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British Contributions to Sweden's Industrial Development

Some historical notes by Emil Sahlin

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INLEDNING

Sveriges Allmänna Exportförening utgav 1964 i stenciltryck skriften "British Contributions to Sweden's Industrial Development" författad av Emil Sahlin, f.d. svensk generalkonsul i London.

Emil Sahlin föddes 9 januari 1879 i Vollsjö, Malmöhus län, som son till fabriksägaren Carl Petter Sahlin och hans hustru Maria Persson. Efter studentexamen i Malmö 1897, studier vid Falu Bergsskola 1899-1900 och studieresor i bl.a. USA och Canada anställdes Sahlin 1903 som pappersmästare vid Örebro pappersbruk. En befattning som ingenjör vid Skutskärs cellulosafabrik 1904-05 följdes av affärsuppdrag i Sydafrika 1906. Under åren 1907-12 var Sahlin handelsattaché i Ostasien. Via uppdrag i Australien och Nya Zeeland kom Sahlin 1913 till svenska beskickningen i London, där han 1918 blev generalkonsul fram till sin pensionering 1943. Emil Sahlin avled den 16 juni 1966.

Polhem tackar Exportföreningen för tillstånd att utge Emil Sahlins skrift i nytryck. Ett tack riktas även till R. A. Buchanan, som skrivit ett förord till denna utgåva.

Introductory note

The History of Technology has always relied heavily on the reports of eye-witnesses observing new machines and processes, and on the accounts of diligent recorders who have tried to preserve for posterity the names and achievements of people who have contributed to technological developments. Swedish travellers in Europe and elsewhere have established a distinguished tradition of careful reporting on innovations which have then been able to enrich technical expertise in Sweden, and they have provided incidentally a valuable source of historical documentation. The role of Mårten Triewald, Jonas Alströmer, and many other such shrewd observers, in giving an impetus to Swedish industrialization from the early eighteenth century onwards, is now well recognized. Less is known, however, about a parallel tradition: that of inventors and industrialists leaving Britain in this period to exploit their comparative expertise in countries which had not yet acquired such a technological lead. The compilation of Emil Sahlin is of particular value in drawing attention to this formidable group of people who brought the techniques of the British Industrial Revolution to Sweden.

Emil Sahlin (1879-1966) was an engineer and businessman, but he worked for many years, from 1918 to 1943, as a Swedish Consul in London. He tells us that during these years he became interested in the activity of British people in the growth of Swedish industry, and that he began to collect information about these individuals.

In 1964, Sahlin consolidated all this material into a typescript which was then circulated by the General Export Association of Sweden. He hoped that it would eventually be possible to publish an edition of the typescript, but this was not achieved before his death two years later, and since then the work seems to have remained virtually unknown except to a small group of scholars. The work certainly deserves a wider circulation, and POLHEM is providing a valuable service for its readers in making Sahlin's material more generally available.

The text is uneven and occasionally repetitive. Sahlin was more knowledgeable in handling contributions to the iron and steel and engineering industries than he was in dealing with textiles, tanning, and food processing, which tended to receive a much more perfunctory treatment in his account. The element of repetition is apparent because prominent figures like Daniel Fraser, who followed Telford to Sweden to provide mechanical engineering support for the Gotha Canal project, and stayed to establish a great engineering firm at Motala and to be buried in the graveyard there; or William Chalmers, who had a share in many mercantile enterprises and endowed the technical school from which Chalmers University has sprung; occur at several different points in the text. This is in addition to the useful lists of Britons with industrial connections in Sweden which Sahlin places at the end of his work. But the compilation throws a fascinating light on the high degree of friendly personal collaboration between British and Swedish interests in the process of rapid industrialization. It is encouraging to be reminded of the mutual benefit which derives from such relationships, and it is to be hoped that the publication of Sahlin's work will promote further scholarly investigation of them.

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PREFACE

During my years in London, I became absorbed in the part played by the British in the growth of Swedish industry. This led me to the collection of cuttings and some fairly detailed research. As the material increased in volume, I became more and more convinced that its publication would help to fill the obviously very wide gaps in our knowledge of the part played in our industrial history by British industrial pioneers, particularly in the latter part of the 19th century.

This connection between Great Britain and Sweden, traceable with succeeding generations of prominent British families, should be sufficient to interest their descendants of today. But in addition one could perhaps call the work a primer on the subject, with its systematic arrangement of industries and trades, which by its nature also provides a fair amount of source material of use to future writers and students in the field.

The transformation of the somewhat bulky dossiers into a finished product would never have reached completion but for the generous help I have received from several quarters. The completed survey now appears in multilith print, thanks to the assistance of the General Export Association of Sweden. It is my hope that it will be found of sufficient interest to warrant an illustrated letter-press edition eventually.

