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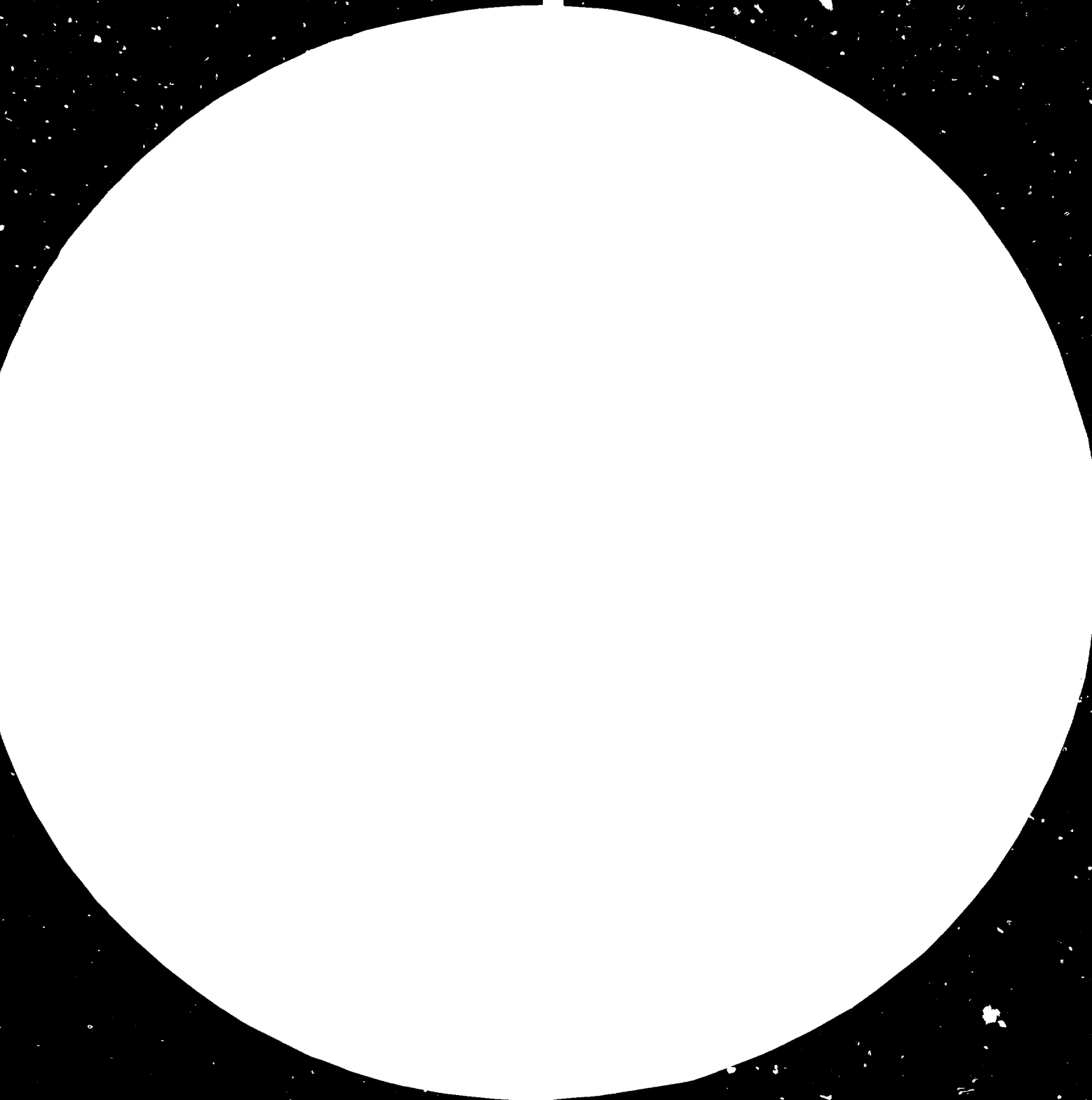
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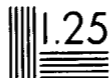
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**ENGINEERING, TECHNICAL EDUCATION  
AND INDUSTRIALIZATION**

