nav. arch. (KTH, 1938)
1968–1977, Bengt Hultgren ⁹¹	Sea captain
1978–1983, Gösta Karlbom	Nav. arch. (Chalmers, 1960)

Source: Attman, "Broström", 74 f. & 136; Lybeck, Sveriges rederier; Meinander, Gränges, 442 ff.; Rinman, Rederiet, 137; Lundmark, Rederi-Svea, 452; Bodman, Chalmers Tekniska Institut: Matrikel; Indebetou & Hylander, eds., Svenska Teknologföreningen; Sveriges civilingenjörer, bergsingenjörer och arkitekter; Sveriges högskoleutbildade mekaniker, skeppsbyggare & flygtekniker; Katalog över Chalmersingenjörer, 1976–1985; Archives of the Stockholms Rederi AB Svea⁹² (FSF).

As we can see, the technical departments have mostly been led by naval architects, more often from Chalmers than from KTH. In some of the companies, the technical departments were set up under the leadership of people with a nautical training. As these men retired they were replaced by engineers, who in practice came to monopolise the position – compare with the pattern for the managing directors of the shipyards, Table 5.3.

While the non-engineers had usually worked in the company for many years before they became technical managers, some of the engineers who reached the position came directly from other organisations, such as shipyards, Lloyd's Register or the Naval Material Administration. Yet others had worked in the shipping company's technical department for a few years before becoming its head. A feature most of these engineers had in common was that they had worked at shipyards

⁹¹ In contrast to his predecessors, who had been technical managers, Hultgren was only head of a technical section which was part of the company's "Ship department", headed by Rudolf Jender, see: Minutes, board meeting, December 12, 1967 and board meeting December 11, 1970, Annex. C "Befattningsschema": Shipping Company Stockholms Rederi AB Svea (FSF).

⁹² Minutes, board meetings 1964; "VD:s ämnesordnade handlingar: Tekniska avdelningen"; "Tekniska avdelningen: Vecko- och månadsrapporter", 1965–1975, Shipping Company Stockholms Rederi AB Svea (FSF).

for many years, sometimes for more than two decades. This meant that they had both a deep understanding of matters of production and that they were personally acquainted with many people at the shipyards, hereby being able to function as “translators” and a link between the shipowner and the yard.

Of course, the technical managers were not the only college-trained engineers at the technical departments; Broströms and Nordstjernan in particular came eventually to employ several engineers.⁹³

As shown in Chapter 4, after 1940 there was a sharp increase in the number of people, working for shipping companies, who became members of STF's section for naval architecture and TSG's section for mechanical engineering and naval architecture. Here they could meet engineers from shipyards, the Naval Material Administration and the technical colleges, and exchange knowledge and experience.



Engineers of a private shipyard together with representatives of a shipping company – in 1947 Götaverken was building the passenger vessel Stockholm for the Broström-owned Swedish American Line (SAL). The first person from the left is unknown, then follow: Allan Borgström (engineer at Götaverken), Axel Jonsson (managing director of SAL), Eric Th. Christiansson (engineer and technical manager of the Broström Group), Karl Erik Jacobson (managing director of Götaverken), N. O. Nilsson and Nils Svensson (the latter two engineers at Götaverken). (Photo: Varvshistoriska Föreningen)

⁹³ *Sveriges civilingenjörer, bergsingenjörer och arkitekter 1961* (Stockholm, 1961), S1–S56.

Conflicts with other groups

We might ask how the engineers themselves reflected upon the fact that they also came to work for the shipowners. At a meeting of STF's section for naval architecture in 1922, Nils Ljungzell, who was lecturer at KTH and editor of the naval architecture issue of *Teknisk tidskrift*, argued that it was important that "technical expertise" was well represented in the inspection departments of the shipping companies.⁹⁴ That this was not always the case, and could have costly consequences, was all too clear. He maintained that if the shipping companies more often employed naval architects, co-operation between them and classification societies, shipyards, and the Ships' Inspectorate would improve.

Wilhelm Lundbohm, technical manager of the shipping company Trafik AB Grängesberg-Oxelösund, who was not himself a college graduate but had served at sea as an engine-room officer, strongly objected to Ljungzell's assertion, which he interpreted as a slur on the competence of those employed in the technical departments of Swedish shipping companies. He argued that the inspector's work was mainly of a financial nature. However, in recent years the shipping companies had increasingly begun to utilise "technical expertise."⁹⁵ In the case of his own company, he emphasised that the staff was fully competent, for instance, to produce the working data for the ships.

Ljungzell replied that he had not intended to criticise any particular company, but still maintained that Swedish shipping companies employed comparatively few technically trained men. To have former sea captains or engine-room men at the technical departments was not sufficient since, according to Ljungzell, they did not have the necessary theoretical qualifications: "at least in some, even large, Swedish shipping companies there is a lack of a really formally trained engineering force in the inspection departments, and instead staff trained in schools of navigation have an influence which their technical knowledge hardly justifies." He concluded that "this state of affairs can surely scarcely in this technological age be to the benefit of the financial results of such shipping lines."

To conclude, even though college-trained engineers seldom reached the position of managing director of the shipping companies, they came to have substantial influence on the development of new technology in their posts as technical managers. It was, however, not self-evident that the kind of expertise possessed by the engineers was the critical one. Other groups, sea captains and engine-room staff, represented other kinds of expert knowledge which could have enabled them to reach the leading positions in the technical departments. The engineers, however, successfully asserted their interest against these groups. In the following section we shall study a field where the engineers were not really as successful, viz. their competition with naval officers within the Royal Naval Material Administration.

⁹⁴ Discussion following Nils G. Nilsson's paper "Skeppsredaresynpunkter och skeppsbyggaresynpunkter å fartygsbyggandet", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 30, 1923, 39 ff.

⁹⁵ Ibid., 42.

5.6 The Royal Naval Material Administration

In addition to those working for the shipowners, there was one more group of engineers who worked for an important customer of the private shipyards and that was the naval engineers of the Royal Naval Material Administration. Almost half of all graduates in naval architecture from KTH between 1900 and 1929 worked for the Navy at some time in their lives and approximately one quarter worked there the greater part of their careers. We shall now look at this large group.

As long as ships were made of wood and powered by sail, most naval vessels were built in the Navy's own yards. However, with the introduction of iron and steam, which mainly occurred from the mid-19th century onwards, private engineering workshops became the Navy's principal suppliers of ships.⁹⁶ The trend was international and followed from the fact that the new technology originated in the private sector.

There was a revolutionary change not only in the vessels themselves but also in their weapons, thanks to new chemical-technical and metallurgical processes, and to improved machine tools. In this field, also, private firms, such as steelworks and engineering workshops, were in the vanguard while the Navy's established suppliers were of secondary importance.

According to Jan Glete the new technology eventually led to a complete revision of established doctrines with regard to the use of weapons. At first most naval officers were sceptical or even hostile to the new ideas and instead favoured conservative changes, that is improvements to the existing technology. However, gradually the attitude changed, which Glete attributes to the fact that in the international race for naval supremacy, there were always some navies which were more open to new technology than others. France was particularly quick to introduce steam-powered armoured ships. When one navy had adopted an innovation, others had to follow suit, so as not to fall behind. During this phase new weapons came first and the doctrines for their use had to be drawn up afterwards. When a dialogue between the Navy and the private manufacturers finally began, new technology could again be geared more closely to actual naval requirements.

Glete argues that by the early 1880s most naval officers agreed on a policy for the build-up of the Swedish Navy.⁹⁷ Despite the fact that technology continued to change rapidly, the innovations became less radical. A new network of military engineers, naval officers and representatives of private industry had emerged which proved to have a stimulating effect both on the Navy, who wanted the most modern ships of the day, and on parts of a growing Swedish industry – shipyards, arms

⁹⁶ Jan Glete, *Kustförsvar och teknisk omvandling: Teknik, doktriner och organisation inom svenskt kustförsvar 1850–1880* (Stockholm, 1985), 10–19. See also: idem., " 'Demand Pull' och 'Technology Push': Doktriner och ny teknik i svenskt sjöförsvar 1850–1880", *Dædalus: Sveriges Tekniska Museums Årsbok* 1986, 135–145. On the work of the Navy Yard in Karlskrona during this period of technological transformation, see: Ann Hörsell, "Från segel och trä till ånga och stål 1866–1910", in *Karlskronavarvets historia, del 2, 1866–1992*, ed. Erik Norberg (Karlskrona, 1993), 7–80.

⁹⁷ Glete, *Kustförsvar*, 81–87.

manufacturers etc. – who needed customers. The importance of naval orders to the expansion of the Swedish shipyards was discussed in Chapter 2 and, as we saw, many larger vessels were built in the 1890s and the first years of the new century, in particular, and eventually also in connection with the two world wars.

From the early 19th century onwards the Maritime Affairs Administration functioned as the Navy's supreme technical and economic body and was, among other things, responsible for the procurement of new ships.⁹⁸ In 1878 the Administration was reorganised as *Kungl. Marinförvaltning* (the Royal Naval Material Administration). This organisation originally had three departments: military, engineers and civil. The number gradually grew, with the military department being split into a supplies department and a mines and artillery department in 1884, and the addition of a torpedo department in 1900, a fortifications department in 1902, a medical department in 1903 and a nautical department in 1908. The decisions of the Administration were taken by a board on which the various department heads were represented.

The Corps of Naval Engineers

In the engineers' department naval engineers, under the director-general, did design work on new vessels. The naval engineers all belonged to the Corps of Naval Engineers, which was formed in 1868.⁹⁹ In contrast to its precursor, the Construction Corps of the Navy, which had been organised on military lines, the new Corps was partly civilian, partly military in form. This meant that it was a civilian organisation but that the engineers were sometimes in command of military personnel on board ships and at the navy yards.¹⁰⁰ The engineers also had military titles.

To become a naval engineer one had to have graduated from the Technological Institute in Stockholm – from 1877 known as KTH, have studied naval architecture in Gothenburg or abroad, for instance at the *École d'application du Génie Maritime*, Paris, and have worked for two years in engineering workshops or shipyards.

In the parliamentary discussion of the formation of the Corps of Naval Engineers in 1866–67, there seems to have been no disagreement over proposals that the naval engineers should have an advanced theoretical education. The Sea Defence Commission of 1861 had suggested that future naval engineers, like the members of

98 The history of the Royal Naval Material Administration and its precursor the Board of the Admiralty and the Maritime Affairs Administration have been documented in five volumes: Einar Wendt, *Amiralitetskollegiets historia*, vol. I: 1634–1695 (Stockholm, 1950) and vol. II: 1696–1803 (Malmö, 1974); Folke Wedin & Magnus Hammar, *Amiralitetskollegiets historia*, vol. III: 1803–1877 (Malmö, 1977); Folke Wedin, *Amiralitetskollegiets historia*, vol. IV: 1878–1920 (Stockholm, 1981) and vol. V: 1920–1968 (Stockholm, 1983); A shorter account of the organisation's history is: E. Wendt, *Amiralitetskollegiet – Marinförvaltningen 1634–1934* (Stockholm, 1935).

99 The Corps was until 1905 called the Staff of Naval Engineers.

100 See: SOU 1944:44 *Betänkande med förslag rörande utnyttjandet av ingenjörtekniskt utbildad personal inom försvarsväsendet och därmed sammanhängande frågor*, 54 ff.

the Naval Corps of Mechanics, ought to have graduated in civil engineering from *Högre artilleriläroverket* (the School of Gunnery) at Marieberg in Stockholm. The Corps of Mechanics was responsible for the Navy's buildings, dry docks etc. and the commission had suggested that it should be dissolved and its work taken over by the planned Corps of Naval Engineers. The Minister of Naval Defence, Baltzar von Platen, however, found the education offered at the Technological Institute to be "incomparably more relevant to the career of the naval engineers than that given to the civil engineers at the school at Marieberg."¹⁰¹ The Technological Institute, he argued, also offered another advantage: it had many more students which meant that the Corps could be more selective.

The Corps was at first composed of one director-general (with the rank of colonel), two chief naval engineers (with the rank of lieutenant-colonel), and five naval engineers (with the rank of lieutenant).¹⁰² In the draft bill to parliament in 1867 the Minister of Naval Defence had suggested that the Corps should include two more posts – two chief engineers at the level between the naval engineers and the chief naval engineers. In its communication the Standing Committee of Supply (*Stats-utskottet*) maintained that these posts were superfluous and stated that "in view of the nation's limited assets and the costly nature of modern naval munitions, it may be safely assumed that the procurement of warships will in the future be so restricted that both the making of drawings and the supervision of building sites can be accomplished by a personnel less numerous than that now proposed."¹⁰³ Instead the money saved should be used to increase the salaries of the other naval engineers so that they would have wages comparable with those of engineers at private companies.

The prediction that fewer naval engineers would be needed in the future due to reduced acquisition of warships proved wrong – on the contrary, with rapid technological change, more engineers were needed. In 1875 the government granted funds for two temporary-staff naval engineers, two assistant engineers and two master builders. The latter, who were responsible for, among other things, the buildings at the navy yards, did not count as naval engineers but as specialist engineers. The need for engineers with specialist competence increased as new weapons evolved and therefore in 1888 three posts for mine engineers were added. Two of these were

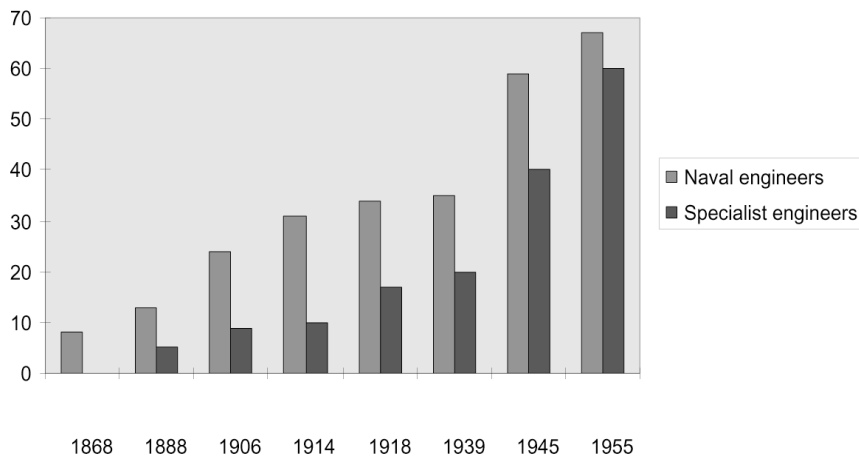
101 "1866 års Stats-råds protokoll öfver Sjöförsvars-departementets ärenden", November 20, 1866: Ministry of Naval Defence (RA).

102 Gustaf Halldin, *Skeppsbyggmästare – mariningenjörer: Kring ett jubileum 1948* (Malmö, 1948), 30.

103 Parliamentary documents (*Riksdagstryck*): *Stats-Utskottets Utlåtande*, 1867, Nr. 37, 5.

later redesignated torpedo engineers. The expansion of the corps is shown in Figure 5.3 below.

Figure 5.3 Number of posts in the Corps of Naval Engineers, 1868–1955



Source: Svenska flottans/marinens/försvarsväsendets rulla, 1869–1955.

As mentioned earlier, the Swedish Navy went through a phase of rapid expansion around the turn of the century and this led to an increased need for naval engineers. Between 1900 and 1906 the number of posts rose from 13 to 24. There were further sharp increases during the two world wars. The growing number of specialist engineers is especially striking. With the increased use of electricity and the Navy's adoption of wireless telegraphy the need for people with knowledge in these areas became urgent. But since at first the numbers were small, no training program was developed and experienced engineers from industry were hired when needed. From World War II onwards the specialist engineers began to approach the naval engineers in numbers. These engineers were mainly electrical engineers and mechanical engineers.

Naval engineers at work

What kind of work did the naval engineers in the Naval Material Administration's engineers' department do? At an early stage in the planning of new ships, they had to work out different design proposals. This work could, as in the case of armoured vessel *Sverige*, built in the 1910s, take many years.¹⁰⁴ When the plans began to materialise the naval engineers had to draw up costed proposals which the Administration submitted to the government.¹⁰⁵ If parliament granted the funds the next step in the work of the engineers' department was to draft a contract, based on drawings and specifications, and send it to the shipyards so that they could tender.

When the Administration had signed a contract with the chosen shipyard and work had begun, naval engineers were stationed at the yard as inspectors. Often the shipyard's responsibility was restricted to the ship with its engines and related equipment, while the Naval Material Administration, through its different military departments, directly purchased guns, torpedoes, radio, navigation instruments etc. The shipyard usually installed this equipment in the ship but the Administration had an important function in co-ordinating the supply of material.

Promotion within the Corps

In the early 20th century the requirements for admission to the Corps were changed to put greater emphasis on military aspects of shipbuilding. The experts who, in 1904, had delivered their recommendations on reorganisation of the Corps had criticised the requirements for theoretical and practical training which had applied since 1868. They argued that a person could become a naval engineer and still be totally unfamiliar with warship design and work at navy yards.¹⁰⁶

Mainly in accordance with the experts' suggestions new requirements came into force in 1906. First, a person had to spend five months as a stoker on warships before becoming a cadet naval engineer and taking the four-year degree course in naval architecture at KTH. From 1935 the young men had to go through a year of military training, which among other things included four months of study at the Royal Naval College, before entering KTH.¹⁰⁷ During the summers the cadets had to serve on board naval vessels, at navy yards and at private shipyards. After graduation two,

104 Ivar Hult, "Sverigeskeppens projektering, konstruktion och modernisering", in *Klart skepp: Boken om Sverigeskeppen Sverige, Gustaf V och Drottning Victoria*, ed. Birger Steckzén (Stockholm, 1949), 69 f.; Anders Sandström, *Pansarfartyg åt Sveriges Flotta: En studie om flottan och striden om F-båten 1906–1909* (Stockholm, 1984); Wedin, *Amiralitetskollegiets historia*, IV, 139 ff.

105 Gustaf Holmberg, "Svenska flottans fartygstyper och fartygsbyggnad", in *Svenskt skeppsbyggeri*, ed. Halldin, 273.

106 Parliamentary documents (Riksdagstryck): Kungl. Maj:ts proposition Nr. 1 (1905), femte huvudtiteln (sjöförsvarsärenden), 23 ff.

107 Yngve Schoerner, "Mariningenjörskåren och sjökrigsskolan", in *Kungl. Sjökrigsskolan 1867–1942*, vol. I, ed. A. Giron (Eskilstuna, 1942), 25 ff.; *Upplysningar angående antagning och utbildning vid Kungl. Sjökrigsskolan 1947: Del IV Mariningenjörslinjen* (Stockholm, 1946).

and after 1917 three, of the cadets could become trainee naval engineers and work at shipyards in Sweden and abroad for some years. As we saw in Chapter 3, in the first decades of the century they went chiefly to Germany and the United States. Then they returned home and became temporary-staff naval engineers for a period of two years.

When this period came to an end the engineer could finally seek permanent employment in the Corps as a second naval engineer, if a position became vacant – those who did not get into the Corps had to find jobs elsewhere but could still join the Corps reserve. After some years as a second naval engineer, one advanced to first naval engineer. A few eventually rose further, first to become an assistant chief naval engineer which meant being either a mobilisation engineer at the navy yards in Karlskrona or Stockholm, or the person assisting the director-general. If the engineer advanced to the next position he became chief naval engineer, who was the head of the engineering department at the navy yards in Karlskrona or Stockholm. Typically a person who reached the upper position in the hierarchy had worked in all parts of the organisation, that is both at the navy yards, in the Naval Material Administration's engineers' department and as inspector of ship construction at the private shipyards.¹⁰⁸

Eventually, some reached the very top position as director-general of naval construction. This person had the dual role of being both head of the Corps and head of the engineers' department and thereby a member of the Naval Material Administration. As can be inferred from Table 5.8, those who became director-general did so on average 30 years after they had graduated from KTH. This of course also explains why the entry requirements from 1868 and the establishment of naval architecture education at KTH in 1898 do not influence the statistics until 1898 and 1929 respectively. It is interesting to note that the pattern here is similar to the developments in the organisations of the system discussed in earlier sections of this chapter, even if, with the exception of the National Ships' Inspectorate, the engineers in those did not enjoy a *formal* monopoly.

Table 5.8 Directors-general of naval construction, 1868–1972

1868–1877, Johan C. A. d'Ailly	Naval officer's examination 1843
1877–1881, Johan V. Gjerling	Naval officer's examination 1843
1881–1898, Göthe W. Svenson	School of Naval Architecture, 1849
1898–1910, Hugo Lilliehöök	Mech. eng. (KTH, 1865)
1910–1914, Helmer Mörner ¹⁰⁹	Mech. eng. (KTH, 1872)
1914–1921, August von Eckermann	Mech. eng. (KTH, 1880)

¹⁰⁸ Halldin, *Skeppsbyggmästare*, 32; See also the careers of the individual naval engineers in: Indebetou & Hylander, eds., *Svenska Teknologföreningen*, vol. I–II.

