UNIVERSITY OF JYVÄSKYLÄ

THE LIFE AND WORK OF SIR WILLIAM FAIRBAIRN: A CASE STUDY IN THE HISTORY OF THE ENGINEERING PROFESSION IN 19TH CENTURY BRITAIN

A Pro Gradu Thesis

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Tuomo Tuovinen

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JYVÄSKYLÄN YLIOPISTO

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Tiivistelmä - Abstract

Tämän pro gradu -työn tarkoituksena on tutkia insinööriprofession kehittymistä teollistumisen myötä 1800-luvun Britanniassa. Tapaustutkimuksena käytetään yhden insinöörin, Sir William Fairbairnin (1789-1874), elämäntyötä. Päälähteinä ovat Fairbairnin elämänkerta, joka julkaistiin pian hänen kuolemansa jälkeen ja hänen oma kirjallinen tuotantonsa. Lisäksi Fairbairnin työ insinöörinä, tehtailijana ja tiedemiehenä pyritään asettamaan laajempaan kontekstiin lähdekirjallisuuden avulla. Tutkimuksen pääkysymyksinä ovat: 1.) Mikä oli Sir William Fairbairnin merkitys insinööriprofession kehitykselle 1800-luvun Britanniassa? 2.) Mikä oli Fairbairnin tieteellisen työn merkitys? 3.) Mitä hän ajatteli tieteen ja teknologian kehityksestä?

Insinööriprofessio syntyi Britanniassa 1700-luvun puolenvälin tienoilla. Teollistumisen edetessä insinöörit saavuttivat lisää valtaa brittiläisessä yhteiskunnassa ja samalla insinööriyhdistysten merkitys kasvoi. Voidaan väittää, että yhdistykset olivat niiden jäsenille eräänlaisia apuneuvoja, joilla insinöörit pystyivät saavuttamaan lisää mainetta ja mammonaa. 1800-luvun ensimmäisellä puoliskolla "The Institution of Civil Engineers" kohosi tärkeimmän yhdistyksen asemaan, mutta 1800-luvun puolivälissä useat muut yhdistykset, kuten "The Institution of Mechanical Engineers", kasvattivat valtaansa. Insinöörien ja insinööriyhdistysten lukumäärä kasvoi huomattavasti koko 1800-luvun ajan. Tästä huolimatta verrattuna eräisiin muihin teollistuneisiin maihin, insinöörien teoreettinen koulutus oli varsin vähäistä 1800-luvun Britanniassa, koska siellä korostettiin käytännön oppipoikakoulutuksen merkitystä. Teoreettisen koulutuksen väheksymisen ja insinöörien assosioitumisen perinteiseen maa-aateliin on katsottu vaikuttaneen jossain määrin Britannian teollisen kehityksen taantumiseen 1800-luvun lopulla. On kuitenkin ymmärrettävä, että yliopistokoulutuksen tarve ja aatelistuminen koskivat vain pientä osaa insinööreistä; suurin osa heistä säilyi keskiluokkaisena ja tuli toimeen käytännön koulutuksella.

Sir William Fairbairn oli monella tapaa poikkeus verrattuna suureen enemmistöön 1800-luvun britti-insinöörejä. Tapaustutkimuksena mielenkiintoisen ja harvinaisen Fairbairnista tekee se, että hän vastasi Samuel Smilesin 1800-luvun toisella puoliskolla lanseeraamaa "The True Gentleman" -arkkityyppiä, joka oli noussut köyhistä oloista varakkaaksi tehtailijaksi ja julkisuuden henkilöksi moraalisen nuhteettomuutensa ja uutteruutensa ansioista. Fairbairn olikin varsin kyvykäs insinööri, mutta häneltä puuttui tieteellinen koulutus, mikä sai hänessä aikaan alemmuuskompleksin suhteessa tiedemiespiireihin. Fairbairn vaati useissa kirjoituksissaan insinöörien teoreettisen koulutuksen tehostamista, koska hän oli aitiopaikalla todistamassa Britannian teollisen mahdin heikkenemistä suhteessa Preussiin, Ranskaan ja Yhdysvaltoihin. Fairbairnin toimintaa monissa eri insinööri- ja tiedeyhdistyksissä voi analysoida joko siten, että hän käytti yhdistyksiä oman valtansa pönkittämiseen tai siten, että hän halusi oikeasti vaikuttaa profession kehittymiseen. Ajatukset luonnontieteiden ja tekniikan kaikkivoipaisuudesta ihmiskunnan ongelmien ratkaisussa voimistuivat teollistumisen myötä 1800-luvulla. Fairbairn ei ollut tässä suhteessa poikkeus ja hänen kirjoituksiaan on mielenkiintoista tutkia esimerkkinä teknokraattisesta ajattelusta, joka on varsin suosittua myös tämän hetken maailmassa.

Asiasanat Britannian historia, teknologian historia, insinöörit, professiot

Säilytyspaikka Historian laitos

Muita tietoja

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Tiivistelmä - Abstract

The purpose of this thesis is to study the history of the engineering profession in 19th century Britain. The case study of an individual engineer, Sir William Fairbairn (1789-1874), is particularly interesting because, while reflecting the history of the engineering profession, it also shows how much more complicated the story of an individual engineer was. The main sources of this study are the biography of Fairbairn, which was published a couple of years after his death, and his own writings. Furthermore, the life and work of Sir William is placed in the larger context of the history of British engineering by using secondary source material. The main questions of the thesis are: 1.) What is the significance of the life and work of Sir William Fairbairn to the history of the engineering profession in 19th century Britain? 2.) What is the significance of Fairbairn's scientific work? 3.) What were his ideas and beliefs concerning progress in science and technology in 19th century Britain?

The engineering profession was born in Britain in the mid-18th century. The industrialisation made it possible for engineers to gain more power and prestige in British society, and, it could be argued that the engineering institutions were important tools for career making. The Institution of Civil Engineers was the most important institution in the first half of the 18th century, but the 'railway boom', which began in the 1830s, increased the possibilities of the other engineering institutions, such as The Institution of Mechanical Engineers, to raise their status. The number of engineers and engineering institutions grew enormously in the 19th century, but the uncontrolled institutional proliferation resulted to the downfall of the status of the British engineers. Compared to some other industrialised countries, the education of the engineers in Britain lacked theoretical instruction because the British engineering education was traditionally based on a practical system of apprenticeship. It has been argued that the poor theoretical education and gentrification of engineers had important influence on the decline of the British industrial competence in the last decades of the 19th century. However, most of the 19th century engineers needed little theoretical instruction, and they did not associate themselves with the landed aristocracy.

Sir William Fairbairn was not a typical example of the 19th century British engineer. The case study of the life and work of Fairbairn is interesting because he was an archetype of Samuel Smiles' 'True Gentleman' who had become a wealthy man and a public figure with the help of his moral character. Although Fairbairn was an able engineer and scientist he suffered from the lack of theoretical knowledge which caused him a sense of inferiority to the men of science. However, despite the weaknesses in his own of education Fairbairn was a strong promoter of scientific engineering because he saw that France, Prussia and the United States had advanced further than Britain in many branches of industry. Fairbairn was also an active member of the various engineering institutions. His work in these institutions can be understood either in the way that he really wanted to promote the engineering profession or in the way that he used the engineering institutions as vehicles for upward social mobility. The ideas of technological and scientific progress were very popular in 19th century Britain and Fairbairn was not an exception. His ideas and beliefs are interesting source material as an example of the technocratic thinking, which is also very popular in the modern world.

Asiasanat history of Britain, history of technology, engineers, professions

Säilytyspaikka Department of History

Muita tietoja

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1. INTRODUCTION[1]

The rise of the modern professions[2] has been one of the key events in the social history of the 20th century. Harold Perkin has suggested that the rise of a professional society is the third revolution[3] in human history and this post-industrial revolution is created by the experts of the new technology, the professionals. Furthermore, Perkin argues that the professional society is the logical continuation of industrial society of the 19th century.[4] It is important to study the historical roots of professionalisation because the status of the different professions has changed drastically during the last two centuries. This thesis concentrates on the social history of the engineering profession in Britain in the 19th century. The case study of Sir William Fairbairn is particularly interesting because, while reflecting the history of the engineering profession in Britain, it also shows how much more complicated the story of an individual engineer was.

[1] This thesis is based on the ideas and materials which I have collected during my exchange year in Britain, in the University of Kent at Canterbury, in 1997-1998. I am grateful to my tutor Dr. Crosbie Smith for his help concerning the *Extended Essay*, which was my first paper on the subject. Also his courses, *Science and Technology, 1750-1914* and *Literature and Science in the 19th Century Cultures*, have given me invaluable insights which have helped me to create this thesis.

[2] The concept of profession has been the cause for endless debates among the social scientists, but I will not concentrate on it in this historical study. The Collins Dictionary and Thesaurus (1996) defines profession as 'an occupation requiring special training in the liberal arts or sciences, especially one of the three learned professions, law, theology, or medicine'. The Oxford English Dictionary (OED 1998) definition of the profession is more comprehensive: 'The occupation which one professes to be skilled in and to follow. a. A vocation in which a professed knowledge of some department of learning or science is used in its application to the affairs of others or in the practice of an art founded upon it. Applied spec. to the three learned professions of divinity, law, and medicine; also to the military profession'. However, the historical scale of professions is far broader and the engineers are included in it. Gerstl and Hutton have suggested that the concept of profession in the 19th century contained three basic elements: 'specialised qualifications, independence in the establishment of its own code of conduct, and a strong commitment or attachment to intrinsic occupational goals.' Gerstl and Hutton 1966, p. 25.

[3] The first was the Neolithic Revolution and the second the Industrial Revolution. Perkin argues that the rise of the professional society is, like its predecessors, a revolution in human organisation. Perkin 1996, p. 2-7.

[4] Ibid., p. 5-6.

Sir William Fairbairn (1789-1874)[5] was a manufacturer, engineer and scientist who lived in Manchester[6] during the time when the British society experienced enormous changes caused by industrialisation.[7] Fairbairn was a promoter of these changes, who believed in the brave new world of the machines. François Crouzet has suggested that industry before the industrial revolution was an industry without industrialists.[8] The industrialists were not an analogous group to the engineers, but some of the engineers, such as Fairbairn, were also factory owners. In the 1840s, Fairbairn employed over two thousand workers in his factories at Manchester and Millwall.

Sir William Fairbairn is not as famous an engineer as, for example, the Stephensons[9] or Brunels[10] because he does not belong to the 'pantheon of heroic inventors'. However, during Fairbairn's working life it was possible for one man to cover almost the 'whole field of engineering' and he actually contributed to branches of engineering as diverse as millwork, iron shipbuilding, bridge construction, the design of waterwheels and the design and safety of steam boilers.[11] In his last address at the meeting of the Manchester Scientific and Mechanical Society in October 1873, Sir William Fairbairn gave his view of the history of the engineering profession in the 19[th] century Britain:

> As compared with many other professions, engineering has been in a dormant state within a period in my own recollection. In the year 1804, when I first entered business as an apprentice,

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[5] See the picture of Sir William Fairbairn in Appendix A. Pole 1877, p. 1.

[6] Manchester, situated in south-eastern Lancashire, became the first modern industrial city in the early 19[th] century.

[7] The term Industrial Revolution is often said to be misleading because the process of industrialisation took place over a rather long period of time. Therefore, the term industrialisation is preferred in this historical study. See Ahonen 1993, p. 128.

[8] Daunton 1995, p. 196.

[9] George Stephenson (1781-1848) is generally acknowledged as 'the father of the railways'. His son, Robert (1803-1859), is most famous for the design of railway bridges.

[10] Sir Marc Isambard Brunel (1769-1849) was a French émigré who designed machine tools for the mass manufacture of ships' blocks. His son, Sir Isambard Kingdom Brunel (1806-1859), is perhaps the best known Victorian engineer. I. K. Brunel's engineering work was culminated in his design of the three giant steamships: SS Great Western, SS Great Britain, and SS Great Eastern.

[11] Hayward 1977, p. 18.

> there were not in the whole kingdom above half a dozen persons deserving the name of engineer ... These facts show the low ebb at which mechanical science was fifty years ago, and how much we are indebted to the late Mr. Roberts and our talented friend Sir Joseph Whitworth and others for the introduction of new and more perfect tool machinery, which has given not only mathematical precision, but almost creative power - as one machine creates another.[12]

This thesis is a study of the historical process described by Fairbairn, who was a representative of the new profession, the engineer, which had started to gain power and credibility in the British society in the late 18th century. The social mobility of the middle classes in the 19th century was a remarkable, phenomenon and William and his brother Peter Fairbairn were one of the most striking examples of the men who used the possibilities created by the industrialisation to raise their social status.[13] He had an active role in the various engineering associations, which enabled him to influence on the institutional development of the profession. However, it is arguable, whether Fairbairn used the engineering institutions for his own purposes or he was truly promoting the institutional development of the profession. In any case, Fairbairn had a significant role in several engineering institutions which influenced on the decision makers of the British society in the 19th century.

Although Sir William Fairbairn has been almost forgotten now, his engineering works are often mentioned in the standard histories of technology.[14] Fairbairn is probably most well known for the design of the Britannia Bridge over Menai Strait, but, however, Robert Stephenson gained the most credit from it. Fairbairn also held an important position between the men of science and the men of practical knowledge. He was a self-educated scientist who systematically applied scientific theories to his engineering works. Fairbairn managed to further the adoption of natural

[12] Pole 1877, p. 421.

[13] Daunton 1995, p. 197-198. Sir Peter Fairbairn was the younger brother of William Fairbairn. However, the source material does not give any details about him, which suggests that the relationship between the two brothers was not very close. Perhaps Peter Fairbairn, the Mayor of Leeds, received his baronetcy mainly as a political favour.

sciences to industry which was relatively slow in Britain compared to some continental European countries in the second half of the 19th century.[15] However, some recent studies have tried to prove that the symbiosis between science and industry in Britain developed earlier and was more significant than has been previously known. Margaret C. Jacob has argued that Newtonian mechanics and the new chemistry of the 18th century had a prominent role at the beginning of the Industrial Revolution.[16] The case study on Sir William Fairbairn will give some new explanations to the relation between science and technology in the 19th century.

The idea of progress was very popular among the engineers of 19th century Britain, and Sir William Fairbairn was no exception. It is interesting to compare his ideas and beliefs to the ideas of the other 19th century authorities. Fairbairn was not a very original thinker, but he collaborated with the early philosophers of technology, such as Andrew Ure and Charles Babbage, who influenced his writings. Fairbairn had a conservative ideological background, but some of his views differed from the views of the other 19th century British conservatives.

The first main objective of this historical study is to investigate Sir William Fairbairn's role as an engineer in the context of the process of industrialisation in the 19th century Britain. Fairbairn was a famous engineer during his lifetime, but now he is almost forgotten. Therefore, this thesis is an attempt to bring light to the forgotten history of the 19th century British engineering. The second main objective of the thesis is to study Fairbairn's scientific work and his role as a promoter of the engineering science. Fairbairn's position being in the middle between scientists and industrialists is a key to understand the relation between science and technology during the process of industrialisation. The third main objective

[14] See, for example, Cardwell 1994, p. 219.
[15] Ahlström 1982, p. 79.
[16] Jacob 1997, p. 3.

is to study Fairbairn's ideas and beliefs on progress and society in the context of the 19th century Britain.

The development of the modern professions has been a rather popular subject of study among sociologists also in Finland.[17] Unfortunately, historians have not studied this complex subject as enthusiastically as social scientists. Harold Perkin has written several books on the social history of professions and his ideas have helped to place this case study in the larger context of the history of professionalisation.[18] It is crucially important to understand that the notion of profession has never been static.[19] For historians, the sociological methods to study the 'traits and attributes' of the professions are often too deterministic, but when the sociological and historical approaches are combined, the results are most fruitful. Carr-Saunders and Wilson created over sixty years ago the model which explains the professionalisation as a part of occupational development and strategy. In this model the main goals of the professional people are the desire for higher status, autonomous control of conditions of work and control of the market in the interest of higher honorary and financial rewards.[20] This method is flexible enough to avoid the anachronistic view that people should have been intentionally developing their profession while they were, in fact, only developing their own career. The Carr-Saunders - Wilson approach is used experimentally in this case study in the history of the engineering profession in the 19th century Britain.

The history of the engineering profession has traditionally been written by the engineers themselves, which has caused some lack of clarity in this branch of social history. One of the most serious failures has been the hero-

[17] Esa Konttinen has written several books on the development of the modern professions in Finland and he has also studied the concept of profession in universal terms. Pasi Tulkki and Tuomo Särkikoski have studied the professionalisation of engineers in Finland.
[18] See Perkin 1989 and Perkin 1996.
[19] Morrell 1981, p. 980.
[20] Morrell 1981, p 981. The Carr-Saunders - Wilson approach was originally presented in their book, *The Professionals*, Oxford, 1933. Unfortunately, the author of this thesis could not find this book available in reasonable time.

worship, which means that, while the small group of the famous 19^{th} century engineers are treated heroes of the industrialisation, the majority of engineers and the importance of the engineering societies and organisations are left without investigation. Some of the modern historians of technology have started, following the example of the historians of science, to borrow methodologies and analytical tools from sociology. The purpose is to understand technology as shaped by the society and culture within which it is practised.[21] Margaret C. Jacob's cultural argument on how the industrialisation occurred first in Britain due to the late 18^{th} century application of scientific knowledge by the British entrepreneurs and engineers is very powerful, but this study concentrates more on the 19^{th} century and on the institutional history of the engineering profession. Furthermore, Jacob has mainly used the case of Watt and the steam engine as an example, which can be seen only as a narrow segment of the process of industrialisation.[22] However, Jacob's account is a very useful source for the history of scientific engineering in Britain also in the 19^{th} century. R. A. Buchanan is probably the most influential student of the institutional history of British engineering and this thesis is much in debt to his work.[23] However, his model for the professionalisation of the engineers is perhaps too deterministic. Above all, the development of the engineering profession was not a straightforward movement towards the full recognition of engineers as a professional group in the early 20^{th} century. Furthermore, Buchanan describes the engineering institutions as mere 'stepping stones' towards professionalisation, whereas they should be understood more as 'vehicles' for making careers.[24] W. H. G. Armytage and A. F. Burstall have also written historical studies on the professionalisation of the engineers, but they represent an even more old-fashioned view than Buchanan does. The value of their work is in the detail in which they have studied the institutional history of the profession.