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1 INTRODUCTION

Economic growth and industrial performance has been studied by economists and economic historians for several decades. During the post-war period the interest in these studies increased substantially and new insights into the growth process were gained. This was especially the result of the "discovery" of the residual or "technic" factor, but also a result of a growing concern with the economic progress - or the absence of such progress - of the Third World. It was established that a country's economic growth was to a large extent explained by factors other than inputs of physical capital and labour only. In this context, investments in education, i. e. "human capital", and technological change are of paramount importance.

In the entire process of growth and in the industrial performance, the engineer is an important factor, especially at the innovatory stage, when basic research and new inventions are put to economic use. A thorough theoretical and practical technical education is necessary and has been so at least from those nineteenth-century years when the science-based industries generally assumed a leading position in the industrial sector of the economies.

However, although matters such as business organisation and costs on Research and Development (R & D) have been scrutinised for various countries, studies applying the results of this research to industry are relatively scarce; and although the quality of education in various countries has been discussed - for the twentieth as well as the nineteenth century - there has been little explicit discussion concerning the extent of the technical education system in general on a quantitative and comparative basis, let alone any investigation into a specific type of technical education. One reason for this is seen in the countries' unsatisfactory national statistics and consequently our limited knowledge of the number of qualified and professionally active engineers during different periods of time.

In my study Engineers and Industrial Growth<sup>1)</sup> the purpose has been to increase our knowledge concerning the highly qualified engineers, i. e. those with an education from schools which were already, or were later in the nineteenth century converted into, technical universities. Calculations and estimations of their number and choice of careers makes it possible to present a discussion from partly new angles of approach concerning the reason for and content of an institutionalised technical education, the demand for highly qualified engineers, the social status of an education and career in engineering, etc.

Although it is impossible to measure the importance of a specific type of engineer in the growth process, especially at a highly aggregated level, the similarities and deviations found between the studied countries - England, France, Germany and Sweden during the 19th and early 20th centuries - indicate, and support, the contention that highly qualified engineers played an essential part in the process of industrial growth. When engineers with lower formal qualifications are also taken into account, the main result of the study is strengthened; of course, the technical education of man-power at all levels must be considered in a nation's educational system.

In the present paper the main findings of the study are presented in Section 2.

Certain conclusions are stressed further in the final Section 3 and dissimilarities between the developed nations today, in their early industrialisation, and the developing countries are pointed at. Hypothetically the positive implications of investments in an institutionalised technical education in the developing countries are emphasised.

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1) The full title is Engineers and Industrial Growth. Higher Technical Education and the Engineering Profession During the Nineteenth and Early Twentieth Centuries: France, Germany, Sweden and England. London, Croom Helm, 1982.

## 2 QUALIFIED ENGINEERS AND ENGINEERING - SOME FINDINGS FROM THE INDUSTRIALISED WORLD

### 2.1 Engineering Education

- Content, Organisation, Purpose
- Number of Engineers

It may sound trite to say that technical education has always existed in one way or another. The knowledge of how to make things has always been taught; father to son, man to man, master to apprentice. However, it is only when technical knowledge was brought into institutionalised forms that we can speak of a formal system of technical education. It was towards the end of the eighteenth century that this type of education was developed; first in France, then in the nineteenth century in the Austrian monarchy and the German states. The education was also adopted in Sweden.

In England, on the other hand, the idea of "learning by doing" was predominant, along with a long-lasting belief in the "practical man".

In the case of England however, the pioneering country of the first industrial "revolution" in the late eighteenth and early nineteenth centuries - for the sake of simplicity we retain the expression "revolution" - it should be made clear that a technical education based on the principle of "learning by doing", "trial and error", etc., empiricism playing a vital part, was adequate.