The author is solely responsible for the data quoted and the opinions expressed in this survey.

Stockholm in June 1964

EMIL SAHLIN

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IRON AND STEEL

Introduction

Iron began to be produced in the south of Sweden about 150 B.C. Denmark was the stepping-stone for its introduction from continental Europe. Lake and bog ore were the first sources of Swedish iron; rock ore did not come into more general use until the end of the 12th century and occurred farther north in what is known as the Iron Belt of central Sweden.

About the middle of the 18th century Sweden was the foremost iron-producing country in the world, with an output corresponding to one-third of world consumption, and she was as a matter of course the largest exporter of iron. All iron was at that time based on charcoal as fuel. As an iron manufacturer, Sweden had a decided advantage over England and to some extent also over the nations of continental Europe, for while ore was available to most of them, their forests were severely depleted. In this way Sweden achieved something of a monopolistic position, which in fact she used by limiting production and thereby keeping up the prices of iron.

In England, a decline in iron production began in about the 1620's, and in the following hundred years production fell to a half of what it had been. At the end of the 18th century, four-fifths of the Swedish output was exported, and by 1720 about 65 per cent of her exports was taken by England. The following Swedish export-figures from 1637 to 1717 give an indication of the trend over this period:

1637-1641 (annual average)	11,670 tons
1650	17,950 "
1685	26,560 "
1711-1716 (annual average)	32,800 "

The purity of her ore, the abundance of her charcoal supplies and the presence, almost everwhere, of easily harnessed waterpower were the three fundamentals on which the unique position of Sweden as a producer of "the world's best iron" was established. England had at one time, it was thought, unlimited forest supplies for the charcoal needed in her forges, but the end of these supplies was approaching

before a way had been found to turn the fossil coal into a fuel suitable for ore smelting. Yet in the 1730's coke was already being used in English blast-furnaces, and in the 1780's came the puddling process, by which ordinary coal could be used for the production of malleable iron. Before the arrival of this new epoch, the quantity of iron produced in Sweden had varied from 40,000 to 60,000 tons a year. This is not much today, but at that time it was equal to 30-35 per cent of the world's entire output. Of the Swedish production, exports amounted to 80-85 per cent, of which between one-half and two-thirds went to England.

It was felt in Sweden that the new methods adopted in England, and the opportunities offered by them to reduce the cost of manufacture, called for their introduction in the home country together with other money--saving improvements. So puddling furnaces, for instance, were built in conjunction with rolling-mills, principally for plates.

But although the introduction of the puddling process in the 1780's had caused certain apprehensions in Sweden, it was difficult for people to realise that a new era had made its entry. At the beginning of the 19th century, disquiet within the industry rose appreciably with the increased knowledge that the old method of producing wrought iron was outdated and had to be cheapened. As it turned out, it was not long before this happened. A notable ironmaster, Johan Ekman, was the man who brought what is known as the Lancashire method from England. This was in the 1830's. And it was this new method, with its wide applications, that kept the earlier Swedish iron production going until the ingot methods, and later the electric furnaces, entered the field. But even as late as 1895 the production of wrought iron in Sweden amounted to 200,000 tons. Today the output is insignificant.

Blister Steel

The process by which blister steel was made is called cementation, the transformation of bar iron into steel by the penetration of carbon into the wrought material. The bars were packed into long, fireproof stone boxes filled with charcoal, after which these were surrounded by coal and heated. The firing was continued for a week or ten days. Blister steel was the principal raw material in the manufacture of crucible steel, the production of which at one time formed a highly important industry in the Sheffield district.

England is the classical home of blister steel, and it was in England that manufacture on an industrial scale originated. (A patent of 1614 has been

discovered.) The blister steel process was introduced into Sweden not from England, however, but from Germany, probably in 1653. At the beginning of 1750, there were 18 separate works in Sweden for the manufacture of blister steel, with 22 furnaces all told. At this time the appearance of Benjamin Huntsman's crucible process made the manufacturers of blister steel improve their methods, particularly in the Dannemora district. By 1820 about fifty blister furnaces were in operation in central Sweden. After a relatively quiet period, fresh activities started, and in the period 1835-1846 no less than 45 new blister furnaces were installed. In 1860 the total number was 93, with an annual production of 6,000 tons. The leading provinces were Värmland and Dalsland. The largest blister works were operated by the Uddeholm company. The period between 1853 and 1860 may be considered as the final chapter in the history of Swedish blister furnace building. Generally the Swedish furnace type of three cases had been replaced by the English system of two cases. These had a total charge of 2,300-3,300 lbs. The run of a heat varied between 9 and 12 days. x)

Lancashire bars were mostly used and not so much Walloon iron. The number of furnaces gradually decreased. While 93 were registered in 1860, as mentioned, only 18 remained in 1880, and of these only a few were in operation. Bessemer ingot steel had replaced the blister type.