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[21] See footnote #1. These ideas are based on the lectures and seminars of Dr. Crosbie Smith held at the University of Kent at Canterbury during the academic year 1997-1998.
[22] Wengenroth 2000, p. 10.
[23] See the next paragraph for Buchanan's studies.

This thesis is divided into four principal chapters with different themes. The first of them, chapter 2, is a brief social history of the engineering profession in Britain before the 20th century. Fairbairn's name is only briefly mentioned because the purpose of the chapter is only to provide the social background for the closer examination of his life and work. The main sources for this chapter are Buchanan's book, *The Engineers*[25], and his articles on the same subject[26]. However, Jacob's book is an important source for this chapter because her cultural argument is free from the rigid structures of institutional history. Some sociological tools, such as the Carr-Saunders - Wilson approach, are also used in this chapter in order to avoid Buchanan's determinism. Chapter 3 concentrates on the career of Sir William Fairbairn in the context of Victorian engineering. The biography of Sir William Fairbairn is the main source for this chapter and it is also the main primary source of the thesis. *The Life of Sir William Fairbairn* was published in 1877, four years after the death of Fairbairn, and the editor of the biography, William Pole (1814-1900), was also an engineer.[27] The book is a mixture of Fairbairn's autobiographical notes, his letters, and Pole's own remarks.[28] Although *The Life of Sir William Fairbairn* is an interesting example of the Victorian biography[29], other primary sources are used to get a deeper examination on Fairbairn's career as an engineer. His letters to William Cawthorne Unwin are especially interesting primary source material because Fairbairn wrote in them about his opinions straightforwardly and without Pole's filtration. Chapter 4 is an analysis of

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[24] Morrell 1981, p. 988.

[25] Buchanan, R. A., *The Engineers, A History of the Engineering Profession in Britain, 1970-1914*, London, 1989.

[26] Buchanan's articles are: 'Gentleman Engineers: The Making of a Profession', 'Institutional Proliferation in the British Engineering Profession 1847-1914' and 'The Rise of Scientific Engineering in Britain'. See the bibliography for further details.

[27] Pole was also a Fellow of the Royal Society, Secretary of the Institution of Civil Engineers, and a doctor of music. He became a professor in engineering at University College in 1859.

[28] Fairbairn's autobiographical part ends to the year 1840. The rest of the book is created by Pole, who used Fairbairn's letters and other writings as source material.

[29] According to John Tosh, 'In Victorian times the characteristic form of biography was commemorative: for the heirs and admirers of a public figure the most fitting memorial

Fairbairn's scientific work, concentrating on his collaboration with the British Association for the Advancement of Science. Fairbairn's biography and the book, *Gentlemen of Science* by Jack Morrell and Arnold Thackray[30], are the most useful sources for this chapter. The last chapter investigates the ideas and beliefs of Sir William Fairbairn as a representative of engineers and manufacturers. Fairbairn was a productive writer and he had rather elaborate opinions about many current issues of 19th century Britain. For example, in the three series of *Useful Information for Engineers*, Fairbairn presented his ideas on popular education and scientific progress. Finally, the conclusion of the thesis gathers the observations of the four preceding chapters into results.

2. *SOME ASPECTS OF THE HISTORY OF THE ENGINEERING PROFESSION IN BRITAIN IN THE 18TH AND 19TH CENTURY*

2.1. Industrialisation, Institutionalisation and Institutional Proliferation

The social origins of the engineering profession derive from the 18th century when the spread of industrialisation caused a remarkable expansion in British engineering. According to Buchanan, 'about the middle of that century, a number of men engaged in practical works of construction and land drainage in Britain began to describe themselves as "civil engineers"'.[31] This new group of engineers was a strange assortment of mechanics, stonemasons, millwrights, and instrument makers.[32] The main figure of this period was John Smeaton (1724-1792), who formed the Society of Civil

was a large-scale 'Life', based almost exclusively on the subjects own papers...'. Tosh 1996, p. 77.

[30] Morrell, Jack and Thackray, Arnold, *Gentlemen of Science: Early Years of the British Association for the Advancement of Science*, Oxford, 1981.

[31] Buchanan 1989, p. 11.

[32] Buchanan 1985a, p. 42.

Engineers in 1771.[33] Smeaton was an unusual eighteenth-century engineer because he came from a middle-class legal background, his father being an attorney in Leeds. His experience of the legal profession was extremely useful to the developing engineering profession. After Smeaton's death in 1792 the Society was renamed as the Smeatonian Society of Engineers.[34]

By the time of Smeaton's death the Society had only about thirty members. It could be argued that Smeaton's Society was an alternative form of gentlemen's club rather than a professional institution for engineers. Nevertheless, Smeaton's Society helped to create a new group consciousness among engineers. Above all, the Society was not a 'stepping stone' towards professionalisation, but it was a tool for the individual engineers to gain wealth and credibility in British society. Smeaton was a member of the prestigious Royal Society before he founded the Society of Civil Engineers. Thus, the latter became a sort of poor man's Royal Society.[35] Smeaton used the older professional institutions, such as those of law and medicine, as models for his society.

Whatever his model for the Society of Civil Engineers, John Smeaton helped to raise the legal status of the engineering profession when he created the distinct engineering hierarchy: consultant, assistant, resident, pupil. This professional system did much to enhance the status of the individual engineers. Furthermore, Smeaton obtained recognition for professional engineering statements in a court of law, which also contributed significantly to the esteem of the profession.[36] Thus, by the end of the 18th century, engineering practitioners had begun to acquire many of

[33] The term 'civil engineers' excluded those artisans and craftsmen who served in the military. 'Civil engineer is a person who is qualified to design and construct public works, such as roads, bridges, and harbours.' Collins English Dictionary and Thesaurus (1996), p. 196. OED's (1998) definition is very similar: 'Civil Engineering meant the art of large-scale construction, for civil and not military purposes: it included the manufacture of engines, machinery, and iron structures, which later fell under rubric of mechanical engineering', Morrell & Thackray 1981, p. 261.
[34] Buchanan 1983, p. 411.
[35] Ibid., p. 412.

the characteristics of a professional group even though the total number of civil engineers remained very low.

In the first half of the 19th century the number of institutions of professional engineers started to grow. W. J. Reader has suggested that the growing complexity of Victorian industrial society and the advance of technology and science were the main reasons for the increase in the number of the engineering professional institutions.[37] It is, however, too deterministic to see the professionalisation of engineers as a necessary consequence of industrialisation. Above all, the pursuit of various forms of power, including success in persuading the public to pay well for services, was an essential trait of the professionalisation.[38] Thus, the institutional history of the engineering profession has to be studied from a more sociological perspective than has been customary for historians.

The foundation of the Institution of Civil Engineers in 1818 by a group of young engineers was a response to the exclusiveness of the Smeatonian Society of Civil Engineers. Thomas Telford, one of the leading civil engineers of the period, became the president of the new institution in 1820. Telford was convinced that the engineering institutions should be kept alive by the voluntary efforts of its members, since the British government did not establish such institutions as in France and Germany.[39] The Institution of Civil Engineers grew steadily under Telford's supervision during the 1820s, recruiting widely from the younger engineers and gradually winning over the support of most of the older generation. When Telford died in 1834, the Institution of Civil Engineers had become the leading organisation in the profession, serving the professional and social needs of its members.[40]

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[36] Ibid., p. 413.
[37] Reader 1966, p. 145.
[38] Morrell 1981, p. 982.
[39] Armytage 1961, p. 123.

It is not very difficult to understand why the Institution of Civil Engineers became so popular. One important factor was the attainment of the Royal Charter in 1828, which gave a realistic basis to its claim to represent the whole of the engineering profession.[41] According to Reader, the Charter was the official recognition by the State that the civil engineering has achieved professional standing.[42] Another important factor was that especially the younger generation of engineers was not willing to accept the restrictive hierarchy of the Smeatonian Society of Civil Engineers. However, it is dangerous to exaggerate the role of one person in the history of the engineering institutions. Telford was the main figure, but there were dozens of other active promoters of the civil engineering in Early Victorian Britain. William Fairbairn was chosen to the Institution in 1830 and the letter of acceptance was signed by Telford.

During the 18th century, before the development of the steam engine and the growth of precision engineering, it was difficult to differentiate between mechanical and civil engineering.[43] However, the railway boom, which began in the 1830s, increased dramatically the number of mechanical engineers who specialised in the construction of railways and locomotives. William Fairbairn was one of the early mechanical engineers who seized the opportunity to become experts in railway engineering. These men were concerned about the lower status of the mechanical engineering compared to that of civil engineering. The promoters of mechanical engineering were often from the recently industrialised provincial towns, such as Manchester and Birmingham, and they often found the metropolitan interests too restrictive. According to Reader, in the first half of the 19th century

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[40] Buchanan 1983, p. 414.
[41] Buchanan 1989, p. 64.
[42] Reader 1966, p. 164.
[43] 'Mechanical engineering is a branch of engineering which is concerned with the design, construction, and operation of machines.' Collins English Dictionary and Thesaurus (1996). 'A contriver or maker of engines. The precise sense has varied from time to time in accordance with the development of meaning in engine. In present use the *engineer* in this sense is a maker of steam engines or of heavy machinery generally.' Oxford English Dictionary (1998).

mechanical engineering could hardly be considered a profession, whereas the civil engineers belonged to the professional group from the census of 1861.[44]

The Institution of Mechanical Engineers was founded in 1847 by a group of frustrated railway engineers. They felt that their profession's entry into railway work was being discouraged and that George Stephenson, 'the father of the railways', had been excluded from the Institution of Civil Engineers. Thus, the older Stephenson became the president of the new rival institution while his son Robert was a respected member of the Institution of Civil Engineers.[45] The fact that the mechanical engineers organised themselves as a separate organisation has been seen as an act of retaliation against the civil engineers, who looked down on the mechanical engineers.[46] However, there is no reason to think that the creation of the Institution of the Mechanical Engineers was intended to disrupt the engineering profession.[47] The reason for the split was that the mechanical engineers of the province, such as William Fairbairn, wanted more power in the new industries.

The formation of the Institution of Mechanical Engineers set a pattern of institutional proliferation, which gained more speed in the second half of the 19th century. The number of engineering institutions and the total membership of these institutions grew remarkably and the engineers became accepted as professional men, whose status was equivalent to the status of legal and medical practitioners.[48] Furthermore, the leading engineers, such as I. K. Brunel and Robert Stephenson, became public figures in Britain, which helped to raise the self-esteem of the engineering profession. However, in the long run, the proliferation resulted in the lower status of the engineers. It could be even argued that the profession lost its

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[44] Reader 1966, 149.
[45] Buchanan 1983, p. 416.
[46] Ahlström 1982, p. 86.
[47] Buchanan 1985a, p. 48.

direction because of the uncontrolled proliferation. The ability of the Institution of Civil Engineers to represent the whole profession was progressively weakened during the second half of the 19th century. By 1890, there were nine institutions for engineers and over 15,000 members of these institutions.[49]

The Institution of Naval Architects was established in 1860 as the first national organisation to emerge after the Institution of Mechanical Engineers. According to Buchanan, the foundation of the institution did not provoke any jealousy from the existing organisations.[50] Shipbuilding underwent a series of radical changes in the mid-19th century, when iron and steel replaced wood as the ships' construction material and steam replaced wind as the means of propulsion. William Fairbairn was among the first British manufacturers who tried to make iron shipbuilding profitable in the 1830s and 1840s. However, the transition from wood to iron occurred slowly and incoherently and those who were first in adapting new technology often experienced severe hardships. In the second half of the 19th century shipbuilding engineers felt that they had to secure their interests in these developments and the existing institutions did not support them enough. The institution was founded to promote the interest of the small group of individuals who had the opportunity to gain wealth and credibility from the boom in shipbuilding, which lasted into the 20th century. As Harold Perkin states, the post-industrial revolution is created by the professionals who have constructed the technological system, which in turn has created them.[51] By using the Carr-Saunders - Wilson approach the development of the Institution of Naval Architects can be seen as a part of occupational development and strategy of this particular group of engineers. The Institute of Marine Engineers (1889) and the Institution of

[48] Ibid., p. 42.
[49] Buchanan 1983, p. 416.
[50] Buchanan 1989, p. 93.
[51] Perkin 1996, p. 6.

Municipal Engineers (1871) were also formed as the results of the technological development in the existing branch of engineering.

The second type of professional engineering body emerged in the older industries. The growing pressure to become more scientific was (*de facto*) the main reason for the foundation of the Iron and Steel Institute in 1869. Iron and steel industry had become the subject of intensive scientific investigation in the second half of the 19th century.[52] William Fairbairn had an important role in this process as a promoter of the scientific research on the properties of iron, but he had no significant role in the development of the Institute. The third type of professional engineering institution was created by the development of completely new technology. The Society of Telegraph Engineers (1871) was a good example of that kind of development. The initiative for the formation of the Society came largely from military engineers.[53] The fourth and last type of the new engineering institutions was the simple breakaway from the existing institutions.

The 19th century engineering institutions were not trade unions, but professional institutions. However, it is highly important to avoid imposing unqualified modern notions of professionalisation on the institutions and individuals of the past.[54] All the types of the institutional proliferation mentioned above have to be understood rather suggestive than definitive. Buchanan's account on the institutional history of the engineering profession has to be scrutinised with the help of sociological models of professionalisation. The fragmentation of the profession continued to the 20th century and it has still impact on the status of the engineers in Britain, which is lower than in many other European countries.

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[52] Buchanan 1985a, p. 51.
[53] Ibid., p. 52.
[54] Morrell 1981, p. 988.

2.2. The Education of Engineers and the Relation Between Science and Technology

The institutional history of the British engineering profession in the 19th century was different compared to the development in the leading industrial countries in Continental Europe. This was especially the case with regard to the existence of technical institutions in the training of the engineers.[55] The formal education of engineers in Britain was based on the practical training of apprenticeship. Before the 1850s, virtually all of the professional engineers had acquired their skills by a process of pupilage in the office of a practising engineer.[56] British engineering education remained very practical in the first half of the 19th century and theoretical instructions and examinations were even despised by some of the engineers. The only significant exception was the Royal Military Academy at Woolwich where the Royal Engineers received military instruction.[57] The leading industrial countries in Continental Europe were far ahead of Britain in the institutional development of scientific engineering. It has been argued that the neglect of scientific instruction in 19th century Britain produced generations of employers who failed to appreciate the place of scientific and technical knowledge in industry.[58]

Britain was the first country in the world to experience the process of industrialisation from the mid-18th century onwards. Therefore, it is rather difficult to understand why the adaptation of scientific education of engineers was so slow. The earlier industrial successes of Britain were achieved by the men who had acquired most of their knowledge by means of practical experience. Furthermore, the main purpose of the British universities had traditionally been the education of gentlemen who came mainly from the upper class. The engineers were a new group of professionals who had difficulties in becoming accepted at the old

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[55] Ahlström 1982, p. 86.
[56] Buchanan 1985b, p. 219.
[57] Ibid., p. 219.

universities. However, there were some exceptions among the engineers who had received some scientific education. John Smeaton, the founder of the Society of Civil Engineers, presented a paper to the famous Royal Society. James Watt was also a member of the Royal Society and he used Joseph Black's studies of heat before he invented the separate condenser for the steam engine in 1769.[59]

Margaret C. Jacob has suggested that the relation between science and industry developed in Britain already in the 18th century. Her cultural approach emphasises the role of British scientific societies, which were populated by the men of land and finance. These societies made scientific information available for those who wanted to apply this knowledge to innovations. According to Jacob, the role of institutionalised education of engineers was not important because the scientific knowledge was absorbed by the industrialists without the help of institutions. These early industrialists did not make a clear distinction between science and technology.[60] The modern meaning of the term 'science' was only developed in the early 1830s when the definition of the term began to narrow to mean only natural and physical sciences. This process has been linked with the foundation of the British Association for the Advancement of Science and to the work of the Cambridge scholar William Whewell.[61] Of course, there were no such concepts as applied and pure science in the 18th century Britain, but the diversification of the sciences developed further during the 19th century. The humanistic tradition of the British university system, which preferred the education of arts to the education of sciences, has often been linked to the slow development of scientific engineering in Britain. However, according to Jacob, 18th century Britain witnessed the application of mechanical science to the manufacturing and transportation

[58] Ahlström 1982, p. 85.
[59] Buchanan 1985b, p. 219.
[60] Jacob 1997, p. 108.
[61] Yeo 1991, p. 177.

systems without the help of scientific institutions.[62] Unfortunately, the mental landscape painted in Jacob's cultural argument[63] is much more difficult to prove than the institutional development of the scientific engineering. Ulrich Wengenroth agrees that science was on the agenda of early 19th century industrial figures and very much influenced the way how the technological problems were discussed, but, however, he also points out that there is still no conclusive evidence that science had an impact on technology beyond the sharing of a common methodology and ideology.[64] Thus, according to Wengenroth, there was no great demand for scientific education for industrialists at the beginning of the 19th century and science was more a mental than a material foundation of industry.[65]

The relationship between engineers and men of science developed further in the 19th century. One significant event was the collapse of Robert Stephenson's Dee Bridge at Chester in 1847. After the disaster, cast iron was abandoned as a building material for railway bridges, and engineers, including the younger Stephenson, started to investigate the properties of wrought iron. William Fairbairn and the mathematician Eaton Hodgkinson carried out model tests, which resulted in the new wrought iron tubular bridge design used in the Britannia Bridge over the Menai Straits in Wales. Buchanan describes the bridge building process as a highly significant break-through in scientific engineering.[66]

The other area of engineering where the scientific approach received a positive response before the 1850s was shipbuilding. However, despite the efforts of some individuals, the training of engineers remained very practical in the first half of the 19th century. The engineering profession was expanding both in numbers and in prestige; thus, many of the engineers thought that there was no reason to change what had become a successful

[62] Jacob 1994, p. 32.
[63] Jacob 1997, p. 5.
[64] Wengenroth 2000, p. 11.
[65] Ibid., p. 40.

form of training. Furthermore, many engineers thought that the development of academic engineering posed a threat to traditional methods of instruction.[67]

The Great Exhibition in London in 1851 was to some extent the starting point for scientific education for engineers in Britain. The Exhibition showed the British producers that some foreign producers had advanced further in the industries, which required scientific application.[68] As already mentioned, the British university system had traditionally been rather anti-utilitarian, which might have slowed down the speed of industrial development. The universities were not interested in engineers and vice versa before the mid-19th century. However, an increasing number of British politicians started to complain about how the lack of scientific education of engineers weakened the status of Britain. A result of the London Exhibition was the founding of the School of Mines and the Department of Science under the Board of Trade.[69]

The other important factor in explaining the development of engineering education in the late 19th century was the growth of the railway system in Britain as the first country in the world from the 1830s onwards. The social standing of engineers rose remarkably as a consequence of the railway system. The Victorian upper classes, in contrast, started to feel insecure about their social status in the railway organisations. The universities started to claim that the monopoly in the education of engineers belonged to them instead of the engineering associations such as the Institution of Civil Engineers. It could be even argued that the university courses in engineering were an attempt to secure the positions of the upper class in

[66] Buchanan 1985b, p. 220.
[67] Ibid., p. 221.
[68] Alhström 1982, p. 79.
[69] Ibid., p. 79.

the railway organisation.[70] However, some of the engineers, who came mainly from the middle classes, were also promoting the scientific education for engineers in the second half of the 19th century.