¹⁰⁹ Between 1912 and 1914 Mörner was on sick leave and Sven Pauli occupied the position.

1921–1929, Johannes Lindbeck	Mech. eng. (KTH, 1896)
1929–1942, Yngve Schoerner	Nav. arch. (KTH, 1901)
1942–1954, Harald Qvistgaard ¹¹⁰	Nav. arch. (KTH, 1918)
1954–1966, Ivar Oldenburg	Nav. arch. (KTH, 1928)
1966–1972, Bernt Wallin ¹¹¹	Nav. arch. (KTH, 1934)

Source: Halldin, *Skeppsbyggmästare*, 30 ff; Wedin, *Amiralitetskollegiets historia*, vol. V, 205; *Indebetou & Hylander*, eds., *Svenska Teknologföreningen; Vem är det 1975*.

The engineers' influence

In the late 19th century the question of what influence the engineers, and the director-general in particular, should have within the Naval Material Administration was debated. The instructions of 1884 had given the director-general the authority to exercise "overall supervision in a purely technical respect" of all new building and maintenance work as regards both the Navy's ships and the docks and buildings at the navy yards.¹¹² His responsibilities included directing the production of drawings, proposals and technical regulations and finally approving of them.

That the director-general of naval construction should exercise overall supervision in a technical respect at the same time as the Naval Material Administration should exercise supreme technical management of the Navy gave rise to the question of who really had the right to decide on the development of new technology. In 1893, the majority of the members of the Material Administration, in a communication to the Minister of Naval Defence, complained that this state of affairs was unsatisfactory and that even if it had not so far caused any serious troubles, the situation "could on a critical occasion well be disastrous."¹¹³ Was the director-general superior to or in some way equal in rank to the Administration as a whole as regards technical matters? In either case, such an interpretation of the instructions would be wrong, they argued – the director-general of course, had to be subordinate to the Administration and to exercise his powers on the basis of his position as one of its members.

Not surprisingly, Director-General Göthe Svenson did not share the majority view. He recorded a dissenting opinion, arguing that if he was to be subordinate to the Naval Material Administration in technical matters, questions of the design and

¹¹⁰ Between 1947 and 1954 Qvistgaard was on leave for other duties (first he became Head of the National Industry Commission and later Director-General of the National Board of Economic Defence) and Bror T. Zetterström (1947–49) and Birger T. Swenzén (1949–54) served as acting director-general of naval construction.

¹¹¹ Between 1968 and 1972 Wallin was on leave, working as managing director of the Swedish Ship Research Foundation and Harry W. Hallberg was head of the Corps.

¹¹² Official Series of Laws of Sweden (*Svensk Författningssamling*): SFS 1884, Nr. 44, instruktion för öfverdirektören vid mariningeniörstaten, 2.

¹¹³ Communication from the Naval Material Administration to the Minister of Naval Defence: "Skrivelse Kungl. Marinförvaltningen – Chefen för Sjöförsvarsdepartementet", September 27, 1893, "Gemensamma arkivhandlingar: Koncept": Royal Naval Material Administration (KRA).

construction of ships, machinery and other equipment would be decided by a voting procedure in which all members of the Administration took part. Since many of these did not have the necessary knowledge, a situation might appear in which the director-general "would have difficulty in the face of this plurality [i.e. the members] in making his expert knowledge count, especially as the non-experts, who while feeling responsible often also feel uncertain would undoubtedly often obtain information wherever they could find it, even outside the Administration, information which might at times be misleading and could even on many occasions be incorrectly understood and applied."¹¹⁴ This meant that the decisions of the Naval Material Administration threatened to be "upset by the plurality's voting on and intervention in matters which it could not assess."¹¹⁵

Svenson's reservation did not find any political support. Instead, the Minister of Naval Defence, Jarl Christerson, who was a military officer who had earlier been head of the Naval Material Administration's artillery department, took the same line as the majority of the members of the Administration. The new instructions issued in June 1896 stated that the director-general should henceforth be responsible to the Administration in the exercise of his authority.¹¹⁶

However, the restriction of the director-general's influence implied by the instructions of 1896 does not seem to have been sufficient to placate the naval officer faction. An article entitled "Militarism in the Fleet" ("Militarismen inom flottan") in *Tidskrift i Sjöväsendet*, a journal issued by an association of naval officers, queried the position of the naval engineers within the Navy, asking "whether it would be for the best of the fighting service, and thus of the country, if the purely technical element represented in the service by the naval engineers had the ultimate influence at the Navy's dockyards and in the Naval Material Administration rather than the purely military, as represented by naval officers."¹¹⁷ The article argued that there had been attempts to expand the engineering influence at the expense of the military, and that "these had been made with a force commensurate with the energy, the knowledge and the feeling of indispensability which has permeated the representatives of the engineering side."¹¹⁸

Under certain circumstances it would of course be logical to put engineers in charge, it was argued in the article, that is if warships were nothing more than transport facilities and if the navy yards were primarily production plants. However, this was not the case. A naval vessel had a solely military purpose and should be seen as a floating fortress rather than a ship, since the term ship may have the wrong connotations. The only one who was capable of dealing with the strategic and tactical

¹¹⁴ Svenson's reservation to the Naval Material Administration's communication to the Minister of Naval Defence, February 5, 1895, "Gemensamma arkivhandlingar: Koncept": Royal Naval Material Administration (KRA).

¹¹⁵ Ibid.

¹¹⁶ Official Series of Laws of Sweden (Svensk Författningssamling): SFS 1896, Nr. 60, instruktion för öfverdirektören vid mariningeniörstaten, 1 ff.

¹¹⁷ "Militarismen inom flottan", *Tidskrift i Sjöväsendet*, 1897, 115f.

¹¹⁸ Ibid., 116.

questions of where, when and how the warship should be used, was an experienced naval officer. On military grounds he would prescribe a certain speed, protection and seaworthiness for the ship in order for the artillery to have its maximum effect. Of course, when the military requirements had been laid down, the engineer, with those means that “science and experience place at his disposal,” had a task of great responsibility in designing the ship.

Regarding the navy yards, it was argued that these should not be seen as production plants – the importance of the yards lay in their function as military mobilisation centres. In an emergency situation the pure design questions would naturally be of minor importance. What mattered, instead, was to “get the vessels ready for naval warfare at the right time, in the right order and properly equipped,” which called for a naval officer.¹¹⁹

The article concluded that since warships were weapons, “the nature of which only those who have to use them in battle ought to decide,” and since the navy yards were military establishments, it was “obvious that the supreme authority of the dockyards should be military and that the military side should take the decisions in the Royal Naval Material Administration.”¹²⁰ It was clear that the engineers did not share this opinion but hopefully they would think better of it if they were more aware of the competence possessed by the officers.

The statements above clearly show that there were differing opinions of what kind of expert knowledge was superior to other kinds of knowledge. On the one hand there were engineers, here represented by Göthe Svenson, who saw the *development* or *production* of new technology as the crucial problem, and on the other naval officers who considered the *use* of the technology to be of major importance. In the tug-of-war on whose perspective should count, the naval officers were the stronger party.

Despite the fact that the naval officers had a strong position within the Naval Material Administration and that the power of the director-general was formally curtailed by the instructions of 1896, the naval engineers had every opportunity to influence the shape of new naval technology in the period covered by this study. Part of the reason for this was that the naval engineers were the ones to co-ordinate all the different requirements specified with regard to the vessel. Military requirements were often contradictory, for instance heavier artillery and armour were incompatible with increased speed. Here the engineers had to work out technically feasible solutions within given cost ceilings. The naval engineer did not of course have expert knowledge of all the technologies needed on a warship. But in addition to designing the hull, choosing suitable machinery etc, which he had been trained for, he also had overall responsibility for integrating all components into a functioning system.

¹¹⁹ Ibid., 117.

¹²⁰ Ibid.

In the late 1940s the naval engineer Ivar Hult, who had been a member of the Corps for some three decades, maintained that “with the introduction of power-driven vessels, the use of electricity for different purposes on board, the advent of new weapons and technological progress in general, the concept of naval shipbuilding has become increasingly comprehensive and in fact involves a synthetic application of experience of a large number of different specialised scientific and technical fields.”¹²¹ Of course, the naval engineer could not have a detailed grasp of all these fields but his task was, Hult went on, to “guide the synthesis in such a direction that the result as a whole appears the best solution to the requirements laid down for the type.”¹²²

Through its naval engineers, the Naval Material Administration had a broad interface with other parts of the shipbuilding system, which facilitated an exchange of knowledge in both directions. This took many forms. First, of course, there was a direct relationship during the building of a ship, when naval engineers, both those who worked in the engineers’ department and those who were inspectors of construction, worked with the engineers of the shipyard.

During World War II, co-operation was especially extensive. Because of the heavy workload, much of the work usually done by the Naval Material Administration’s engineers’ department was instead done by the shipbuilders.¹²³ The larger shipyards had special naval sections whose personnel worked on naval building. To speed up production, in 1941 the Naval Material Administration set up the Naval Construction Centre at Götaverken in Gothenburg.¹²⁴ Here, under the supervision of naval engineers, technical personnel of Götaverken prepared detailed working drawings for destroyers to be built at Götaverken, Eriksberg and Öresundsvarvet. The naval engineers were given far-reaching authority to approve drawings on the spot, so that only the most important drawings had to be sent to the engineers’ department in Stockholm for approval. Not the least important duty of the Naval Construction Centre was the co-ordination of all purchases of material for the building of the destroyers, a function that was especially important with the wartime shortages.

Conflicting interests

Overall, co-operation between the Naval Material Administration and the private shipyards seems to have been smooth during the period of this study.¹²⁵ There are several possible reasons for this, the most obvious one being that both parties shared

¹²¹ Hult, “Sverigeskeppens projektering”, 71.

¹²² Ibid.

¹²³ Wedin, *Amiralitetskollegiets historia*, vol. V, 74–86.

¹²⁴ Ibid., 77 ff.

¹²⁵ See for instance: Allan Borgström, “Götaverkens leveranser till svenska örlogsflottan”, in *Götaverken 1841–1941* (Göteborg, 1941), 69



Engineers of a private shipyard meeting engineers representing the Royal Naval Material Administration, in connection with the building of the destroyer Nordenskjöld at Götaverken in 1927. From the left: Tage Widén (engineer at Götaverken), Runar Thollander (engineer at Eriksberg), Johannes Lindbeck (director-general of naval construction), Hugo Hammar (managing director of Götaverken), Erik Löfvén (naval engineer) and John Schneider (rear admiral and head of the Naval Material Administration). Except for Schneider all were college-trained engineers. Furthermore, in 1927 all six in the photo were members of the Swedish Association of Engineers and Architects. (Photo: Varvshistoriska Föreningen)

an interest in ensuring that the building of advanced warships took place at all. Of course, there were conflicts too. The engineers of the Naval Material Administration and their counterparts at the shipyards sometimes held very different views on technical problems and sharp exchanges of words could take place at the meetings of STF's section for naval architecture.

An example of this occurred in November 1912, following a speech by Hugo Hammar on the desirability of simplifying the building of warships. He began by saying that it was important to discuss:

the possibility of producing not only the most constructionally perfect, regardless of cost, as has hitherto been the practice in all navies, but also the most inexpensive possible without sacrificing the qualities which are necessary for the vessel to fulfil its function in battle. This is in fact, for the engineer, a far more demanding, and therefore more responsible, assignment than simply producing the most perfect from a technical or design point of view. It obviously calls for judgement and really sound knowledge to achieve in practice the same result using simpler and cheaper resources and working methods as when one is able to use the finest that money can buy.¹²⁶

¹²⁶ Hugo Hammar, "Önskvärdheten af förenklingar vid krigsfartygsbyggnader", *Teknisk tidskrift: Skeppsbyggnadskonst*, February 19, 1913, 3.

He went on to suggest several simplifications in design and choice of material which would lead to lower production costs without necessarily reducing fitness for combat. For instance he wanted to replace certain metals, such as copper and tin, with cheaper cast steel, and teak with pine. Further he hoped that the Naval Material Administration would accept components which did not completely fulfil the stipulated requirements and not reject them as sub-standard. "It is a known fact," he said, "that nowhere, and least of all in the engineering industry, can anything be made absolutely perfect, and that there must therefore always be allowed a certain tolerance; rejecting perfectly satisfactory goods merely because they do not meet the specification to the letter is as unjustified as accepting inferior workmanship or inadequate material dimensions."¹²⁷ For instance, considering the high quality of Swedish steel, it would be a great waste to throw away parts just because there were a few pinholes or porosities in them.

In Hammar's opinion, the simplifications he suggested would benefit both the shipyards and the Navy. He attributed the frequent difficulty in gaining a hearing for such changes to conservatism in military circles which did not know what was best for them. He said that he often had heard comments like "it is not the Navy way" or "it is not first-class" when he tried to bring up the subject.

Other representatives of private firms who were present at the meeting agreed with Hammar. Thore Thelander at Bergsunds Mek. Verkstad stated that during the three decades he had worked in the field, the Naval Material Administration's engineers' department had become increasingly bureaucratic. He found that members of its staff were now afraid to shoulder responsibility and tended to "hide behind paperwork and attach most importance to avoiding censure."¹²⁸ As a result they would rather reject than accept a component which did not fulfil the stipulated requirement, but would have worked sufficiently well. They acted in this way because they lacked practical engineering experience, he argued.

The naval engineers were quick to reply. They argued that the engineers at the shipyards did not understand the military demands. Chief Naval Engineer Carl Richson said that naval vessels were of relatively lighter construction than merchant ships and that for the necessary strength one had to use material of superior quality. Furthermore, the workmanship had to be considerably more precise than for merchant ships. Naval vessels would reach higher speeds than ordinary ships and therefore vibration could be a problem. Another aspect which had to be taken into consideration was that a warship is subjected to great strain when firing its heavy artillery. Therefore, only the best material and workmanship was acceptable.

Whereas the privately employed engineers had accused the naval engineers of lack of economic realism in their search for technically superior solutions, the latter

¹²⁷ Ibid., 5.

¹²⁸ Ibid., 6.

replied that the shipyards only wanted to earn money with no consideration of the customer's future maintenance costs. While for the last fifty years the shipyards had been the Navy's principal suppliers of ships, the navy yards still carried out most of the repair and maintenance. Chief Naval Engineer Karl Rundgren said that "when the shipyards have done their work and carried out the trial trip they think they have done their duty, but then the customer has to maintain the material, and the shipyards have as a rule no experience of this after handing over the vessel."¹²⁹

To conclude, the privately employed engineers and the naval engineers sometimes had conflicting interests. The engineers of the shipyards had a *producer* interest, i.e. the financial interest of their companies. The naval engineers, on the other hand, represented a *user* interest, i.e. the military interest, many aspects of which they shared with naval officers.

Social networks

The building of warships at the private shipyards was not the only area where naval engineers exchanged knowledge and experience with people from other parts of the shipbuilding system. As indicated above, another meeting place was STF's section for naval architecture. Here the naval engineers formed the largest individual group of members. From minutes of meetings and annual reports it is clear that they were active members who read papers, took part in discussions, served on the board and worked for the section in other ways.

The naval engineers also functioned as vehicles of knowledge in other contexts: for instance they were represented on the boards of research institutes – the Swedish State Shipbuilding Experimental Tank and the Swedish Shipbuilding Research Foundation. Some of them also taught at the Royal Naval College and the Royal Naval Staff College as part of their service.¹³⁰

Other points of contact resulted from the naval engineer's mobility within the shipbuilding system. While many of them spent their entire careers in the military, others left the Corps and took jobs in private companies. At times this constituted a problem to the Naval Material Administration: in the mid-1950s almost one-third of all positions for naval architects and mechanical engineers were vacant, which meant that design work was delayed.¹³¹ The military background seems to have been highly rated in the business community and former naval engineers sometimes reached leading positions. Some eventually became managing directors of the

¹²⁹ Ibid., 7.

¹³⁰ *Upplýsingar angående antagning och utbildning vid Kungl. Sjökrigsskolan 1947*; A. Giron, ed., *Kungl. Sjökrigsskolan*, vols. I–II; Jens Stefenson, ed., *Kungl. Sjökrigsskolan 100 år: Del III 1943–1967* (Stockholm, 1967).

¹³¹ Wedin, *Amiralitetskollegiets historia*, vol. V, 183.

shipyards (see Table 5.3): Gösta Lundeqvist (Kockum), Hilding Nielsen (Lindholmen, Öresundsvarvet, Götaverken), Pehr Perno (Lindholmen), Gustaf Löwenhielm (Lindholmen), Johan Schreil (Uddevallavarvet) and Per Alsén (Eriksberg). Others reached middle-management positions, for instance Anders Lindén, who after 17 years as a naval engineer and four years at Atlas Diesel and NOHAB, in 1951 became technical manager and head of the engine department at Götaverken, a position he held until 1969.¹³²

Elsewhere in the system we find former naval engineers in leading positions, for instance as the technical managers of shipping companies (see Table 5.7): examples were Gösta Kaudern (Broströms) and Torsten Blixt (Svearederierna). Another naval engineer who moved within the system was Nils Rogberg, who ended up as managing director of a maritime insurance company.¹³³

Former naval engineers not only went to work for private companies but some became professors at the engineering colleges (see Table 5.9): Olof Falkendal, Curt Falkemo, Harald Lange, Jan Stefenson (all at Chalmers) and Erik Steneroth (at KTH). In research, too, we find former naval engineers (see Table 5.10 and 5.11) – Walter Vollert, Bernt Wallin and Gösta Kaudern, who were managing directors of the Swedish Shipbuilding Research Foundation, had such a background.¹³⁴

Having so far considered engineers working for both producers and users of ships, and for organisations setting up rules and regulations, the rest of this chapter will deal with other supportive functions of the system, beginning with engineering education and technical research.

5.7 Technical colleges and research institutes

Many engineers came to work as carriers of technical knowledge in a very direct sense: they became teachers at the engineering colleges or elsewhere within the field. As we saw above, many engineers did some teaching alongside their regular job at, for instance, the shipyards. Here we shall only deal with those who taught full-time and reached the position of full professor. We shall also take a closer look at those who became heads of the research institutes.

¹³² Indebetou & Hylander, eds., *Svenska Teknologföreningen; Vem är det* 1975.

¹³³ See Section 5.8.

¹³⁴ If we extend the period to the 1980s, we find that head of SSPA between 1986 and 1988, Hans Peder Loid, had also been a naval engineer.

Professors of naval architecture

The educational backgrounds of the professors in the field of naval architecture and marine engineering are shown in Table 5.9. Before the 1940s, the two schools had only one chair of naval architecture each. Later the chairs were divided into certain specialities. The abbreviations below refer to, for Chalmers: t – theoretical shipbuilding, p – practical shipbuilding, m – marine engines, and for KTH: h – hydromechanics, s – shipbuilding.

Table 5.9 Professors, late 19th century to the 1990s (before 1912: senior lecturer)

Chalmers

1887–1893	Carl A. O. Trygger	Ex. Navy designer 1841
1894 (1912) –1916	Henrik Lindfors	School of Nav. Arch. 1874
1917–1930	Johannes Rosengren	Nav. arch. (Chalmers, 1897)
1933–1954 (t after 1941)	Anders Lindblad	Nav. arch. (Chalmers, 1913)
1941–1951 (p)	Gustaf Ambjörn	Nav. arch. (KTH, 1910)
1954–1983 (p)	Anders Svennerud	Nav. arch. (Chalmers, 1943)
1955–1967 (m)	Olof Falkendal	Nav. arch. (KTH, 1925)
1957–1985 (t)	Curt Falkemo	Nav. arch. (KTH, 1947)
1967–1981 (m)	Harald Lange	Nav. arch. (KTH, 1938)
1983–	(p) Anders Ulfvarson	Nav. arch. (KTH, 1969)
1983–1990 (m)	Jan Stefenson	Nav. arch. (KTH, 1948)
1985–1994 (t)	Gilbert Dyne	Nav. arch. (Chalmers, 1952)
1994–	(t) Lars Larsson	Nav. arch. (Chalmers, 1969)

KTH

1893 (1912) –1925	Fredrik Lilliehöök	Mech.eng. (KTH, 1886)
(1925–1955 – no professor of naval architecture) ¹³⁵		
1943–1957 (h)	Einar Hogner	Civ. eng. (KTH, 1916)
1955–1989 (s)	Erik Steneroth	Nav. arch. (KTH, 1949)
1957–1985 (h)	Bengt Joel Anderson	Eng. physics (KTH, 1941)
1992–	(s) Olle Rutgersson	Nav. arch. (Chalmers, 1970)

Source: Olsson, *Utbildning av skeppsbyggnadsingenjörer*, 33–47; “*Ny professor*”, Chalmers-Nytt, 1994:3, 12; Rutgersson, “*Sjövärldiga snabba fartyg*”, 38.