But at later stages in the process of industrial performance, with the growing and soon dominating importance of science and its application in industry, this type of education became insufficient. An adequate education for persons in industry, especially for those in leading positions, now meant - in England as well as on the Continent - a qualified theoretical and practical education based on scientific principles.



Thus, it is clear that a scientific education for occupations within industry was for a long time non-existent in England and the only technical education of a more extensive character during the early half of the 19th century was the kind offered at the Mechanics' Institutes, a large number of training centres founded during the 1820s. However, the activity at these institutes was on a lower level, technical as well as social, and could not become the base for a qualified technical education system.

Voices in favour of founding a system of the continental type in England were heard from early on and especially in connection with the international industrial exhibitions during the second half of the 19th century. These exhibitions showed a continuous relative English decline in the international competition, after her great success in the Great Exhibition in London in 1851.

However, despite several public investigations concerning the technical education in England and other countries, very little happened and not until 1889 did the first Technical Instruction Act come into being. From the 1880s onwards technical colleges were founded, but it was only when the Imperial College of Science and Technology was founded in the early 20th century out of three London higher technical institutions from the 1840s, 1850s and 1880s - the Royal College of Chemistry, the Royal School of Mines, the Royal College of Science - that England received a concentrated institution of importance for higher technical education.

By international standards however, the number of students in technology/engineering remained low and at the time of World War I the total number of English full-time students in science and technology at universities, colleges and technical institutes was only about 3.000. Almost half of these were studying at the technical institutes, which offered a training at a somewhat lower technical level, while a large proportion of the other formally more qualified students was studying at the classical universities, preferable in the pure sciences - not in engineering.

The institutionalised higher technical education on the Continent was introduced at the end of the 18th century and the beginning of the 19th. As was mentioned above France was the pioneering country and especially the establishment of the École Polytechnique and its specialisation schools meant something complete new. École Polytechnique and schools like the École des Mines, the École des Ponts et Chaussées and the École Centrale des Arts et Manufactures (not a specialisation school for the Polytechnique) were - and still are - among the most prestigious French engineering schools, the Grandes Écoles.

The French system was important to the development in the German-speaking states and influenced the creation of technical schools of a new type, the Gewerbeinstitut. These schools, which were founded from the 1820s onwards, later developed into technical universities, the Technische Hochschulen. The principle of the Fachschule - i. e. specialisation within the school, introduced in the early 1830s - was from an organisational point of view basic in the German development.

Generally seen - and taking into account the technical education at all levels - the German system of education was imitated in Sweden.

The explicit purpose of the institutionalised technical education in all three countries was to improve the national industry. It was realised that the means to attain this was a thorough - according to the standards of the time - technical education, which should include both theoretical and practical components. The latest knowledge gained in the field of science was considered an important element in the training. Consequently, "scientific" principles in a technical education based on mathematics were introduced at an early stage.

Normally, the schools - which in no sense were related to the classical universities - were founded by the government, often together with private individuals, in order to provide the public and private sector of the economy with qualified engineers.

The result of the educational policy in terms of number of highly qualified engineers in the three countries at various points in time is shown in the table below.<sup>2)</sup>

	<u>France</u>	<u>Germany</u>	<u>Sweden</u>
1850/54	7.100	4.000	1.700
1870/74	12.700	13.200	1.200
1890/94	22.800	34.000	1.700
1910/14	40.600	62.600	3.300

It should be noted that in the middle of the 19th century the total number of these engineers in France was almost double the German figure, while twenty years later - when 'Germany' had become a political entity - the German figure exceeded the French. At the time of World War I France had around 40.000 highly qualified engineers, while the German number exceeded this figure by more than 50 per cent.

However, as a proportion of the economically active male population, there were from the 1880s onwards no significant differences between France and Germany and at the time of World War I there were three qualified engineers per thousand of the economically active male population in both countries. The corresponding figure for Sweden at that time was two per thousand.