Buchanan suggests that the first of the great exponents of engineering science in the British universities was William Macquorn Rankine who succeeded Lewis Gordon to the Regius Chair of Civil Engineering and Mechanics at Glasgow in 1855.[71] However, without Gordon's struggle to win academic recognition for engineering science in the 1840s, Rankine and his fellow academics, such as William Thomson[72], would have had serious difficulties in organising the University of Glasgow as a world-famous centre of applied science. Rankine aimed at establishing engineering science as an intermediate mode of knowledge between pure science and pure practice that should be taught in the universities.[73] Thus, engineering began to acquire the characteristics of science in Rankine's department at Glasgow.

Apart from Glasgow, the main focus of scientific engineering in the mid-19th century was Manchester. There were two institutionalised bodies promoting engineering science: Manchester Literary and Philosophical Society and the Owens College, which was founded in 1851. However, despite the importance of engineering in the Manchester area, Owens College did not show much interest in engineering education in its early years. The pressure of some prominent engineers, such as Fairbairn, Whitworth and Nasmyth, led to the establishment of the new chair in engineering at Owens College in 1868. These industrialists offered £9,505 to endow the chair.[74] Osborne Reynolds, who held the first chair in

[70] Guagnini 1991, pp. 18-19. It should be kept in mind that the traditional professional institutions, such as those of law, medicine and theology, used the university education to monopolise the knowledge and to close the profession from the others.
[71] Buchanan 1985b, p. 225.
[72] Later Lord Kelvin.
[73] Buchanan 1985b, p. 225.
[74] Guagnini 1993, p. 28.

engineering, followed the example of Rankine and wanted to create the discipline of academic engineering with the highly practical and utilitarian character of applied science.

The appointment of Fleming Jenkin to the chair of engineering in Edinburgh was significant because Jenkin also successfully followed the example of Rankine. He wisely avoided direct confrontation with the promoters of traditional British engineering education based on apprenticeship. It is interesting to see that two out of the first three universities having proper engineering education in their curricula were situated in Scotland. Perhaps this was because many of the famous 19th century engineers had a Scottish background.

As mentioned before, the increasing public pressure concerning foreign competition demanded the allocation of public resources to technical education in the late 19th century. The Paris Exhibition in 1867 again showed the public how British technology was being overtaken by the German and the French. The growing fear of the military power of Germany and some other countries must have already influenced the decision-makers in the last three decades of the 19th century. Buchanan describes the development of the academic institutions for the education of engineers as a success story: a small elite of the engineering academics managed to increase the scope for engineering education, and, in particular, to incorporate the laboratory practice and research as a counterpart to theoretical instruction in the developing schools of engineering.[75] However, according to Anna Guagnini, the number of engineering students who prepared for certificates or degrees remained modest during the 19th century and the attendance to courses of engineering at the turn of the century was even lower than in Italy.[76]

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[75] Buchanan 1985b, p. 227.
[76] Guagnini 1993, pp. 16-17.

In the last third of the 19th century the London colleges[77] assumed the leading positions in engineering education. At University College, William Pole held the chair of civil engineering from 1859 to 1867.[78] His successor, A. B. W. Kennedy, established the first genuine engineering teaching laboratories, and, in 1908, the separate Faculty of Engineering was set up at University College. The number of engineering students at King's College started to increase substantially in the 1880s. Under John Hopkinson, the professor of electrical engineering, the college had the largest school of engineering in Britain in the 1890s. The third college, which had an important influence on the scientific education engineers, was the Central Institution of City and Guilds Institute, which become the Central Technical College in 1893 and a part of Imperial College in 1910. Under William Cawthorne Unwin's leadership, the college gained a reputation for scientific engineering. Both Cambridge and Oxford, in contrast, were relative slow in accepting the engineering sciences to their disciplines. Nevertheless, at Cambridge, some engineering had been taught at the university before the foundation of the first chair in mechanism and applied mechanics in 1875.[79]

The relationship between engineers and the men of science developed further in the last decades of the 19th century. The increased application of scientific methods in engineering works corresponded to the education of engineers in the last decades of the 19th century, and, finally, the government enacted the Technical Instruction Act in 1889. However, in comparison with the development on the Continent, especially in Germany, British technical education still lagged behind, quantitatively as well as qualitatively.[80] The traditional engineering education based on

[77] At King's College the prospectus of a course in civil and mechanical engineering was issued already in 1838. University College founded the chair of civil engineering in 1841 and the chair of mechanical engineering in 1846. However, these two colleges suffered from the lack of students, teachers, and funding during their first decades.

[78] Buchanan 1985b, p. 227. The same Pole was also the Secretary of the Institution of Civil Engineers and the biographer of Sir William Fairbairn.

[79] Ibid., p. 228.

[80] Ahlström 1982, p. 80.

apprenticeship training remained into the 20th century. Those engineers who received scientific education were mostly civil engineers, and the Institution of Civil Engineers decided to accept the university qualifications in engineering for admission to membership in 1897.[81]

It is interesting to study how Jacob's cultural approach differs from the institutional approach used by Buchanan. Despite the lack of institutionalised scientific education for engineers the industrialisation occurred first in the world in the late 18th century Britain. Perhaps during the earlier phases of industrialisation the role of science was not as important as the role of technical innovations in the creation of the new industrial society. Those engineers who were also self-educated scientists, such as William Fairbairn, were among the first to notice the need for academic institutions for scientific engineering in Britain. These self-educated industrialists could be understood as 'missing links' between Jacob's cultural approach and the institutional history of the academic engineering in the 19th century.

2.3. Gentlemen Engineers?

D. C. Coleman states in his famous essay, 'Gentlemen and Players': 'the social structure of pre-industrial revolution England had only one really important division: between those who were Gentlemen and those who were Players'.[82] He continues: 'in one sense the industrial revolution was a revolution of those who were not gentlemen'.[83] The engineers were a professional group, which gained wealth and social respectability during the process of industrialisation. Thus, according to Coleman, the engineers were making a social revolution in 19th century Britain. They were new

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[81] The Institution of Municipal Engineers was the first engineering institution to begin to devise their own examination requirements for entrance to their membership.
[82] The Gentlemen vs. Players cricket match was played at Lord's Cricket Ground, London, annually from 1806 to 1962.
[83] Buchanan 1985a, pp. 96-97.

players in the social structure of Victorian Britain. Perhaps Harold Perkin would have agreed with him about the social revolution, but the main question of this section is: did the engineers become gentlemen during the 19th century?

It is rather difficult to define the concept of gentleman in the context of Victorian Britain. Above all, it is important to make a distinction between the concepts of gentleman[84] and gentry[85]. The gentry, associated with the possession of large landed estates, were a far more distinct social group than gentlemen.[86] Furthermore, according to Samuel Smiles[87], true gentlemanliness was within reach of any virtuous Briton.[88] Smiles was the author of *Self Help* which sold nearly a quarter of million copies between its publication in 1859 and the end of the 19th century.[89] Thus, Smiles' account must have had an influence on the general idea of gentlemanliness in mid- and late Victorian Britain. According to Smiles, gentlemanliness was a mixture of virtues, not a social rank or status. Smiles also wrote the work, *Lives of Engineers*, which consisted of three volumes of the biographies of engineers. He thought that the engineers were the best example of the 'self-made men'. It is possible that even contemporary Victorians were confused by the social status of the new professions, such as the engineer. Nevertheless, most of them believed, following the example of Smiles, in the practical doctrine of justification by works, which helped the engineers to achieve their social reputation.

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[84] OED (1998) defines the term gentleman as: 'a. A man of gentle birth, or having the same heraldic status as those of gentle birth; properly, one who is entitled to bear arms, though not ranking among the nobility, but also applied to a person of distinction without precise definition of rank. b. Appended to the name of a man, as an indication of his rank. c. Used as a complimentary designation of a member of certain societies or professions.'

[85] OED (1998) defines the term gentry as: 'a. Rank by birth (usually, high birth; *rarely* in neutral sense). b. The quality or rank of gentleman. c. What is characteristic of a gentleman; polish of manners, good breeding; also courtesy, generosity; an instance of good-breeding, a gentlemanlike action.'

[86] Buchanan 1983, p. 409.

[87] Samuel Smiles was a Scottish physician who had turned journalist and publicist.

[88] Best 1982, p. 269.

[89] Buchanan 1983, p. 409.

Geoffrey Best suggests that a person could not be sure whether he was a gentleman or not until he had received a judgement in his favour from the appropriate social authority, such as the particular elite group by whom he was anxious to be recognised.[90] For example, in Fairbairn's biography, *The Life of Sir William Fairbairn*, there are over fifty pages describing Fairbairn's scientific honours, honorary degrees, and memberships in the gentleman clubs.[91] Best points out that the concept of gentleman had more to do with social acceptance than social mobility. However, Best warns his readers not to confuse the moral ideal with the social reality.[92] Smiles might have thought that any British man could be a gentleman, but in reality, wealth, education and family background were the key factors in deciding who was a gentleman. M. J. Daunton suggests that the belief that mobility was open to anyone with ability was only a useful means for making the people to accept inequality by forming an important myth for the justification of industrial capitalism.[93]

But it remains questionable whether engineers turned into gentlemen or gentry in the 19th century Britain. Both Coleman and Buchanan argue that the engineers eventually achieved the status of gentlemen. However, the term 'gentleman engineer' is rather ambiguous because the idea of practicality forces against the idea of gentlemanliness and vice versa. As was briefly mentioned in the last section, the education of gentlemen and the education of engineers differed drastically from each other in their pursuits and goals. Thus, the engineers were something new in the social structure of the Victorian Britain. They were a new professional group similar to academic teachers and architects, and they wanted more power and prestige in the industrial society.

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[90] Best 1982, p. 268.
[91] Pole 1877, pp. 151-165, 239-255, 343-361.
[92] Ibid., p. 269.
[93] Daunton 1995, p. 197.

The role of the engineering institutions, such as the Institution of the Civil Engineers, was important when engineers strove for upward social mobility. Thus, membership of engineering institutions grew from about 1700 in 1860 to over 23,000 forty years later. According to T. R. Gourvish, the members of the professional associations had a strong desire for the gentlemanly status, which was part of an attempt to differentiate themselves from the 'trade' aspects of their work.[94] Furthermore, Gourvish's conclusion is that professionals adopted the ideal of the educated gentlemen, which contributed significantly in the perpetuation of pre-industrial distinction between the gentlemen and the players.[95] However, the possibilities of the engineers to rise in the social structure of the Victorian Britain just by being members of the engineering institutions were scarce. Despite Samuel Smiles' definition of the 'True Gentleman', the reality was that the aspirants of social mobility had to be considerably wealthy to become a gentleman.

Martin Wiener has claimed that the gentrification of the inventors and entrepreneurs led to the decline of the industrial spirit and was the main reason for Britain's downfall in industrial performance in the late 19th century.[96] However, according to Coleman, the industrial spirit of the Industrial Revolution, with its hesitant response to innovation, persisted far too long[97], which caused problems in the late 19th century. Furthermore, Harold Perkin suggests that 'the decline of the industrial spirit, then, was in reality the retreat of the entrepreneurial ideal before the incursions of professionalism'.[98] Above all, it is important to understand that gentrification, education, and institutionalisation of the engineering profession affected each other. The case study of Sir William Fairbairn offers an interesting insight into how his work as an engineer and scientist was influenced by his ideas and beliefs.

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[94] Gourvish 1988, p. 31.
[95] Ibid., p. 33.
[96] Perkin 1989, p. 363.
[97] Gourvish 1988, p. 34.

3. *THE CAREER OF WILLIAM FAIRBAIRN IN THE CONTEXT OF VICTORIAN ENGINEERING*

3.1. 1800-1830: From Millwright to Mechanical Engineer

William Fairbairn was born at Kelso in the Scottish Lowlands in 1789. During his childhood, he received a good basic education despite his relatively poor family background. His father, Andrew, worked as a gardener in Kelso. In 1804, Fairbairn's family moved to Northumberland and William was apprenticed to the millwright at the Percy Main Colliery.[99] After spending some years gaining experience in the workshop, he was put in charge of the pumps and the steam engine of the coal mine.[100] Apprenticeship gave Fairbairn the practical experience, which helped him to become a millwright, but he was not content with his education. Thus, he was a frequent visitor to the library at Shields where he studied natural sciences and famous writers such as Gibbon, Hume, Milton, and Shakespeare.[101] Fairbairn completed his seven-year apprenticeship in 1811 and later in the same year he decided to try his fortunes elsewhere and sailed to London.

During the next three years Fairbairn wandered from job to job in England, Wales and Ireland. He experienced, for example, the brutal murders of his neighbours in London[102] and the members of the trade unions 'whose moral character was far from exemplary'.[103] Fairbairn settled in Manchester at the end of 1813. Manchester was, together with Birmingham, the major

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[98] Perkin 1989, p. 376.

[99] The work in the coal mine was occasionally very hard for the young Fairbairn and is described in his biography: 'From that day to this I never witnessed the same extent of demoralisation as I did that time. Pitched battles, brawling, drinking, and cock-fighting seemed to be the order of the day...'. Pole 1877, p. 70. Perhaps his experiences were thought to be a part of the practical education of apprenticeship.

[100] Hayward 1977, p. 2. Fairbairn also met his lifelong friend, George Stephenson, in Northumberland.

[101] Pole 1877, p. 74. Fairbairn probably exaggerates his educational achievements in his biography, but, however, he was an ambitious person with a strict self-discipline.

[102] Ibid., p. 87.

industrial city of Britain in the 19th century and it offered great prospects for entrepreneurs and engineers to gain wealth and prestige. Three years later, he had saved enough money to marry Dorothy Mar who was the daughter of a Kelso burgess.[104] The marriage to the daughter of a respected family shows that Fairbairn's social status was rising. Fairbairn himself described the marriage as a new epoch in every man's history:

> It did so in mine; and the responsibilities which it involved operated as a powerful stimulus to carry into effect what I had long before contemplated, namely, an ardent desire to emancipate myself from daily labour, and to acquire that independence of position which I was most anxious to attain.[105]

Thus, Fairbairn strove for upward social mobility and his desire for independence most obviously suggests that he wanted to become a professional. According to the Carr-Saunders - Wilson approach, Fairbairn had a desire for higher status and autonomous control of working conditions.

By 1817 Fairbairn had gained further experience by working as a millwright and draughtsman. He was employed by a master, Thomas Hewes with whom he had some disagreements. As a result, Fairbairn decided to set up a business of his own:

> Disappointed in my hopes of rising in the profession so long as I continued as a workman, and having before me the prospect of an increasing family, I determined no longer remain the servant of another, but by one bold effort to take an independent position.[106]

Fairbairn wanted to achieve the status of professional engineer and entrepreneur and it was not possible for him while he worked for Hewes. However, it could be argued that the intentions of the young Fairbairn were not as clear as he explains in his biography several decades later. Fairbairn persuaded his former workmate, James Lillie, to join him, and the partners rented an old shed in High Street, Manchester.

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103 Ibid., p. 93.
104 Hayward 1977, p. 2.
105 Pole 1877, p. 104.
106 Ibid., p. 106.