¹³⁵ Between 1925 and 1941 the position as professor of naval architecture was vacant and H. F. Nordström (Mech.eng. – KTH, 1910) and Nils J. Ljungzell (Nav. arch. – KTH, 1908) shared the responsibility for the study programmes. In 1941 the chair was replaced by a specialist post which Ljungzell held until 1955.

As earlier, we have a monopoly-like situation: virtually all those who became professors had graduated as naval architects. KTH graduates became professors more often than Chalmers graduates. If we take a closer look at the professors' backgrounds we find that until the 1950s they usually had substantial practical experience, having worked at shipyards or for the Naval Material Administration for many years.¹³⁶ Only one had pursued further theoretical studies abroad – Gustaf Ambjörn studied naval architecture at the Massachusetts Institute of Technology in 1912–13. Before becoming professors they had had some experience of teaching, for instance as temporary lecturers or acting professors. Usually they had published a few articles on practical aspects of naval architecture. These articles appeared in technical journals or trade journals such as *Teknisk tidskrift: Skeppsbyggnadskonst* and *Svensk Sjöfartstidning*. Very few published anything in foreign journals. Generally they had not carried out much research and had not obtained the doctor's degree, even though it was possible to do so at KTH from 1927 onwards.

For a professor of an applied subject field, such as naval architecture, it was important to have close contacts with representatives of private industry and to follow the latest developments in the field. This they did in many ways. For instance, the professors were often active members of technical associations. They also acted as consultants.¹³⁷ In this capacity some professors were engaged by shipyards, shipowners and others in designing ships, dry docks, engines and other equipment. A few also worked occasionally as inspectors of vessels or as the classification societies' surveyors. In this way, they maintained contacts with different parts of the system.

The careers of two engineers, Anders Lindblad and Einar Hogner, who became professors in the 1930s and 1940s, are interesting since they mark a change regarding the professors' scientific qualifications, a change which was to reach its full effect in the post-World War II period.

Anders Lindblad (1888–1956) graduated in naval architecture from Chalmers in 1913 and worked at shipyards in Sweden and the United States until 1918, when he became an assistant professor of naval architecture at the University of Michigan, Ann Arbor – in 1917–18 he had had a second job as a teacher at the Case School of Applied Science, Cleveland. The department at Ann Arbor had a towing tank, and model-testing became Lindblad's major interest. In 1923 he obtained a doctor's degree and in 1928 he became associate professor at the same university. He published several articles in American journals such as the *Transactions of the Society of Naval Architects and Marine Engineers* and the *Marine Review*. When he applied for the chair at Chalmers the appointing committee found him the most qualified and he returned to Sweden in 1933. In the late 1930s he was closely involved in the

136 Cf. Ulf Larsson, "Vetenskap och teknik i teori och praktik: Professorstillsättningar vid KTH 1921–86", Diploma thesis at the Department of History of Science and Technology, Royal Institute of Technology, Stockholm, 1990.

137 Ragnar Woxén, *Vägen från Roslagen* (Stockholm, 1989), 87; Torsten Althin, *KTH 1912–62: Kungl. Tekniska Högskolan i Stockholm under 50 år*, (Stockholm, 1970), 168.

building of the Swedish State Shipbuilding Experimental Tank and in the following decade he carried out model-testing there.¹³⁸

Unlike most others who became professors of naval architecture, Einar Hogner (1892–1957) was not a naval architect but had graduated in civil engineering from KTH in 1916 and thereafter studied at Stockholm University College and the University of Uppsala for several years. In 1925, he obtained a doctor's degree in Uppsala and became associate professor of mechanics and mathematical physics. He stayed there until 1937, when he became professor of mathematics and engineering mechanics at Chalmers. Hogner's research focused on wave resistance and other aspects of hydromechanics and he published many articles in scientific and technical journals. For shorter periods he had also done research abroad: between 1926 and 1928, and again in 1931, he had spent time at a German experimental tank, the Hamburgische Schiffbau-Versuchanstalt. In 1943, he became a professor of hydromechanics at KTH.¹³⁹

From the mid-1950s those who became professors of naval architecture had usually worked for some years as researchers, for instance at KTH, the two Swedish maritime research institutes or the Swedish atomic energy company, AB Atomenergi, and had obtained either a licentiate or a doctor's degree in engineering.¹⁴⁰ Like their earlier counterparts, however, they also had practical experience as engineers at the private shipyards, for the classification societies, for the Naval Material Administration, for shipping companies, or elsewhere.

The changes in the professors' backgrounds mirror the change in the aims of the engineering schools during the period. For a long time KTH and Chalmers were training establishments pure and simple. Whether there was any research depended on the interests of the individual members of the staff. A gradual change, however, came about in the interwar years.¹⁴¹ As we shall see in Chapter 6, there was an increase in industry-related technical research in Sweden from World War I onwards. In 1917 KTH moved into new larger buildings with modern laboratories. Ten years later the school acquired the right to confer the doctor's degree and from 1932 the directions of the school stated for the first time that one of its assignments was "technical-scientific research."¹⁴² Nevertheless, the research conducted was limited. As we saw earlier, in 1937 Chalmers acquired the rank of university and in 1940 it

138 Anders Svennerud, "Lindblad, Anders Fredrik", in *Svenskt biografiskt lexikon*, vol. 23 (Stockholm, 1980–1987).

139 Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 971; Thomas Kaiserfeld, *Vetenskap och karriär: Svenska fysiker som lektorer, akademiker och industriforskare under 1900-talets första hälft* (Lund, 1997), 128 f.

140 Svante Lindqvist has shown that while in the early 20th century only one-third of the professors at KTH had obtained the doctor's degree (and these were usually professors of basic scientific subject fields, for instance physics, mathematics, etc.), by 1960 two-thirds had done so, see: Svante Lindqvist, "Ideology and institutional structure: The historical origins of the present crisis in Swedish engineering schools", in "Universities and the sciences: Historical and contemporary perspectives", ed. Giuliano Pancaldi, special issue of the Bologna university journal *Alma Mater Studiorum* (1993), 193.

141 Henrik Björck, "A distinguished scientific field? Pursuing resources and building institutions for engineering research in Sweden, 1890–1945", in *Foundations of Engineering Competences: Profession, practices and the role of knowledge* (forthcoming).

142 Official Series of Laws of Sweden (Svensk Författningssamling): SFS 1932, Nr. 382, kungörelse om ändrad lydelse i vissa delar av stadgarna den 8 april 1921 (nr 262) för tekniska högskolan, 1.

received the right to confer the doctor's degree. Two years later, in 1942, the government set up *Statens tekniska forskningsråd* (the Swedish Council for Technical Research) to fund technical research. It was not until after World War II, however, that research actually became a major concern of the universities of technology.¹⁴³

The field of naval architecture to some extent follows this general pattern. While some professors had done research work earlier, institutionalised research in naval architecture at KTH and Chalmers was a product of the post-World War II period. However, the change was gradual and rather slow, which is indicated by the doctoral and licentiate degrees conferred.

The first person to obtain a doctor's degree in naval architecture at KTH was H. F. Nordström, who did so in 1931. He was at that time a lecturer in naval architecture there and responsible for the school's towing tank. In 1940 he became head of the Swedish State Shipbuilding Experimental Tank. After Nordström's there were no dissertations in the subject until 1950, when two engineers obtained the doctor's degree, both in hydromechanics. For the rest of the 1950s there were no doctoral dissertations in the field.¹⁴⁴

In 1943 a licentiate of engineering degree was introduced, which was halfway between a master's and a doctor's degree. The first such degree in naval architecture was awarded in late 1940s and in the next ten years six people obtained the degree, mainly in hydromechanics but also in welding technology and solid mechanics.¹⁴⁵

At Chalmers post-graduate studies in naval architecture evolved later than at KTH. While a few had obtained licentiate degrees before, it was not until 1969 that the first person, Gilbert Dyne, obtained a doctor's degree in the field.¹⁴⁶

During the 1950s and 1960s, the staff of researchers at Chalmers and KTH grew. Often the focus of research work was on the technical problems which the Swedish shipyards encountered at this time, for instance the increasing size of oil tankers, and the difficulties that these presented.

To conclude, from the late 19th century onwards, college-trained engineers were the ones to hold the chairs in the field of naval architecture. In that capacity they could exert influence on technical developments in the shipbuilding system, not least since they were the ones who decided the immediate content of the courses, thereby stipulating what knowledge the future naval architects should have when

143 Svante Lindqvist, "A Cost-Benefit Analysis of Science: The Dilemma of Engineering Schools in the Twentieth Century", in *Science, Technology and Society: University Leadership Today and for the Twenty-First Century: Festschrift to Professor Janne Carlsson* (Stockholm, 1998), 106–116.

144 Dagmar Odqvist, ed., *Förteckning över Kungl. tekniska högskolans Doktorsavhandlingar 1928–63* (Stockholm, 1964), 5 f. In addition to the three dissertations in the field of naval architecture there were also dissertations in other subjects, for instance aeronautical engineering or solid mechanics, within the larger School of Aeronautical Engineering and Naval Architecture.

145 *Redogörelse för verksamheten vid Kungl. tekniska högskolan, 1949/50 – 1957/58*. In addition to these six licentiate degrees there was also a further one in welding technology applied to shipbuilding. This degree, however, was awarded within the School of Mechanical Engineering.

146 *Inbjudan till teknologie doktorspromotion vid Chalmers Tekniska Högskola* (Göteborg, 1968), XIV.

they left Chalmers or KTH. Moreover, the professors were able to influence the direction of research in the field, either through their own departments or as members of the research institutes' boards and committees.

Heads of research institutes

A striking feature of the post-World War II period was that research increasingly became a full-time occupation, in its own right, at the new industrial research institutes. These institutes, which I will deal with in detail in Chapter 6, were the Swedish State Shipbuilding Experimental Tank (SSPA), established in 1940, and the Swedish Shipbuilding Research Foundation (SSF), established in 1955 and closed down in 1978. In these organisations engineers were the ones to carry out research as well as to obtain the leading positions. Tables 5.10 and 5.11 show the heads and their educational background. For SSF, the abbreviation DR means director of research and MD managing director.

Table 5.10 Heads of the Swedish State Shipbuilding Experimental Tank, 1940–1999

1940–1955, H. F. Nordström	Mech.eng. (KTH, 1910)
1955–1981, Hans Edstrand	Nav.arch. (KTH, 1940)
1982–1986, Hans Lindgren	Nav.arch. (Chalmers, 1948)
1986–1988, Hans Peder Loid	Nav.arch. (Chalmers, 1968)
1988–, Hans Broberg	Mech.eng. (Chalmers, 1970)

Source: SSPA annual reports: *Berättelse över Statens Skeppsprovsningsanstalts verksamhet, 1940–1955*; Edstrand, “Nordström, Hugo Fredrik”; *Vem är det 1983*; Lindgren, “Marintekniska Institutet SSPA”; Chalmersska Ingenjörsföreningens katalog, 1985–1995.

Table 5.11 Heads of the Swedish Shipbuilding Research Foundation, 1955–1978

1955–1962, Lennart Swenson (DR)	Nav.arch. (Chalmers, 1947)
1963–1968, Gustaf Backman (DR)	Nav.arch. (Chalmers, 1960)
1964–1968, Walter Vollert (MD) ¹⁴⁷	Nav.arch. (KTH, 1940)
1968–1977, Bernt Wallin (MD)	Nav.arch. (KTH, 1934)
1977–1978, Gösta Kaudern (MD)	Nav.arch. (KTH, 1938)

Source: SSF annual reports: *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Årsberättelse, 1955–78 (SSPALib)*; Sveriges civilingenjörer, bergsingenjörer och arkitekter 1961.

¹⁴⁷ Until 1964 the director of research was the head of the organisation. Then for a few years the managing director of the Swedish Shipbuilders' Association was also managing director of SSF and shared the responsibility with the director of research, see instructions for the two positions, Minutes, SSF's board of directors, August 5, 1964: SSF (CKG). After 1968 SSF only had one top position, that is as managing director.

As we can see, all the men who became leaders of these organisations were college-trained engineers from Chalmers or KTH. Not surprisingly, we again see a monopoly-like situation. Regarding their backgrounds, the two research institutes show different patterns. Those who became heads of the state-owned institute SSPA had worked on research and development for several years, usually within the organisation, and both Nordström and Edstrand had obtained the doctor's degree.¹⁴⁸ The more industry-oriented institute SSF, on the other hand, recruited people from outside the organisation as leaders. These men were not academically trained researchers but engineers who had earlier worked at shipyards, for shipowners or as naval engineers. Their experience of research was restricted to, for instance, having been responsible for questions of research within their earlier organisations or having been members of the boards of SSPA and SSF.

As we have seen, throughout the period college-trained engineers held the leading positions in engineering education and research, and had the ability to exert an influence upon the content of these two fields. Since engineering science was at the heart of the engineers' world it is difficult to imagine what other groups could also have aspired for these posts. The only likely candidates would have been university-trained scientists, but with the emphasis on both practical and theoretical knowledge at the engineering schools and research institutes engineers were the preferred choice.

5.8 Other parts of the shipbuilding system

Finally we may briefly consider engineers in other parts of the shipbuilding system. As we saw in Section 5.1 some of the naval architects became consultants. Usually they did so after having worked at shipyards for a long time – 10 to 30 years. As consultants they did design work, to a large extent for shipowners. Other clients were the shipyards and various public authorities, among them the Swedish State Railways (train ferries) and the National Administration of Pilotage, Lighthouses and Buoys. In the late 19th century and the first decades of the 20th century those who worked as consultants usually also functioned as the classification societies' surveyors and as part-time teachers at engineering colleges and schools of nautical studies.¹⁴⁹

¹⁴⁸ Hans Broberg has obtained the doctor's degree, but that falls outside the period of this study.

¹⁴⁹ For data on the careers of some who became consultants, see: Indebetou & Hylander, eds., *Svenska Teknologföreningen*, p. 151 (Frithiof Linde), 214 (Gustaf Bremberg), 219 (Wilhelm Hök), 440 (Hilding Schalin), 441 (Gustaf Seth), 572 (Otto von Sydow); "Johan Johnson †", *Teknisk tidskrift: Skeppsbyggnadskonst*, September 28, 1921, 96; "Seldén, Folke", *Svensk uppslagsbok*, vol. 25 (Malmö, 1957), 799. On the consulting engineers in Swedish industry, see: *Svenska konsulterande ingenjörers förening 1910–1920* (Stockholm, 1920); Torsten Althin, *Vattenbyggnadsbyrån 1897–1947* (Stockholm, 1947); Gunnar Eriksson, *Kartläggarna: Naturvetenskapens tillväxt och tillämpningar i det industriella genombrottets Sverige 1870–1914* (Umeå, 1978), 89 f.

Like the shipyards, the sub-contracting firms were producers of various items. The larger ones among them employed several engineers. For instance, the manufacturer of equipment for electric welding, ESAB, had naval architects on its staff, who worked in close co-operation with engineers at the shipyards.

Regarding the engineers' positions in the hierarchy of the company, ESAB to some extent resembles the shipyards. The founder of the company, Oscar Kjellberg had both passed an engine-room officer's examination and had a shorter technical education. When he died in 1931, Walter Edström, who had graduated in electrical engineering from KTH in 1913, became managing director. From that time until a British firm, Charter, bought ESAB in the mid-1990s, college-trained engineers, either electrical or mechanical engineers, have held the position of managing director.¹⁵⁰ ESAB differs from the shipyards in that engineers were not eventually superseded by people with an advanced economics education. However, from 1980 onwards the engineers who became managing directors also had studied economics and management.

While it may have been natural for engineers to work as consultants and for sub-contractors, it is less obvious that they should also have worked for organisations associated with the users. One category of organisation which employed naval architects was the maritime insurance companies. These organisations needed engineers, among other things, to inspect damaged ships and to deal with the shipping companies' technical departments regarding the question of repair.

A few engineers reached leading positions in insurance companies, for instance Nils Rogberg. He had graduated as a naval architect from KTH in 1921 and entered a career as a naval engineer, which to begin with meant two years of work in Germany. After two more years as an temporary-staff naval engineer he left the organisation, remaining, however, in the Corps' reserve, and obtained a job at Götaverken. From 1928 onwards he worked for maritime insurance companies, first at Sjöförsäkrings AB Öresund in Malmö where he stayed until 1933. Then he became managing director of Sjöförsäkrings AB Ägir in Stockholm. In 1954 he became managing director of Sjöförsäkrings AB Öresund and he also held other important positions of responsibility, for instance he was chairman of the Swedish Association of Marine Underwriters.¹⁵¹

150 The managing directors of ESAB were: 1904–1931, Oscar Kjellberg (technologist and engine-room officer), 1931–1956 Walter Edström (electrical engineering, KTH 1913), 1956–1970 Göran Edström (mechanical engineering, KTH 1943), 1970–1980 Åke Ahlström (electrical engineering, KTH 1948), 1980–1991 Bengt Eskilson (mechanical engineering, KTH 1961 & advanced management program at Harvard Business School, USA, 1977), 1991–1994 Lars Westerberg (electrical engineering, KTH 1972 & Economist, university level, Stockholm University 1980). Source: Bertil Lundberg, *Maskinhistorik 1904–1990* (Göteborg, 1992), 4; *Sveriges civilingenjörer, bergsingenjörer och arkitekter; Sveriges civilingenjörersförbund: Matrikel 81* (Stockholm, 1981); *Vem är det?*, 1937–1995.

151 Indebetou & Hylander, eds., *Svenska Teknologföreningen*, 1109; Jan Kuuse & Kent Olsson, *Sjöfart & sjöförsäkring under 125 år: Sveriges Ångfartygs Assuransförening 1872–1997* (Göteborg, 1997), 270.

5.9 Concluding remarks

The aim of this chapter has been to evaluate the influence which the engineers had in the Swedish shipbuilding system as a whole, focusing both on the engineers' dispersion to different organisations within the system and their positions in the hierarchy of these organisations.

Engineers came to work all over the system. They represented not only the producers of ships, but also the organisations responsible for drawing up rules and regulations, the two main categories of the shipyards' customers, and organisations performing various supportive functions, such as teaching, research and insurance. The great majority of the engineers in these organisations were naval architects. The most marked difference between those who had graduated from Chalmers and those from KTH was that the former dominated at the private shipyards and the latter at the Naval Material Administration.

Did the engineers possess the necessary influence to be able to function as a social group of technology carriers? From the 1910s and until World War II, in particular, college-trained engineers, most of them naval architects, gained leading positions within the system. The private shipyards which were the dominant components of the system were the engineers' greatest stronghold and here they came to have something of a monopoly of the position of managing director until the 1960s and 1970s. Gradually the engineers came also to dominate middle-management positions at the yards, positions which had earlier been occupied by technologists with substantial practical experience.

The shipyards were not the only organisations where engineers acquired leading positions. The technical departments of the shipping companies show a similar pattern, with engineers gaining an informal monopoly of the position of technical manager. Regarding the two government organisations dealt with above, it was a formal requirement that people in leading positions should be engineers. As early as 1868 the directions of the Corps of Naval Engineers stated that its members, who functioned as the Naval Material Administration's technical staff, had to have graduated from KTH. From its founding in 1915 the top positions of the National Ships' Inspectorate were reserved for college-trained engineers. Other leading positions within the system, for instance as professors or heads of the research institutes, were also the engineers' domains.

It was not inevitable that the engineers should gain the top positions in the production system. As we have seen, there were other groups who could also lay claim to these posts on the strength of other kinds of expert knowledge. At the shipyards the theoretically trained engineers had to compete with practically trained technologists. In organisations such as the shipping companies and the Ships' Inspectorate, nautically trained men, with their knowledge and experience of the operation of ships, could have been the ones to obtain the leading positions. Moreover, the majority of the decision-makers in the Naval Material Administration were

not engineers but naval officers. All these kinds of expert knowledge were needed within the organisations of the system, and it was in no way self-evident which kind should entitle its carriers to the leading positions.

This chapter has shown that college-trained engineers successfully competed with technologists and nautically trained people for power over several of the organisations in the system and that by the time of World War II, they had acquired most leading positions there.

Of course, the engineers did not emerge triumphant everywhere. One group whose members were able to withstand the assault of the engineers were the naval officers of the Swedish Navy and the Naval Material Administration. In contrast to the seamen of the merchant fleet, the naval officers belonged to the old elite of society. They were properly organised and had substantial political influence.

A further limitation to the engineers' influence on the shaping of new technology was that they could not to any significant extent influence the international classification societies.

Despite these reservations, we may conclude that the engineers, as a group, gained a position strong enough for them to function as a social group of technology carriers, an example of which will be presented in the next chapter. Not the least important aspect of this was the fact that they held positions of great responsibility in most parts of the system and that they made up an influential "old boy"-network, sharing the same backgrounds and knowing each other from many different contexts such as their student days at KTH or Chalmers, the professional associations or the workplaces. The engineers' mobility between different employers within the system contributed to the extension and reinforcement of this network.