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2) These figures are extracts from Ahlström, op. cit., Table 2.1., p 38. My methods of calculation the number of practicing engineers are presented in the book. For annual numbers of qualified engineers in France, Germany and Sweden 1800-1914, see pp 106-108.

Taking also engineers with lower theoretical and technical qualifications into account, one can recognize an educational hierarchy, looking like a pyramid, with the highly qualified engineers on top, engineers with lower qualifications on a second level and at a third and lowest level, industrial workers. The "pyramid" describes well the German and Swedish pattern, while the French education of theoretically trained engineers for middle range position was conspicuously small.

## 2.2 Demand for and Careers of the Engineers

Technical education does not by itself create a modern industry. There must also be a demand for engineers. That a market for engineers existed in Germany from early on is a fact and, for example, Lyon Playfair in his Industrial Instruction on the Continent (1852) emphasised the large demand for the engineers graduated from the Gewerbeinstitut. It is also clear that a dominating proportion of the German industry, irrespectively of company size, towards the end of the 19th century and onwards possessed technically qualified engineers in management and leading positions.

In Sweden, like in Germany, qualified engineers went into all fields of occupation, but especially industry, and a dominating proportion to the private sector. The demand for them was great, and to a large extent they reached leading positions rather quickly.

Against the background that engineers with an advanced technical education were supposed to hold leading positions in the industrial activities and that the engineers in production and design in the private sector especially were considered to be essential to this process, the French case is notable. Thus, the aggregate figures on the stock of engineers at various times conceal the fact that in France a comparatively small number was active within industry, particularly in the private sector. This was actually the reason why the École Centrale des Arts et Manufactures was founded (1829), as the demand of

the private sector for qualified engineers was not met by the École Polytechnique and its specialisation schools. For example, only 10-30 per cent of the École des Mines (Paris) graduates were active within the private industry from 1830 up to World War I, and less than 10 per cent of the École Polytechnique graduates during 1870-1914. While almost 80 per cent of the polytechniciens during this period chose a purely military career, two thirds of those who joined the Corps Civil were in civil engineering - and of course were of greatest importance here in building up the French infrastructure.

But only a small proportion was active within production and design. It should be emphasised though, that École Polytechnique graduates as well as graduates from, for example, École des Mines and École Centrale were active within all types of French industries, where they rapidly attained leading positions. However, although the Grandes Écoles engineers in production and design were comparatively few in number, they were to a large extent responsible for the pioneering tradition of French industry.

The conditions of demand for and careers of the engineers in England are in a sense more clear. Thus, it is a fact that the demand for highly qualified engineers was low and that the engineers' chances of entering a career leading to a top post within business were small. This was also reflected in the difficulties of recruiting students to those few higher technical institutions that did exist.

A survey of the careers of 850 students from the Royal College of Science and Royal School of Mines during the second half of the 19th century, illustrate the careers of the qualified English engineers.<sup>3)</sup> It was found that only 20 per cent had entered industry at some stage in their careers, and that the majority of those who spent some time in industry entered mining and brewing and frequently held

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3) See Roderick, G.W., Stephens, M. Education and Industry in the Nineteenth Century, London, Longman, 1978, p 106.

positions in the inspectorate - but not in management or research. About one third went abroad, and a slightly lower per cent entered the teaching profession.

We can now and then read that in case of England there was - and still is - a "lack" or "shortage" of qualified engineers in industry as well as in government and the public sector. However, it must be emphasised that from a pure economical point of view it is incorrect to use such a terminology when there was no demand for these engineers. In such a situation it is better to use the term "unmet need" - an expression coined by J. Jewkes<sup>4)</sup> - a term implying that not merely the supply but the demand, too, was inadequate. Various ways of identifying a situation of an "unmet need" are available. One of these is establishment of positive correlations between industrial output and number of scientists and engineers employed in industry - on the presumption that an increase in the number of these personal categories will increase industrial production - another is by making international comparisons.