In the late 1810s, the manufacturing industry in Britain was recovering from the Napoleonic wars, and high food prices caused by bad harvests, unemployment and the introduction of improved textile machinery, led to riots and machine breaking in Manchester. Fairbairn and Lillie also experienced hardships in the beginning of the partnership. The two men built themselves a lathe and James Murphy, a muscular Irishman, was hired to provide the power to turn it. During the next few years, Fairbairn and Lillie were engaged in constructing and installing new shafting and gears for several local cotton mills.[107] The work was demanding, and Fairbairn explains his experiences with a bitter voice: 'Working on Sundays, and on the previous and following nights, had a most injurious effect on the morals and condition of that class to which I belonged'.[108] After Fairbairn had settled in Manchester he had become a member of the Unitarian congregation at Cross Street Chapel, which was quite unusual considering his Presbyterian background.[109] Although Fairbairn was a member of the Unitarian Church, his faith did not totally prohibit working on Sundays. Perhaps Fairbairn reference to the 'class' could be understood as his religious group, but there is no evidence that Fairbairn was a very religious person. How Fairbairn became an anti-Trinitarian remains a mystery, but there is a special section in the biography, 'Peculiar Notions of Religious Toleration', in which Pole praises the open-mindedness of Sir William Fairbairn.[110] It is interesting to note that also another famous Scottish engineer, James Watt, made a secularising journey from Calvinism (Presbyterianism) to Unitarianism.[111]

In the beginning of the 1820s, the partnership started to be increasingly profitable. Fairbairn and Lillie achieved a reputation from their millworks which resulted in new orders: 'The services we had rendered and the

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[107] Hayward 1977, p. 3.
[108] Pole 1877, p. 114.
[109] Fairbairn's parents were members of the Church of Scotland. Pole 1877, p. 57.
[110] Ibid., pp. 458-459.

improvements which were introduced, caused us to be much talked of as good millwrights and ingenious young men'.[112] With their business expanding the partners moved first to an old building with a cellar, and then in 1822, to a small mill specially built for them in Canal Street. They also purchased 'a 16-horsepower second hand Boulton and Watt's steam engine', which was a rather bold investment 'without a farthing of capital'.[113]

In 1824, Fairbairn and Lillie acquired additional premises in Canal Street and rented a yard in nearby Back Mather Street. That year they employed over sixty workers and had enough orders in hand to last for two years. In the 1820s, Continental Europe was still recovering from the Napoleonic wars and the partners got orders from Switzerland and France, which helped them to gain an international reputation. Fairbairn came to the conclusion that peace was good for business: 'The industry of all nations was bursting into new life, and the prospects of a good understanding and a long peace amongst nations gave renewed energy to the industrial resources of every country in Europe'.[114]

In 1830, Fairbairn and Lillie employed over 300 workers, and they had enough surplus capital to build a foundry. The partners specialised in the construction of fireproof mills.[115] Although they were one of the leading proponents of this type of construction, the credit for the invention belongs to an earlier generation of millwrights whose ideas were exploited by Fairbairn and Lillie. The design and erection of waterwheels was the second type of construction in which the partners specialised. The former employer of Fairbairn, Thomas Hewes, was the original inventor of the new type of waterwheel used by Fairbairn and Lillie. Thus, Fairbairn was

[111] Jacob 1997, p. 128.
[112] Pole 1877, p. 116.
[113] Ibid., p. 117.
[114] Ibid., p. 125.
[115] Textile mills constructed in the 18th century were made of timber and they were thus vulnerable to fire.

not a great inventor, but he adapted the earlier inventions to innovations, which often became economically profitable. W. H. Mallock, who was a conservative thinker in the late Victorian Britain, might have considered Fairbairn as a *primus motor* in the development of the capitalistic industrial society because Fairbairn was an innovator creating new wealth to himself and to the whole society.[116]

In 1830 Mr. Fairbairn joined the Institution of Civil Engineers, which was, according to Pole, 'a society then newly incorporated, but which has since taken gigantic dimensions, and has become one of the most important scientific bodies in the world.'[117] The certificate of Fairbairn's election was signed by Thomas Telford, the president of the Institution. Pole may have exaggerated the role of the Institution in science, but for Fairbairn it was a useful vehicle also for his career. In the beginning of the 1830s, at the age of forty-one, Fairbairn was no longer millwright, but a civil engineer. Furthermore, according to R. A. Hayward, he actually 'abolished the millwright and introduced the mechanical engineer'.[118] Mechanical engineering was highly valued in British society during the age of industrialisation, but there were thousands of mechanical engineers promoting the profession, and despite the 'pioneering' role of Fairbairn, he could not, of course, achieve the status of the profession by himself.

3.2. 1830-1840: Iron ships, Steam Engines and Railway Locomotives

Even though the partnership had been very rewarding for Fairbairn he decided to sever his partnership with Lillie in 1832. Lillie's disagreement with Fairbairn's desire to branch out into other types of engineering was the main reason for the break-up. Fairbairn bought Lillie's share of the business despite resistance on the part of Lillie. Fairbairn was not totally

[116] Halmesvirta 1999, p. 180-181.
[117] Pole 1877, p. 130.
[118] Hayward 1973, p. 59.

confident of this solution: 'Perhaps there was some reason in these observations; but after a careful consideration of the circumstances I felt convinced that we could no longer go on together with safety or comfort'.[119] Fairbairn wanted to become a pioneer of the new area of engineering: iron-ship building.[120] He was first employed by the canal owners who, with the opening of the Liverpool and Manchester Railway in 1831, were afraid of the growth of the railway system.[121] In the 1830s, there was 'still light at the end of the canal tunnel' because the railways could not fulfil all the transfer needs of both passengers and cargo. Some canal companies were actually strong enough to survive to the end of the 19th century. It is possible that the Institution of Civil Engineers tried to prevent the rise of the railways because of its members' connections with canal owners.

Between 1830 and 1835, Fairbairn constructed eight iron ships at his Manchester works, and *The Manchester Guardian* proclaimed that the town was becoming a shipbuilding centre.[122] In 1830, Fairbairn constructed *Lord Dundas;* a twin hulled steamer with the paddlewheel placed between the hulls, for the Forth and Clyde Canal Company. His purpose was to investigate the properties of light iron steamboats, which were meant to become competitors to the railways. Fairbairn made several trials with *Lord Dundas;* the voyage from Liverpool to Clyde almost turned into a disaster because of the compass deviation due to the ship's magnetism. In his biography, Fairbairn came to the conclusion that canal boats could not be used for the purpose of passenger carrying because they were too slow:

> The experiments made with the *Lord Dundas* were sufficient to convince the most sanguine of the canal proprietary that nothing could be effected in the shape of high velocities on canals to compete with the new locomotives, then in the

[119] Pole 1877, p. 148.

[120] The first iron steamship had been built in 1821 by Aaron Manby. However, due to the problems caused by the compass deviation in iron-ships the application of iron in shipbuilding took rather a long time. Finally, in the 1850s, iron started to substitute for wood as a shipbuilding material.

[121] It is interesting to note that many canal engineers, such as Thomas Telford, were members of the Institution of Civil Engineers.

[122] *Manchester Guardian,* for example, 26 February and 2 April 1831.

> process of development on the Liverpool and Manchester Railway.[123]

Perhaps Fairbairn realised already in the 1830s that the age of the canals was coming to an end. He wrote a book[124] about his investigations into canal boats, which was reviewed by the *Mechanics' Magazine* in 1831:

> Mr. F. very properly cautions his readers against supposing that a steam-boat, such as we have just described, though well adapted to canal, river, and coasting navigation, would answer equally well for long voyage at sea.[125]

This suggests that industrialists did not believe in the future of the iron ships in the 1830s. Manchester proved to be an unsuitable place for shipbuilding because there was no proper connection to the sea, and in 1835 Fairbairn set up a shipyard at Millwall, London.

In the beginning of the 1830s, Fairbairn also started to manufacture steam engines to provide power for the iron ships. Within a few years much larger engines were built, and in 1833 Fairbairn introduced a steam engine for powering cotton mills. By the end of the decade, Fairbairn was a renowned steam engine manufacturer and his works in Manchester were literally choked with orders.[126] The firm also constructed several types of pumping engines for the collieries all over Britain, but the construction of steam boilers was more important for Fairbairn's business. Steam boilers were usually made separately from steam engines because their construction needed special skills. However, boilermaking formed a substantial part of the output of Manchester works. In the mid-1830s, about fifty boilermakers were employed in Manchester, but, in 1837, most of them went on strike. As a consequence, Fairbairn introduced a new invention, the riveting machine, which was designed by Fairbairn and his assistant engineer. Fairbairn explained the properties of the new patent:

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[123] Pole 1877, p. 142.

[124] The name of the book is: *Remarks on Canal Navigation, Illustrative of the advantages of the use of Steam as a Moving Power on Canals*. It was published in London in 1831.

[125] *Mechanics' Magazine*, 15 October 1831, 'Iron Steam-Boat Adapted to Canal and Coasting Navigation', pp. 34-37.

[126] Hayward 1973, pp. 10-11.

> The introduction of the riveting machine gave great facilities for the despatch of business. It fixed, with two men and a boy, as many rivets in one hour as could be done with three men and a boy in a day of twelve hours on the old plan; and such was the expedition and superior quality of the work, that in less than twelve months the machines were preferred to those made by the hand, in every part of the country where they were known.[127]

Fairbairn was thus convinced that new machines could be introduced to replace humans in the most difficult industrial working tasks even though he had to use child labour, which was a common phenomenon everywhere in industrialised Britain during the early 19th century. The role of rivets in the history of technology in the 19th century is described by Joseph Conrad's narrator's voice in the heart of darkest Africa on the river Congo after a shipwreck: 'What I really wanted was rivets, by heaven! Rivets. To get on with the work - to stop the hole, Rivets I wanted.'[128]

The two railway manias, from 1836 to 1837 and from 1845 to 1847, led to the construction of the main trunk railway system in Britain, the first country to have one. Conventional histories tend to describe the growth of the railways as a victorious struggle fought by remarkable engineers and entrepreneurs such as Robert Stephenson and George Hudson. However, the role of the railway companies was more important than the role of some individual engineers. The railway companies' activity during this era has been described as 'reckless oligopolistic competition'.[129] The railway network did grow, indeed, but the growth was something far larger than just making more railways. The railways in Britain in the 19th century were a system which had many similar traits with the Thomas Hughes's pattern of the evolution of the large technological systems.[130] Furthermore, the British railway system created the railway culture which spread all over the world during the last decades of the 19th century.[131]

[127] Pole 1877, p. 164.
[128] Conrad, Joseph, *Heart of Darkness*, London, 1994, first published in 1902, p. 40.
[129] Simmons 1978, p. 46.
[130] Hughes 1987, pp. 53-54.
[131] Schiewelbusch 1977, chapter 6.

William Fairbairn was also involved in the creation of the railway system: his main areas of interest were locomotives and railway bridges. Again, he was no inventor, but his innovations in the railway engineering works brought fortunes to his company. Fairbairn entered the business in 1838, at the age of 49, and by the following April one of his locomotives was in service on the Manchester and Bolton Railway. This type of locomotive was also supplied in large numbers to other railway companies.[132] Another type of locomotive made in the Manchester Works exploded, causing the death of three men.[133] Indeed, the boiler explosions were quite common among the early locomotives due to the short development time and the lack of scientific knowledge. As a result of these setbacks, Fairbairn founded the Association for the Prevention of Boiler Explosions in the early 1850s. Meanwhile, many types of railway locomotives were being produced in the Manchester works, which was a prosperous business to the end of the 1850s. For example, in 1852, Fairbairn produced *Barineza,* the first locomotive to be used in Brazil. Fairbairn claimed in his biography that he had constructed over six hundred locomotives.[134]

In 1838, Fairbairn received an invitation from the Sultan of the Ottomans to carry out certain technical reforms in Constantinople. He travelled to Turkey the following year to have an audience with the Sultan, which never took place because the Sultan died the very morning of the appointment.[135] However, Fairbairn was allowed to continue his work to investigate the technical failures and introduce new technical products in Turkey. Fairbairn criticised the way the Turkish people used new technology: 'But with all this new plant, little or nothing was doing [sic] in the shape of manufacture, through the apathy of the Turks and their

[132] See the picture of locomotive *Vulcan* in Appendix B. Hayward 1977, p. 13.
[133] Ibid., p. 12.
[134] Pole 1877, p. 317.
[135] Ibid., p. 168.

aversion to new things'.[136] However, Fairbairn succeeded in selling the products of his company to Ohanes Dadian, his Armenian friend. For example, he erected some corn mills near the town of Izmet. The visit to Turkey lasted four years and was good business for Fairbairn.

3.3. 1840-1850: The Millwall Shipyard and Britannia Bridge

Iron shipbuilding started to attract much public attention in the 1830s, although the whole business of cutting, shaping and joining iron plates in a watertight manner was still being developed.[137] Fairbairn was one of the entrepreneurs who wanted to become the owner of the basic patents of the new industry.[138] In 1835, forty-six-year old Fairbairn opened the Millwall shipyard on the River Thames, and put his young pupil, Andrew Murray, in charge of the business. Fairbairn had to take care of the business in Manchester, and, thus, he had no time to manage the Millwall shipyard although he often visited it. William Pole suggests that Fairbairn's desire to make himself more known in the world was the main reason why he chose London area for his shipyard.[139] The Millwall yard had to compete against the other shipbuilders on the Thames who had entered the business as early as Fairbairn, but Fairbairn felt secure because 'we were well supported by the Government and the East India Company, and by increased orders from abroad'.[140] In the following year they had orders from the East India Company for twelve iron ships for navigating the Ganges. The late 1830s was a relatively prosperous time for the Millwall business: for example, in 1837, the firm built the *Sirius*, an iron steamship which weighted 180 tons. By 1840, Fairbairn employed over 2,000 men, two-thirds of whom were in his yard at Millwall.[141]

[136] Ibid., p. 169.
[137] Banbury 1971, p. 172.
[138] Ibid., p. 172.
[139] Pole 1877, p. 336.
[140] Ibid., p. 154.
[141] Atkinson 1996, p. 72.

As mentioned in the previous section, Fairbairn went to Constantinople in 1838 to work for the Ottoman Empire, which took him about four years to complete. When Fairbairn returned from Constantinople, he found that the affairs both in Manchester and Millwall were in great confusion. The Millwall shipyard had to be subsidised from the profits of the Manchester business. Furthermore, in 1846, the Admiralty ordered an iron steam frigate *Megaera*, and under the impression that the order was confirmed, Andrew Murray bought a large consignment of iron plates. However, the Admiralty changed the order, which rendered the iron plates almost useless.[142] The Millwall shipyard was now bankrupt and stayed open until 1849 only to finish the *Megaera*. During this time the yard was also used for the experiments on the tubular bridge components which resulted in the completion of the Britannia Bridge. Fairbairn was certainly not happy with the situation, and his son Thomas wrote a rather bitter memorandum about the Millwall catastrophe:

> Eight years of my own time and devoted attention were taken up in bringing the disastrous Millwall concern to close. I was taken away from an intended university career in 1840, and was engaged at Millwall until the final close in 1848, excepting some ten months in 1841-42, which I spent in Italy. The loss sustained at Millwall altogether was over £100,000, the whole of which had to be made good from the profits of the business in Manchester.[143]

Only the large profits made by Fairbairn's Manchester works saved him from bankruptcy. It must have been a relief for Fairbairn to close down the Millwall establishment, although it was first bought by his London rivals and it was subsequently used by Scott Russell and I. K. Brunel for the construction of the famous iron steamship *Great Eastern*.

Banbury suggests that Fairbairn's failure was largely his own fault rather than government and industry being too slow in adapting the iron

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[142] Pole 1877, p. 338.
[143] Ibid., p. 342.

steamships for their purposes.[144] However, Fairbairn's experiments in the Millwall shipyard helped him to become an expert on iron shipbuilding in the second half of the 19th century. Fairbairn took out two patents for improvements in marine steam technology. The first was in 1841 for certain improvements in the construction of steam engines. In 1842, he took out a patent for an improvement in the mode of driving the screw propeller, which, however, proved too troublesome for general application.[145] The Millwall shipyard was not economically profitable because its technology was too modern for contemporaries who relied on the old wooden ships, but Fairbairn's investments in iron ships turned profitable in the 1850s when the major ship companies and the Navy changed to iron. Fairbairn's workload during the 1840s must have been enormous because he was also engaged in the construction of the Britannia Bridge in North Wales.

The construction of the railway bridges was part of the new railway culture as was the fact that the railway stations became centres of the urban areas. The massive iron bridges symbolised the 'golden age of the engineers'. In 1845, fifty-five-year old Fairbairn together with Eaton Hodgkinson was consulted by Robert Stephenson on the design of a bridge to carry the Chester and Holyhead Railway across the Menai Straits to Anglesey. The Britannia Bridge was a gigantic piece of work and it took four years to complete the design. The problem confronting the designers was this: the British Admiralty insisted that any such bridge must be sufficiently high to allow the tallest mast of the biggest warship to pass underneath the bridge at the highest spring tides.[146] After some disagreements, the three designers came to the conclusion that the only solution was a huge iron tube supported by chains, a kind of semi-suspension bridge, and, furthermore, wrought iron was considered the only feasible material. The tube was successfully raised in April 1848. By a combination of systematic investigations, trial and error, mathematical theory, and application of

[144] Banbury 1971, p. 173.
[145] Burnley 1888, p. 988.

existing knowledge, the engineers had arrived at the optimal design for the tubular bridge.[147] In fact, the bridge proved capable of carrying the heaviest steam locomotives and also the British Admiralty was content with the solution. The bridge was at once an object of great public interest and Queen Victoria visited it together with Robert Stephenson in 1852.[148] Samuel Smiles concluded that 'The Britannia Bridge is one of the most remarkable monuments of the enterprise and skill of the present century'.[149]

William Fairbairn's own account of the history of the Britannia Bridge differs from the 'official history' described in the last paragraph. Fairbairn remained very enthusiastic in the bridge building process nearly to the completion. In the biography, Fairbairn replies in his letter (9 June 1847) to Robert Stephenson:

> I have made up my mind to devote my best energies to the construction and due completion of the tubes, and I will watch narrowly and regularly the progress of each construction, that the work be well done, and free from blemish in every respect.[150]

Perhaps Fairbairn came to the conclusion that without his help the bridge could not have been accomplished.