Crucible Steel

Benjamin Huntsman's Crucible Works at Attercliffe, near Sheffield, is one of the establishments which have made that town famous. It was Huntsman who discovered the crucible process of making high-grade steel. According to reliable sources, it was the desire to avoid the irregularities of imported blister steel that was the incentive behind his efforts. Usually 1740 is understood to be the year in which he succeeded in perfecting his important steelmaking process for practical application. Huntsman was originally a clockmaker and needed first-rate steel for his springs. No patent was taken out, and the method in its early days was surrounded by very great secrecy.

x) Carl Sahlin: Svenskt stål före de stora götstålsprocessernas införande (Swedish Steel up to the Arrival of the Ingot Steel Processes), Stockholm 1931, Ivar Haeggströms Boktryckeri AB. The late Dr. Carl Sahlin was the leading authority on the history of iron and steel in Sweden.

The oldest type of crucible furnaces consisted of a rectangular melting-chamber about 40" deep and with a 24" x 24" surface. The furnace bottom was made up of iron bars which served as a fire grid. Crucibles, generally of graphite, were placed in this furnace on slabs of fire-clay, charged and provided with tight-fitting lids. Then the space between the crucibles was filled with coke. Gas-fired regenerative furnaces, in which the crucibles were placed on the flat bottom, gradually came into use.

Sweden seems to have been the country to which the Huntsman crucible steel process first migrated, and there the erection of the first plant was begun as early as 1770. This was natural enough, since it was a question of adopting a process which appeared to be greatly dependent on Swedish raw material for its successful application.

Jernkontoret (the Swedish Iron-Masters' Association) had sent a prominent metallurgist, Bengt Quist, to England to study the new process. He stayed there in 1766 and 1767, and on his return built at Ersta, a suburb of Stockholm, a small melting-shop of six holes. It would appear that at the outset he had to contend with great difficulties, as in the first place he failed to produce any durable crucibles. There was an export ban on the English Stourbridge clay, nor was the sale of English crucibles permitted. Gradually the difficulties were overcome, but it was not until 1780 that the plant could be said to have reached full-scale size. Quist died in 1799, and the works were closed down shortly afterwards.

The Broling Crucible Works in Stockholm were founded in 1808 by another Swedish metallurgist, Gustaf Broling, who had studied the English iron industry in the years 1797-1799. His crucible works in Stockholm closed down in 1838.

It is usually said that the number of crucible steel works in Sweden about that time was a dozen. Some of them, however, were modifications of the original Huntsman principle. Only three works of the group need therefore be mentioned here: Österby, Söderfors and Fagersta. Österby is situated in the Dannemora mining district, and iron from its forges had been considered an almost indispensable raw material for the Sheffield crucible works. It was not until 1869, however, that the production of crucible steel was taken up at Österby. At Söderfors and Fagersta crucible steel was made during the years 1904-1916 and 1905-1912 respectively.

One may well ask why, if the raw material for the crucible steel industry abroad came from Sweden, the method itself was not adopted in

that country on a wider scale. It is not possible to get away from the fact that a great deal of slackness was evident among the leading Swedish industrialists at the time, and that here, if ever, one may speak of a period of lost opportunities. Mitigating facts may be adduced, of course. Swedish crucible steel had to be exported, the home market was too small, and an export trade in such a commodity as special steel required an organisation for which the necessary competence or readiness was not available in Sweden. The unfinished article from the forges sold itself and fetched a very high price, so why worry? Then there were the shackles and restrictions by which industry in general was tied up during the guild-system period. These obstacles, of course, were felt not least in the iron industry.[x)]

Puddling

In 1793 an article was published in Sweden about a new English method for making bar-iron with raw coal and grooved rolls. The description given was stated to have been borrowed from an English journal. Anyway, it was the epoch-making discovery of Henry Cort that the writer was dealing with. Cort had received a patent in 1783 for puddling and for a rolling-mill with grooved rolls.

This new bar-iron method, the puddling process, came about under the pressure of the increasing shortage of charcoal in England. The process made it possible to fine the pig-iron to malleable iron with the aid of pit-coal. The obvious consequence was an almost complete reversal of Sweden's position as an iron producer. The danger to the Swedish iron trade that this new method represented was soon realised, and Jernkontoret sent a well-known metallurgist, E. Th. Swedenstierna, to England to study the Cort process. He returned in 1803, but it was a long time before his report was made public. He had declared himself very pessimistic with regard to Sweden's means of meeting British competition with the methods then available. Jernkontoret did not make any move, but in some quarters within the industry it was proposed that both puddling and the use of grooved rolls should be adopted without further delay. Anxiety grew, and Jernkontoret finally decided in 1817 that puddling should be tried on a full manufacturing scale at Skebo, a forge some 50 miles north of Stockholm. The trials went on from 1819 to 1822 and again 1824. Two

x) Concerning crucible steel, see also Carl Sahlin: Svenskt stål före de stora götstålprocessernas införande (compare note on page 9).