In order to get plausible answers to issues concerning supply, demand and careers of the engineers it is necessary to consider the cultural and social aspects of technology and engineering in the various countries.

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4) Jewkes, J. "How much Science?", The Economic Journal Vol. LXX, 1960, p 3.

### 2.3 Cultural Aspects on the Engineer and Engineering Occupations

Like most students in higher education in nineteenth-century Europe, those in higher technical education in France, Germany and Sweden were usually drawn from the middle class, but a notably large and growing proportion came from the upper class. From the very beginning of the century, France appears to have had a slightly larger number of upper-class students in the technical fields than the other countries and it is also notable that France around 1800 was the only country where the engineering activity could be considered a learned profession.<sup>5)</sup> This was mainly the result of the standing of the higher technical education in the country. In the middle of the century, France also obtained its national organisation of non-military engineers - la Société des Ingénieurs Civils - out of the student organisation of École Centrale. A national organisation of this type is important to the furthering of the professional interest of the engineers.

In the German states there was a rapid development towards professional status of the engineers in connection with the founding of the Gewerbe institutes and the associations formed by former students at these schools. In the 1850s the German engineers established their national Verein Deutscher Ingenieure. A similar development - but with a certain lag - can be seen in Sweden.

The status of higher technical education in Germany was growing during the nineteenth century in connection with the rapidly increasing interest in science and Technik. Around 1900, the German technical universities also formally retained the same status as the classical university through the right to confer doctor's degrees. Also in this respect the Swedish development - and again with a certain lag - was similar to the German one.

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5) A profession is defined as an occupation whose members possess a high degree of specialised, theoretical knowledge, are expected to carry out their tasks while taking certain ethical rules into account, and are held together by a strong sense of esprit de corps arising from a common education and adherence to certain doctrines and methods. See Ahlström, op. cit., p. 22.

In France, however, the engineering activity as such does not generally seem to have had a high status. This may seem somewhat paradoxical, considering that entrance requirements to French engineering schools have always been high. In comparison with the situation in Sweden, for example, the competition for a place at the most prominent engineering school was - and is - much harder.

The assertion made here concerning the engineering activity is based on information supplied in the secondary literature and on information regarding the choice of careers of the Grandes Écoles students. The choice of occupational fields showed that on the whole only a small number of the Grandes Écoles graduates were active within engineering in any real sense. Thus it seems reasonable to conclude that the prestige which goes with a degree from one of the leading Grandes Écoles was and has always been high, whereas the engineering occupation as such has generally, but above all in mechanical engineering, had a lower status in the French society. A career in public service - the French "technocrats" have an old history - particularly a military one, or the kind one might expect on joining the Corps Civil as a civil engineer, was more attractive. In general terms, it seems reasonable to speak of social differences in this respect between France on one hand and Germany and Sweden on the other.

In many respects England deviated - and still deviates - from the development in France, Germany and Sweden. This has been shown or indicated above concerning the institutional and organisational aspects of engineering education, the number and qualifications of the engineers, the demand for them, their career patterns, etc. It is only concerning the cultural and social aspects of engineering occupations it is possible to establish similarities between England and France, i. e. with regards to the low social standing of this type of activity.



The reasons for the slow and deviating development in England can be explained by three factors and/or indicators, which of course are strongly interrelated.

The first of these - the low general demand for technical education, as it was manifested in industry's demand for the theoretically and practically educated engineers - has already been mentioned. However, one consequence of only employing a small number of persons with a scientific and technical education, especially in higher management, has not been emphasised: Of course, it produced generations of employers who failed to appreciate the place of scientific and technical knowledge in industry. It is here reasonable to talk about a hereditary transmission of valuations.

The second factor concerns the development of engineering as a profession in the English society, which in comparison with the development in the other countries must be considered as unsatisfactory. This is especially the case with regard to the comprehensiveness of the theoretical basis - i. e. the existence and use of technical institutions in the training of the engineers - but also concerning the degree of esprit de corps, which is reflected in the professional organisation.