However, when the Britannia Bridge was almost finished, Fairbairn wrote a book, *An Account of the Construction of the Britannia and Conway Tubular Bridges* (1849)[151], because he wanted to clarify his role in the bridge-building process. Fairbairn was clearly irritated because he thought he had not gained sufficient reputation from his work. More than ten years later, in his letter to William Cawthorne Unwin, Fairbairn reveals his feelings:

> Have you seen Mr. Pole's "History of the Tubular Bridges" in Jefferson and Pole's Life of Robert Stephenson? All the

[146] Cardwell 1994, p. 256.
[147] See the picture in Appendix C. The spans of the Britannia Bridge over the Menai Straits being manoeuvred into position. A lithograph by G. Hawkins. Armytage 1961, p. 64.
[148] See the picture of the Britannia Bridge in Appendix D. Garrison 1991, p. 161.
[149] Cited in Cardwell 1994, p. 260.
[150] Pole 1877, p. 209.
[151] Unfortunately, the author of this thesis could not find the book available in reasonable time.

> experimental researches are given to Stephenson and a more garbled statement of facts I have seldom read. Everything done by Stephenson although it is well known he never was present at any of the experiments but twice and that only for half an hour at a time. But Pole and Calache were both of them employees of his and he paid them well for subverting the truth.[152]

If the Pole who Fairbairn mentions in the letter is the same person as the editor of *The Life of Sir William Fairbairn,* William Pole had changed his views considerably in ten years. The letter to W. C. Unwin is interesting source material because Fairbairn's opinions are presented in it without Pole's filtration of the unpleasant information.

It seems that Robert Stephenson used Fairbairn's knowledge in the erection of the tube, but afterwards he took all the honour for it. In 1846, Fairbairn and Stephenson took a patent out for the new principle of wrought-iron girders. Fairbairn states in regard to this patent:

> The patent for wrought-iron girder bridges was a joint affair between Mr. R. Stephenson and myself. It was in my name as the inventor, but he paid half the expense, and was entitled to one half of the profits, but it ultimately became a dead letter, and was abandoned by Mr. Stephenson.[153]

Although Fairbairn and George Stephenson were old friends, Fairbairn was rather critical in his description of Robert Stephenson.[154] In his letter (5 January 1847) to Fairbairn George Stephenson explains his denial of the proposed wrestling match:

'Although you are a much taller and stronger looking man than myself, I am quite sure that I could have smiled in your face when you were laying on your back! I know your wife would not like to see me do this, therefore let me have no more boasting, or you might get the worst of it.

Notwithstanding your challenge, I remain yours faithfully,

Geo. Stephenson.'[155]

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[152] Fairbairn, William; *Letter to W. C. Unwin*, 30 December 1864, London University: Imperial College Archives, Room 455.

[153] Pole 1877, p. 213.

[154] It is possible that Fairbairn's disagreements with R. S. rose in the 1860s and 1870s.

3.4. 1850-1874: The Public Figure

Both the Millwall shipyard and the Britannia Bridge were massive work projects, and the over sixty-year old Fairbairn was surely exhausted in the beginning of the 1850s. In 1853, when Fairbairn's two sons[156] had joined the business[157], he decided to retire for other activities such as working with the problems of engineering science and being a public figure. Nevertheless, Fairbairn had not completely lost his interest in the manufacturing business. For example, in November 1850, Fairbairn took out a patent for an improvement in the instrument called the crane.[158] The Manchester works were very profitable during the 1850s due to good business conditions. According to Pole, 'between 1848 and 1860, the large loss at Millwall was not only made good by the Manchester works, but considerable fortunes were amassed by all the partners'.[159] In 1870, Fairbairn stated that he had 'built and designed, with the assistance of the Fairbairn Engineering Company, nearly 1,000 bridges'.[160] However, the biography gives a rather polished picture of the history of the Fairbairn Engineering Company during the 1860s and 1870s, and, therefore, it is not very reliable source material. R. A. Hayward's account from 1973, which will be reviewed next, gives a more realistic view of the later years of the Manchester works.

The Manchester business had several setbacks in the 1860s and 1870s. During the third quarter of the 19th century the engineering industry was slowly changing, some firms were beginning to specialise in certain fields. Due to competition from locomotive specialists, such as Sharp and Stewart, Fairbairn's firm ceased to build locomotives, which had been good business during the previous decades. In 1862, the Parliament passed a new

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[155] Pole 1877, p. 194.
[156] Fairbairn had in total seven sons and two daughters.
[157] In 1840, Fairbairn's second son Thomas (1823-91) entered the business as a partner, and, in 1846, they were joined by another son, William Andrew (1824-1910).
[158] See the picture of a steam crane in Appendix E. Pole 1877, p. 322.
[159] Ibid., p. 329.

Companies Act, under which any group of seven people could register as a limited liability company. The Fairbairn Engineering Company Limited was registered in January 1864, with a share capital of £250,000.[161] Thomas Fairbairn, Henry Harman and six other men were now the main proprietors of the Manchester works. The company occupied only two of the four sites originally used; these were the main Canal Street works and the Back Mather Street works. In the following ten years, The Fairbairn Engineering Company Limited undertook several large contracts. Early in 1868 the firm was ordered to construct the ironwork for the roof of the Central Hall of Arts and Sciences[162]. During February 1870, The Fairbairn Engineering Company Limited was accepted by the Secretary of State for War for the construction of the armour-plated forts at Spithead. The manufacture, test erection, and final erection at Spithead were all carried out under Henry Harman, who had been the manager of the Manchester works since 1859. Soon after that Harman had to retire because of his ill health and he died in 1875, which was probably a serious blow for the company.

Steel started to substitute for iron in many branches of the manufacturing business in the last decades of the 19th century. The iron manufacturing industry started to suffer from the long-term stagnation in demand. The fortunes of the Fairbairn Engineering Company Limited[163] reached their lowest ebb in 1869-70, but the Spithead forts improved the situation in 1871. The company's report from the year 1872 stated that the firm was 'fully and profitably employed, the works in progress being more extensive than at any time since 1866'.[164] However, in reality, the situation was getting even worse than in the late 1860s. Sir William Fairbairn retired from the board of

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160 Ibid., p. 213.
161 Hayward 1973, p. 62.
162 It was later renamed the Royal Albert Hall.
163 It is difficult to find exact data about the fortunes of the Fairbairn Engineering Company Limited because the company's final act in 1899 was to destroy its own records! Hayward 1973, p. 67.
164 Ibid., p. 69.

the company in 1872 and he died in 1874 at the age of eighty-five. In 1875, only nine months after Sir William Fairbairn's death, the company went into liquidation.

R. A. Hayward suggests that the 'Great Depression' which began in the 1870s and lasted to the end of the century was the main reason for the bankruptcy. However, most of the modern British economic historians claim that the 'Great Depression' was not a very significant event and some of them have even questioned the very existence of it. Fairbairn's sons were perhaps less able entrepreneurs; Thomas Fairbairn, for example, retired to lead the life of a country gentleman. Martin Wiener's argument on the negative effect of the gentrification of engineers to industry works in the case of Fairbairn's sons. The company's decision in the 1860s to concentrate most of their resources on the construction of the iron structures was a failure. William Fairbairn was not pleased with the decision to change the firm to a limited liability company and he has been reported to have said already in 1852:

> ...no joint stock company could successfully compete with individual manufacturers, either as to price or quality. The former had not that powerful inducement of pleasing their customers, nor did they feel the necessity of always striving for the improvement.[165]

However, Fairbairn influenced the company's affairs as a shareholder and a member of the board up to the 1870s, and, thus, he was also responsible for the downfall of the company. Nevertheless, in the second half of the 19th century Fairbairn was more interested in being a public figure.

According to William Pole, the culminating point of William Fairbairn's life was the publication of his book *An Account of the Construction of the Britannia and Conway Tubular Bridges* in 1849.[166] Fairbairn wanted to write his name in the history of engineering as one of the great engineers of the 19th century, but the credit for the Britannia Bridge went mainly to Robert

[165] Ibid., p. 79.
[166] Pole 1877, 241.

Stephenson. It could be argued that the reputation of the engineers has never been as high as in the middle decades of the 19th century during the era of the railways. Although Fairbairn lost his battle for prestige to Robert Stephenson, he was not left without an appreciation of his merits. In 1850, Fairbairn was elected a Fellow of the Royal Society. Fairbairn had been a member of the BAAS and Literary and Philosophical Society of Manchester almost twenty years, but the Royal Society was a far more prestigious society than the two others. The proposal for his admission was made by another famous engineer, George Rennie, although the Royal Society was above all a scientific institution. Another, perhaps even more prestigious admission, was given to Fairbairn in 1851 when he was chosen to be a member of the National Institute of France: 'Les grands et beaux travaux que vous avez dirigés et executés vous mettent au nombre des personnes sur lesquelles doit se porter la pensée de l'Institut'.[167] Education in the applied sciences had been more developed in France since the Great Revolution because of the French state's control over education of the engineers as opposed to the British system of practical apprenticeship. Therefore, Fairbairn's election into the National Institution of France was a very rare honour given to a British person.

The third important distinction for Fairbairn came in 1853 when he was elected to the Atheæum Club. Pole states that this highly exclusive institution was founded for the 'association of individuals known for their scientific or literal attainments, artists of eminence of any class of the fine arts, and noblemen and gentlemen distinguished as liberal patrons of science, literature, or the arts'.[168] Thus, according to Pole, Fairbairn was accepted to gentlemanly institutions after the publication of his account on the construction of the Britannia Bridge. Furthermore, Fairbairn was awarded the Royal Society Gold Medal, one of the most distinguished scientific honours of 19th century Britain, in 1860. However, Fairbairn was

[167] Ibid., pp. 243-247.
[168] Ibid., p. 252.

not an educated gentleman and he probably did not appreciate the lifestyle of the traditional aristocracy. Fairbairn even refused the knighthood he was offered in 1861. In his reply to the Queen (23 October 1861) Fairbairn explained his decision:

> During a long life I have tried above all things to make myself useful. For more than seventy years I have found the plain names I bear sufficient for the furtherance of the great object of my life, and I pray Her Majesty to permit me to retain them in their simplicity to the end.[169]

Perhaps Fairbairn preferred the engineering institutions, which were not meant for gentlemen, but for professional men. Above all, Fairbairn saw himself more as a self-made gentleman portrayed by Samuel Smiles than an aristocrat.

Fairbairn had been a member of the Institution of Civil Engineers since 1830 and he had published several papers in the Transactions of the Civils. However, Fairbairn probably felt himself more at ease with his fellows in the Institution of Mechanical Engineers and he had joined the Mechanicals in 1847, which was the same year it was founded. The first president of the Mechanicals was George Stephenson, who mainly promoted the interests of the railway engineers. Fairbairn held the presidency of the Institution of Mechanical Engineers during the years 1854 and 1855. It could be argued that Fairbairn joined the engineering institutions because it was beneficial for his reputation. According to Jack Morrell, 'we must be alert to the possibility that past institutions were vehicles, not just for professionalisation but making of careers, the exercise of patronage and the promulgation of ideologies by controlling coteries'.[170] Fairbairn's authority as an engineer was thus as well based on his social connections as on his engineering works. Some of the most celebrated 19th century engineers and scientists were his friends. Perhaps Fairbairn also used the institutions as 'vehicles' towards higher social recognition. The Carr-Saunders - Wilson approach works in the case of Sir William Fairbairn to a certain extent, but

[169] Ibid., p. 391.
[170] Morrell 1981, p. 988.

Fairbairn also wanted to promote the engineering profession, especially engineering education as a science. Thus, it is not realistic to understand Fairbairn's activities in scientific and engineering institutions only as a tool for career making. Although Fairbairn did not accept a knighthood in 1861, he accepted a baronetcy in 1869 at the age of eighty because it was conferred on him for his scientific achievements.

In addition to what has been described in the previous sections, Fairbairn also had many other activities during the 1850s and 1860s. In the mid-1850s, he visited Scandinavia together with his son Peter. Fairbairn's international reputation enabled him to make appointments with the King of Sweden and the Emperor of Russia. The biography gives an interesting account of Fairbairns' visit to Sweden: 'Here [in Uppsala] I was received by the students as if I had been the friends of Linnæus or Berzelius. Our arrival, they told me, had been announced in the papers, and they welcomed me to Sweden as if I had been a great man.'[171] Fairbairn's scientific work on the properties of iron had also reached the Swedish academic audience, which was probably very interested in hearing about Fairbairn's investigations because Sweden had traditionally been a big exporter of iron ore. After Sweden Fairbairn sailed to Russia: 'We hope to reach Abo [sic], in Friedland [sic], on Wednesday night, and Petersburgh [sic] on Saturday or Sunday.'[172] The Grand Duke Alexander received Fairbairn personally and 'listened with great interest to everything I had to say about the bridges'.[173] The rulers of the two countries were interested in Fairbairn's knowledge concerning the new technology, especially the properties of iron for shipbuilding purposes.

Fairbairn acted as a juror in the machinery department of the Exhibitions of 1851 and 1862 in London. In the Paris Exhibition of 1855, Fairbairn was nominated as a chairman of one of the mechanical sections. Fairbairn was

[171] Pole 1877, p. 365.
[172] Ibid., p. 366.

aware of the growing international competition in several branches of industry, but he still believed in the superiority of British Engineering. One of the most important areas of international competition was military engineering, especially the building of warships. During the last twelve years of his life Fairbairn was frequently consulted by the Admiralty. However, the biography does not give many details about Fairbairn's work with the Admiralty because that was considered confidential in the 1870s. Another great engineering task in which Fairbairn was specially interested in the 1860s was the Atlantic cable. The first telegraph cable under the Atlantic was laid in 1858, but after a couple of days it had ceased to work due to problems with the copper wire's insulation. As a consequence, Fairbairn was asked to join a commission whose purpose was to find the 'best form for the composition and outer covering of submarine telegraph cables'.[174] The best insulation material for the cable was a rather difficult question, but, finally, the Atlantic Telegraphic Company decided to use gutta percha.[175] The second cable was laid by the *Great Eastern* in 1865, but the operation failed again. Fairbairn wrote in the paper for the British Association for the Advancement of Science: 'The recent disaster and loss of the greater portion of the Atlantic cables is one of those casualties which may be considered national, and looked upon as a misfortune much to be regretted'.[176] Fairbairn remained optimistic, and the third cable, which was laid in 1866, proved to be successful. However, Fairbairn's role in this project should not be exaggerated.

In October 1873, Fairbairn participated in the opening ceremony of the new buildings of Owen's College in Manchester where he caught a severe bronchial cold from the effects of which he never recovered.[177] Sir William Fairbairn died at his home on 18 August 1874 at the age of eighty-five. The public figure received a public funeral: the number of the people present

[173] Ibid., p. 366.
[174] Ibid., p. 381.
[175] A whitish rubber substance derived from several tropical trees with leathery leaves.
[176] Fairbairn 1866b, p. 178.

was estimated to be 50,000 to 70,000. The obituaries of the leading British newspapers praised Fairbairn's achievements. For example, *The Manchester Examiner* said: 'Some of the greatest works of peace and war in our time are associated with Sir William Fairbairn's name.'[178] William Pole does not criticise Fairbairn in his part of the biography. However, Pole suggests that 'he had perhaps an excessive ambition for popularity and fame; but this foible had one redeeming feature, namely, that he aimed not so much at obtaining the applause of the million as at standing well with the good and wise'.[179] The word 'useful' is often mentioned in Fairbairn's biography. In his letter to some unknown person (19 February 1858) Fairbairn states: 'Men only live while they are useful, and my hope is that my years will not be prolonged beyond that period.'[180] Perhaps this 'need to be useful' explains Fairbairn's relation to his work as an engineer, manufacturer, and public figure. This suggests that he had utilitarian views in his religious ethics.

4. FAIRBAIRN'S SCIENTIFIC WORK

4.1. The British Association for the Advancement of Science

The British Association for the Advancement of Science (BAAS) was created in 1831 by a group of enthusiasts who believed in the progress of science. The relation between science and technology was developing during the process of industrialisation. The new generation of scientists wanted to emancipate themselves from the old academic disciplines such as theology. Although the Royal Society rejected theological speculation it

[177] Pole 1877, p. 428.
[178] Ibid., p. 436. The author of this thesis could not reach the original copy of *The Manchester Examiner*, but used only Pole's quotation.
[179] Ibid., p. 472. Fairbairn wanted to be recognised as a man of science as it is argued in the next chapter.
[180] Ibid., p. 452.

was found to be old-fashioned by this new generation. In 1830, Charles Babbage (1792-1871) wrote the book, *Reflections on the Decline of Science in England*, which strongly influenced the formation of the BAAS. Babbage looked forward to the division of labour in science and to the emergence of a systematic applied science.[181] Thus, some of the leading figures of BAAS were also promoters of an engineering science. William Fairbairn's selection to be a member of BAAS in the beginning of the 1830s was a result of his success as an engineering manufacturer and his participation in gentlemen associations such as the Manchester Literary and Philosophical Society in the 1820s. The role of the Mancunian Society must have been important for Fairbairn's scientific career. Through these societies the early mill owners, merchants, capitalists, and engineers absorbed scientific information[182] in a similar way as it is presented in Jacob's cultural approach. Perhaps the Literary and Philosophical Societies were ideological predecessors of the BAAS. However, the BAAS was created during the Age of Reform when the men of scientific knowledge gained further prestige, and, according to Morrell and Thackray, Fairbairn was one of those men.[183] Fairbairn's collaboration with the BAAS, together with mathematician Eaton Hodgkinson, was very fruitful, and the partners became respected members of the Association.