well-known experts, Uhr and Broling, were sent to England in 1820 to investigate the puddling process and other methods connected with the iron industry. The ironmasters were not enthusiastic, but finally agreed that comparative tests with rolling and hammer treatment should be made. This decision was undoubtedly influenced by the exhibition of a model of a grooved rolling-mill made by Broling himself. Broling, who was a supporter of the rolling-mill, had in the summer of 1798, during his first visit to England, seen a grooved mill at the works of Joshua Walker at Rotherham. During his second visit to England in 1820 he probably also studied rolling-mills, and it is probable that his model was copied from a working mill. Uhr, with his great prestige in Swedish metallurgy, was against any method that embodied the use of a rolling mill in the making of bars. The controversy between the old school of hammer adherents and the supporters of the rolling-mill went on.

As we have said, the trials at Skebo went on from 1819 to 1822, but it should be mentioned that some years earlier trials had also been made at the Kloster and Bispberg Works. The English forging made the large-scale production of bar-iron possible at appreciably lower prices than the old Swedish methods could achieve. As it was considered out of the question - no doubt with justification - to base Swedish iron production on imported coal fuel, a solution was sought in an improvement of technique so that the superior quality of charcoal iron, despite its higher price, would enable it to compete with the mineral coal product.

The adoption of the puddling process made possible an increase in the use of rolling-mills. Hence the two forms of production are interwoven in the historical data given in the two chapters concerned on puddling and on rolling-mills. Below is a survey of the more important ironworks where puddling was introduced.

The trials carried out by Jernkontoret at the Skebo Ironworks, under the pressure of public opinion, so to speak, have already been mentioned. The first place where puddling was privately introduced was probably Kloster (about 1812). Charcoal was used instead of mineral coal, but the new process gave the owners a good deal of trouble, and they had to use billets made in a German hearth. The rolling-mill, installed for the production of plate, was constructed by Samuel Owen, the British machine-shop owner then active in Stockholm. At his premises at Bergsund, also in Stockholm, puddling was also tried about 1811, but it was not a success. Owen himself also installed a

puddling furnace. However, he did not use charcoal but imported ordinary coal. To mention other places, trials with puddling were made at Bispberg in 1820, and at Nyby, about 55 miles west of Stockholm, a rolling-mill with puddling-furnaces was built in 1832. Wood was used as fuel, and the furnaces soon had to be remodelled, but they gave good results after a period of trouble. English craftsmen were engaged for both puddling and rolling, and were at first somewhat reluctant to use wood instead of coal. At the Motala Engineering Works on the eastern shore of Lake Vättern in southern Sweden, a rolling-mill with three puddling-furnaces was started in 1843. In 1860, rails were rolled here for the first time in Sweden - light sections made from puddle-iron. The managing director, D. Fraser, was a British engineer, who in due course was to gain a very prominent position in Swedish industry. At another important engineering works, Nyköping, puddling-furnaces were installed in 1842. At Surahammar, two wood-heated puddling-furnaces were started in 1848 in connection with the rolling of plate. Puddling was stopped in 1907 and Surahammar was the last place where it was used. The Degerfors Works, now large producers of commercial steel, started a rolling-mill with coal-heated puddling-furnaces in 1873. For a short while, puddling was carried on at the Avesta Ironworks at the beginning of 1875.

The Lancashire Wrought-Iron Process

With the English puddling method, it was possible to produce commercial iron which, by reason of its lower price, found a very much wider market than could be reached by Swedish charcoal-iron made in a German or Walloon hearth in the normal way. In England, large-scale production of bar-iron had been achieved, and what that meant to Swedish exports can be easily understood. The English ironworks had, by their close proximity to coal mines, a decided advantage. Naturally, experiments were made at many places in Sweden with puddling-furnaces on imported coal, but these had no important results. The introduction of a method that would enable lower-cost production of bar-iron to be adopted was therefore a national economic problem insistently demanding solution. But the necessary change had in fact to wait until the early 1830's.

Two modifications of the Walloon hearth had come into use in Britain, in Lancashire and South Wales respectively. In South Wales

the main product was rough plate, used largely for production of tinplate. The Lancashire form of Walloon forging was a process in which the blooms were not welded in the melting-hearth but in a separate furnace. Before rolling, the bloom was cut into pieces which were welded independently. In this way each bloom was rolled to a bar section which ensured the requisite density. The first hearth-fining method to be used in Sweden was the method known as German forging. (One spoke of a "German hearth" and a "German forge".) The slabs obtained from the immediately preceding charge were welded in the same hearth and at the same time as the pig--iron for the next charge was dealt with. Only one hearth was used, and one man looked after both processes. German forging had a much wider application than Walloon. The latter was used mainly in the Upland Walloon district, but also in the ironworks districts where the Walloons had been settled on arrival in the country. The difficulty with German forging was to obtain an even composition of the iron.