The history of the English engineering organisations goes back to the 18th century and in the second decade of the 19th century the engineers in civil engineering were organised on a national level. However, the mechanical engineers were not organised on a national level until 1847 and then it was seen as an act of retaliation against the civil engineers, who looked down upon the mechanicals. It is notable that it is only in the beginning of the 1960s that the various English engineering organisations created an national organisation in the common interests of the engineer.

In order to become a member of an engineering organisation on the Continent or in Sweden, a specific theoretical-technical education was required. In England the responsibility of evaluating a person's qualifications for membership had to be considered by the organisation in every single case, something that, of course, was the consequence of the leading principle of professional education in England - apprenticeship. Written examinations for membership, to avoid arbitrariness, were introduced very late; the Institution of Civil Engineers did so in 1897 and the Institution of Mechanical Engineers in 1912.

The third factor and/or indicator is connected with the society's view of activities entailing science and engineering, especially among the upper and middle classes.

Before the industrial revolution, the social structure in England only possessed one essential division, the one between the gentility and the common people. The industrial revolution meant a possibility of crossing this divide and become a gentleman, an existence characterised by living idly and without manual labour. However, it is obvious that - to quote D. C. Coleman - "When the business and technological drive of the English industrial revolution loses some of its momentum in the later nineteenth century perhaps, /.../ it is because too many of the revolutionaries are too busy becoming gentlemen".<sup>6)</sup>

The gentleman should be educated, a process undergone at the public schools and the classical universities. Pure science was included in this education - as an intellectual exercise - but not technology/engineering.

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6) Coleman, D.C. "Gentlemen and Players", Economic History Review, 2nd Series, Vol. XXVI:1, 1973, p 97.

The most serious consequence of this educational ideal was - and still is - that intellectual talents were attracted to fields of work and careers which did not, at least not directly, stimulate the industrial development.

The reason for the passive role played by various governments is also to be found in the social attitudes of a distinguished class society. Political leaders, the civil service and those who sat on the boards of the chief industrial companies, i. e. "the establishment" were themselves - to quote G.C. Allen in his The British Disease - "the victims of anachronistic institutions".<sup>7)</sup> He refers here to the English class system and the educational arrangements associated with it.

#### 2.4 Some conclusions

In an indicative way it has been possible to show the relevance of the contemporary - and, looking back, self-evident - view concerning the need for qualified engineers within industry, especially in leading functions. The availability of a large number of these engineers was important for the industrial performance of the countries.

Germany stands out here as the successful case in point. This also goes for Sweden, although the number of highly qualified engineers as a proportion of the economically active male population was somewhat lower in that country than in Germany, as well as in France. But in the case of France the number of highly qualified engineers active within the industry in production and design was more limited; in addition, there were too few engineers and technicians for middle-range positions. In England there was generally an "unmet need" for qualified engineers but especially for those with a highly qualified technical education, i. e. demand and supply were both too small for the nation's industrial needs.

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7) Allen, G.C. The British Disease, London, The Garden City Press Ltd, 1979, p 48.

It is a fact that from the latter half of the 19th century, the structure of British industry in comparison with the other countries - especially Germany - was superannuated, and that the passage of time exacerbated the problem. Besides, the growth of the British industry was lower than in Germany, but not - at least not in a long-term perspective - lower than in France.

From a technological point of view, however, there were general differences between Britain and the Continent. The relative British decline has to a large extent been discussed in the context of Britain's being the first nation in the world to become industrialised and her consequent inability and unwillingness to adjust the economy to changed industrial-technological conditions. There are important sociological and cultural reasons for supporting this view. However, from a purely economical and theoretical point of view, the idea that being the first in the process of industrialisation necessarily constitutes a disadvantage is hardly a convincing argument. It is thus equally possible to argue for the advantage of "forwardness" in a period of accelerated technological change.