Regarding the engineers' interests, again we have seen both conflicting and shared ones. For instance, the naval engineers and the engineers at the private shipyards held very different opinions on whether it was desirable to carry out certain simplifications of the design of warships. While the privately employed engineers represented the producer interest, clearly seeing to their companies' economic interests, the naval engineers represented a user interest, for which lower building costs might lead to increased maintenance costs in the future or to a ship of inferior quality, less useful in time of war. Furthermore, we have seen additional indications of the engineers' interest in the actual process of creating new technology.

In Chapter 6, we shall study research in the field of naval architecture. At the same time as this activity increasingly became a part of the engineers' daily lives from the 1940s onwards, the establishment of the two research organisations also illustrates how engineers functioned as a social group of technology carriers, fulfilling all the requirements of having knowledge, interest and power, and being suitably organised.



6. Industrial Research Institutes

This chapter will deal with the establishment of Swedish industrial research institutes in the field of naval architecture and with the role of engineers both as promoters of such facilities and as researchers. In contrast to many other fields of technology, such as electrical or chemical engineering, shipbuilding was not very dependent upon technical-scientific research. Early, research was mainly restricted to the field of hydromechanics, but from World War II onwards it came increasingly to deal with other aspects of shipbuilding as well. The chapter is a case study of how the engineers functioned as a social group of technology carriers. It also deals with how the research organisations came to function both as producers of new knowledge and as a forum for the exchange of experience between people from different parts of the system.

6.1 The Swedish State Shipbuilding Experimental Tank

Ship-model testing abroad

As early as in the 18th century many people were interested in the question of developing theoretical methods for calculating different hydromechanic properties of a ship. Since it proved to be impossible to determine analytically the resistance of a complex body such as a ship moving through water, tests were carried out using models.

Model tests were conducted in several countries, most notably in France and England.¹ In Sweden, the well-known master shipwright Fredrik Henrik af Chapman (1721–1808) used model tests in an attempt to verify a geometrical method of estimating the resistance of a vessel. Even if the results of his tests proved disappointing, the systematics of the experimental work pointed to the potential value of such tests.²

In the age of sailing ships, the main benefit would be to find a hull shape that, at a given displacement and speed, would give a minimum of resistance. Later, when ships began to be powered by engines, two questions became important. First, of

1 Friedrich Neumeyer, "Den hydrodynamiska modellprovnigen från Mariotte till Chapman", *Skrifter utgivna av Sjöhistoriska Samfundet II* (Uppsala, 1941), 25–57; idem., "Christopher Polhem och hydrodynamiken", *Arkiv för matematik, astronomi och fysik*, Band 28 A (1942), No. 15.

2 Daniel G. Harris, *F H Chapman: The First Naval Architect and His Work*, (London, 1989), 168–189; Boel Berner, "Experiment, teknikhistoria och ingenjörens födelse", *Dædalus: Tekniska Museets Årsbok* 1982, 39–52.

course, if the resistance of a ship of a given size and cargo-carrying capacity, and at a given speed, could be reduced, that would yield important savings in fuel consumption. In the case of warships, less resistance would give a higher speed. By comparing the test results of different hull shapes it would be possible to decide how to design the real ship. The second question was how to estimate, in advance, the resistance of a given ship at a certain speed, in order to decide the power required of its engines. If a ship, at delivery, did not satisfy the requirements of the contract with regard to speed, a shipowner would be entitled to damages from the shipyard.

If one wanted to calculate the resistance of a full-scale ship, the major problem with model tests was the conversion of the test figures into the corresponding figures for the real ship. In the 1870s, William Froude (1810–1879) came up with a satisfactory solution to the problem of scale. He divided water resistance into two components, one dependent upon the friction between the hull and the water, and the other arising from the waves produced by the hull. By calculating a dimensionless number, later called the Froude number, it was possible to scale the wave component of the resistance. The technique he suggested involved measuring the total resistance of the model, subtracting the resistance due to friction, scaling the wave resistance and then adding the full-scale friction resistance.³

Froude's methods attracted great attention and became the guiding principle behind model tests. Funded by the British Admiralty, Froude built a towing tank at Torquay, England, in 1871, which became a model for other tanks all around the world.⁴ Before World War I a large number of experimental tanks were built, often with military applications in mind, in Britain, France, Germany, the United States, Italy, Russia, the Netherlands and Japan. As we saw in Chapter 2, naval technology was one of the period's edge technologies and in Britain, and somewhat later in other countries, there emerged a powerful military-industrial complex concentrating on the building of warships.

Table 6.1 shows the major experimental tanks built before the Swedish one in Gothenburg. Note the many tanks constructed, first in the period from the 1870s until the 1910s, and then again from the late-1920s onwards. Of course, experimental tanks were also built after 1940.⁵ The point here, however, is to place the construction of the large Swedish tank in a broader international context.

3 Gilbert Dyne, "Fartygs motstånd: Kompendium i kursen Modellförsöks och Propellerteknik", Chalmers Tekniska Högskola: Institutionen för Marinteknik, Avd. för Hydromekanik: Göteborg, 1991, 2.

4 A. T. Crichton, "William and Robert Edmund Froude and the Evolution of the Ship-Model Experimental Tank", *The Newcomen Society: Transactions*, vol. 61, 1989–90 (London, 1991), 33–46; David I. Moor, "Ship Model Experiment Tanks: The First Century – A British View", *North East Coast Institution of Engineers and Shipbuilders: Transactions*, vol. 101 (1984), 19 ff.; Fred M. Walker, *Song of the Clyde: A history of Clyde shipbuilding* (Cambridge, 1984), 47 ff.

5 For an account of tanks built after 1940, see: Moor, "Ship Model Experiment Tanks", 27 ff.

Table 6.1 Major experimental tanks built by 1940 (the small Swedish tank at KTH has been included as a comparison)

Torquay	Great Britain	1871
Amsterdam	Netherlands	1876
Dumbarton	Great Britain	1883
Haslar	Great Britain	1886
La Spezia	Italy	1889
Uebigau, Dresden	Germany	1892
St. Petersburg	Russia	1893
Washington, DC	USA	1898
Bremerhaven	Germany	1900
Charlottenburg,	Berlin Germany	1903
Clydebank	Great Britain	1904
Grenelle, Paris	France	1906
Nagasaki	Japan	1908
Marienfelde, Berlin	Germany	1909
Tokyo	Japan	1910
Teddington	Great Britain	1911
St. Albans	Great Britain	1911
Hamburg	Germany	1915
Vienna	Austria	1916
Stockholm (KTH)	Sweden	1921
Tokyo	Japan	1927
Langley Field	USA	1929
Rome	Italy	1929
Ottawa	Canada	1930
Haslar	Great Britain	1932
Wageningen	Netherlands	1932
Madrid	Spain	1932
Newport News	USA	1933
Moscow	Soviet Union	1933
Hoboken	USA	1935
Delft	Netherlands	1938
Trondheim	Norway	1939
Carderock	USA	1940
Gothenburg	Sweden	1940

Source: Moor, "Ship Model Experiment Tanks", 19–27; Oosterveld, "Advances in maritime hydrodynamic research", 156; Edstrand, "Remarks on Ship Model Testing", 3 ff.; Lindblad, "Modellrännor för experiment", 99–103; Smedberg, "Hydrometriska provningsanstalter", 30 ff.; Warholm, "Intryck från några moderna tyska försöksanstalter", 74 ff.

Early Swedish efforts to build a tank

In Sweden, too, model-testing attracted attention. As early as 1892 the consulting engineer Johan Johnson gave a speech on the subject to a meeting of the Gothenburg Technical Society.⁶ In the early 20th century, in the course of discussions on the arranging of higher technical education in Sweden, the lecturer in naval architecture at KTH, Fredrik Lilliehöök, suggested that a smaller experimental tank should be built, intended for educational use at the school. Partly in order to learn more about how tanks were designed, he visited Germany in 1904.⁷

The question of building an experimental tank came up at a meeting of STF's section for naval architecture in April 1908.⁸ Richard Smedberg, staff engineer at the Hydrographic Office, had written a paper on the subject but was unable to attend the meeting, so it was read by one of the engineers present. The paper described how "hydrometric testing laboratories" had been built in other European countries and urged that Sweden too should build one. As the name indicates, these laboratories could be used both in civil engineering, to measure the flow of water in canals and rivers, and in naval architecture. To be practically useful, a tank had to be sufficiently large, probably some 150 metres in length. A shorter tank would lead to less accurate measurements and to greater wear on the mechanical equipment.

In the field of shipbuilding, there were, according to Smedberg, three main parties who would benefit from a Swedish tank. First and most important, such a laboratory would be valuable to KTH. In order to offer an engineering education of high quality, the teaching staff ought to take the lead in conducting "technical-scientific" research, as the contemporary term read, which required experimental facilities. Secondly the tank would be valuable to the Navy and especially its corps of naval engineers. That the Swedish Navy had to employ foreign tanks for model-testing was not satisfactory: it was expensive and one could not be sure that these tanks would keep the results secret. A Swedish tank was desirable for this purpose. Finally, the private shipbuilding industry, which was going through a depression, might find an experimental tank useful. In Smedberg's view, the section ought to recommend the commission which was investigating Swedish higher technical education to include a tank of appropriate size in their plans for an extension of KTH.

In the ensuing discussion Fredrik Lilliehöök said that he was pleased that the issue had been brought up, but that unfortunately the work of the commission was almost finished and it was therefore too late for a statement from STF's section. After further discussion it was decided that a statement should be made nonetheless but, as Lilliehöök had anticipated, it did not influence the proposals of the com-

6 Johan Johnson, "Experiment med fartygsmodeller och progressiva profresor", *Industrien: Tidning för tekniska meddelanden* 1:7–9 (1892), 53–55, 61–62, 73–75.

7 Fredrik Lilliehöök, "Några meddelanden rörande iakttagelser inom skeppsbyggnadskonsten från en studiefärd i Tyskland", *Teknisk tidskrift: Allmänna afdelningen*, January 14, 1905, 12 ff.

8 Richard Smedberg, "Hydrometriska profningsanstalter", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 13, 1908, 29–36, 48.

mission.⁹ When new buildings were erected for KTH between 1914 and 1917, only a small tank, intended for both the civil engineering and naval architecture departments, was installed.

In fact Swedish shipbuilders did only a small amount of model-testing at this time, most of it connected with the building of warships. When Götaverken built the destroyer *Hugin*, ordered in 1909, which was the first Swedish naval vessel powered by steam turbines, the company and the Naval Material Administration tested models at the tank in Bremerhaven in Germany. In 1912 the Naval Material Administration carried out tests on the large warship *Sverige* in the same tank.¹⁰

As World War I brought increased activity in the shipbuilding business, the issue of an experimental tank arose again. In March 1916, the lecturer in hydromechanics at KTH, H. F. Nordström, reported in *Teknisk tidskrift* on Norwegian plans to raise money from private industry to build a large towing tank. Ending his article by commenting on conditions in Sweden he said that a tank would be of great value to Swedish shipbuilding and the Swedish Navy: "This is particularly so in view of the times ahead, when competition between nations is going to become keener than usual; the advantages of being wholly independent of other countries in such circumstances are evident."¹¹ Nordström did not believe that, within a reasonable period of time, it would be possible to persuade the government to provide the funding for the construction of a tank. Instead he argued that, given the current prosperity of the shipping business, it seemed a propitious time for raising money from private interests.

At a meeting of STF's section for naval architecture in April 1917, Nils G. Nilsson, director of the newly created Ships' Inspectorate, said that he considered the hydrometric laboratory under construction at KTH too small for the commercial testing of ship models.¹² In order to avoid undesirable scale effects, one had to use large models, at least five metres long, requiring a tank which, in Nilsson's estimation, needed to be approximately 150 metres long, 8 metres wide and 4 metres deep. As Nordström had done a year earlier, Nilsson emphasised that the time for a large tank was ripe due to the boom in the Swedish shipping and shipbuilding business. Possibly half of the money required for the erection of the plant might be raised from the industry. The government would have to come up with the rest. Nilsson emphasised that the best way to raise state funding would be to present the question

9 "Frågan om en svensk skeppsbyggnadsteknisk försöksanstalt", *Teknisk tidskrift: Skeppsbyggnadskonst*, September 12, 1917, 35; H. F. Nordström, "Skeppsbyggnadslaboratoriet för släpförsök vid K. Tekniska Högskolan", *Teknisk tidskrift: Skeppsbyggnadskonst*, February 17, 1923, 2.

10 Ernst A. Heden, "Tankförsök med modeller till jagaren Hugin", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 29, 1910, 43 ff.; In 1909 the naval engineer Johannes Lindbeck gave a speech entitled "Några resultat från försök med fartygsmodeller" at a meeting of the Gothenburg Technical Society, see: *Tekniska Samfundets Handlingar*, No 4, 1909; "Modellsläpförsök för pansarbåten F", *Teknisk tidskrift: Skeppsbyggnadskonst*, October 30, 1912, 102 ff.

11 H. F. Nordström, "Frågan om en försökstank för fartygsmodeller i Norge samt läget af motsvarande fråga i Sverige", *Teknisk tidskrift: Skeppsbyggnadskonst*, March 8, 1916, 8. These plans for a large Norwegian tank did not materialise, see: Tore Jørgen Hanisch & Even Lange, *Vitenskap for industrien: NTH – En høyskole i utvikling gjennom 75 år* (Oslo, 1985), 61 ff.

12 "Frågan om en svensk skeppsbyggnadsteknisk försöksanstalt", 35 ff.

as one of engineering education. Therefore the natural location would be close to KTH.

After a short discussion the meeting decided that the section should set up an experimental tank committee to examine the question. Nilsson became chairman of the committee.¹³ The other members were the chief engineer at Finnboda, Albert Hector, the shipowner Axel Ax:son Johnson, professor Fredrik Lilliehöök, and chief naval engineer Johannes Lindbeck.

In April 1919, Nilsson summarised the work of the committee's first two years.¹⁴ It had begun by examining how foreign tanks were designed. Then the costs of building a tank in Sweden had been estimated and different locations evaluated. Towards the end of the war, there had been a downturn in the shipping and shipbuilding business and the committee, which had now nearly finished its deliberations, decided to adjourn for a while. Given these circumstances, Nilsson argued, it would not be possible to make shipowners and shipyards pay for the tank. The only way to get a tank built would be to make the government more interested. He ended by asking those present whether the committee should carry on its work or ask to be relieved of its duties. It was decided that work should continue.

A year later, in May 1920, Nilsson presented the ideas that the committee had come up with so far at a meeting of the Swedish General Shipping Association.¹⁵ Considering that many shipowners were members of this association, Nilsson's speech seems to have been intended to convince this group to give financial support to the project. He stated that, now that the war was over, competition on the global shipping market would become stiffer. The difficulties of Swedish shipowners were aggravated by the introduction of the eight-hour working day. Ships would therefore have to be made more efficient, not least as regards fuel consumption, by applying "the latest results of engineering science."¹⁶ He said that at present the shipyards could not alone provide all the capital needed for an experimental tank. The committee had not yet succeeded in obtaining government funding. Since, as he put it, shipowners would be the ones to benefit most from a tank, they too should invest capital. Ending his speech saying "it is to the generosity of the individual member of the association that I have chosen to appeal," he also expressed a hope that representatives of the Shipping Association would become more involved in the issue.¹⁷

Repeated references in Nilsson's speech to the potential benefits of engineering sciences indicate that the work of the committee had been inspired by attempts in other branches of Swedish industry to benefit from scientific research. Nilsson also

13 Nils G. Nilsson, "Redogörelse för Kommitténs för försöktank arbete", *Teknisk tidskrift: Skeppsbyggnadskonst*, October 29, 1919, 135 f.

14 Ibid.

15 Nils G. Nilsson, "Sjöfarts- och skeppsbyggerikontor", *Sveriges Allmänna Sjöfartsförenings Tidskrift* 18 (1920), 175–182.

16 Ibid., 178.

17 Ibid., 182.

openly stated this, saying: "We have the advantage of being able to study the example of and learn from other branches of industry which have trodden this road before."¹⁸

The late 19th and early 20th centuries had witnessed the establishment of industrial research laboratories in Germany – mainly in the chemical industry – and the United States – in the electrical engineering industry.¹⁹ World War I reinforced belief in the importance of science to the development of new technology. Thanks to its large chemical industry, Germany was able to carry on the war effort without a supply of strategic raw materials from abroad. For instance, its industry developed large-scale processes for producing gunpowder synthetically, which became of crucial importance when the naval blockade had cut off the import of saltpetre from Chile.

Bo Sundin, who has studied what he calls the "organization of technological research" in Sweden in this period, argues that supply problems during the war and a fear of increased competition between the industrial countries after the armistice stimulated industry-related technical research. In this way the war constituted a catalyst in the establishment of organisations such as the Royal Swedish Academy of Engineering Sciences, the Wood Pulp Research Association and the Institute for Metals Research.²⁰ These efforts were also assisted by the prosperity enjoyed by Swedish industry during the first years of the war. According to Sundin, this was of great importance in the establishment of the two last-mentioned organisations. If the initiatives had been taken towards the end of the war, when trade conditions had become less favourable, the plans would probably not have been realised.

Some plans for research institutes never materialised at all, for instance a proposed institute for energy and fuel. However, in many private firms there was a small but growing interest in industrial research and a few companies set up laboratories of their own, for instance Uddeholm, Reymersholmbolaget and Thulin's Aeroplane Factory. Research also strengthened its position at the institutes of higher technical education. In the 1910s, KTH had expanded considerably and in the following decade, after many years of discussion, the school finally acquired the right to confer the doctor's degree.²¹

The tank committee's proposal for a maritime research institute can therefore be seen as a manifestation of the spirit of the times in the form of a growing interest

18 Ibid., 177.

19 On the origin and growth of industrial research laboratories in Germany and the United States, for instance, see: John J. Beer, "Coal Tar Dye Manufacture and the Origins of the Modern Industrial Research Laboratory", *Isis* 49 (1958), 123–131; Georg Meyer-Thurrow, "The Industrialization of Invention: A Case Study From the German Chemical Industry", *Isis* 73 (1982), 363–381; Ernst Homburg, "The emergence of research laboratories in the dyestuffs industry, 1870–1900", *The British Journal for the History of Science* 25 (1992), 91–111; Leonard S. Reich, *The Making of American Industrial Research: Science and Business at GE and Bell, 1876–1926* (Cambridge, 1985).

20 Bo Sundin, *Ingenjörsvetenskapens tidevarv: Ingenjörsvetenskapsakademin, Pappersmassekontoret, Metallografiska institutet och den teknologiska forskningen i början av 1900-talet* (Umeå, 1981); idem., "Stålprovare och metallografer", in *17 uppsatser i svensk idé- och lärdoms historia*, ed. Bo Lindberg, (Uppsala, 1993), 151–165. See also: Thomas Kaiserfeld, *Vetenskap och karriär: Svenska fysiker som lektorer, akademiker och industriforskare under 1900-talets första hälft* (Lund, 1997), 126–148.

21 Henrik Björck, *Teknikens art och teknikernas grad: Föreställningar om teknik, vetenskap och kultur speglade i debatterna kring en teknisk doktorsgrad, 1900–1927* (Stockholm, 1992).

in the potential usefulness of engineering science. In his address to the Swedish General Shipping Association, Nilsson said that the newly founded Academy of Engineering Sciences in its central position in technical-scientific research “would seem to provide one of the fundamental conditions for the development and adaptation of our industrial life which [...] is necessitated by the new times.”²² He also mentioned the efforts to establish other organisations, such as the Wood Pulp Research Association and an institute for energy and fuel matters, and argued that for the same purposes and benefits a “Shipping and Shipbuilding Research Institute” ought to be created. While its main task, of course, should be to run the tank, and to carry out tests on model ships and propellers, the research institute ought to deal with a variety of other problems too. In the course of its work the committee had gradually become convinced of the need for a broader approach. As subjects to be dealt with, he mentioned solid mechanics, ice-breaking technology, safety at sea, labour-saving methods and electric welding. The institute should also function as a body of expert knowledge which governmental agencies could draw upon.

What those who were present at the meeting thought of Nilsson's proposal is difficult to say since no one commented on it, which in itself might indicate caution or lack of interest. The chairman suggested that the board of the General Shipping Association and the board of STF's section for naval architecture should together investigate the question further, a proposal which the meeting approved.

Despite the efforts of Nilsson and others, no large towing tank was built in this period. The shipping and shipbuilding business, like other industries, slid into a depression in the early 1920s and the interest in spending large sums of money on a research institute vanished.²³ At a meeting of the section for naval architecture in May 1926, it was finally decided that the “tank committee” should be wound up.²⁴ In the interwar years, therefore, the only experimental tank in the country was the small one at KTH, which teachers and students of naval architecture shared with those of civil engineering.²⁵

In April 1922, H. F. Nordström, who was in charge of the naval architects' activities at that tank, told STF's section for naval architecture that the tank had finally been equipped for testing ship models.²⁶ Being intended mainly for educational use, Nordström hoped that it also might become useful to people outside the school. However, the dimensions of the tank – length 53 metres, width 3 metres and depth 1.35 metres – made it too small for practical use by the shipyards.