Characteristic then of Walloon forging is that fining and welding for hammering or rolling take place in different hearths and that only small quantities of pig-iron are worked in for each charge. The pig-iron is introduced in the form of long "pigs" through an arch behind the hearth and fed forward over the twyer (tuyère), where it melts and flows down into the hearth. About 25 kilos (55 lbs) of pig-iron is melted and worked each time, after which the solid lump is transferred to the extending hearth to be welded and then hammered. Despite the limited quantity of Walloon iron produced, it created a new epoch in the history of iron--making. For this iron, because of its purity, became the world's finest steel-making material and came to mean a great deal for the reputation of Swedish iron, particularly in England.

The two pioneers of the English methods in Sweden were Carl Fredrik Waern (1787-1858) and Gustaf Ekman (1804-1876), both having close ties with the iron industry, the former as owner of the Bäckefors works in the Dalsland province, 80 miles north of Gothenburg, the latter as technologist to the Iron-Masters' Association and at the family works at Lesjöfors in the province of Värmland, some 130 miles west of Stockholm. His family had acquired it in 1813.

Gustaf Ekman, then 24 years old, went to England in 1828, partly to study the puddling process, which was then much talked about in Sweden, but also to visit forges at Ulverston in Lancashire and at Bunan in Scotland, where pig-iron was melted with charcoal. At these places he found

"specially constructed hearths", as he called them, and noted that a great saving of fuel was attained. Ekman returned home in September 1829. In that year C. F. Waern, after consulting his buyers in Hull, Cowie & Brandström, decided to introduce a new English hearth method in his forge at Bäckefors. Forgemen were brought over from South Wales in the autumn of 1829 and put to work immediately. It should not be forgotten that we are now dealing with two different methods. The method later put into practice by Ekman was used in Lancashire, whereas in South Wales another form of equipment had been devised. In Swedish technical terminology they were both, to begin with at least, called "English Walloon forging" or "English charcoal fining". In Lancashire, bar-iron was made, in South Wales plates for tinning. Considerable divergencies existed between the two methods, but there is no reason for going into the details here.

It was at a forge called Dormsjö that Ekman in 1830 began his first trials with a hearth he had constructed on the Lancashire pattern, largely a copy of the forge he had seen at work at Ulverston. At another forge, at Söderfors, experiments were made in the same year, and Ekman himself says that it was practically an unchanged Lancashire method that he used. The work proceeded smoothly, thanks largely to workers from a Walloon forge district in the neighbourhood, who were placed at Ekman's disposal. At Bäckefors it was evidently found necessary to begin by adopting the same working methods as in South Wales, hence there was a specific difference between the two methods in question. Five families were brought over to Bäckefors from South Wales. Houlder was the name of the foreman, and he was accompanied by three sons and a son-in-law, named Whittington.

The first forges in Sweden at which Ekman introduced the English method were, besides Dormsjö and Söderfors (1831), which have already been mentioned, Ferna, Furudal, Lesjöfors and Dådran. In 1834 the number was increased by Liljendal, Fagersta and Hammarby. Ekman realised quite early that it was essential to make use of rolling-mills in Lancashire forges - apart from the need for this method in other sectors of iron production. But the introduction of rolling-mills demanded the use of an effective welding-furnace to enable rolling to take place while the iron was still at yellow heat. Rolling of brown-heated iron did not yield the best results in respect

of density.

However, Ekman had to begin by preparing the ground for a more general use of the Lancashire method. For example, English forgemen were called in to serve at various ironworks as instructors in the new working processes to the frequently somewhat recalcitrant Swedish smiths. The welding-furnace itself needed several years of experimentation and structural changes before Ekman felt it really fulfilled its purpose. It was not until well into the 1840's that this stage was reached. After that the welding furnace gradually came into general use. The rolling-mill planned by Ekman took a few more years to complete and it was not until 1850 that he was able to construct such a mill - at Lesjöfors - in conjunction with Lancashire forging and combined with his own welding-furnace.

The differences between the two hearth-methods introduced in Sweden evidently disappeared in time, and Lancashire became the term generally used, even at works where the South Wales method had been adopted. The Lancashire method, as it was later generally adopted in Sweden, showed no difference from the practice introduced by Ekman at Dormsjö and Söderfors. The methods used at these two forges and at Ulverston were practically the same. It may be mentioned in passing that in the 1850's a new hearth-fining process was introduced from France, known as Franchecomté forging. However, it attained only very limited use and was discontinued after a time.