But this is not the place to develop and take a definite stand among the arguments concerning the relative merits of being "first" in the industrialisation process, i. e. a stand that forms a kind of objective view. It is a very difficult issue and boils down to a question of the relative weight of various factors, factors which are not easy - often impossible - to identify, isolate and measure.

At the base of such a discussion, though, there must be a question as to what choice of investments and industrial technologies was made. Normally, the various kinds of action taken here were the results of decisions made by individuals in management and leading positions in firms and companies. The "right" decision always requires a thorough knowledge of the market and the industrial pro-

cesses, from a technological point of view too. The long-term views are vital, i. e. the ability to see the development and growth potentials of an investment.

Whether the long-term perspectives have been foreseen can only be established with the aid of hindsight, but here most studies indicate a general British failure - and there is no getting past the need for generalisations. Behind all such indicators and symptoms - for example, that the best British practices were not on the technological frontier, that entrepreneurship and technology was defensive, that British innovations were exploited more rapidly and effectively abroad, the great contribution to industrial technique made by people of foreign birth and training or by Britons with foreign training - we find the engineer and his technical qualification, mostly in production and design. The British "unmet need" for qualified engineers must - to take an expression from Saul in his discussion of the British preference for the practical rather than the theoretically-trained man - be seen as "a legacy of an early start in industrialization...."<sup>8)</sup> In this respect it is relevant to talk of the pioneer's disadvantage - not because of any inherent necessity, but because earlier industrial successes had caused effects of a social and cultural kind, which at later stages in the industrial development worked against the introduction and acceptance of a necessary advanced technical education.

The low social esteem in which the English engineer was held, and his limited career chances, were also part of these effects. The Continental pattern of technical education in general, but especially at the highest level, the number of the engineers, their careers and positions, and the various technological and industrial performances of France, Germany and Sweden strongly indicate the importance of the qualified engineer in the process of growth in the 19th and early 20th centuries.

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8) Saul, S.B. The Myth of the Great Depression 1873-1896, London, The Macmillan Press Ltd, 1968, p 48.

In spite of all changes during later decades, the main part of the established characteristics of the countries are still relevant.

### 3 PRECONDITIONS FOR INDUSTRIALISATION - THE INDUSTRIALISED WORLD AND THE THIRD WORLD

The preconditions for modern industrial production can be summarized as the availability of capital, workers at various levels and markets - factors which are daily created in an industrial society. During the late 18th century and the 19th century, these preconditions were, in various ways, created in nations like England, France, Germany and Sweden.<sup>9)</sup>

It has been pointed out in this paper how the investments in engineering education on the Continent and Sweden from early on were carried out, often in close collaboration between the private and public sector of the economies. A general basic education - not discussed in this paper - was also created. England stands here out as the exception to the other countries, with her specific characteristics of technical - as well as general - education and its organisation.

Regarding the initial phase of industrialisation and the shaping of the system of technical education in the individual country, we can, to a certain extent, see a parallel to Gerschenkron's view on European industrialisation during the 19th century, on the basis of the country's degree of economic backwardness. Thus in the most advanced country,

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9) For a decade or so a debate has been going on among economic historians on these issues. The Swedish research has recently been surveyed and discussed by L. Schön in Industrialismens förutsättningar (The Preconditions of Industrialisation), Liber, Lund, 1982.

England, we find the least developed technical education, while Germany and Sweden are on the other extreme of the countries discussed. France takes a middle range position.<sup>10)</sup>

While in England during the first phase of industrialisation there was a market for technical man-power - which at that stage did not need a "scientific" education - the markets for the qualified technicians and engineers at later stages - when they were essential in the process of industrial performance - for various cultural and social reasons, were more limited.

A main purpose of the institutionalised technical education was originally to catch up with England in the process of industrialisation and if possible overtake her. Germany especially was very successful in this respect, but also in certain respects France.