²² Nilsson, “Sjöfarts- och skeppsbyggerikontor”, 175.

²³ For instance, see the 1923 article by H. F. Nordström below. Compare with the corresponding unsuccessful efforts to build a tank in Norway at this time, see: Hanisch & Lange, *Vitenskap for industrien*, 64.

²⁴ *Teknisk tidskrift: Skeppsbyggnadskonst*, March 19, 1927.

²⁵ Wolmar Fellenius, “Vattenbyggnadslaboratoriet vid Kungl. Tekniska Högskolan”, in *Kungl. Tekniska Högskolan: Historik och beskrivning rörande nybyggnaderna* (Stockholm, 1918), 99–107; idem., *Vattenbyggnadslaboratoriets vid Kungl. Tekniska Högskolan utveckling under de senare åren* (Meddelande Nr. 3 från Vattenbyggnadsinstitutionen vid Kungl. Tekniska Högskolan, Stockholm, 1922).

²⁶ H. F. Nordström, “Skeppsbyggnadslaboratoriet för släpförsök vid K. Tekniska Högskolan”, *Teknisk tidskrift: Skeppsbyggnadskonst*, February 17, 1923, 1–3, & March 31, 1923, 9–13.

Two years later, in 1924, Nordström reported on fresh developments at the tank: among other things, the length had been extended to 60 metres.²⁷ He said that the laboratory had attracted great attention among shipbuilders but he feared that some people had misunderstood its purpose: "Obviously, bearing in mind the great difference in resources with regard to both personnel, equipment and available funds, one cannot apply the same criteria to our laboratory as to the experimental establishments abroad. But nor is the Institute's [KTH's] laboratory meant to be competing with them."²⁸

However, despite the fact that it was primarily an educational laboratory, a number of interesting experiments had been carried out. Models of the warship *Sverige*, launched in 1915, and of a Götaverken-built ore carrier had been tested and the results compared with those obtained earlier in foreign commercial tanks with larger models of the same ships. In this way it was possible to evaluate the accuracy of results achieved at the KTH tank. Experiments had also been carried out on behalf of the Royal Naval Material Administration as models of submarines and destroyers were tested. Finally, Nordström had made model tests on motor boats and on a Chinese junk.

Nordström seems to have been satisfied with the results but ended his speech by saying that even if the issue of building a large experimental tank in Sweden had been put aside for the moment he believed that sooner or later it would have to be resurrected.

Research and increasing international competition

In an international perspective, the late 1920s and the 1930s was a period of increased use of model-testing in connection with commercial shipbuilding. In a speech to Swedish engineers in 1939 the chief ship surveyor of Lloyd's Register in London, James Montgomerie, identified research in experimental tanks as one of the major development trends in shipbuilding in Europe and the United States.²⁹ There seems to have been a similar upsurge in interest in the issue in other parts of the world. In her study of Japanese shipbuilding, Yukiko Fukasaku says that at the Mitsubishi Nagasaki Shipyard "model test became standard practice in the second half of the

27 Idem., "De senare årens utveckling av Kungl. Tekniska Högskolans skeppsbyggnadslaboratorium och några resultat därifrån", *Teknisk tidskrift: Skeppsbyggnadskonst*, October 18, 1924, 81–86, & November 15, 1924, 89–94, & December 20, 1924, 97–102; A short paragraph ("Efterföljansvärt exempel") in *Teknisk tidskrift: Skeppsbyggnadskonst*, June 30, 1923, p. 44, also reports the tests with the Götaverken-donated model of an ore carrier.

28 Nordström, "De senare årens utveckling", 81.

29 James Montgomerie, "Utvecklingstendenser inom skeppsbygget", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, September 16, 1939, 77.

1920s.”³⁰ Further indications of the increased interest in hydromechanic testing and research at this time is provided in Table 6.1.³¹ The period from the 1880s until about World War I had witnessed the establishment of a large number of tanks. Then followed a period when the establishment of new research institutes came to a halt. From the late 1920s until World War II, however, there seems to have been a renewed interest in the issue: never before had so many large tanks been built over such a short period of time.

In Sweden, too, research in the field was attracting more attention. As we saw in Chapter 4, in the 1930s there was an increase in the number of papers on model-testing at the meetings of the Swedish Association of Engineers and Architects and the Gothenburg Technical Society. Some engineers also visited foreign tanks and reported on their visits in *Teknisk tidskrift*.

In 1928, the naval architect Kurt Söderlund made a study visit to shipyards and experimental tanks in Great Britain. He had graduated from KTH in 1920 and held the position of senior assistant at the school's tank in 1924–25. Then he became a designer at Kockum in Malmö, where he reached the position of head of the ship drawing office in 1933. In his travel report on conditions in Britain he wrote: “More and more the shipyards are beginning to use the services that the model-testing establishments are in a position to supply, and nowadays no major ship construction begins without extensive experiments having been carried out in the model-testing tank with a view to ascertaining both the most appropriate shape and the most economical propeller [...] and finally determination of the power required for a given speed.”³² He went on to say that Britain had both state-owned and private tanks. The state-owned ones, he argued, had or at least should have as their main purpose pure research. However, at present they were “overwhelmed with orders from shipyards, which makes it impossible to devote as much time to scientific work as would be desirable.”

Two years later, in 1930, Axel Warholm visited Germany and had a chance to see several tanks. He had graduated in naval architecture from KTH in 1921 and had succeeded Söderlund as senior assistant at the school's towing tank, working there from 1925 until 1946 when he gained a position at the Swedish State Shipbuilding Experimental Tank in Gothenburg.³³ His overall impression after having visited both experimental tanks and large shipyards was that in Germany “the awareness of the value of experiments with models [...] is very high, with the relatively

30 Yukiko Fukasaku, *Technology and Industrial Development in Pre-War Japan: Mitsubishi Nagasaki Shipyard 1884–1934* (London, 1992), 101.

31 In an article on ship model testing David I. Moor points to the same trend; see fig 1. (page 20) in his “Ship Model Experiment Tanks”.

32 Kurt Söderlund, “Skeppsbyggnadstekniska iakttagelser och rön från England och Skottland 1928”, *Teknisk tidskrift: Skeppsbyggnadskonst*, July 20, 1929, 61.

33 For information on Warholm's career, see: Directories of SSPA's staff – “Personalmatriklar: Befattningshavare som slutat”: SSPA (GLA).

insignificant outlay of a few thousand kronor on model tests showing itself an exceptionally good investment.”³⁴

At a meeting of STF's section for naval architecture in November 1937, Kurt Söderlund discussed the use of model-testing in ship design work. He argued that a naval architect could design quite a good ship without experiments in experimental tanks: there was enough accumulated experience at the shipyards for this and the engineer also had at hand standard series for resistance and propulsion. However, with increased competition, a “good” ship was not good enough; now it was necessary for the shipyards to “produce vessels of the very highest rank with regard to efficiency.”³⁵ He went on to say that to do this “without the aid of model tests is, I would maintain, impossible. An experienced designer may perhaps draw lines and propellers which have to be considered very good, but that they are the very best that it is now possible to obtain in the case concerned is very unlikely. If they are, then it must surely be regarded as a stroke of luck.”

Another naval architect to emphasise model-testing as a way for the shipyards to become more competitive was Folke Seldén, who had graduated from Chalmers in 1912 and worked at Götaverken for most of his career, eventually as chief engineer and chief designer. In a 1936 article he stated that “to be competitive one must not only be able to offer an attractive price but also to a very high degree be able to offer a superior product.”³⁶ This, he went on, was “particularly apparent at times of shortage of orders and therefore twice as important in achieving the goal for which every industry strive: an even flow of work.” He stated that model tests had become increasingly important in the period after the Great War. Swedish shipyards had so far had to do their testing in foreign tanks. Earlier this arrangement had worked well enough but “recently our friends abroad have definitely become increasingly secretive.” Partly, this was a result of “the strong national aspirations of recent times” where every country protected its own knowledge of engineering sciences. Since Sweden now had a large shipbuilding industry it, too, had to be self-sufficient in maritime research. Moreover, to be able to take part in international scientific co-operation, Sweden had to produce research work of its own: “it is obvious that if you can offer findings of your own you are better placed both to be permitted to learn of the experiences of others and to absorb what may come from abroad.”

As we have seen, hydromechanic testing and research attracted increasing attention in the 1930s. Furthermore, the knowledge of such experimentation was growing in the shipbuilding system as a result of both the work carried out by Swedish organisations at foreign tanks and study trips by individual engineers.

34 Axel O. Warholm, “Intryck från några moderna tyska försöksanstalter för skeppsbyggnad”, *Teknisk tidskrift: Skeppsbyggnadskonst*, October 17; November 21 & December 19, 1931 (the quotation is on page 90, December 19); Another engineer to report on foreign tanks was Ernst C. H. Almquist, “Hollands nya skeppsbyggnadstekniska försöksanstalt”, *Teknisk tidskrift: Skeppsbyggnadskonst*, November 19, 1932, 77 ff.

35 Kurt Söderlund, “Modellförsök, några reflexioner av en fartygskonstruktör”, *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, January 22, 1938, 1.

36 Folke Seldén, “Den nya fartygsprovningsanstalten i Göteborg”, in *Götaverken*, No. 6 (Göteborg, 1936), 25.

Establishing a Swedish experimental tank

It was the managing director at Götaverken, Hugo Hammar, who in the late 1920s began the process which eventually led to the building of a large Swedish experimental tank. In 1929 he wrote that a research institute ought to be created where everybody interested in shipping, shipbuilding or oceanography would be welcome, whether worker, scientist, shipowner or seaman. The institute should have an extensive library, with literature on ocean research, shipping and shipbuilding, and of course also house a towing tank. It ought to “work hand in hand with the shipping and shipbuilding industries and be available to their people with advice on and assistance with the numerous difficult problems that arise daily in international competition.”³⁷ For the shipyards, which were now prospering, to consolidate their position in the world market it was desirable to make use of the latest research in the field. They also needed to have access to a tank when designing new ships. So far they had had to carry out model tests at foreign tanks, and this had its drawbacks. One was that concept design often left no time to carry out model tests abroad: “As last time it involved destroyers of a size and speed that had not been built in this country before, the yards that were going to build the ships were obliged first to give all the guarantees that the Navy demanded with regard to speed and horsepower and then have people in England look into how far this was possible. These investigations ought of course to have taken place first.”³⁸ Another and possibly even more serious drawback which Hammar mentioned was that it was unsatisfactory to be dependent on foreign tanks. He stated that as long as the Swedish shipyards had been small there had been no problems, but now that they had become “a factor to take into account in the competition on the world market,” foreign tanks were inclined to show more loyalty to their own countries’ shipbuilders.

Hammar argued that the best location for a research institute was Gothenburg and he suggested making it a part of the Maritime Museum there. In 1918 the shipowner Dan Broström had donated one million kronor for a building for the Museum. For several reasons no building was erected in the 1920s but towards the end of the decade plans took more definite shape. From 1929 onwards, Hammar was a member of the board of the Broström Bequest, which was in charge of the building project. In Hammar’s view, the museum ought to be not only an exhibition of old artefacts to popularise the shipping business among the public but also a forum for lectures, conferences and research.

In 1931 work began on the new building and in 1933 the museum opened its doors to the public. At the opening ceremony in July, Herbert Jacobsson, who was chairman of the Broström Bequest between 1925 and 1933, and thereafter of the museum’s board, said that the museum should not only exhibit the past but also

37 Hugo Hammar, “Fackutbildning av Skeppsbyggnadsingeniörer: Återblick och framtidsönskemål” in *Chalmers Tekniska Institut 1829–1929: Minnesskrift*, ed. Gösta Bodman (Göteborg, 1929), 293; See also: “Sjöfartsinstitut för skeppsbyggare dir. Hammars idé”, *Ny Tid*, February 10, 1929.

38 Hammar, “Fackutbildning av Skeppsbyggnadsingeniörer”, 290 f.

work for the future. He went on to say: "Shipping and its industries must, in order to assert their position in world competition, make use of all the opportunities that research can offer [...] Our great objective is to bring into being a research institute with well-equipped laboratories, library, an experimental tank etc."³⁹ Jacobsson was therefore happy to announce that Hugo Hammar had donated 300,000 kronor to a fund to facilitate the establishment of such an institute. From 1930 onwards Hammar had refrained from drawing 50 percent of the bonus due to him as managing director of Götaverken and the company had transferred this money to the intended research fund.⁴⁰

While in 1933 the intention was obviously still to locate the tank alongside the museum, Hammar soon came to adopt another strategy. According to the director of the museum, Olof Traung, the tank was never built adjacent to the museum building since there was not enough land available.⁴¹ Another reason, however, might have been that Hammar saw a better chance of realising the plans as he became involved in the issue of whether the Chalmers Institute of Technology should be reorganised and given the rank of university. In September 1934 a commission was set up to examine the question. Its chairman was the director of the Royal Swedish Academy of Engineering Sciences, Axel Enström, and the other members were Hugo Hammar, Edvard Björnsson and Anders C. Lindblad, the two last-mentioned being members of the Swedish parliament. When the question of giving Chalmers university status had been investigated in 1919 and 1929, both times without result, there had been suggestions that an experimental tank should be built for the naval architecture department. It should be noted that Hammar had been a member of the commission of 1919. As we saw above, the educational aspect had also been present in the earlier discussions at STF's section for naval architecture. To Hammar, the best way of making parliament willing to put up the funding would probably be to depict the issue of establishing a tank as a question of higher technical education.⁴²

The 1934 commission delivered its report in November 1935, which was too late for such a complex question to be considered by parliament the following spring.⁴³ Not until the spring of 1937, therefore, was Chalmers' future status finally dealt with, the result being that the school acquired university status from July that year and changed its name to *Chalmers Tekniska Högskola* (the Chalmers University of Technology). There had, however, been one question which had been picked out and considered separately in the spring of 1936 and that was the question of education of naval architects.

39 Quoted in: Olof Traung, "Sjöfartsmuseet: En översikt", *Unda Maris* 1942, 46.

40 Hugo Hammar's deed of gift, July 11, 1933: The museum's doss. archive (SMG).

41 Olof Traung, "Hammars forskargärning", in *Hugo Hammar 1864 4/3 1939*, ed. Olof Traung (Göteborg, 1939), 227 ff.

42 We do not know for sure what importance Hammar attached to the educational aspect in 1934; in 1941, however, he maintained that even in the early 1910s he had already realised that the only way to make the government interested in funding a tank was to present it as an educational issue, see: Hugo Hammar, "Statens skeppsprovsningsanstalt: Historik, allmän planering, kostnader", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, November 15, 1941, 101.

43 See copy of letter from Sven Hultin to Edgar Sjö Dahl, March 14, 1936, "Handlingar ang. den högre tekniska undervisningens organisation": Chalmers University of Technology (GLA).

As mentioned in Chapter 3, the commission suggested that the department of naval architecture at KTH should be closed and all training in this field concentrated on Chalmers. With this increase in the number of students, the department at Chalmers would need new buildings. Also the department lacked a laboratory. The cost of an experimental tank depended on its range of application. If it was to be used for educational purposes only, it could be small, but for scientific research and commercial testing it ought to be 150 metres long, 10 metres wide and 5 metres deep.⁴⁴

The commission recommended that the government provide the funds for the building of the tank. Organisationally, it ought to be separate from the school and do commercial work as well as being used for research and education.⁴⁵ Private industry should be given a say in the running of the facility, in order to encourage a feeling of responsibility for its performance and to attract the necessary capital for its operation. While the board of Chalmers could also function as the board of the new institute, a special committee should be responsible for the running of the facility. The members of this committee should represent Chalmers, the Royal Naval Material Administration, the shipowners and the shipyards. Already, the commission noted, industry had promised to put up initial capital of 50,000 kronor to cover expenses during the first year of operation, when commercial testing could not be expected to reach full capacity due to the time required to run in machines and instruments. The promise would only be binding if parliament approved the plant in 1936.

In its report, the commission stated that it had considered the shipbuilding industry's, as well as the Navy's, need for a tank. It realised that the testing of models had become increasingly important. So far these tests had been carried out abroad, usually in Germany, England, or the Netherlands. This, however, was unfavourable from a competitive point of view: "Given the keen competition with foreign yards, this arrangement has naturally been extremely inopportune for the Swedish shipbuilding industry."⁴⁶ The commission went on to argue that it was necessary to have a tank "if Sweden is to be able in international competition to uphold the place and to retain the earning capacity that the country has won for itself in the field of shipping and shipbuilding."⁴⁷ For the military, too, the commission argued, it would be "invaluable to have access to such a testing facility within the country."⁴⁸ The commission referred to plans to build large tanks at the technical universities in Denmark and Norway and stated that in other countries, where people had had a greater "awareness of the importance of shipping and allied industries to the national economy," measures had been taken to strengthen this sector "with those means

44 Betänkande och förslag angående omorganisation av Chalmers tekniska instituts högre avdelning till en teknisk högskola m.m. (unpublished 1935), 58 f.

45 Ibid., 188 ff.

46 Ibid., 62.

47 Ibid., 64.

48 Ibid., 62

that scientific research had to offer.”⁴⁹ The Swedish shipyards had so far avoided having to ask for direct subsidies, preferring state aid in other forms, such as the provision of facilities for education and research. An experimental tank would make the shipyards more competitive.

Being a member of the commission, Hammar is most likely to have been the one to assert the shipyards' interest in the issue. Indications that this was so may be found in some of the wording of the commission's report, which is identical with Hammar's contribution to a discussion at a meeting at the Royal Swedish Academy of Engineering Sciences as early as February 1935.⁵⁰ On several occasions he had also emphasised how important it was to have a Swedish tank and in a letter to Axel F. Enström in January 1936 he wrote: “With every day that competition intensifies, I note the necessity of calculations based on exact experiments.”⁵¹

Representatives of several organisations were invited to comment upon the commission's report. While some, such as the teaching staff at Chalmers, the Federation of Swedish Industry and the Swedish Shipbuilders' Association, where Hammar was chairman, took a very positive attitude to the proposal, others were highly sceptical of parts of it.⁵² Since the commission suggested a concentration of all higher naval architecture education in Sweden at Chalmers, and consequently a closing down of the corresponding department at KTH, the teaching staff of the latter school were upset. Being convinced of the need for a large tank in Sweden, they strongly doubted whether it was advisable to site it at a technical university. This followed from the fact that at a commercial tank, with its larger dimensions, the operating expenses would be very high, making it impossible for a school, with its limited financial resources, to do experimental work. Nowhere abroad, they argued, had a large commercial tank been successfully combined with a school. They also questioned the idea that Gothenburg would be the best location for a tank. In other European countries, they argued, it had not been considered vital to locate such facilities near the major shipbuilding centres. On the contrary, in England, Germany, France and Italy, state-controlled tanks had been built in the capital, which lacked shipbuilding of any significance. In the KTH staff's opinion, to place a Swedish tank in Stockholm had many advantages, not the least being that one could expect many assignments from the Naval Material Administration.

The Royal Academy of Engineering Sciences stated that it was vital for a maritime research institute to be established, in order to enable Sweden to secure its

49 Ibid., 63.

50 Minutes from a meeting at IVA on February 4, 1935 – “Protokoll fört vid sammankomst på Ingenjörsvetenskapsakademiens lokal den 4 februari 1935 för överläggning rörande den högre tekniska undervisningen inom skeppsbyggnadsfacket ordnande med hänsyn till de två utbildningsanstalterna tekniska högskolan och Chalmers tekniska institut”, page 22 & 24, “Handlingar ang. omorganisation av skeppsbyggeriavdelningen”: Chalmers University of Technology (GLA).

51 Copy of letter from Hugo Hammar to Axel F. Enström, January 13, 1936: Hugo Hammar's archives (SMG).

52 Parliamentary documents (Riksdagstryck): Kungl. Maj:ts proposition Nr. 135 (1936), angående Chalmers tekniska institut m. m., 34–45.

position among the shipbuilding nations. It too, however, doubted whether a towing tank could be successfully combined with a technical university, an opinion that it shared with representatives of the Navy. Speaking for the Naval Material Administration, the Director-General of Naval Construction Yngve Schoerner, who had graduated in naval architecture from KTH in 1901, strongly emphasised the Navy's urgent need for a Swedish tank. He argued that it would permit much more model-testing, as testing abroad was very costly. He, too, questioned the choice of Gothenburg, since testing there would be more expensive for the Administration than in Stockholm. However, due to the commitment that people in Gothenburg had shown and the sacrifices they were prepared to make, he did not object to the erection of a tank there. A similar willingness to compromise on the location was expressed by the staff of KTH, despite their criticisms.