As has been pointed out in another context, the great importance of the Lancashire method was that it bridged the period between a threatening stagnation in the Swedish iron industry and the arrival of the ingot production methods. The credit for introducing Lancashire forging proper into Sweden belongs without the shadow of a doubt to Gustaf Ekman, and it is difficult to see how there could ever have been differences of opinion on the subject.

Today the production of Lancashire iron is very modest indeed. At the end of the first quarter of 1957 there were 13 hearths in existence, five of them working. Production in that quarter was 1,000 tons in all, or at the rate of 3,500 to 4,000 tons per annum. Nowadays, of course, it is only used for highly specialised purposes, and it is astonishing that the process still survives.[x)]

x) Among the literature consulted may especially be mentioned an article by J.A. Leffler entitled Lancashiresmidets införande i Sverige (The introduction of the Lancashire Hearth Method into Sweden) in En Bergsbok, a publication dedicated to Dr. Carl Sahlin in 1921 to commemorate his 60th birthday.

Bessemer Steel

The malleable iron obtained by puddling, like that derived by means of various fining hearths such as the Lancashire hearth, is a product of the wrought-iron method. Production by this method is at low temperatures, so that the iron has a high slag-content. With the advances in the engineering industry, requirements became more and more exacting as far as iron was concerned, and the creation of new production methods became a crying need. These needs were met by the introduction of what is known as the ingot steel processes. The first of these was the method invented in the 1850's by Henry Bessemer.

The revolutionary idea in this process was to force air through molten pig-iron and, by thus removing the silicon, manganese and carbon, to convert the pig-iron into steel. This could now be done without the use of fuel. At the outset it was imagined by Bessemer and his first licensees that any kind of pig-iron was suitable for the new process. But they did not know that what was right for the puddling-furnace was wrong for converters lined with silicious materials. So when the first converters were erected and ordinary pig-iron was used, the results were disastrous. Bessemer saw that the problem had to be tackled in a different way: he had to get phosphorus-free pig-iron. So he sent to Sweden for some of the pure pig--irons used there. Meanwhile some eighteen months had been spent in useless experiments. It may be interesting in this connection to quote from one of the sources used for this survey what Bessemer said at the time: "Happily for me the end was nigh. The pure pig--iron I had ordered from Sweden arrived at last, and was converted into pure soft malleable iron and also into steel of various degrees of hardness."

Bessemer gave no clue to the actual cause of this dramatic and swift change in his fortunes, and we come now to the part played in this transformation by a Swedish merchant in the town of Gävle, G.F. Göransson (1819-1900). Although we may seem to the reader to be recalling the snows of yesteryear, it is difficult not to mention in this connection the impression prevalent in Sweden for many years that Göransson's contribution to the success of the Bessemer process was not duly acknowledged in England. Relevant in this context is a quotation from Bessemer, Göransson and Mushet by Ernst J. Lange:

"No one can study the history of the Bessemer process of steel-making without feeling that no adequate attempt has ever been made by any writer on the subject, including Bessemer himself, to place in their proper light and exact significance the parts played by Göransson and Mushet in the successful development of this epoch-making process." (From Volume 57, Part III of Memoirs and Proceedings of the Manchester Library and Philosophical Society, Session 1912-13)

Göransson, who was himself a producer of iron on a small scale (and, it may be added, also became the founder of the now world-famous Sandvik Steel Works) had heard of the Bessemer process, went over to England and acquired the rights for Sweden. In 1857 he started his experiments at the Edsken blast-furnace plant. But the results were, like Bessemer's own, unsatisfactory. Finally, almost in desperation, Göransson increased the apertures in the converter through which the air was forced into the liquid pig-iron, and also changed the position of the apertures. The resulting ingots were sent to the neighbouring forge to be tested, and were found to consist of excellent steel. The first charge with the altered converter was made on 18th July, 1858. The improvements made in Sweden were in due course accepted by Bessemer, and, as we know, his steel process was adopted all over the world.

It may be of interest to the metallurgical student to read the following extract from Lange's above-mentioned publication: "On Göransson's visit to England in the autumn of 1858, he found that Bessemer was making steel by granulating the converted charge, running it into water and then classifying it according to the carbon percentage; the granulated metal being then remelted in crucibles." Göransson was able, during his visit, to put Bessemer into the way of his Swedish practice of blowing, after which, as far as I can learn, the granulating was abandoned, although not immediately - and the process thus established on a proper basis. There is an entry in an old diary for 1859 at Bessemer's plant, worded as follows: "first steel made direct". This was on June 18th, and thus fixes the date of the change. It should be noted that neither in his autobiography nor in his account of the history of his process did Bessemer mention his indebtedness to Göransson.