Of great importance here is the fact that the market for technical educated man-power existed or was created from early on in France, Germany and Sweden. Closely inter-related with it of course was the cultural and social aspects on a technical education and a career in engineering. Of specific interest here is the French case with its sophisticated engineering philosophy and mathematical based training - the tradition of Descartes, Saint-Simon, "the technocrats". The outcome of this at the highest level of education was - and is - the French Grandes Écoles, with its enormous prestige in the society. But generally the social standing of a career in engineering was less prestigious.

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10) Se Gerschenkron, A., Economic Backwardness in Historical Perspective, Praeger, New York 1965, p 353 ff. and Sandberg, L.G. "Ignorance, Poverty and Economic Backwardness in the Early Stage of European Industrialization. Variations on Alexander Gerschenkron's Grand Theme", The Journal of European Economic History, Vol. 11, Number 3, 1982.

A general conclusion is that a considerable weight should be attached to cultural and social factors in a discussion on industrial growth and performance.

Another conclusion related to this is that when we at hindsight - and on a general level - try to evaluate the industrial performances in relation to the supply of engineers of various countries, it is not sufficient to concentrate on the figures on industrial growth only. We must also scrutinize the content of the industrial growth, something which says a lot of the quality of the country's industrial production and consequently of its quality of technical education.

It is a well-known fact that the situation of the Third World - again it is necessary to generalise - is different to that of the western world of the 18th and 19th centuries.

For several countries of the Third World, it is, for example, not relevant to talk of agrarian societies - like England of the 18th century or Sweden before the 20th century - from which a process of industrialisation could start. In the developed nations capital was created via the national and/or international markets for products from the agrarian sector, markets for raw materials and further on the markets for industrial products. As we have seen there were markets for man-power as well as markets for other factors of production.

In these countries the old class society with its feudal features were broken up. Instead of privileges of various types we got societies in which the relations of the markets in all aspects became dominating. A climate for investment was created; the surplus of production was not wasted on luxury and unproductive consumption.



To create similar preconditions for industrialisation seems to be a necessity for the developing countries. The problem of course is how it should be done.

It is evident that a good general education is a basic cultural need and should exist in all countries. Besides this obvious fact however, there are reasons to assume that in a world where technical and industrial progress go faster than ever, an institutionalised qualified engineering education - on the highest level unrelated to the classical university - will be the best mean to implement the relevant technology in a developing country, as well as to create the necessary positive attitudes towards technological and entrepreneurial matters in the society.

Modern theories of economic growth has shown the importance of investments in human capital. In that context it is reasonable to assume that in the developing countries investments in engineering education - for all levels of occupation - is the best mean for good pay off of investments in education, because of the usefulness of engineers in various functions in a society. To some extent - as has been shown - we can here judge from the historical experiences of the industrialised world.

A problem is of course that the investments in an institutionalised technical education for all levels and categories of technical man-power are very expensive. Consequently the developing country may have to make priorities in these respects.

If that is the case, it seems plausible to argue that the developing country initially should concentrate on a technical education of engineers for the middle and lower positions.

Irrespectively of a country's industrial structure - existing or planned - highly qualified engineers in leading functions within industry, as well as in other sectors of the economy, are necessary. But for these functions, comprising a fairly limited number of persons in initial stages of industrialisation, the Third World has the possibility to "borrow" from the industrialised world, and in that way satisfy its need for these engineers. This could be done either by importing this man-power from the industrialised nations or by educating the native engineer for the leading functions abroad.

For the mass of engineering activity, including middle and lower range positions, the situation is different. Here we will find the man-power of native origin, who to a large extent will carry out the actual engineering work. Furthermore, this section of the population will carry a socially important function in printing new positive attitudes towards technological change and industrialisation.

This suggestion of priorities is based on a judgement of the financial and short run aspects of investments in technical education. In the long run, an institutionalised technical education for all levels of occupation is the best mean for good industrial growth and performance.