In his part of the biography, William Pole mentions Fairbairn's role in the BAAS only briefly, which suggests that either the BAAS was no longer important in the 1870s, or that Pole had something personal against the Association. Fairbairn's collaboration with the BAAS began in the 1830s when he started to investigate the properties of wrought and cast iron for shipbuilding purposes. His first scientific publication, *Remarks on Canal Navigation* (1831), received positive reception, and, for example, Thomas Telford, the President of the Institution of Civil Engineers, praised

[181] Cardwell 1994, p. 272.
[182] Morrell & Thackray 1981, p. 12.
[183] Ibid., p. 17.

Fairbairn's work.[184] Fairbairn had friends in Manchester who were similarly interested in scientific issues: 'Hodgkinson[185] was an able mathematician; Woodcroft[186] was an original inventor; Nasmyth[187] imaginative; Elliot[188] cautious and persevering; and I myself with a slight mixture of the whole...'.[189] In 1835, at the meeting of the BAAS in Dublin, Fairbairn and Hodgkinson were assigned to investigate the strength and other properties of iron obtained by the hot and cold blast methods. This launched the long series of grants to Fairbairn and Hodgkinson for their research. Fairbairn complained to the President of the Association in 1836 about the problems in their research:

> A seeming reluctance has been evinced in some quarters to give information, but notwithstanding this desire to withhold such facts as were deemed essential to accurate investigation, we have nevertheless obtained sufficient data on which to found pretty accurate results.[190]

This reluctance suggests that Pole was correct in his description of the iron-masters who had come to the conclusion that the new process of manufacture by the hot blast deteriorated the quality of the iron produced.[191] However, Fairbairn and Hodgkinson managed to continue their investigations, and, at the meeting of the BAAS in Manchester in 1837, they received another grant for their scientific work.[192] The Reports of the BAAS contain plenty of material concerning Fairbairn's investigations on the properties of iron. BAAS encouraged engineers and manufacturers to provide resources for research in mechanical science. Fairbairn thus helped Hodgkinson with the work on the strength of materials by providing the facilities of his Manchester engineering works.[193] Fairbairn and Hodgkinson

[184] Pole 1877, pp. 134-135.
[185] Eaton Hodgkinson was retired pawnbroker from Manchester who later made a remarkable career as a scientist.
[186] Bennett Woodcroft was the scientific advisor of the Commissioners of Patents.
[187] James Nasmyth was the famous Mancunian engineer and the inventor of steam hammer.
[188] John Elliot was the foreman of the millwrights at Manchester and he assisted Fairbairn in the building of the iron ships such as *Lord Dundas*.
[189] Pole 1877, p. 156.
[190] Morrell & Thackray 1984, p. 225.
[191] Pole 1877, p. 160.
[192] The additional funds of £100 per year were voted to their work in 1837, 1838, and 1839.
[193] Morrell & Thackray 1981, p. 12.

received further funding for their investigations than most of the other scientists that BAAS funded. The reason for this was probably the importance of their research, but Fairbairn and Hodgkinson also had power to influence the decisions of the BAAS. Furthermore, Fairbairn also gave money to the BAAS in order to promote the research in areas related to technology and applied sciences. According to Pole, 'The results of the temperature experiments were too complicated to admit of brief summary'.[194] Probably the differences between hot and cold blast iron were not very significant and Fairbairn had to reconsider should he publish any further report on the subject to the Association. However, Fairbairn and Hodgkinson continued to investigate the properties of iron in the 1840s because they were consulted by Robert Stephenson for the design of the Britannia Bridge.

Eaton Hodgkinson wrote to Fairbairn on 11 December 1840:

> It is perhaps not less than a dozen years since I first availed myself of your kind offer to afford me the means of making experiments at your works. In that interval more experiments, of a really useful character, have been made there, either by yourself or me, than have been made at any one place in Europe in the time; and when one considers that the expense has been wholly borne by yourself ... your public spirit deserves the highest praise.[195]

Hodgkinson had a very good reason to praise Fairbairn; the investigation had become a turning point in his career and he was catapulted to national scientific eminence in the course of the 1830s.[196] Furthermore, Hodgkinson's election as the Fellow of the Royal Society in 1841 was achieved largely by his contacts made through the British Association. The BAAS also helped Hodgkinson to increase his prestige in the local area and he moved steadily upwards in the hierarchy of the Manchester Literary and Philosophical Society. In 1848, following his election to the chair of engineering at University College, London, the former pawnbroker assumed the

[194] Pole 1877, p. 162.
[195] Ibid., p. 181.
[196] Morrell & Thackray 1981, p. 409.

Presidency of Manchester's most socially exclusive and scientifically distinguished society.[197] In the 1850s, Hodgkinson enjoyed universal recognition, but he was plagued with ill health and he died in 1860.

To a certain extent William Fairbairn took on Hodgkinson's role as the British Association's expert on the strength of materials. The collaboration was beneficial for both Fairbairn and Hodgkinson because it helped them to gain influence in the British Association. In the 1840s, Fairbairn and Hodgkinson continued to investigate the properties of iron and they were funded by the BAAS for their important research concerning the design of the Britannia Bridge. But, however, in the 1850s, Hodgkinson gave only one paper to the BAAS and he did not receive any grants, whereas Fairbairn received grants from the BAAS in 1852, 1854, and 1855.[198] Through the BAAS Fairbairn consolidated his own national standing not simply as an engineer, but also as a scientist.[199] In 1861, when the British Association met in Manchester, its President, William Fairbairn, was no noble lord but for the first time ever an engineer. The retiring President, Lord Wrottesley, gave a speech at the opening of the Manchester meeting (4 September 1861) which flattered Fairbairn:

> Again, if we look at Mr. Fairbairn's claims to scientific distinction, they read to us an important lesson; for they show what can be done by zeal and energy, and the exercise of a strong and resolute will fully determined to carry out objects in which the public is deeply interested.[200]

This kind of speech is, of course, only a good example of the liturgy used by the contemporary authorities to praise each other.

[197] Ibid., p. 410.
[198] However, Fairbairn did not receive all the grants for the purpose to investigate the properties of iron.
[199] Morrell & Thackray 1981, p. 410.
[200] Pole 1877, pp. 385-386.

4.2. Prevention of Boiler Explosions, Geological Investigations and Application of Iron for Military Purposes

One of the branches of engineering industry which Fairbairn was especially interested in was the design of steam boilers. Like many branches of the new technology, also boiler-making industry had some problems at the beginning: boiler explosions caused horror especially in the most industrialised areas in Britain such as Lancashire and Yorkshire. The main idea behind the foundation of the 'Manchester Steam User's Association, for the Prevention of Steam-boiler Explosions, and for the attainment of Economy in the Application of Steam' was, according to L. E. Fletcher, 'to save human life and check the recklessness without hampering the progress'.[201] Fairbairn wrote several papers to the BAAS and the Royal Society concerning the prevention of the boiler explosions. Thus, he was an expert also in this area between science and technology.

In the early 1850s, Fairbairn was engaged in the scientific research undertaken by William Hopkins of Cambridge. Geology was in that time a rather young science, and, for example, the structure of earth remained a mystery. Hopkins was interested in investigating the origin of earth's crust with the help of applied sciences such as engineering. He wrote to Fairbairn in 1851:

> I am very anxious to get some experiments made for the purpose of determining whether great pressure has any sensible effect on the temperature of fusion of any proposed substance (a metallic substance for instance), or what will probably be found to be the same thing, on the temperature at which any substance, in a previous state of fusion, will become solid.[202]

Hopkins was presumably trying to determine the temperature below the earth's crust with the help of these tests, but he had difficulties in finding the correct materials. James Joule also took part in the investigation as an

[201] Ibid., p. 284.
[202] Ibid., pp. 289-290.

expert of mechanical action of heat.[203] Fairbairn and Joule consulted Hopkins with the new experiments and they made some further progress with the help of the funding from the BAAS and the Royal Society, but, however, Hopkins died in 1866, and his research was left unfinished. Perhaps the most important result achieved by Hopkins was presented in his paper for the Royal Society in 1859: he claimed that the actual thickness of the solid crust of the earth must be at least 200 miles.[204] In contrast, the modern research divides the earth into three layers according to their chemical and physical qualities: the hard crust is 5 to 70 kilometres thick, the cover layer is about 2900 kilometres, and the core more than 3000 kilometres thick. The eminent Cambridge mathematician and physicist was slightly misguided by his theories and experiments, but, however, Hopkins's work must have been precious for the next generation of geologists. Perhaps Jules Verne had read Hopkins's studies before he wrote the book, *Voyage au centre de la Terre,* in 1864.[205] It is interesting to notice that in the case of Hopkins's earth experiments science benefited from technology. It raises a question: did science ultimately benefit more from technology than technology did from science in the 19th century Britain?[206]

The last important scientific project with which Fairbairn got involved was the application of iron for military purposes. In 1861, Fairbairn engaged in aiding the Government to build iron ships for war. 'The Wooden Walls of England' i.e. the ships made of timber were becoming nearly useless because the heavy artillery of riffled shells caused bad damage to their hulls from long distance.[207] Fairbairn had for long considered iron the best material for shipbuilding purposes, but he had had difficulties in making the Admiralty to adopt the new materials.[208] Finally, in the late 1850s, the

[203] Ibid., p. 293.
[204] Ibid., p. 308.
[205] Verne, Jules, *Voyage au centre de la Terre,* first published in France in 1864.
[206] Wengenroth 2000, p. 1.
[207] Pole 1877, p. 345.
[208] One important reason for the change to iron was that 'during the eighteenth century and Napoleonic Wars, Britain sacrificed her last great forests to build the ships...'. Headrick 1981, p. 146.

Admiralty decided to follow the example of France and built the iron warship named *Warrior*, which was launched in December 1860. The *Warrior* had some problems in its design, and, according to Pole, 'having already built the ship, they [the Government] began to enquire how they ought to have built her...'.[209] Thus, The Secretary-at-War set up the 'Special Committee of Iron' and both Fairbairn and Pole were selected in it. The committee came to the conclusion that the iron armour-plates placed upon the hull of the vessel were necessary to prevent the damage of the shells. Nevertheless, the plates had to be backed with wood in order to prevent the vibration caused by the shot, to distribute the effect of the blow, to prevent the ship sinking, and to prevent the pieces of shot and shell to entering the ship.[210] Fairbairn attended frequently the meetings and experiments of the Committee and he also published some reports in their proceedings.

In 1865, Fairbairn published the book, *Treatise on Iron Shipbuilding, Its History and Progress*. In the introduction of the book Fairbairn is none too modest:

> '...as one of the pioneers and first experimentalists who proved the value of Iron applied to Shipbuilding, I am probably competent to write on the subject with some authority ... Throughout the work I have sought to inculcate sound principles of construction, and to urge upon constructors the necessity of carrying out this principle, in order to render the Iron Ship what I believe she is destined to become - a bulwark of strength in the defence and security of the British Empire!'[211]

The Crimean War must have influenced Fairbairn's thoughts because he normally did not write about military matters. Perhaps the British Fleet did not fulfil its role as well as expected during the war. However, Fairbairn's writings do not give a picture of the person with a strong sense of militarism.

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209 Pole 1877, p. 350. Pole's criticism is understandable because he was also an engineer.
210 Ibid., pp. 356-358.
211 Fairbairn 1865, pp. 7, 15.

From the 1850s to 1870s Fairbairn published several books and papers on scientific issues.[212] Perhaps the most important of these were the three books published in the 1860s. The first, *Iron: Its History, Properties, and Processes of Manufacture*, was published in 1861, and, Fairbairn proudly wrote in the introduction: 'If we refer to the history of the past, and trace the change from barbarism to a state of intellectual culture, we see at every step the contrivances and appliances of the "cunning workers of iron"'[213]. The second significant work was *Treatise on Mills and Millwork 1 & 2* (1861 & 1863), which remained a standard course book of engineering in the British universities to the end of 19th century. The third book was *Treatise on Iron Shipbuilding* (1865) which is already mentioned.

Fairbairn also wrote several papers for the scientific institutions concerning science policy. In 1858, Fairbairn gave an interesting paper at the meeting of the BAAS in Leeds which was titled 'On the Patent laws'. Fairbairn wanted to develop the patent laws, which were still rather undeveloped in the 1850s if compared to modern age: 'The Patent Law Reform of 1852 was never regarded as a final measure. It was but a first instalment obtained under great difficulty; it only laid the foundation of the superstructure to be raised'.[214] Fairbairn was the owner of some patents, but his applications had also been cancelled few times. Through the BAAS Fairbairn wanted to influence the process of law making, and, thus, to give protection to property in scientific invention. Some people in the British Government were opposing the control over technology, but the anti-patent movement in Britain finally collapsed in the 1870s.[215]

In the 1870s, when Fairbairn was over eighty years old, he still continued to do his research work. In his letter to W. C. Unwin from the year 1872 Fairbairn explains his difficulties:

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[212] A list of Fairbairn's all writings consists of about eighty publications.
[213] Fairbairn 1861, p. 4.
[214] Fairbairn 1859, p. 166.
[215] Aer 1995, p. 85.

> I have an experimental paper on the shearing of rivets and Iron Ship Building which is nearly complete but what from old age ... I am totally unable to finish. If I send it up to you could you find time to review and work out the law of shearing so as to render the experiments useful and satisfactory?[216]

It remains unclear, whether Unwin continued Fairbairn's work or not. Perhaps Fairbairn had already given his best ideas to shipbuilding before the 1870s. In any case, Fairbairn appreciated highly his former secretary W. C. Unwin who became a professor of engineering in the 1870s.

4.3. Promoter of the Engineering Science[217]

Aubrey Burstall quotes William Fairbairn's report of the Paris Exhibition of 1855:

> 'The French and Germans are in advance of us in theoretical knowledge of the principles of the higher branches of industrial art; and I think this arises from the greater facilities afforded by the institutions of those countries for instruction in chemical and mechanical science ... Under the powerful stimulus of self-aggrandisement we have perseveringly advanced the quantity, whilst other nations, less favoured and less bountifully supplied, have been studying with much more care than ourselves the numerous uses to which the material may be applied and are in many cases in advance of us in quality.'[218]

William Fairbairn was deeply worried about the downfall of the status of Britain as the world's leading country of industrial technology. His complaint is understandable because he was an engineer and industrialist who believed that machines would bring wealth and progress to the British society. However, Fairbairn's opinions were largely accepted by the British public because the countries such as Prussia and France had a better system of technical education than in Britain and those countries were growing

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216 Fairbairn, William; *Letter to W. C. Unwin*, 21 November 1872, London University: Imperial College Archives, Room 455.

217 The concept of 'scientific engineering' is difficult to define because engineering can hardly be included within the general pursuit of knowledge according to Baconian natural philosophy. However, engineering was taught in the British universities already in the 19th century as an applied science.

218 Quoted in Burstall 1963, p. 202.

faster in many areas of industrial technology than Britain. According to Donald Cardwell, 'the Exhibition [1851] could almost be taken as symbolic of Britain handing over the torch to other countries in what was the relay race of technology'.[219] However, in the mid-1850s, Britain was still the world's strongest industrial power, and its technological superiority helped to maintain and enlarge the British Empire in the second half of the century. The undeveloped relation between science and technology did not weaken the international status of Britain immediately, but it had serious consequences in the late 19th century and especially in the 20th century. Fairbairn himself lacked university education and suffered from limitations of his knowledge in natural sciences. Furthermore, in the second half of the 19th century time was running off from 'universal geniuses', such as Fairbairn, who were not specialised in a certain area of art or science. However, despite his own weaknesses, Fairbairn was striving for the specialised education of engineers because it was incompetent in Britain compared to some other industrialised countries.

Lord Ashburton wrote to Fairbairn in 1856 (27 January) and explained his views on the problems of technical education: 'If you ask me my present private opinion of the cause of this ignorance, I feel disposed to impute it to the monastic teaching of our universities, which impart to all the special instruction required for the Church'.[220] It is very likely that Fairbairn shared Ashburton's opinions on this subject because he was against the religious education as a part of popular education.[221] Fairbairn explained his views in his presidential address of the BAAS meeting in Manchester in September 1861:

> I shall therefore not dwell so much on the progress of abstract science, important as that is, but shall rather endeavour briefly to examine the applications of science to the useful arts, and

[219] Cardwell 1994, p. 304.
[220] Pole 1877, p. 376.
[221] See the next chapter on Fairbairn's opinions on popular education.

> the result which have followed, and are likely to follow, in the improvement of the condition of society.[222]

Although Fairbairn wanted to present himself as a man of science, his lack of university education prevented him to understand the meaning of science in a similar way as the representatives of the universities did. For Fairbairn, the purpose of science was mainly progress in technology. Furthermore, his address to BAAS was directed to a certain audience that wanted to hear about the progress of engineering science. Above all, Fairbairn was a person who almost blindly believed that science and technology would expand the condition of the society.