To sum up, all the parties consulted were in favour of the establishment of a Swedish experimental tank. This was also emphasised by the Minister of Education and Ecclesiastical Affairs, Arthur Engberg, in his conclusion to the government bill. He did not find the arguments against a connection between the tank and a technical school convincing. Nor did he doubt that Gothenburg, with its shipbuilding industry, was the ideal location for the tank. Since shipyards and shipping companies had shown a great interest and made funds available, both for start up and for research, the government ought to seize the opportunity: "It seems to me of great importance that the authorities should not miss this opportunity, now that it is possible to meet both the educational need and the interests of industry at the same time, of supporting and promoting the development of the shipbuilding industry, which is so important to our national livelihood."⁵³

As mentioned above, the industry would only put up the starting fund of 50,000 kronor if a decision to build the tank was made in 1936. The same condition, that parliament had to decide upon the issue in that year, was also attached to a donation of 500,000 kronor from Martina Lundgren, widow of the shipowner Wilhelm Lundgren. This fund, which she had set up after discussion with Hugo Hammar, was intended for research work at the tank.⁵⁴ Other funds, without provisos concerning when the tank should be built, were the above-mentioned fund of Hammar and Götaverken, which in 1935 amounted to 500,000 kronor, and a fund of 100,000 kronor for research in maritime technology, established in 1930 by Ann-Ida Broström, widow of the shipowner Dan Broström.

By an act of parliament in April 1936, it was decreed that the tank should be built. In August a committee was appointed to plan and direct the erection of both a building for the Department of Naval Architecture and the towing tank. Hugo Hammar was appointed chairman. Among the other members were Erik Friberger (architect), Sven Hultin (rector of Chalmers), and Anders Lindblad (professor of naval architecture). In 1938 the committee's brief was extended to cover all new

⁵³ Ibid., 55.

⁵⁴ Copy of letter from Sven Hultin to G. Z. Topelius, February 3, 1936, "Handlingar ang. omorganisation av skeppsbyggeriavdelningen": Chalmers University of Technology (GLA).

building projects at Chalmers. Hammar remained chairman of the committee until his death in 1947.

From the beginning Hammar was the live wire on the committee, involved in all kinds of tasks. He planned and organised the work, travelled around Europe to study foreign tanks, negotiated with subcontractors and met various parties, such as shipowners, industrialists and politicians, who came to be involved in the project.⁵⁵ Hans Edstrand, head of SSPA between 1955 and 1981, later maintained: "Countless were [...] the meetings with ministers, representatives of local and central authorities, industrial corporations, shipping companies and individuals, which Dr. Hammar arranged in the interest of the experimental tank, and in which his great authority and prestige was probably many times of decisive importance."⁵⁶

In 1938 the committee engaged Ragnar Rödström to assist it in its work. He had graduated in naval architecture at Chalmers in 1934 and then worked at the Eriksberg shipyard, during which time he had also had a chance to learn about foreign experimental tanks: in 1936 he spent five months at the Dutch tank in Wageningen and one month at the German one in Hamburg.⁵⁷ Working for the committee between 1938 and 1940 he was inspector at the building site and directed the work of installing all mechanical and instrumental equipment.⁵⁸ He also went on study trips to a dozen tanks in Europe and the United States.

The members of the 1934 commission had estimated the cost of the tank and a building for the department of naval architecture at 1.2 million kronor. By 1941, the real amount had risen to 2 million kronor. From this about a quarter of a million had gone to the naval architecture building.⁵⁹ One reason for the increase was the decision to make the tank longer (260 metres).

The Swedish State Shipbuilding Experimental Tank in operation

As recommended by the Commission, the experimental tank did not become a part of Chalmers: instead it was organised as a government institute, under the Ministry of Commerce.⁶⁰ Its name became *Statens Skeppsprovsningsanstalt* (the Swedish State Shipbuilding Experimental Tank; henceforth its Swedish abbreviation SSPA will be used). The facility began operation in October 1940. Hammar became chairman of

55 Minutes, "Chalmersska Skeppsbyggeriinstitutionens Byggnadskomite", 1936–40: SSPA (GLA).

56 Hans Edstrand, "P.M. beträffande Dr. Hugo Hammars betydelse för statens skeppsprovsningsanstalt", "Historiska papper": SSPA (GLA).

57 For Rödström's curriculum vitae, see: Directories of SSPA's staff – "Personalmatriklar: Befattningshavare som slutat": SSPA (GLA).

58 Hans Edstrand, "Svensk skeppsprovning under 250 år", *Svensk Sjöfartstidning*, 1990:47, 22; cf. Ragnar Rödström, "Statens skeppsprovsningsanstalt: Den instrumentella utrustningen", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, May 16, 1942, 41–48.

59 Hammar, "Statens skeppsprovsningsanstalt", 103 ff.

60 H. F. Nordström, "Statens skeppsprovsningsanstalt: Uppgifter, organisation", *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, November 15, 1941, 107 f.

the special committee which was responsible for running it. He was also a member of the board. H. F. Nordström was appointed managing director of the tank and Ragnar Rödström works engineer.

Hugo Fredrik Nordström (1888–1971) had graduated as a mechanical engineer from KTH in 1910.⁶¹ In 1914 he was appointed instructor in hydromechanics there, a position he held until 1940. From 1925 he also was a lecturer in naval architecture. As mentioned above he became responsible for the operations of the tank at KTH from its start in the early 1920s and there, with limited resources, he carried out research which was soon noted by shipbuilders.⁶² In 1931 he completed a doctoral dissertation entitled *A study on the Interaction between the Engine, the Screw Propeller, and the Ship*. As mentioned above, only four years earlier, in 1927, KTH had acquired the right to confer the doctor's degree in engineering sciences; Nordström was the eighth to obtain the degree at that school and his dissertation was the first in the field of naval architecture.⁶³

While the funds for building the tank had been provided by the government, it was to be run on a commercial basis, with all the costs covered by revenue from its clients, who mainly came to be shipyards, the Naval Material Administration and shipowners. If the department of naval architecture at Chalmers wanted to use the tank on its degree courses or for research it would have to pay like everybody else, but with a 30 percent discount.

Before SSPA began operation, there had been uncertainty as to whether the demand for model-testing was sufficient for the economic operation of the tank. However, by May 1941 the board concluded that there was a great demand for the service that SSPA could offer: "The to some extent unexpected but at the same time gratifyingly lively business has led to a rise in the Tank's income above what was stipulated."⁶⁴ The staff, which at this time numbered eighteen, had had to work overtime. The loss for the first year of operation (1940–41), when the tank was being run in, only amounted to about 6,000 kronor which meant that 44,000 kronor remained of the fund that industry had set up for the purpose. Then, for the rest of the 1940s and for most of the 1950s, the tank made a profit every year.⁶⁵

61 Hans Edstrand, "Nordström, Hugo Fredrik", *Svenskt biografiskt lexikon*, (Stockholm, 1991), 446 ff.; Torsten Althin, "Hugo Nordström, 1888–1971", in idem., *Minnesord över bortgångna ledamöter av Ingenjörsvetenskapsakademien framförda vid Akademiens högtidssammankomst åren 1965–76* (Stockholm, 1977), 37 f.

62 For instance, see: Hugo Hammar, "Lastfartygens konstruktion med hänsyn till isnavigering och vintertrafik", in *Beretning om det nordiske ingeniørmøde i København 28.—31. August 1929 samt om den Polytekniske Lærestalts 100-aars fest* (København, 1930), 485–502; idem., "Statens skeppsprovvningsanstalt", 101.

63 "Den första doktorsdisputationen inom Fackavdelningen för Skeppsbyggnad vid Kungl. tekniska högskolan", *Teknisk tidskrift: Skeppsbyggnadskonst*, June 20, 1931, 46. See also: Torsten Althin, *KTH 1912–62: Kungl. Tekniska Högskolan i Stockholm under 50 år* (Stockholm, 1970), 162.

64 Minutes, board meeting, May 9, 1941: SSPA (GLA).

65 Only in the fiscal year 1953–54 was the tank run at a loss, see SSPA's annual reports: *Berättelse över Statens Skeppsprovvningsanstalts verksamhet och medelsförvaltning, 1940/41–1943/44*, (SSPALib); *Berättelse över Statens Skeppsprovvningsanstalts verksamhet och medelsförvaltning, 1944/45–1957/58*, (Cirkulär från Statens Skeppsprovvningsanstalt, Nr. 3, 6, 8, 10, 12, 13, 16–23.)



The Swedish State Shipbuilding Experimental Tank began operation in 1940. Note the war-time camouflage painting of the arched roof over the tank. (Photo: SSPA)

Götaverken became an important client of SSPA. In 1941, the company was the largest individual customer and accounted for a quarter of all assignments.⁶⁶ Other clients during the first years of SSPA's existence were private shipyards, shipowners, individual researchers and the department of naval architecture at Chalmers – the department had a few students who worked on their diploma theses at the tank. Another customer of major importance was the Naval Material Administration. The number of models of warships which were tested was smaller than that of merchant vessels but the warship tests were more complex and therefore more expensive. In the annual report for the year 1941–42 it was stated that despite the fact that cargo ships made up the majority of models tested, the testing of warships accounted for about half of the revenues.⁶⁷

While testing was at first carried out for Swedish clients only, towards the end of the war assignments came from customers in Norway, Denmark and Finland, and after the end of the war from England, France and Iceland.⁶⁸ In 1946–47, as much as 50 percent of the revenue came from foreign customers. In the following year that

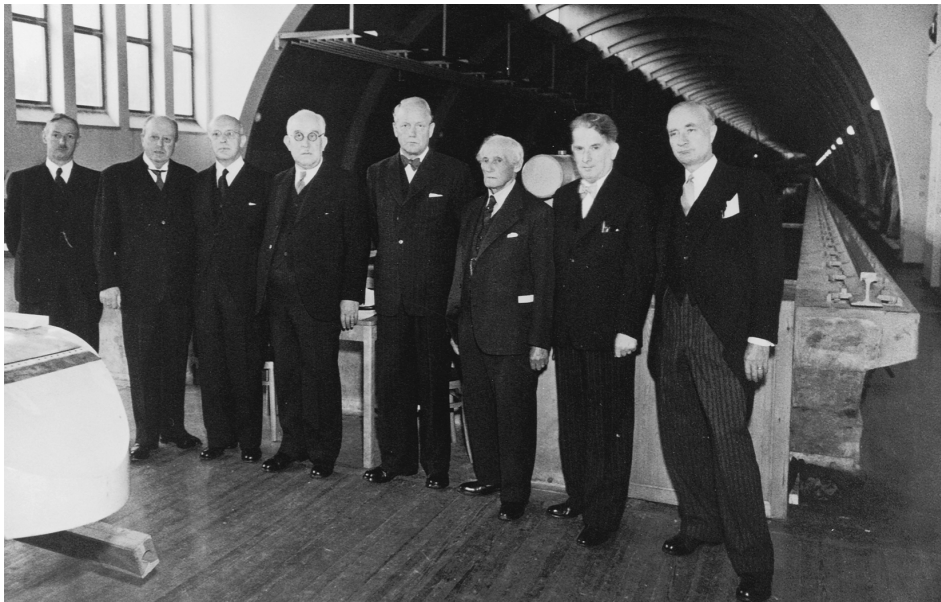
⁶⁶ List of testing assignments of SSPA – “Förteckning över uppdrag vid Statens Skeppsprovsningsanstalt”: SSPA (GLA).

⁶⁷ SSPA annual report: Berättelse över Statens Skeppsprovsningsanstalts verksamhet och medelsförvaltning under räkenskapsåret 1941/1942, p. 2, (SSPALib).

⁶⁸ That testing during the first years was carried out only for Swedish clients is true with one exception; the very first assignment in October 1940 was for the Swedish-born shipowner Gustaf Thordén who at that time had his shipping business in Finland, see: List of testing assignments of SSPA – “Förteckning över uppdrag vid Statens Skeppsprovsningsanstalt”: SSPA (GLA).

figure dropped to 23 percent and over the next decade the proportion of assignments from Swedish clients stabilised at approximately 80 percent.

The statutes of SSPA stated that, in addition to model-testing, it should also carry out technical scientific research within the field.⁶⁹ While individuals began to do research almost from the start, the unexpectedly large demand for commercial testing forced SSPA to neglect research of its own, since the staff was kept fully occupied with assignments for its clients. In the annual reports from the 1940s and 1950s there are repeated complaints about this state of affairs. From the late 1940s onwards, however, SSPA managed to increase its research activities. When the shipping market became less buoyant and the demand for commercial model-testing declined, the institute began to study how the calculation methods used could be improved, a question that had been discussed at an international conference for “Ship Tank Superintendents” in London in 1948.⁷⁰ These investigations were completed in the



Prominent representatives of Gothenburg's industry at the transfer of the "Hugo Hammar Fund for International Maritime Research" to SSPA in 1944. From the left: Sven Hultin (professor and former rector of Chalmers), Sven Steen (architect), Hilding Törnebohm (manager of SKF), Anders Lindblad (professor of naval architecture), Malte Jacobsson (county governor and chairman of the board of SSPA), Hugo Hammar (former managing director of Götaverken), H. F. Nordström (managing director of SSPA) and Rolf Sörman (shipowner). Except for Jacobsson all were graduates from Chalmers or KTH. (Photo: Gilbert Alvegård)

⁶⁹ Official Series of Laws of Sweden (Svensk Författningssamling): SFS 1940, Nr. 739, instruktion för statens skeppsprovsningsanstalt, 1501.

⁷⁰ SSPA annual report: *Berättelse över Statens Skeppsprovsningsanstalts verksamhet och medelsförvaltning*, 1948/49, (Cirkulär från Statens Skeppsprovsningsanstalt, Nr. 12), 5.

financial year 1950–51. Other studies were performed too, but lack of qualified personnel restricted these efforts.

For individual researchers who wanted to do research at the tank, there were several possible sources of grants. As we saw earlier, a few funds had been created in the 1930s. They were followed by others, for instance “the Hugo Hammar Fund for International Maritime Research” of 100,000 kronor, established in 1944 by Göta-verken, various shipping companies and a bank to mark Hammar’s eightieth birthday. Research grants also came to be awarded by the Swedish government.

In 1951, the board of SSPA requested an increased appropriation from the Swedish state on the grounds that resources were insufficient for the research that the institute was obliged to carry out. In the petition the board stated that the institute had to do research in order not to stagnate and went on to argue “that a substantial augmentation of the institute’s staff resources can no longer be deferred, if the institute is to be able to assert itself in the important research which belongs to its field of activity.”⁷¹ Not only did the staff have to be augmented but the experimental facilities too – among other things SSPA wanted resources to build a cavitation laboratory.

Cavitation on propellers, which caused loss of power, material erosion, vibration and noise, and steering difficulties, was a problem of which there was a growing awareness at this time, having become more severe in recent years with increases in the ships’ speed, size and engine power. In 1947 and 1948, the head of the SSPA computation department, Hans Edstrand, had visited various experimental tanks in the United States and there seen a cavitation laboratory.⁷² While applied research on cavitation was carried out in many countries, Edstrand argued that basic research was mainly performed in America. In Sweden there was a cavitation laboratory at the plant of the propeller manufacturer Karlstads Mek. Werkstad in Kristinehamn; as early as 1923 the company had set up its first small laboratory of this kind and in 1942 a new and larger one was built.⁷³ SSPA had established co-operation with the company but by the early 1950s it wanted a cavitation laboratory of its own. At this time, however, the government was not willing to finance such facilities.

After the mid-1950s, the volume of work done for the Naval Material Administration increased considerably as the Administration developed new types of naval vessels.⁷⁴ To some extent these assignments differed from earlier ones since they involved increasingly complicated problems, which required further research. The same trend was apparent in the tests ordered by civilian customers. The question of a cavitation laboratory was revived as the Naval Material Administration was willing to put half a million kronor at SSPA’s disposal for the erection of a smaller one. This

71 Quoted in: “Skeppsprovningens syften äventyras av medelsbrist”, *Svensk Sjöfartstidning*, 47:34 (1951), 1231.

72 Hans Edstrand, “Skeppsprovningstekniken av i dag i USA”, *Teknisk tidskrift*, September 18, 1948, 589 ff; idem., “Kavitation vid propellrar – forskningens nuvarande läge och mål”, *Teknisk tidskrift*, June 17, 1950, 571–579.

73 Elov Englesson, “KaMéWa-propellern”, *Teknisk tidskrift: Skeppsbyggnadskonst och flygteknik*, September 17, 1938, 75; Hans Edstrand, “Kavitationstank för fartygspropellrar”, *Teknisk tidskrift*, May 20, 1944, 60 f ff.

74 SSPA annual report: *Berättelse över Statens Skeppsprovningens verksamhet och medelsförvaltning*, 1955/56, (Cirkulär från Statens Skeppsprovningensanstalt, Nr. 21), 3 ff.

cavitation tunnel began operation in 1957 and was used for certain design problems concerning new naval vessels. It was also viewed as a prototype giving valuable experience for the designing of a larger facility. In the mid-1960s the Swedish government finally granted funds for a large cavitation laboratory, which opened in 1970.⁷⁵

At the end of 1954, Nordström retired and Hans Edstrand (b. 1915) was appointed managing director of SSPA. Edstrand had graduated in naval architecture from KTH in 1940 and then worked at Karlstads Mek. Werkstad, where he was responsible for the construction of the company's new cavitation laboratory. During this time he also spent six months in Germany studying such experimental facilities. In 1947 he began to work for SSPA as head of the computation department. Three years later, in 1950, Edstrand obtained a doctor's degree at KTH.

The 1950s and 1960s were a period when the size of oil tankers increased rapidly and since the major Swedish shipyards, to a large extent, had concentrated on producing these ships, SSPA became increasingly involved in testing such models. Ever larger tankers resulted in new and unknown problems, particularly as regards motive power. In the financial year 1955–56, 17 out of 28 models of merchant ships tested were of oil tankers and in the following years about half were tankers.⁷⁶

In conclusion, the expansion of the Swedish shipyards after World War II led to a growth in demand for use of the tank. At the end of its first year of operation, in 1941, SSPA had 16 employees, a figure that had risen to 41 by 1954 and to 160 by 1982. As time went by the government granted funds for further equipment and enlargements of the plant. In addition to the investment in cavitation tunnels, funds were raised for a wavemaker, installed in 1955, and a large Maritime Dynamics Laboratory, i.e. a seakeeping and manoeuvring laboratory, which was built in the 1970s.

The case study of the early initiatives and the final efforts to establish a large Swedish experimental tank has illustrated a growing ability of the engineers, active in the Swedish shipbuilding systems, to function as a social group of technology carriers – in this case as carriers or producers of technical-scientific knowledge. Most important, during the period from the early 20th century until the 1930s the engineers gained increased economic influence, not least as a result of the expansion of shipyards. By the 1930s, representatives of the group of engineers were able to mobilise the resources and support necessary for realising the project. Last but not least, being organised in professional associations as well as in private companies, the engineers increased their knowledge of model-testing during the period.

Having dealt with the establishment of facilities for testing and research in the field of hydromechanics, we will now broaden the perspective to include research in other fields of naval architecture, such as strength of materials, machinery etc. In

⁷⁵ Hans Edstrand, *The cavitation laboratory of the Swedish State Shipbuilding Experimental Tank* (Cirkulär från Statens Skeppsprovsningsanstalt Nr 32, 1974).

⁷⁶ SSPA annual reports: *Berättelse över Statens Skeppsprovsningsanstalts verksamhet och medelförvaltning, 1955/56–1957/58*, (Cirkulär från Statens Skeppsprovsningsanstalt, Nr. 21–23).

Sweden and elsewhere, this broader shipbuilding research mainly began in the post-World War II era.

6.2 The Swedish Shipbuilding Research Foundation

Research in the post-World War II period

With numerous major wartime research projects resulting in such innovations as the atomic bomb and radar, and in the development of entirely new materials, and with subsequent extensive investment in research, especially during the Cold War, it may seem that World War II constituted a watershed as regards technical research. On the other hand, the change may not have been so revolutionary. As we have seen, there had been a growing interest in technical research all through the 20th century. Of course, there were important changes during the war, with increased state support for research. In Sweden one example of this was the establishment of *Statens Tekniska Forskningsråd* (the Swedish Technical Research Council) in 1942.⁷⁷ However, the process had been well under way in the 1930s.⁷⁸

Shipbuilding to a large extent followed the general pattern as regards technical research. From the 1910s onwards, research had increasingly attracted attention, a trend which became more marked in the 1930s. The emphasis was on hydromechanics. In the post-World War II period, research extended to cover most aspects of shipbuilding. The country which led the way in devoting more resources to such research was Great Britain. Towards the end of World War II, the trade organisation Shipbuilding Conference took the initiative of founding the British Shipbuilding Research Association (BSRA), which came to function as a central agency for research in the field.⁷⁹ It was funded jointly by the government and the shipbuilding industry. By 1953 the association employed some 80 people. It did not have any laboratories of its own but commissioned research into hydrodynamics, strength of materials, machinery and outfitting from other research laboratories. The British

77 Hans Weinberger, *Nätverkentreprenören: En historia om teknisk forskning och industriellt utvecklingsarbete från den Malmiska utredningen till Styrelsen för teknisk utveckling* (Stockholm, 1997); Svante Lindqvist, "A Cost-Benefit Analysis of Science: The Dilemma of Engineering Schools in the Twentieth Century", in *Science, Technology and Society: University Leadership Today and for the Twenty-First Century: Festschrift to Professor Janne Carlsson* (Stockholm, 1998), 110 f.