Finally it may seem appropriate to mention that in one of the best-known works on the subject, The Metallurgy of Steel by F. W. Harbord and J. W. Hall, the introduction to the chapter on Bessemer steel is worded as follows: "To Sweden belongs the honour of having first carried out the

Bessemer process on a commercial basis".

Later in the same chapter, the name of the Swedish purchaser of the Bessemer patent is mentioned: "In the early experimental days Bessemer was of opinion that high pressure of blast was the important factor, and it was not until G. F. Göransson adopted a large tuyère area, thus securing an abundant air-supply with corresponding shortness of blow, and at the same time increasing the temperature of the blow, that successful results were obtained."

Basic Bessemer. The discovery of a suitable basic lining for the Bessemer converter gave a great impetus to the process on the Continent, as the enormous deposits of phosphorous ore in western Germany, Luxembourg and eastern France could now be used. Dephosphorisation is possible in the puddling process, whilst the silica lining of the Bessemer converter made this impossible. All difficulties in the way of producing a stable basic lining were solved in 1878 by Thomas and Gilchrist, who discovered a method of making basic bricks from magnesium limestone, burnt at a very high temperature with aluminium silicate as a sintering material. The basic Bessemer - or Thomas process, as it was called - had a swift development, as we all know.

ROLLING-MILLS

Introduction

It is fairly common knowledge that a device for rolling various kinds of metal - gold, copper, silver etc. - was used in far distant times in most countries, including Sweden. But in that country it took longer than elsewhere in Europe to make use of rolling-mills as we know them for processing iron and steel. By far the most potent reason for this was the fact that the hammer method had been used ever since the Middle Ages for preparing the Swedish iron that had become so well-known in foreign countries. The Swedish forges were, moreover, very small units, and the rolling-mills, measured by the financial resources then available, were expensive machinery to install. The rolling-mill can hardly be said to have entered into Swedish iron-making on any perceptible scale until the latter half of the 18th century. It was introduced - apart from one set up by that mechanical genius Christopher Polhem in the early years of the century at his Stjärnsund works - by Sven Rinman, a famous ironmaster and metallurgist, at a number of forges such as Iggesund and Elvkarleby in Norrland, Johannesfors in Roslagen north of Stockholm, Garphyttan in central Sweden, and at Ankarsrum and Folkström further south in the province of Östergötland.

In his Patriotic Testament (written 1745 or 1746, printed in Stockholm in 1761 and in Graz in a German translation in 1769) Polhem writes briefly about grooved rolls. This has led some observers to conclude that Polhem must be regarded as the actual inventor of the method of rolling bar-iron with grooved rolls. But, as mentioned before, consumers were insisting on hammered iron. The demand for Swedish iron increased, and during the 18th century Sweden held first place for both quality and quantity among the iron-producing countries. Hammer treatment was considered necessary with the metallurgical methods then in use.

Rolling-Mills and the Lancashire Process

In the 1830's, when the Lancashire process was beginning to be recognised as a promising new method, rolling-mill practice found supporters among an increasing number of ironmasters. As mentioned

in a preceding chapter, Gustaf Ekman, who was to become one of the leading industrialists of that period, returned from his second visit to England in 1831. He had acquired a thorough knowledge of rolling--mill work and wrote a treatise on the subject. However, among the leading men in Jernkontoret a good deal of reluctance still persisted. As usual, the end of the Swedish iron trade was considered certain if the rolling of bars took the place of the careful hammer process. Opinion in favour of rolling-mills nevertheless gradually gained strength, and it was pointed out that the Lancashire process could not in the long run be used to advantage economically and technically without the addition of rolling-mills and proper heating-furnaces. It was here that Gustaf Ekman became the pioneer. His gas--fired heating-furnace made his name known in all iron-producing countries. It was developed during the 1830's and 1840's and afterwards made its way throughout the world. It was one of the main contributions made by Swedish metallurgists to rolling-mill practice. The principal experiments were conducted at Ekman's Lesjöfors forge, and it was installed in its earlier form at the three Uddeholm forges - Gustafsfors, Stjärnfors and Munkfors.

Rolling-Mills for Plates and Sheets

Plates of iron and other metals were produced at a very early stage by hammers, and even after the introduction of plate rolling the hammer and the rolling-mill worked side by side. Strictly speaking, no rolling-mill proper for plates appears to have existed in Sweden until the beginning of the 19th century - at the Bergsund Works in Stockholm, where the Englishman Samuel Owen was works manager between 1806 and 1809. A plate rolling-mill was then built at Bergsund for the Kloster Works in central Sweden, where it was used for making tinplate, and another for Skebo Works in the province of Upland, north of Stockholm, where, incidentally, the puddling method was adopted. Their rolling-mills were considered by experts to be better than the English, though they were slower. After Owen in 1809 had started his own engineering works at Kungsholmen in Stockholm and had got so far as to be able to build steam engines, he needed bar-iron and plates for steamboats and boilers. He then set up a rolling-mill there of his own design. A large-dimensioned hammer with shears attached was also set up. It was called a 'mumbling-hammer', the English word being used as the nearest to

evoking the low key of the noise it made.