Fairbairn wrote the first series of *Useful Information for Engineers* in 1856; a year after the Paris Exhibition. In the section titled 'On a Knowledge of Practical Science' Fairbairn defends theoretical education which was despised by some of the contemporary engineers:

> How very few of our best practitioners in Architecture, and Civil and Mechanical Engineering, are acquainted with the principles, or even with the simplest theoretical rules of their professions; and how often have they to depend upon chance, instead of sound elementary knowledge, for the various constructions on which they elaborate defective, if not abortive results![223]

Fairbairn complained that in Britain there was nothing to compare with the Conservatoire des Arts et Métiers and the Ecole Centrale des Arts et Manufactures in France. Fairbairn thus praised the education system of France, but he does not mention the French Revolution which had been the major cause for the improvements in the French system. In the 1860s, Fairbairn had established his position as the one of the leading industrialists of Britain and the word 'revolution' must have had a rather unpleasant connotation for the people of his class. Probably the only famous British engineer who supported the French Revolution was Thomas

[222] Pole 1877, p. 387.
[223] Fairbairn 1864, p. 2.

Telford in his youth.[224] Fairbairn continues to propagate the importance of Mechanical Arts in the first series of *Useful Information for Engineers*:

> It is true that, that some of our first engineers and some of our most ingenious mechanicians have been men of limited education - men of humble origin, but how more perfect would have been their labours had the emanations of their minds and their subsequent constructions been based upon a wider acquaintance with the unerring laws of natural science![225]

Fairbairn's reference to men with humble origins points to his own childhood in Kelso. It is possible that Fairbairn wanted the university education to be available to everybody although the differences between the social classes were enormous. However, the most important thing for Fairbairn was to provide scientific knowledge to the foremen and managers of industrial works.

As mentioned in the first chapter, the construction of the Britannia Bridge was an important event in the development of the engineering science because the building process could not have been accomplished without scientific investigations. The tests made by Fairbairn and Hodgkinson had a significant role in the design of the bridge. This was Fairbairn's most important work for engineering science. As an active member of the Institution of Civil engineers and the Institution of Mechanical Engineers Fairbairn was able to influence the opinions of the contemporary engineers. Furthermore, he had connections to scientific circles, which enabled him to 'lobby' the universities and the colleges to bring scientific engineering to their curriculums. Eaton Hodgkinson became a first professor of engineering at the University College in 1848. W. C. Unwin, Fairbairn's former secretary, was a professor of engineering first at the Royal East Indian Engineering College at Coopers Hill, and in 1900 he was appointed as the University of London professor of engineering. Professor Unwin, who was also an active supporter of engineering science, argued that 'it is more and more recognised that although an engineer cannot be made in

[224] Buchanan 1989, p. 181.
[225] Fairbairn 1864, p. 5.

college, yet a college education is an essential part of the training of an engineer'.[226] Despite his remarkable age, Fairbairn continued his crusade for the establishment of scientific engineering in Britain in the 1870s. For example, he wrote to *The Times* in October 1873: 'The age of the rule of thumb is at an end, and all the designs and constructions must be founded on the unalterable laws of scientific truth.'[227]

3.4. Gentleman of Science

William Fairbairn was a learned man and one of the leading engineers of his time. However, it has been argued that Fairbairn's lack of university education made him suffer from the sense of inferiority towards the men of science.[228] He was not an educated gentleman, which must have worried him while he was looking forward to get into the scientific societies such as the BAAS. Fairbairn explains his passion for science in the biography:

> I could not, however, suppress the desire I always had of giving to the world such information as I had collected in the varied forms and pursuits of my profession. I confess that nature had endowed me with a strong desire to distinguish myself as a man of science. I was pleased to see myself in print, and the only fear I entertained was the imperfections in style, and the great difficulty I had to encounter in expressing my ideas in a clear and perspicuous manner.[229]

It is rather difficult to understand why Fairbairn had this sense of inferiority to the men of science.[230] After all, he had been selected to the BAAS already in the 1830s and his reputation as a man of science had been rising since that. For example, in the 1860s, Fairbairn received honorary degrees from two British universities: from the University of Edinburgh in 1860 and from the University of Cambridge in 1862. William Whewell, a famous Cambridge professor, congratulated Fairbairn in his letter to him

[226] Buchanan 1985b, p. 229.
[227] Fairbairn 1873, p. 10.
[228] Atkinson 1966, p. 71.
[229] Pole 1877, p. 157.
[230] The term 'men of science' is not used to discriminate women, but it is used because the term 'scientist' was not commonly accepted during this time period.

from May 1862: 'I find that at the Chancellor's suggestion you are to receive an honorary degree on the occasion of his installation. I hope when you come to Cambridge you will consider yourself my guest'.[231] Although Fairbairn was unable to make some mathematical calculations, which were needed in his experiments concerning the properties of iron, he had talented people, such as Eaton Hodgkinson and W. C. Unwin, helping him as scientific advisors. Fairbairn's sense of inferiority can be also interpreted as 'false humility' because he wanted to represent himself as a self-made man in the style created by Samuel Smiles.

It could be argued that Fairbairn's goal to become a gentleman of science derives back to the early 19th century, but this is perhaps too a deterministic view, and the biography of Sir William Fairbairn strengthens this 'predestination' of his life. In the beginning of his career he concentrated on his work as an engineer and manufacturer, which was economically profitable time and enabled him to focus his attention on scientific issues in his later years. In the 1830s, Fairbairn had a flourishing engineering business in Manchester, and during that time he got engaged in the activities of the BAAS. Fairbairn and the BAAS had a symbiotic relationship: Fairbairn gave his skills and money to the disposal of the British Association, which gave Fairbairn the status as a man of science and some funding for his experiments. During the last twenty years of his life Fairbairn received several scientific honours, including the election to the National Institute of France in 1851 and the Royal Society Gold Medal in 1860. In other words, Fairbairn had already in the 1850s established his reputation as a gentleman of science. However, there always remained a certain controversy in his roles as a 'self-made engineer' and a gentleman. Fairbairn's children had already alienated from 'class of the engineers' because they preferred the aristocratic lifestyle of a country gentleman.

[231] Pole 1877, p. 394.

Despite all 'sociological explanations', Fairbairn's role as a gentleman of science was above all achieved by his important work as an engineer and scientist rather than by his 'social skills'. The Carr-Saunders - Wilson approach does not work when explaining Fairbairn's scientific work. One example of Fairbairn's popularity as a man of science was that he received letters from the various kinds of inventors who needed Fairbairn's help to get more credibility for their inventions:

> I got a letter from a person at Ilchester some time ago, saying that a friend of his, a mechanic, ... had discovered a new engine which was likely to supersede steam; and he was a free trader, he had pitched upon me as the only person to whom he would impart his secret.[232]

Probably this secret invention never superseded steam, but was forgotten soon after the inventor realised that he could not make any profit of it.

5. FAIRBAIRN'S IDEAS ON PROGRESS AND SOCIETY

5.1. The Ideas of Technological Progress

William Fairbairn was not a philosopher of science or technology, but he had some interesting ideas on progress and society. His manufacturer's point of view was very different compared to the views of the famous social critics of the 19^{th} century, such as Marx and Engels.[233] More close to Fairbairn's ideas were those pundits who praised the blessings of the industrial development.

Friedrich Engels wrote his famous book, *Condition of the Working Class in England in 1844*, when he was living in Manchester. The book was based on

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[232] Ibid., p. 368.

[233] Karl Marx and Friedrich Engels developed the ideology of communism, the purpose of which is to build a classless society in which private ownership has been abolished and the means of production belong to the community.

his experiences in the city where he worked in a branch of family business. Engels had a good opportunity to study the living conditions in a city that could be described as the intellectual and technological capital of the industrial revolution.[234] According to Engels, the living conditions were dreadful:

> 'Such is the old town of Manchester, and on re-reading my description, I am forced to admit that instead of being exaggerated, it is far from black enough to convey a true impression of the filth, ruin, and uninhabitableness, the defiance of all considerations of cleanliness, ventilation, and health which characterise the construction of this single district, containing at least twenty to thirty thousand inhabitants.'[235]

Engels thought that industrialisation had a negative impact on the lives of the common people. However, the areas that Engels studied were restricted and his ideological background probably influenced his description of Manchester as 'Hell upon Earth'. It has been pointed out that the main reason for the bad living conditions in Manchester was the huge influx of people; the problem, which could not be solved either politically or administratively.[236]

Another explanation on the effects of industrialisation, very different compared to the views of Engels, was presented by Charles Babbage (1792-1871) who was Fairbairn's contemporary.[237] As mentioned before, Babbage's first book, *Reflections on the Decline of Science in England*, influenced strongly the formation of the BAAS. His second book, *On the Economy of Machines and Manufacturers* (1832), was a study of the new technological society that had emerged in Britain. Babbage realised the problems of the developing industrial production system and designed an analytical approach to study

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[234] Cardwell 1994, p. 271.

[235] Engels 1892, pp. 45, 48-53. These page numbers are extracts from Engels's work, *Condition of the Working Class in England in 1844*, which are published on the Internet. The printed copy of the book was not available in reasonable time.

[236] Cardwell 1994, p. 271.

[237] Charles Babbage is probably most well known as the 'inventor of computer'. In 1822, he built the difference engine; the first device that could be considered to be a computer in the modern sense of the word. Fairbairn and Babbage sent letters to each other concerning, for example, the Paris Exhibition of 1855. Pole 1877, p. 372.

it.[238] Cost accountancy was making progress at this time, but the most significant results were made at the level of the firm, not by any individual scholar.[239] Babbage also tried to find a harmony between worker and manager. According to Babbage, a worker needed a certain incentive to co-operate with the manufacturers. He created a bonus system for workers who worked hard. However, Babbage was more concerned about the technological efficiency than the social condition of the workers.

Babbage's views were shared by Andrew Ure (1778-1857), a professor at the University of Glasgow and an enthusiast for the new manufacturing system. In his book, *The Philosophy of the Manufacturers* (1835), Ure explains motivations of a new class, the manufacturers:

> The constant aim and effect of scientific improvement in manufactures are philanthropic, as they tend to relieve the workmen either from the niceties of adjustment which exhaust his mind and fatigue his eyes, or from painful repetition of efforts which distort or wear out his frame.[240]

Thus, Ure did not close his eyes from the poor working conditions, but he highlighted the importance of the mechanisation of the manufacturing industry. He was convinced that industrialisation is beneficial also for the working class. According to Ure, 'the concentration of mechanical talent and activity in the districts of Manchester and Leeds is indescribable by the pen...'[241] Fairbairn surely agreed with Ure on many things, but he probably did not want to get his later reputation. Ure's eulogy of the delights of factory life, particularly for children, together with his attacks on trade unions, made him a target of criticism by Marx and Engels.[242] However, despite their critics, both Ure and Babbage are regarded as pioneers of the modern management science. In his book, *The Exposition of 1851*, Charles Babbage explains his ideas about humanity: 'It is not a bad definition of

[238] Takala 1994, p. 34.
[239] Wilson 1995, p. 30.
[240] Ure 1835, pp. 5-8, 14-15, 20-21, 23, 29-31. These page numbers are extracts from Ure's work, 'The Philosophy of the Manufacturers', which are published on the Internet. The printed copy of the book was not available in reasonable time.
[241] Cardwell 1994, p. 273.
[242] Ibid., pp. 274-275.

"man" to describe him as a "tool-making animal". His earliest contrivances to support uncivilised life were tools of the simplest and rudest construction.'[243] Although Darwin had not yet published *The Origin of Species* (1859), Babbage had already reduced man to a level of animal.[244]

The belief in progress was very common among the 19th century British engineers, and their engineering achievements, such as railway bridges, were the symbols of the industrial progress. However, this belief was also shared by many other people of the 19th century British society. It has been even argued that a belief in progress was an aspect of 19th century religion.[245] As already mentioned, William Fairbairn was a member of the Unitarian congregation in Manchester. It is interesting to study whether his religious faith had any traits of the belief on progress. However, most of Fairbairn's writings concerning the belief in progress are on social or technical matters, which suggests that Fairbairn made a clear distinction between his ecclesiastical and secular ideas.

Fairbairn wrote several times about the progress of engineering and science in Britain. On his third series of *Useful Information for Engineers* Fairbairn wanted to highlight the 'influence of the progress of science and art on society': '...we have a reason to be thankful that we were born in an age of progress, and that we have been witnessed to the introduction of the first principles of science applied to the purposes of everyday existence'.[246] Fairbairn believed, like many of his contemporaries, that the technological development of the 18th and 19th centuries had been a major cause for advances in society. This belief had a strong influence on Fairbairn's thoughts; perhaps it made him blind to some social consequences of industrialisation.

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243 Ibid., p. 277.
244 Some 18th century thinkers had already similar ideas to Darwin. Herbert Spencer (1820-1903), the creator of social Darwinism, was also an engineer.
245 Buchanan 1989, p. 188.

However, Fairbairn had also rather elaborate opinions of some important issues concerning the problems of the mid-Victorian society. Industrialisation had caused the huge increase of pollution, especially in the cities such as London and Manchester, which was also noted by many contemporaries. Fairbairn believed that a qualified engineer could solve the environmental problems with the help of practical science. In 1862, Fairbairn gave a paper on public health for the National Association for the Promotion of Social Science in which he wrote:

> Now we are better housed, better fed, and better clothed than at any former period; and what were luxuries to our forefathers, have to us become the necessaries of life. Nothing, therefore, but a state of war and anarchy would again drive us back to the cheerless homes, and rude enjoyments of a previous state.[247]

Fairbairn admitted that there are some health problems, the drainage system in London being totally inadequate.[248] However, Fairbairn remained optimistic: 'Let us therefore hope that the time is not far distant when we may calculate on the removal of every nuisance affecting the public health, and the utilisation of the products of the drainage of our towns'.[249] Of course, Fairbairn was not worried about the environmental problems in a modern sense, but he wanted to maximise the useful work and minimise the waste. This suggests that Fairbairn had ideas of utilitarianism[250], which was popular in the 19th century Britain.

Another interpretation of Fairbairn's paper on public health is that engineers wanted to increase their business and the status of their profession by participating in the public discussion concerning the environmental problems that were solvable by them. For example,

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[246] Fairbairn 1866, p. 42.
[247] Fairbairn 1862, p. 60.
[248] Ibid., p. 63.
[249] Ibid., p. 64.
[250] Collins Dictionary and Thesaurus (1996) defines utilitarianism as 'doctrine that the morally correct course of action consists in the greatest good for the greatest number, that is, maximising the total benefit resulting, without regard to the distribution of benefits and burdens'. Jeremy Bentham (1748-1832) has been acknowledged as the creator of utilitarianism.

Fairbairn's son-in-law, John Frederic Bateman, had arranged the water supply of Manchester.[251] Fairbairn's interest in public health could be interpreted as a way to provide new employment opportunities for his fellow engineers. Engineers, as well as doctors and lawyers, participated in the public health debates since that often promised the enhancement of the status of their profession and employment opportunities.[252]

In his famous book, *Industrial Biography,* Samuel Smiles quotes Fairbairn's inaugural address as President of the BAAS at Manchester in 1861 concerning the development of machine-tool industry:

> When I first entered this city the whole of the machinery was executed by hand. There were neither planing, slotting, nor shaping machines; and, with the exception of very imperfect lathes and a few drills, the preparatory operations of construction were effected entirely by the hands of workmen. Now everything is done by machine tools with a degree of accuracy, which the unaided hand could never accomplish. The automaton or self-acting machine tool has within itself an almost creative power; in fact, so great are its powers of adaptation that there is no operation of the human hand that it does not imitate.[253]

Fairbairn had similar thoughts as Charles Babbage had presented couple of decades before in his book, *On the Economy of Machines and Manufacturers.* The organisation of industrial work was thus solved by the mechanisation of the manufacturing industry. It could be argued that Fairbairn had evolutionary ideas about machine tools that had 'almost creative powers of adaptation'. However, it is difficult to estimate how much evolutionary ideas affected Fairbairn's religious beliefs and there is no evidence that Fairbairn would have accepted the theories of Darwin or those of Darwin's ideological predecessors.

[251] Pole 1877, p. 158.
[252] Gourvish 1988, p. 35.
[253] William Fairbairn's Presidential address at the meeting of the British Association for the Advancement of Science in Manchester 1861, quoted in Smiles 1863, p. 299.

5.2. Manufacturers, Workers and Trade Unions

Industrialisation caused significant changes in the nature of labour work. There has been lot of discussion among the economic and social historians whether the conditions of the working class became better or worse during the process of industrialisation.[254] At the beginning of the industrialisation the working conditions were surely poor, but the situation became better in the second half of the 19th century even though children and women were still used in some branches of industry. It has also been argued that the industrialisation only brought the poor social conditions of the working class visible. Peter N. Stearns suggests that the workers were in misery from a modern point of view, but whether they felt themselves to be miserable, is far from clear.[255] It is interesting to investigate what a 19th century manufacturer thought about the condition of the working class.

The British engineers were conformists both in their political and religious opinions in the 19th century. Actually, it is very difficult to find any engineer as a political or religious radical in this period.[256] Also Fairbairn was conservative in his opinions concerning the problems of labour in manufacturing industry[257]. However, Fairbairn had some ideas which were not conservative, such as his thoughts on popular education.[258] Fairbairn's conservatism is most visible in his writings that concentrate on economic matters whereas his ideas on religious tolerance were far from conservative.

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[254] See, for example, Stearns 1967, pp. 73-83.
[255] Ibid., p. 127.
[256] Buchanan 1989, p. 181.
[257] The term 'conservative' appeared first in its modern political sense in the Tory-publication *Quarterly Review* in 1830. See Halmesvirta 1999, p. 208.
[258] Fairbairn gave an interesting analysis of his parents' political views in the biography: 'In politics my father was a Liberal, or what was considered in those days a staunch Whig, with a tendency to Jacobinism; but he was never violent, as my mother, who was more Conservative, exercised considerable influence over him, and retained him within the bounds of moderation.' Pole 1877, p. 57. This quotation also suggests that Fairbairn had a conservative ideology.