78 See for instance: Stefan Lindström, "Implementing the Welfare State: The Emergence of Swedish Atomic Energy Research Policy", in *Center on the Periphery: Historical Aspects of 20th-Century Swedish Physics*, ed. Svante Lindqvist (Canton, MA, 1993), 187 f.; Thorsten Nybom, "The Socialization of Science: Technical Research and the Natural Sciences in Swedish Research Policy in the 1930s and 1940s", in *Center on the Periphery*, ed. Lindqvist, 164; Henrik Björck, "A distinguished scientific field? Pursuing resources and building institutions for engineering research in Sweden, 1890–1945", in *Foundations of Engineering Competences: Profession, practices and the role of knowledge* (forthcoming).

79 Robert Fredrikson, "Skeppsbyggeri, sjöfart och forskning", *Teknisk tidskrift*, September 21, 1954, 769 ff.; S. Livingston Smith, "The Organisation of the British Shipbuilding Research Association", *IVA: Tidskrift för teknisk-vetenskaplig forskning*, 25:1 (1954), 5–12.

association came to serve as a model in the setting up of similar research associations in Holland, Belgium, France and eventually in Sweden. In Germany, where research had traditionally held a strong position, committees within the Schiffbautechnische Gesellschaft were the instigators of research. Just after World War II, the Ship Structure Committee was established in the United States. Its aim was to carry out applied research into the strength of hulls, which was of immediate interest since many ships built during the war had structural weaknesses.

In addition to Britain, efforts to promote shipbuilding research in Norway were a major source of inspiration to Swedish shipbuilders and therefore it is appropriate to look more closely into the situation there.⁸⁰ Norwegian shipowners were among the most important customers of the Swedish shipyards from the late 1920s to the 1960s and close friendships developed between these parties. In the late 1940s, SSPA and the experimental tank in Trondheim began co-operating on mutual problems and exchanging experience.⁸¹ From the 1950s close co-operation on technical matters developed between the Swedish shipyards and the Norwegian classification society, Det norske Veritas (DnV). It should also be kept in mind that similarities in language and culture between the two countries facilitated an exchange of information.

In 1951, *Skipstekniske Forskningsinstitutt* (the Ship Research Institute of Norway) was established in Trondheim near the Norwegian Technical University.⁸² Behind the institute were the Norwegian Shipowners' Association, Det norske Veritas, and various shipyards. The purpose was to make Norwegian shipping more competitive. In the debate preceding the founding of the institute arguments had been put forward that in other countries great resources went into shipbuilding research and if Norway did not start its own research programs, its shipping business would soon be outdistanced on the world market. The institute came to work in close co-operation with DnV and expanded rapidly; by 1957 it had a staff of 25. In addition to being a research institute it also functioned as a consultant engineering firm. The funding came from the government, the member companies and revenues from consultancy work.

The 1950s were also a period when the classification society, Det norske Veritas, became more engaged in research. In their account of the history of the society, Håkon With Andersen and John Peter Collett speak of the 1950s and 1960s as a time when research became the chief concern.⁸³ From having functioned, in the 1920s, as a brake on overhasty introduction of new technology on board ships, forty

80 For instance, see: Fredrikson, "Skeppsbyggeri, sjöfart och forskning", 771; Minutes, November 23, 1951, February 13, 1952 & November 5, 1953: IVA's Committee for shipbuilding research (Kommittén för skeppsbyggnadsteknisk forskning vid IVA:s avdelning I) (IVAA); Gustaf Backman, "En översikt av utvecklingsarbetet inom Stiftelsen för Skeppsbyggnadsteknisk Forskning", *Sveriges Allmänna Sjöfartsförenings Årsbok* 1964-1965, 150.

81 SSPA annual report: *Berättelse över Statens Skeppsprovvningsanstalts verksamhet och medelsförvaltning*, 1949/50, (Cirkulär från Statens Skeppsprovvningsanstalt, Nr. 13), 4.

82 Fredrikson, 771; Håkon With Andersen & John Peter Collett, *Anchor and Balance: Det norske Veritas 1864-1989* (Oslo, 1989), 163 f.

83 Ibid., 199-225.

years later the classification society had become an “accelerator of new developments and inventions.”⁸⁴ By the mid-1960s, DnV housed one of the largest research staffs in Norway and had at its disposal almost half of all the country’s researchers in the field of shipping and shipbuilding.

Discussions among Swedish shipbuilders

The first serious Swedish efforts to establish research into a wide range of subject fields connected with shipbuilding were made by the Royal Swedish Academy of Engineering Sciences (IVA), which in 1949 set up a committee for research in the field of shipbuilding technology.⁸⁵ The members were H. F. Nordström (SSPA), Director-General of Naval Construction Birger Swenzén (chairman of the committee), Professor Einar Hogner, Robert Fredrikson (technical manager of the Nordstjernan shipping company) and Kurt Söderlund (technical manager of Kockum). In 1950 the professor of naval architecture at Chalmers, Anders Lindblad, was appointed to the committee. During its first few years the committee concentrated on identifying the areas where research was most urgently needed. That hydrodynamics came to be strongly represented is not surprising, since both Nordström and Hogner were professionally active in this field.

At a meeting in February 1952, Nordström presented a plan for expansion of the committee’s activities.⁸⁶ He argued that, considering the prominent position of Swedish shipping and shipbuilding, larger resources ought to be devoted to shipbuilding research, as in other countries, such as Britain, the United States, Holland and Norway. Nordström suggested that sub-committees should be appointed for research and for investigation. In this way it would be possible to bring engineers working at the shipyards into contact with experienced scientists in the field, in order to stimulate an exchange of knowledge and to create personal contacts.

The members of the committee were sympathetic to Nordström’s proposal. Robert Fredrikson stated that Sweden lagged behind other countries as regards shipbuilding research and said that it was “alarming that as a result of lack of basic knowledge we may become dependent on foreign knowledge.”⁸⁷ While the main committee should stick to its administrative function, the sub-committees should engage in actual research. In particular, young engineers should be engaged in the research since they were very “enthusiastic about their work.”

⁸⁴ Ibid., 200.

⁸⁵ Minutes, 1950–55: Committee for shipbuilding research (IVA A).

⁸⁶ Minutes, February 13, 1952: Committee for shipbuilding research (IVA A).

⁸⁷ Ibid.

The meeting decided that two sub-committees should be appointed; one for hydrodynamics and one for solid mechanics. The sub-committee for hydrodynamics began its activities in April 1952 with Hans Edstrand as chairman. The other sub-committee, with Nils Eckerbom as chairman, did not begin work until February 1954. In these committees engineers met to discuss different questions in, as Eckerbom later described it, “a club-like” atmosphere.⁸⁸

In October 1953, the shipowner Axel Ax:son Johnson made a donation of 100,000 kronor to IVA to be used for shipbuilding research.⁸⁹ With that, the main committee acquired an additional function – to distribute research grants.

Nordström was the leading spirit of the committee and, after setting up the sub-committees, he went one step further and drew up plans for converting the committee into a separate research organisation, a “collaborating body under the auspices of the academy with representatives of shipyards, shipowners and research institutes.”⁹⁰ Hopefully, the government would provide a large proportion of the necessary funding. The rest had to come from the industry, that is shipyards and shipowners. The proposed statutes stated that the organisation should initiate and support research, and to some extent be responsible for its financing. The board should be made up of twelve members: four appointed by IVA, four by the Shipbuilders’ Association and four by the Shipowners’ Association. The existing sub-committees were to be integrated and new ones added.

Statements by the members of the committee indicate that earlier it had been difficult to interest the executives of the shipyards in research, but by 1953 these had started to show a “greater realisation of the value of research.”⁹¹ Within the Swedish Shipbuilders’ Association, there was no discussion of the issue in the early 1950s. The first time it was brought up was in August 1953, when the managing director of the Association, Gösta Kaudern, who had graduated from KTH in 1938 and then been a naval engineer until 1952, presented a memorandum outlining how, in his opinion, the Association should extend its organisation and arrange its activities in the future.⁹² Among other things he suggested that the Association should co-ordinate Swedish shipbuilding research. He mentioned that corresponding organisations in other countries, for instance Norway, included this among their functions.

The issue of research did not lead to any discussion on this occasion. Instead, what seems to have started things rolling was a talk by H. F. Nordström to the

88 Minutes, August 22, 1955: SSF’s research board: SSF (CKG).

89 Letter from Axel Ax:son Johnson to Edy Velander, IVA, October 23, 1953: Committee for shipbuilding research (IVAA).

90 Minutes, November 5, 1953; February 4, 1954 & March 18, 1954: Committee for shipbuilding research (IVAA).

91 Minutes, September 22, 1953: Committee for shipbuilding research (IVAA).

92 Minutes, August 17, 1953, Annex A: Swedish Shipbuilders’ Association (CKG).

members of the Association in February 1954.⁹³ He began by stressing the importance of research to the development of technology in different fields and argued that nowadays almost no advances in engineering could be accomplished without “a basic research.” Increased competition made research even more important. Among urgent research tasks in shipbuilding, he mentioned hull shape, strength and machinery. Nordström also described how research was organised in other countries, particularly Britain and Norway, and what the IVA committee had done so far. He ended by presenting the committee’s plans for a separate research organisation.

An animated discussion followed his address. All the managing directors of the leading shipyards were in favour of the idea of founding a Swedish research organisation. If it was Nordström’s intention to stimulate interest among the shipbuilders he was indeed successful, in fact so successful that the Shipbuilders’ Association, as things eventually turned out, set up a research organisation of its own, outside IVA.

At a meeting of the Shipbuilders’ Association in April 1954, the discussion was resumed.⁹⁴ The managing director of Götaverken, Karl E. Jacobson, who, as we saw in Section 5.2 was not an engineer but an economist, was somewhat sceptical of the idea of a shipbuilding research organisation within IVA, since he doubted whether the results would match the costs. However, he acknowledged that research was important and that the Association should become more engaged in such matters.

The efforts of the IVA committee made a greater impression on the engineer and managing director of Kockum, Gösta Lundeqvist, who recommended that the Association should support the project financially. The managing directors of Eriksberg and Lindholmen, Erik Häggström and Gustaf Löwenhielm, who were also engineers, both expressed the opinion that the best solution would be for the shipbuilding industry to organise research itself. However, due to the high cost it would be better if IVA handled the matter, at least for the moment. Gösta Kaudern acknowledged that research would cost money, but argued that the purpose of such work was to make the shipyards more competitive and therefore in the long run it would actually save money.

After further discussion, it was decided to appoint a committee to examine the question. Erik Häggström became chairman, and Kaudern and Anders Lindén, the head of the engine department at Götaverken, became the other members of this “research committee.”

A person who came to play an important role in later developments was Gösta Lundeqvist (1892–1962). He had graduated in naval architecture from KTH in 1915 and been a naval engineer until 1927 when he left the military to work for private industry, first as managing director of the London branch of Atlas Diesel and then, from 1936, as deputy managing director of Kockum. In 1940 he became managing

93 Minutes, February 8, 1954, Annex A, “Referat av överdirektör H.F. Nordströms orientering om forskningen och den därpå följande diskussionen”: Swedish Shipbuilders’ Association (CKG).

94 Minutes, April 29, 1954: Swedish Shipbuilders’ Association (CKG).

director of the shipyard, a position he held until 1958. After his appointment as chairman of the Shipbuilders' Association in April 1954, he became a major advocate of a Swedish shipbuilding research foundation. As we saw above, one of his managers at Kockum, Kurt Söderlund, was a member of IVA's committee on shipbuilding research. When Söderlund died in 1953, Lundeqvist began to attend the committee meetings even though he was not formally a member. He was therefore well informed about the efforts of IVA to create a research organisation.

In September 1954 the managing director of IVA, Edy Velander, reported to the IVA committee on talks with representatives of the Ministry of Commerce.⁹⁵ The result was disappointing. For the moment many research organisations in other fields were regarded as having greater priority for state funding. The committee therefore came to the conclusion that the best solution would be if the shipyards and the shipowners organised a research foundation without government involvement.

At a board meeting of the Shipbuilders' Association, three days later, Lundeqvist brought back the news from the committee meeting at IVA.⁹⁶ Since the government would not be willing to give financial support to the project, he suggested that a foundation should be established by the Shipbuilders' Association, the Shipowners' Association and the Marine Underwriters' Association. These three should share the costs. The foundation would be independent of IVA and the government. Lundeqvist's proposal was accepted with the rider that representatives of IVA and other organisations might become members without right to vote.

Opinions differed on whether the shipbuilders alone should establish the research organisation. At a board meeting of the Association in December Lundeqvist emphasised the importance of starting research work as soon as possible and said that negotiations with shipowners might take a long time. Karl E. Jacobson agreed and said that he believed the shipowners considered shipbuilding research to be a matter for the shipyards. Häggström, who was chairman of the committee set up by the Association to examine the question, disagreed, arguing that the shipowners in fact had a very strong interest in the issue. After some discussion it was decided that the marine underwriters should be left out while the shipowners should be asked whether they wished to participate or not. Despite the fear that these discussions might take too much time, Lundeqvist found it natural for the shipping companies to be represented: "We are not doing research for the sake of it, but to produce better vessels for the shipowners."⁹⁷ On the other hand he wished the shipyards to have a majority on the board to safeguard their interests. He also believed that the shipbuilding industry should cover all the costs, which indicates that the reason for including the shipowners was not financial but rather to utilise their knowledge and experience.

95 Minutes, September 6, 1954: Committee for shipbuilding research (IVAA).

96 Minutes, board meeting, September 9, 1954: Swedish Shipbuilders' Association (CKG).

97 Minutes, board meeting, December 20, 1954: Swedish Shipbuilders' Association (CKG).

At the next meeting of the Shipbuilders' Association, in January 1955, Lundeqvist reported that he had spoken to the chairman of the Shipowners' Association, Emanuel Högberg, who said that they did not insist on being among the founders.⁹⁸ Indeed, they were content to have a representative who could convey their point of view in different matters. Therefore, Lundeqvist argued, the board of the foundation should consist only of members appointed by the Shipbuilders' Association with the exception of one member representing the Naval Material Administration. The reason for this was a belief that if a representative of the Material Administration, who was in fact a representative of the Swedish state, was included, it would be possible to make the financial contributions of the shipyards to the research organisation tax-deductible.

The establishment of the Swedish Shipbuilding Research Foundation

At a meeting in April 1955 the members of the Swedish Shipbuilders' Association took the formal decision to establish *Stiftelsen för Skeppsbyggnadsteknisk Forskning* (the Swedish Shipbuilding Research Foundation; henceforth referred to as SSF).⁹⁹ SSF began its activities at the beginning of May. Lundeqvist became chairman of the board, a position he held until 1957. The board had four members appointed by the Shipbuilders' Association and one by the Naval Material Administration. Lennart Swenson (1925–1962) became the head of SSF, with the title director of research. He had graduated in naval architecture from Chalmers in 1947 and then worked at Götaverken before obtaining the position at SSF. Among his first tasks as director of research was to travel abroad to visit similar institutions and to attend conferences, for the purpose of establishing international connections and learning about foreign research programs.

To advise the board and the research director on the general outlines of the work, a research board was organised, whose members were leading engineers and scientists, representing the Shipbuilders' Association, the Naval Material Administration, IVA, the Shipowners' Association, SSPA, Chalmers and KTH. The research board also had the power to appoint committees to investigate certain matters.

Statements by the parties involved indicate that there was some rivalry between IVA and the Shipbuilders' Association during the period. In May 1955, Lundeqvist and Swenson wrote to inform IVA that SSF had been established.¹⁰⁰ They also asked IVA to nominate their representative to the research board. Faced with a fait accompli, the people at IVA, however, acknowledged that they were pleased with

98 Minutes, board meeting, January 25, 1955: Swedish Shipbuilders' Association (CKG).

99 Minutes, April 29, 1955: Swedish Shipbuilders' Association (CKG).

100 Letter from G. Lundeqvist & L. Swenson to IVA, May 18, 1955: Committee for shipbuilding research (IVAA).

the efforts of the Association.¹⁰¹ The question now was how to organise a functional co-operation between SSF and IVA's committee.

Gregory Ljungberg at IVA wrote to Birger Swenzén, chairman of IVA's committee on shipbuilding research, saying that "we are surely all agreed that with the limited financial and population resources of this country we cannot have parallel bodies for ship research" and he found it desirable, "without provoking any irritation," to merge the activities of the two organisations.¹⁰² After some months of discussion the committee finally decided that the sub-committees should be wound up, since it could be expected that similar research work would be initiated within SSF. On the other hand, the main committee should be preserved as an advisory body and as IVA's medium of for co-operation with SSF.

In October IVA informed the members of the main committee that there had been a friendly dialogue with representatives of SSF and that "lines on which they could co-operate" had now become clear.¹⁰³ However, the members of the sub-committees still had to be informed and there was a fear that they might be upset. IVA wrote to the chairmen of the two sub-committees, Edstrand and Eckerbom, thanking them for their services and asking them to inform the other members. As compensation the two chairmen were invited to become members of the main committee for shipbuilding research, an offer which both were happy to accept. Already in May that year Edstrand and Eckerbom had become members of SSF's research board.

The direction of SSF research

During its first years of existence SSF steadily expanded its activities. The research carried out was solely of an applied nature, aimed at solving concrete technical problems encountered by the shipyards, and it only covered civil aspects of shipbuilding, despite the fact that the Naval Material Administration was represented on the SSF board and committees. Of course, general problems could have both civil and military applications.

In a 1958 article, Lennart Swenson stated that "research is the order of the day" and that it was natural for the Swedish shipyards to co-operate on such a matter in order "to remain competitive with other countries."¹⁰⁴ He went on to say that the full value of the research would only appear when the results were applied at the shipyards. Therefore, the SSF staff had the important task of informing about these

101 Copy of letter from Edy Velander, IVA to Erik Häggström, June 17, 1955; Copy of letter from IVA to SSF, September 7, 1955: Committee for shipbuilding research (IVAA).

102 Copy of letter from Gregory Ljungberg, IVA to Birger Swenzén, May 20, 1955: Committee for shipbuilding research (IVAA).

103 Copy of letter from IVA to the members of the committee, October 5, 1955: Committee for shipbuilding research (IVAA).

104 Lennart Swenson, "Forskning för svenska varv", *Skeppsbyggaren* 1958:3, 14 ff. Cf. Walter Vollert, "Svensk varvsindustri 1954", *Sveriges Allmänna Sjöfartstförenings Årsbok* 1954–55, 16.

results. Research projects also resulted in written reports, published in SSF series, which were distributed to the member companies.

Besides performing research, SSF monitored and informed about the latest developments abroad. As time went by, an extensive research library of Swedish and foreign journals and research reports materialised, and the literature service became an important activity of the organisation.

SSF at first had its office in Götaverken's office building in Gothenburg, but in 1957 it acquired premises of its own adjoining the office of the Shipbuilders' Association.¹⁰⁵ This did not mean that SSF came to have research facilities of its own. Instead, research was done by suitable persons, usually engineers, who were hired as consultants and carried out their studies at shipyards, ironworks, on board ships or within existing laboratories such as SSPA or those of Götaverken and SKF. Some assignments were placed with different departments at Chalmers and KTH, viz. the departments of naval architecture, solid mechanics, and electrical engineering. SSF only employed a small permanent staff: during most of the 1960s SSF employed one engineer responsible for the library and three research engineers whose task was mainly to co-ordinate research work and to prepare information for the SSF board and the research board.

The research came to focus on four different fields: hydromechanics, design of hulls, marine engines and ship operation. Among the studies that SSF carried out during the first ten years were ones involving full-scale measurements of hull stresses in ships at sea, new structural materials, corrosion, noise problems, the strength of welded joints and standardised calculation methods for longitudinal strength.¹⁰⁶

The increase in the size of oil tankers created a whole range of new problems. As mentioned, the Swedish shipyards' concentration on the production of these ships led SSPA to carry out research and testing in the field. Some of these investigations were initiated by SSF.

In November 1956, the SSF board discussed the subject of oil tankers. At this time people in the industry considered a ship of more than 45,000 tons d.w. very large. Lennart Swenson had been in contact with engineers at the shipyards and found that "the biggest problem with the big tankers is predicting the correction factor needed for translating the results of model tests to full scale."¹⁰⁷ This correction factor could only be obtained when the model-test results were compared with data from trial trips. The way to approach the problem was partly to collect information from trial trips with large tankers, partly to find a theoretical explanation of the scale factor. SSF decided to finance certain investigations at SSPA. In the absence

105 SSF annual reports: *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Årsberättelse, 1955–57* (SSPALib); *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Tio år* (Göteborg, 1965).