William Fairbairn's remedy to many problems of the British society was education and especially the education of working class concerned his mind.[259] Fairbairn explains his views in the article, 'On Popular Education', in the second series of *Useful Information for Engineers*: 'There cannot exist a doubt that the safety and well being, and even the very existence of the state, depends on the education of people...'.[260] Fairbairn continues:

> ...we are still far short of a sound national system of education; and it appears questionable, as society is constituted in this country, whether any system which may be called national would ever supply the wants of the different classes into which the population of the kingdom is divided.[261]

Fairbairn was rather pessimistic concerning the development of the national system of education in Britain. However, he believed that the problems of popular education would be removed 'if the different denominations of religionists could agree upon a sound system of secular education, supplemented by some general principles of faith to which no real professor of Christianity would object...'.[262] Fairbairn's thoughts on popular education were relatively liberal and his claim for secular education hints to a certain kind of 'rational religion'. Or perhaps Fairbairn had ecumenical ideas mixed with his Unitarianism. In any case, as most of his contemporaries, Fairbairn considered religious education important for the society, but he would 'leave all matters of belief to the discretion of parents, as regards the principles upon which their children should or should not be educated'.[263] Fairbairn's secular thoughts must have irritated some of his most religious readers.[264] It is rather difficult to imagine why Fairbairn wrote about popular education as a useful information for engineers. Perhaps he wanted to be a 'moral leader of the engineers' during his later years. Samuel Smiles' ideas about self-educated gentlemen certainly affected him. However, Fairbairn wanted that also the working

[259] Education was a typical remedy for the problems of the working class offered by the upper classes in the 19th century and Fairbairn was no exception..
[260] Fairbairn 1860, p. 146.
[261] Ibid., p. 145.
[262] Ibid., p. 146.
[263] Ibid., p. 146.

class, where he also came from, would receive a good basic education, which was rather liberal thinking in the mid-19th century Britain.

On his third series of *Useful Information for Engineers*, Fairbairn examines the role of labour in the British society. The article, 'On Labour, Its Influence and Achievements', is a revealing source for Fairbairn's thoughts. Fairbairn was a strict disciplinarian, and, thus, he states: 'The Great Author of Nature has evidently so constituted our minds and bodies that we should be dependent on labour for our subsistence...'.[265] Fairbairn divides labour into two distinct heads: 'mental and physical or skilled and unskilled' and both of these are 'essential to our existence'.[266] Compared to Charles Babbage, Fairbairn had slightly more humane ideas about workers:

> 'I do not wish to see the working man as a mere machine, but an intelligent and a thinking being; and I am sure he will best consult his own happiness if he studies to cultivate his mind, as a safe guide to the skilful operations of an intelligent workman'.[267] Fairbairn tried to comfort the people who had to work with the self-acting tools or machines: 'This kind of labour is to some extent monotonous, but the attendant's mind is greatly relieved by the combination of motions and the exactitude with which the work is performed...'.[268]

Fairbairn culminates with the achievements of labour to the work of Galileo, Newton, and Watt. Thus, the philosophers[269] and poets were not highly appreciated in his system. Compared to William Whewell, with whom Fairbairn had some collaboration, Fairbairn's perspective to the history of science was very limited, but both men shared the strong belief in progress in science. Fairbairn's reference to his literary interests in the autobiographical part of *The Life of Sir William Fairbairn*[270] could be interpreted rather as snobbery than real interest in literature. The gospel of

[264] According to Buchanan, 'If engineers were muted in their political opinions, they were positively reserved in their religious beliefs'. Buchanan 1989, p. 187.
[265] Fairbairn 1866, p. 43.
[266] Ibid., p. 44.
[267] Ibid., p. 51.
[268] Ibid., p. 52.
[269] Excluding, of course, natural philosophers, such as Bacon and Newton.

labour is emphasised several times in Fairbairn's writings. This can be understood as capitalist rationalism of a manufacturer, but perhaps it was also morally motivated because Fairbairn believed in the practical doctrine of self-help.

As mentioned in the second chapter, in the late 1830s, Fairbairn, together with Robert Smith, invented the riveting machine. The main reason for the invention was that Fairbairn's works at Manchester were stopped by a strike of the boilermakers. William Pole's account on the strike is interesting: 'The construction of automatic machine tools has been much stimulated and improved by the "strikes" and combinations workmen that have taken place from time to time'.[271] Perhaps the working conditions were sometimes so difficult that the manufacturers were nearly forced to make improvements to their mills unless they wanted to cause deaths to their workers. As a manufacturer, who wanted to make as much profit as possible, Fairbairn was against the strikes.

The mechanisation of the manufacturing industry had started to threaten the status of the skilled workmen in the 19th century. After the foundation of the Amalgamated Society of Engineers, the engineering workmen[272] went on strike in 1851 because they wanted to protect their apprenticeship regulations. According to Pole, over 50,000 people went on strike in England and the strikers were threatening the employers with a social revolution.[273] Fairbairn had no active role in the proceedings of the Committee of Associated Employers, but his son, Thomas, wrote several letters to *The Times* with the signature 'Amicus' and caused much discussion concerning the labour question. William Fairbairn was probably

[270] Pole 1877, p. 74. Fairbairn lists that his favourite writers were Gibbon, Hume, Milton, Shakespeare, Cowper, Burns, and some other more or less famous thinkers and playwrights.
[271] Ibid., p. 46.
[272] The term 'engineer' was still a vague concept in the mid-19th century Britain; the engineering workmen were not engineers, but skilled artisans.
[273] Pole 1877, p. 323.

also against the strike, but he did not present his opinions to the public. Although William Fairbairn wanted to give a picture of him as a 'self-made engineer' who had rose from 'rags to riches' he was alienated from the working class in the 1850s.

Fairbairn did not accept the rise of the trade unions in the second half of the 19th century. Lord Shaftesbury, who was 'a well-known friend of the working classes'[274], wrote to Fairbairn and explained his views concerning the strike. Fairbairn answered to Shaftesbury in December 1851:

> The whole course of your public life, and your unwearied and most disinterested labours for the amelioration of the moral and physical condition of helpless children, women, and all the working class, were to my mind a sure quarantee that the promulgation of socialist doctrines would receive your resistance, from whatever quarter they might spring.[275]

Fairbairn opposed the ideas of socialism, which could be expected considering his background. Actually, almost all 19th century engineers were only interested in maintaining the consensus among their own organisations.[276] Trade unions were a threat to engineers because they represented social organisations of the working class from which the engineers had disintegrated during the process of industrialisation. In the article, 'On popular education', Fairbairn warns his young readers of the dangers of the trade unions: 'In such career there is honour and comfort, and provided his mind is not poisoned and his independence destroyed by unions and trade clubs, he may calculate on a prosperous life and a respected old age'.[277] Fairbairn's concern about the destruction of man's independence by the trade unions suggests that he was well aware of Samuel Smiles' *Self Help*. Fairbairn identified himself with the 'True Gentleman' who came from the humble origins, but who had made good for himself by his moral character. Fairbairn thus agreed with Smiles on the

[274] Ibid., p. 324. It is difficult to find Fairbairn's own opinions from Pole's account of the biography. It is possible that Fairbairn's views concerning the strike were slightly more moderate than Pole's.
[275] Ibid., p. 326.
[276] Buchanan 1989, p. 183.
[277] Fairbairn 1860, p. 160.

issues related to individuality and he rather idealistically believed that any man, regardless of his social class, could be a 'True Gentleman'.

6. *THE LIFE AND WORK OF SIR WILLIAM FAIRBAIRN IN THE HISTORY OF THE ENGINEERING PROFESSION IN THE 19TH CENTURY BRITAIN*

Harold Perkin's argument is that the modern world is the world of the professional expert and also the engineers are included in this elite group. Although his theory about the rise of the professional society is perceptive insight into modern social history, it does not fit very well to the history of the engineering profession in Britain.[278] The status of the engineering profession in Britain was at its highest peak in the middle of the 19th century, but it started to decrease in the last decades of the century. This was due to the proliferation of the engineering institutions, which continued to the 20th century. The engineers did not manage to promote their interests as a single professional group, which resulted in the lower status and the reduction of power of engineers in the late Victorian society. Furthermore, Harold Perkin's cyclical approach to the history of professionalisation is too deterministic; the engineers did not make a social revolution, but they simply seized the opportunity offered by the industrialisation to gain more wealth and credibility. The Carr-Saunders - Wilson approach is an important tool when writing the institutional history of the engineering profession. However, it should be used carefully in order to avoid over-simplification of history. The engineers, such as William Fairbairn, were not always intentionally developing their profession when they were seeking wealth and prestige in the British society, but they also wanted to participate to the work of the professional engineering institutions.

[278] However, it should be noted that Perkin's ideas are far more relevant now, at the beginning of the 21st century. For example, the power of the medical profession in the modern world is remarkable.

The institutionalisation of the engineering profession in the 19^{th} century Britain was a complex process and the case study of an individual engineer can only explain a part of it. William Fairbairn was not a typical 19^{th} century engineer: there were over fifty thousand people present at his funeral. William Fairbairn influenced the development of several branches of engineering and his company in Manchester gained an international reputation. Perhaps Fairbairn used the engineering institutions as 'vehicles' for career making, but this should not be exaggerated because Fairbairn wanted to further the development of the profession. Although it is an exaggeration to say that 'Fairbairn abolished the millwright and introduced the mechanical engineer'[279], his work influenced largely the development of the several branches of mechanical engineering. The period from the 1830s to 1860s was a prosperous time especially for the mechanical engineers due to the development of the new technologies such as railway locomotive and new machine tools. Fairbairn's last address at the meeting of the Manchester Scientific and Mechanical Society in October 1873, which is quoted in the introduction, is a revealing source for Fairbairn's thoughts about the great change in engineering and technology which had occurred during his lifetime. Fairbairn did not mention himself, but it could be argued, without 'hero-worshipping', that he was one of the machine tool geniuses of the 19^{th} century Britain.

Fairbairn's most enduring achievement as an engineer was his work with iron ships. The Millwall shipbuilding factory was not economically profitable, but it helped Fairbairn to become an expert in iron shipbuilding. Thus, in the 1850s and 1860s, he was consulted by the Admiralty in order to build better ships for war. The Britannia Bridge has often been mentioned as a state-of-the-art work in the history of engineering and technology. However, due to later developments, it has been criticised on account of the cost and quantity of material used. In any case, Fairbairn's role in the history of the Britannia Bridge has been neglected by the historians of technology. Perhaps Robert Stephenson did not consciously want to reduce Fairbairn's role in the bridge-building process, but he was surely pleased to be distinguished as the designer of the Britannia Bridge. The Fairbairn Engineering Company Limited survived only nine months after the death of Fairbairn. It was an example of unsuccessful attempts to apply new regulations of industrial capitalism, such as limited liability, to business enterprise. Sir William Fairbairn was soon forgotten after his death by the general public because he was not a great inventor.

In the 1830s, after Fairbairn had achieved enough reputation and capital as an engineer, he wanted to become distinguished as a man of science. Fairbairn suffered from the lack of scientific education, which caused him a sense of inferiority to men of science. Perhaps this was the main reason for Fairbairn's endeavour for scientific eminence. Fairbairn's symbiotic relationship with the British Association for the Advancement of Science was very profitable although the main beneficiary of the collaboration was Eaton Hodgkinson. Fairbairn joined many ambitious scientific projects as a technical consultant and was a well-known figure in the scientific circles. However, he never became a celebrated scientist because he mainly concentrated on adapting the natural sciences for practical purposes and vice versa.

The case study of Sir William Fairbairn offers some further evidence to Margaret C. Jacob's cultural argument: Fairbairn did receive his scientific knowledge without the help of institutionalised scientific education. He was educated mainly through his practical work as an engineer and through the scientific societies, such as Manchester Literary and Philosophical Society. However, Fairbairn became a strong promoter of scientific engineering in the second half of the 19th century. The time of the 'universal geniuses', such as William Fairbairn, was almost over in the 19th

[279] Hayward 1977, p. 18.

century, but Fairbairn was aware of his deficiencies in scientific knowledge. It could be argued that William Fairbairn represents a link between science and technology during the process of industrialisation. The editor of *The Life of Sir William Fairbairn*, William Pole, was himself a professor of engineering and he might have highlighted Fairbairn's role as a promoter of scientific engineering because it also served his own interests. However, also the other source material of the study gives evidence on Fairbairn's strong devotion to this subject.[280]

The lack of scientific education of engineers was an important reason for the fall of the British industrial competence compared to some other industrialised countries in the last decades of the 19th century. The growing foreign competition and the relatively weak results of the International Exhibitions (1851, 1855, 1862, and 1867) forced the decision makers to further the relationship between engineers and the men of science in the second half of the century. However, despite the efforts of some individuals, such as William Fairbairn, the education of engineers remained rather practical because both the engineering associations and the universities resisted the development of the engineering science.[281] It is difficult to estimate the significance of Fairbairn's efforts to promote the engineering science. That issue was close to his heart and he definitely had an influence on the adaptation of engineering science to universities in the late 19th century.

While studying the ideas and beliefs of Sir William Fairbairn, it is important to take into account that they surely changed during his long working career which lasted from the 1810s to 1870s. The source material of this thesis concerning Fairbairn's ideas and beliefs is mainly from the 1850s and 1860s when he was already over sixty years old. Furthermore, William Pole may have mixed his own ideas to the biography. However, Fairbairn

[280] See, for example, Burstall 1963, p. 202 and Guagnini 1993, p. 27-32.
[281] Guagnini 1993, p. 17.

had very clear ideas concerning the progress in science and technology, which he presented, for example, in the series of *Useful Information for Engineers*. Fairbairn lived during the time period when the adaptation of natural sciences to industry became increasingly profitable, and from his manufacturer's point of view the industrialisation was the only way to develop the British society. He also believed that science and technology could ultimately solve the problems of industrialisation and urbanisation, such as waste treatment and poor working conditions. Charles Babbage and Andrew Ure had an influence on Fairbairn's thoughts, but Fairbairn had no own theory on the division of the industrial labour; he just believed in the mechanisation of the manufacturing industry in general. It is tempting but anachronistic to describe Fairbairn's ideology with a modern term as technocratic. The relationship between science and religion did not cause serious problems to Fairbairn because he had a very rational approach towards religious issues. Although Fairbairn was a member of the Unitarian congregation in Manchester, he was open to secular ideas such as religious-free education, which should be made available also for the working class. Fairbairn was a strict disciplinarian and his praise for labour is culminated in the work of the early industrialists, such as Smeaton and Watt.[282] The gospel of labour could be interpreted only as Fairbairn's logical capitalistic thinking, but it could be also interpreted as morally motivated because Fairbairn believed in the practical doctrine of self-help. Fairbairn's conservatism was mainly only manufacturer's self-interest of his business. Fairbairn had no philanthropical ideas and he opposed the ideas of socialism and trade unions because they destroyed the independence of man. Above all, Fairbairn wanted to give a picture of himself as a 'True Gentleman' in a style of Samuel Smiles.

It has been claimed that one reason for the British industrial decline was the gentrification of the industrialists, but this is exaggeration because only a small percentage of them became part of the gentry. Some of them did not

[282] Pole 1877, pp. 14-20.

even want to become members of the old aristocracy. Thus, R. A. Buchanan goes too far in his generalisation that the engineering profession had 'within a century won recognition of its members as being not only gentlemen, as would be required of any acceptable professional body, but as aspirants to social gentility'[283]. Sir William Fairbairn was one of the engineers who achieved the status of gentleman mainly by his engineering works although he also used the engineering and scientific institutions as 'vehicles' for career making. Pole's account on the biography highlights Fairbairn's world-wide reputation and honorific titles, but Fairbairn himself was not especially interested in them. However, in the second half of the 19th century the Fairbairn family could not avoid the trappings of gentrification; Fairbairn turned into a public figure and his sons preferred the lifestyle of aristocracy. Fairbairn was the archetype of Samuel Smiles' 'True Gentleman' and he also knew that. Thus, Fairbairn's references to his humble background can be also interpreted as false humility. Above all, Fairbairn wanted to present himself as a self-help man and gentleman of science, but he did not want to associate himself with the aristocracy because it represented him the 'class of the idle'. Although Smiles claimed that true gentlemanliness was within the reach of any virtuous Briton, the case of William Fairbairn was a rare exception of the upward social mobility. The myth of the self-made man was popular among the industrialist class, but in reality, only few engineers were as successful as Fairbairn.

This study has investigated Sir William Fairbairn's different roles in the history of the British engineering profession. However, it should be kept in mind that the engineer, the manufacturer, and the public figure were the same person. Thus, all his goals and endeavours were interwoven. Furthermore, it is even more difficult to separate Fairbairn's role as scientist from the three roles mentioned above. The case study of Sir William Fairbairn has given some insights to the history of the engineering

[283] Buchanan 1989, p. 192.

profession in the 19th century Britain. Fairbairn was not a typical 19th century British engineer, and, thus, the study of his life and work can only explain a small part of the history of the engineering profession. However, Fairbairn's work for the mechanical engineering was important for the development of the whole profession. The relationship between science and technology in the British industry changed remarkably during Fairbairn's life in the 19th century, and his perspective on this process has been the most valuable finding of this study. Development of the applied sciences in the 19th century was a difficult process to comprehend for the contemporaries, and Fairbairn was among the first British industrialists who realised the possibilities offered by the symbiosis of science and technology. For further research, the history of the ideas of technological progress, concentrating on the ideas of philosophers of the manufacturing industry, such as Andrew Ure, Charles Babbage and Frederick W. Taylor, are especially interesting. Another idea for further research would be to narrow the gap between Margaret C. Jacob's cultural argument and R. A. Buchanan's institutional approach in the study of the relation between the history of science and the history of technology. The institutionalisation of technological education as an intentional effort to promote industrial development is an important phenomenon in understanding the science-technology relationship in 19th century Britain.

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