106 SSF annual reports: *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Årsberättelse, 1955–65* (SSPALib); *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Tio år*.

107 Minutes, board meeting, November 23, 1956: SSF (CKG).



SSF's library in the late 1950s. In the centre is the director of research Lennart Swenson, to the right the engineer Rutger Bennet and to the left the secretary Ulla Fundahn. (Photo in *Skeppsbyggaren* 1958:3, p. 15)

of enough trial trip results, SSPA both carried out model tests and studied the available literature in the field, surveying existing theories. In this way it was possible to extrapolate preliminary correction factors by ascertaining their dependence on some well-defined ship parameters.¹⁰⁸

Of course, hydromechanical problems were not the only ones which appeared in the building of ever larger oil tankers. During the 1960s SSF initiated research into many other matters connected with these ships, for instance overheating of the load affecting the ability to pump and unload the oil smoothly, corrosion in tanks, and the use of high-strength steel in the hull. The latter research was financed by *Malmöfonden* (the Swedish Ore Foundation), and carried out in co-operation with Swedish steelworks.¹⁰⁹

Another subject which attracted considerable attention from the start in 1955 and well into the early 1960s was nuclear propulsion for merchant vessels. In many countries shipbuilders had begun to study this possibility, inspired by the building both of nuclear submarines and of land-based stationary power plants. SSF set up

¹⁰⁸ *Skaleffekt vid modellförsök med stora tankfartyg* (SSF Rapport nr. 8; Göteborg, 1958), 1 ff.

¹⁰⁹ SSF annual reports: *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Årsberättelse, 1960–66* (SSPALib); cf. Jan Kuuse, *Varven och underleverantörerna: Förändringar i fartygsbyggandets industriella länkeffekter* (Göteborg, 1983), 145 ff.

an atomic power committee as early as the autumn of 1955 composed of representatives of the larger shipyards, the Naval Material Administration, the Swedish Atomic Energy Company (AB Atomenergi), Chalmers and the de Laval Steam Turbine Company.

In the following years the atomic power committee investigated different aspects of the new technology, especially operative expenses and safety.¹¹⁰ In 1959 SSF was also able to station engineers in the United States to study the building of the N/S *Savannah*, which was the first nuclear-powered merchant vessel in the world. Parallel to the work of the atomic power committee, the larger shipyards carried out their own investigations concerning nuclear power. Since the people who performed these tasks were usually also members of the committee, experience from the shipyards benefited SSF. In the early 1960s, interest in nuclear propulsion cooled as it became clear that atomic energy would not become economically feasible in the foreseeable future, and eventually SSF only monitored international literature in the field.

The shipbuilding industry was one which began at an early stage to use computers in the designing of new ships. SSF became involved in this development from the late 1950s onwards. It employed individual consultants and firms, such as the aircraft manufacturer SA AB in Linköping, to develop computer programs for a wide range of purposes such as calculating the strength of ship designs, determining the shape of the hull, stability, propellers, damage stability, tank and storage capacities etc. Then SSF carried out calculations for the Swedish shipyards, using available computers, for instance the BESK-computer at KTH and the ALWAC-computer at Chalmers.

These assignments increased rapidly in number: in 1961 SSF executed 111 orders, in 1962 221 and in 1963 some 330. According to Gustaf Backman, who succeeded Swenson as director of research, the SSF policy was "that computer programs that can be used by several yards shall be developed on a common basis, which is undoubtedly the cheapest way for the individual yards to use computers."¹¹¹ When the shipyards eventually obtained computers of their own they could rent programs from the "computer-program library" which in the mid-1960s contained some 40 different programs. In addition to the Swedish shipyards, shipowners and Norwegian shipyards also used the computing service.

Due to the ever increasing use of the service, SSF and its parent organisation, the Swedish Shipbuilders' Association, decided that, beginning in January 1964, the activities should be transferred to a separate organisation, *Varvsindustrins Beräkningscentral* (the Swedish Shipbuilders' Computing Centre). SSF, however, continued developing new programs which the Computing Centre used.

¹¹⁰ For a more extensive account of Swedish research on nuclear-powered ships, see: Lars Olsson, "Skall vi bygga atomfartyg?": Svensk varvsindustri och frågan om atomdrift till sjöss, 1955–65", *Varv: Varvshistoriska Föreningen i Göteborg Årsskrift* 1997, 4–28.

¹¹¹ Gustaf Backman, "The Organization and Activities of Shipbuilding Research in Sweden", in G. Backman, et. al., *Japansk skeppsteknisk forskning: Rapport från IVA och Varvsindustrins skeppsbyggnadsdelegation till Japan i maj 1966*, vol. III, Appendix (SSF Rapport nr. 53; Göteborg, 1967), 5; For information on SSF's computing service, see: Swenson, "Forskning för svenska varv", 18; SSF annual reports: Stiftelsen för Skeppsbyggnadsteknisk Forskning: Årsberättelse, 1958–64 (SSPA Lib).

A subject which began to attract attention in the early 1960s and in which shipbuilders had a shared interest with the shipowners was automation and rationalisation on board. SSF carried out investigations in this field, partly in co-operation with the Shipowners' Association efficiency improvement group.

Eventually the co-operation with the Shipowners' Association became closer. Among shipowners there was an increasing interest in technical questions at this time, which found expression in the setting up of the Association's Technical Committee in 1965. Furthermore, at the suggestion of Gösta Kaudern, who in the same year had become the technical manager of the Broström shipping group and who was the Shipowners' Association representative on SSF's research board, SSF was reorganised, giving shipbuilders and shipowners a shared responsibility for the organisation.¹¹² The new organisational structure came into effect in January 1967 and SSF changed its name to *Stiftelsen Svensk Skeppsforskning* (the Swedish Ship Research Foundation). The change of name indicated that the field of research would now be broader, with a greater emphasis on shipping.

During SSF's first decade, that is from 1955 to 1965, the Shipbuilders' Association had itself financed the research activities, with additional grants coming from the Swedish Technical Research Council, IVA, the Shipowners' Association and a number of private foundations. After the mid-1960s an increasing part of the support came from the Swedish state through the Technical Research Council and the Swedish Ore Foundation. After the reorganisation of SSF in 1967, the Shipowners' Association contributed almost as much to the SSF budget as the Shipbuilders' Association.

Without trying, in any economic terms, to evaluate the importance of the research initiated by SSF, there is another thing about the organisation that should be mentioned here and that is its function as a meeting place of engineers from different parts of the system. Almost all the members of the board and the research board of the organisation were engineers. Under the research board came committees whose function was to discuss and initiate important research assignments and to evaluate the results obtained. There were also a few special working groups. By 1965 SSF had a total of 12 committees and working groups dealing with a large number of subjects such as atomic power, automation and rationalisation, noise, corrosion, materials in machinery, computers, model-testing, trial tests, design of hulls, measuring of hull stresses and stability. These committees and groups contained some 60 members, who were engineers in prominent positions at the shipyards, shipping companies, the Naval Material Administration, research institutes, governmental agencies, steelworks or elsewhere, or who were professors at Chalmers and KTH.¹¹³ In their committee work they got together to discuss questions of mutual interest. Not the least important aspect of their co-operation was the fact that they represented

112 "Varv och sjöfart samordnar skeppstekniska forskningen", *Svensk Sjöfartstidning* 63 (1967), 191; cf. Gösta Kaudern, "Med kurs på framtiden: Något om Broströmskoncernens nybyggnadsprogram och tekniska framtidsplaner", *Svensk Sjöfartstidning* 61 (1965), 2589; idem., "Ett dramatiskt halvsekel: En skeppsbyggare ser tillbaka", *Svensk Sjöfartstidning: Nordisk sjöfartsteknisk årsbok* 1985 81 (1985), 86 f.

113 *Stiftelsen för Skeppsbyggnadsteknisk Forskning: Tio år.*

several different parties in the field and therefore had somewhat different perspectives on the problems – for instance, user-producer perspectives or practical-theoretical approaches. Then, of course, there were a large number of engineers who actually carried out the research tasks, whether at the technical universities, SSPA or the laboratories of the industrial companies. As a result SSF became as much a meeting place of engineers active in the field as it was a producer of new knowledge.

6.3 Concluding remarks

The establishment of SSPA and SSF has illustrated how college-trained engineers functioned as a social group of technology carriers – they took the initiative in promoting research organisations, they mobilised the resources to actually establish them, they came to lead these organisations and they were the ones who became the researchers.

As regards the criteria of knowledge we saw how, from the first decade of the 20th century, engineers discussed the subject of model-testing at the meetings of STF's section for naval architecture. Eventually several engineers gained substantial knowledge of how to perform such tests by studying foreign tanks, carrying out tests there on behalf of the organisations they worked for or carrying out tests at the smaller KTH tank.

The establishment of the two research organisations further shows that engineers had the necessary power or influence to function as technology carriers. While university teachers and other engineers had been the first to actively promote the idea of founding such organisations, it was the influential managing directors of the large shipyards, who were also engineers, who made the plans come true. In the case of the experimental tank in the 1930s it was Hugo Hammar, with the large resources of Götaverken at hand, who was the driving force. Two decades later, the Swedish Shipbuilders' Association, chaired by Gösta Lundeqvist of Kockum, took on a similar role.

Most engineers who expressed their opinions in the discussions on the subject were convinced of the need for Swedish research organisations dealing with maritime technology. In the case of the experimental tank, the only conflicts which appeared concerned the questions of where in the country it should be located and how it should be organised. Here we can identify a familiar dividing line between graduates of KTH and Chalmers, mirroring different interests within the group.

We might ask what interests the engineers had in the issue of establishing research organisations and carrying out research. As discussed above, the advocates of an experimental tank from the 1910s onwards often put forward arguments of

national interest, saying that Sweden would soon meet harder international competition and therefore had to do research of its own. In the “peaceful struggle” between the shipbuilding nations it was important to be self-sufficient in the production of knowledge. Another argument was that the Swedish Navy needed a tank for security reasons. Furthermore, it is clear that the spirit of the age, with its increasing belief in the importance of technical research during and after World War I, inspired those who wanted to create a maritime research institute.

When, in the 1950s, the shipyards established the Swedish Shipbuilding Research Foundation they did so to be able to keep up with the stiff international competition. Again, patriotic reasons were advanced for the argument that it was essential to remain competitive with foreign shipyards. The otherwise competing Swedish yards found here a field in which they had an interest in co-operating.

Of course, it is possible to identify other interests too. The establishment of research organisations would, for instance, open interesting career opportunities for individual engineers as well as offer plenty of chances for them to devote themselves to creative and stimulating work. That engineers could find such research work stimulating and fun can be seen from a statement by Kurt Söderlund in 1937: “To the outside observer of a model test the whole thing may undoubtedly appear an amusing game, but to those taking part as interested parties it is demanding work although, it must be admitted in the interests of honesty, highly enjoyable such.”¹¹⁴

This chapter has also pointed to the importance for the engineers of being organised to function as a social group of technology carriers – through the professional associations they learnt of the results of research work and by holding the leading positions in the companies and the Swedish Shipbuilders’ Association they had the influence and resources to establish such research bodies. On the other hand, SSPA and SSF in themselves came to function as important meeting places between engineers from various parts of the shipbuilding system, and thereby helped to increase the extent to which engineers were organised as technology carriers. As we have seen, the different boards and working groups of SSF gave engineers an opportunity to get to know each other and to work together to solve certain technical problems.

¹¹⁴ Söderlund, “Modellförsök”, 1.

7. Epilogue

This study has investigated the extent to which college-trained engineers, working in Swedish shipbuilding, were able to function as a *social group of technology carriers*. With such a focus I have been able to shed light on the process in which their role in the system was formed. At first glance it might seem natural and even self-evident that engineers would always function as technology carriers but, as we have seen, in order to qualify as such an entity the engineers had to fulfil several “ability” requirements concerning knowledge, interest, influence etc. Considering this, their role was neither self-evident, nor was it constant over time.

To begin with the requirement that technology carriers must have *knowledge* of technology it is hardly surprising that engineers had that, especially as I defined an engineer as someone with a university level education in any of the different branches of engineering. In addition to the theoretical training the engineers’ knowledge, of course, also included work experience, both as regards practical work on the workshop floor before graduation and engineering work, for instance in drawing departments, after graduation. Many acquired this latter experience while working at large modern shipyards abroad for a few years, before returning home again.

The engineers’ knowledge was a key to becoming a social group of technology carriers but there were also other groups within the system, whose members possessed different kinds of knowledge, for instance naval officers, sea captains, engine-room officers, economists and practically trained technologists. All these different kinds of competence were needed for the system to function well but what kind of expert knowledge would entitle its carrier to leading positions within the various companies and other organisations of the system was an open question. Considering the requirement that a technology carrier has to have *power* or *influence* to realise its interest, the extent to which the group of engineers could qualify for the epithet was also an open question, and changed over time.

The engineers’ strongest nests were the private shipyards. Here they began to replace an older generation of practically trained technologists in both middle and top management positions in the early 20th century. Rather soon the engineers established something of a monopoly of the position of managing director and eventually they also gained most middle management positions. The fact that the private shipyards by virtue of their size and central position in the production process dominated the system reinforced the engineers’ influence on developments in the system as a whole and was important for them to be able to function as a social group of technology carriers. Towards the end of our period, that is from the late 1950s onwards, the engineers’ position, however, seems to have become weaker as economists increasingly acquired leading positions, not least as managing directors of the companies.

Within the field of rules and regulations the picture is more dual. On the one hand college-trained engineers held the top positions in the National Ships’

Inspectorate from its inception in 1915, having successfully competed with a group with another kind of knowledge – ship captains, who were versed in nautical matters. On the other hand, in those organisations which exerted the greatest influence on shipbuilding rules and regulations – the classification societies – Swedish engineers, at least, did not have much influence. These societies had offices in most ports and shipbuilding districts of the world, but their governing bodies were located in their home countries, not least in Britain.

When it comes to the shipyards' customers, the private shipping companies and the Swedish Navy, it is clear that engineers seldom or never held the very top position as shipowner or head of the Naval Material Administration. Yet they came to hold influential positions within their organisations. From the early 20th century onwards the larger shipping companies set up technical departments responsible for both maintenance of older ships and the building of new ones. Originally led by former sea captains or engine-room officers, college-trained engineers were eventually, mainly from the 1930s onwards, the ones to become technical managers.

Within the Naval Material Administration the members of the Corps of Naval Engineers were the ones to design new ships. As early as 1868, graduation from KTH was required in order to become a member of the Corps. The head of the Corps and the engineers' department of the Administration was the director-general of naval construction, who always was a college-trained engineer. Another group within the Administration whose members were also anxious to exercise an influence on the shaping of new naval technology were the naval officers. These officers successfully competed for influence within the organisation and at an early stage were able to strengthen their position, which found expression in the director-general's decreasing authority in the 1890s. Despite this, the naval engineers did have a key role in the Administration when it came to building new warships, not least due to their co-ordinating role in that work.

Regarding other supportive functions of the production system, engineers completely dominated in engineering education and technical research, and that throughout the entire period. This was certainly the innermost part of the engineers' world and it is difficult to imagine how other groups could have threatened their positions here, for instance as professors of naval architecture.

The way the engineers, as technology carriers, were *organised* involves several dimensions. First, they were active in, and often also held leading positions in, the many different organisations which constituted the system. The fact that they worked all over the system is essential to their role as technology carriers and it matters less that they held somewhat less influential positions in some categories of organisations than in others.

Secondly, the engineers formed a network to which their common background, especially the education at Chalmers or KTH, was a key. After graduation many became members of professional associations, which functioned as meeting places between engineers from various parts of the system. Here, the engineers socialised and discussed problems of common interest. We find a similar function, with engine-

ers from different parts of the system coming together to solve technical problems, in the boards and working groups of the research institutes, the Swedish State Shipbuilding Experimental Tank and the Swedish Shipbuilding Research Foundation. Throughout the period the number of such meeting places increased, making the group of engineers more organised in this respect – in the first decade of the century sections for naval architecture were established both in Stockholm and in Gothenburg, and in 1918 the Swedish Shipbuilders' Association was established. Then in the 1940s, 1950s and 1960s engineers increasingly came together within the realm of the research institutes.

The professional associations are of particular interest to this study since in the discussion between engineers representing various organisations of the system it is possible to identify conflicting interests within the group. While opinions differed on a wide range of subjects, such as the quality of Swedish labour or the reasons for the decline of the shipbuilding industry in the late 19th century, there are some more marked dividing lines within the group. One was between the *producers* – the shipyards – and the *users* – the shipping companies and the Swedish Navy. To the engineers at the shipyards the critical problems concerned how to design and produce good ships economically, while those of the shipping companies or the Naval Material Administration wanted a ship that was reliable and inexpensive to maintain. Consequently, the two groups had differing opinions on the choice of technology, as was clearly demonstrated in the discussions in 1912 on simplifications in the design of warships or in 1950 on the use of electric welding.

Another dividing line can be found between graduates of KTH and of Chalmers. As we saw, the two groups show different patterns as regards the choice of employer. What is more, and this is especially striking in the first half of the period studied, graduates of the two schools were not equally successful in reaching leading positions in different organisations. While Chalmers graduates dominated as managing directors of the shipyards and technical managers of the larger shipping companies, graduates from KTH were virtually the only members of the Corps of Naval Engineers. On occasions when the question of concentrating all naval architecture education in one school was on the political agenda, this underlying antagonism was exposed. The struggle about where to locate a large Swedish experimental tank should be seen in this context.

Despite these and other differences it is clear that on a more general level there was consensus among the engineers we have encountered. Regardless of whether they worked for shipyards, shipping companies, the Naval Material Administration or elsewhere in the system, they all, caught in a common spirit of nationalism in the early 20th century, argued for an expanding internationally competitive shipbuilding industry; they all hoped that the government would grant money for naval construction; they all wanted a Swedish shipbuilding experimental tank to be built; they had an interest in the technology itself, and so on. Therefore it is reasonable to argue that as regards the criteria of *interest* they in fact constituted a rather homogeneous group of technology carriers.

The conclusion to be drawn from the above is that the engineers' ability to play the role of a social group of technology carriers increased during the first half of the 20th century. It should be pointed out that the question of whether engineers were able to function as technology carriers cannot be answered with a single "yes" or a "no" – on the contrary, it is a matter of degree. From the first decade of the century and onwards the engineers of the shipbuilding system gained increasing influence in their organisations. An illustration of the gradual growth in their power in the system may be seen in the fact that while engineers had worked for the establishment of a large experimental tank from the 1910s onwards it was not until the late 1930s that the tank materialised. Moreover, the engineers had a certain interest in developing the system, they had the required knowledge in a period when production was of prime concern, and they became increasingly well organised, not least in professional associations and committees of the research institutes, in facilitating an exchange of sociotechnical knowledge.

However, a change came about from the late 1950s onwards. The most visible sign of this change was that non-engineers, often economists, began to replace engineers in many leading positions at the shipyards, and most notably as managing directors. That economists increasingly became top executives does not mean that the engineers totally lost their influence. However, the changed situation indicates that the capacity of the engineers to function as a fairly independent group of technology carriers was reduced. Even if they had always been to some extent dependent on other groups, forming what Edqvist and Edqvist would refer to as a *combined* social carrier, this dependency became more marked after the 1950s.

As far as the wider implications of this study are concerned, it is likely that the patterns presented are not unique to shipbuilding but apply to at least some other branches of Swedish industrial life too. Being an industry producing large and complex products for sophisticated and demanding customers, who all had their own specific requirements, shipbuilding had much in common with industries such as construction or production of heavy-duty electrical equipment for the power companies. In the electric light and power system, in particular, there are indications that engineers were able to function as a social group of technology carriers. To mention just one aspect – that of power or influence – we find a similar pattern here with college-trained engineers monopolising the position of managing director of the large manufacturer ASEA (now known as ABB). This was so from the late 19th century until 1980, when a college-trained economist broke the monopoly and became managing director. Similarly, on the customer side, in the Swedish State Power Board, college-trained engineers held the very top position as director-general from the establishment of the organisation in 1909 until the late 1950s.

In the present study I have not dealt with the phase when engineers were increasingly replaced by economists in top executive positions. This process is of great interest and will hopefully be the subject of future historical research. What I have done is to indicate that engineers had a uniquely strong position in Swedish

industrial life during the period from the turn of the 20th century until the 1960s. To find out to what extent they were able to function as a social group of technology carriers more generally, however, requires deeper studies of various other industries or systems.

When it comes to today's discussions on the need for college-trained engineers, this study does not offer any answers either to the question of to what extent engineers are important to economic growth, or to the one of the engineers' role today or in the future. I have outlined a perspective in which the role of engineers can be studied. Furthermore, I have presented an empirical account which has illustrated the initial thesis that the engineers' role is not predetermined but takes shape in an interaction with other groups and that it changes over time. An awareness of this may be of value to those discussing the future need for engineers.



7 *Epilogue*



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