As mentioned above, iron plate was first made in Sweden, as elsewhere, by the use of hammers, first driven by hand and then by water. Three sets of hammers were used. The last set, a comparatively small tool, worked on packets of 6 to 8 pieces. The plates were, of course, small. In the 18th century, the standard size was 18" x 24". Medium and heavy plates had to be made specially. "Osmund iron", a product peculiar to Sweden, was preferred. Plates of iron made by the German hearth process were not considered to be of the same quality.

During the latter part of the 18th century a few small rolling-mills were erected at various places, but none was a success. It was still insisted upon in the trade that plates should be hammered. Now the Kloster Works enter the metallurgical annals. The owners of this forge were authorised in 1801 to install one pair of rolls for tinplate (later also for ordinary plate). The stands were of the type then used in England, the rolls of cast iron made at the Söderfors Ironworks. It was, however, difficult to obtain suitable billets: the quality was uneven. After a while (about 1812) the puddling process was tried, although charcoal instead of mineral coal was used. This was one of the early puddling-furnaces used in Sweden, but the new method gave at the beginning a good deal of trouble. They had for instance to turn to the German hearth for their billets. A new rolling-mill, ordered from Bergsund as already stated, was completed towards the end of 1809. Bergsund also supplied the rolls, which were excellent. But the first rolling-mill had not been made strongly enough, as became evident after a few years. Owen made a heavier stand from cast iron.

Tunner, the German metallurgist, says in his book on Swedish iron production that bar-iron rolling in the mid-1850's had not got very far, but fabrication of thin plate on the other hand had kept pretty well up with the times by adopting foreign, mostly English, methods.

At Kloster they made excellent tinplate, but this part of their production came to an end in 1839. The rolling of black-plate in general continued, however. In the 1860's about 1,000 tons a year were made, and the Kloster Works were famous for their extra-thin plate. The mill was a big plant for those days, and formed a contrast to the general run of small installations. The success achieved at Kloster had induced the owner of Skebo Works in Roslagen, north of Stockholm, to build a similar mill, where the rolling-sets were also supplied by Owen, but from his own works.

The mill consisted of two pairs of rolls to begin with. Skebo was chartered to make 340 tons of black-plate a year. For some time puddling was used. These two rolling-mills, Kloster and Skebo, produced a plate at a price far below that demanded for hammered goods - an economic misfortune for the country, it was considered in some Government circles.

New rolling-mills followed: Nyby, near Torshälla, was one of them (1832). It had two sets of two rolls each. Here a mumbling-hammer was also installed. Wood was used for the puddling, but for that purpose the furnaces had to be remodelled, and all went well after the first difficulties had been overcome. British craftsmen were employed for puddling and rolling. They were at first reluctant to use wood for the puddling-furnace.

The success made by the early mills encouraged the extension of plate production, and in 1865 the following eleven rolling-mills for thin plate were in operation:

Boxholm	Kallinge	Nyköping
Fagersta	Kloster	Skebo
Garpenberg	Motala	Surahammar
Hallstahammar	Nyby	

In due course they were followed by the mills enumerated below:

Björkborn	1873	Domnarvet	1878
Avesta	1875	Gullöfors	1878
Degerfors	1875	Finspong	1881
Flemminge	1875	Skogstorp	1908

Some of the mills for thin plate were extensions to sheet mills from which off-cuts were used for roofing-plate, etc.

To illustrate the length of time it took to get modern rolling-mill practice introduced into Sweden some data are given here.

At Bofors, in cooperation with leading men in the Uddeholm company, the problem of rolling was taken up for investigation. Per Lagerhjelm, the head of Bofors, sent in 1825 two tons of blooms made in a German hearth to be rolled in a mill near London. In 1839 he was authorised to make 40 tons of blooms annually for three years, to be rolled into bars in England. This was in the nature of a trial, and it soon gave rise to a heated discussion in the industry: the old forge-

-owners and ironmasters were afraid of losing their livelihood. Lagerhjelm's plans included the building of two large rolling-mills in central Sweden. The billets would be bought from outside works. Each mill would produce 3,000 tons, a very large quantity for that time. He also proposed to buy the Nyby Works, but could not raise the necessary capital. The time was not yet ripe for a change. The same controversy over the merits of the hammer and the rolling-mill had been going on in all iron-producing countries, but it did not last very long in Great Britain, France and Germany. Of course, out in the forest areas on the Continent, when waterpower was available, small hammer-mills were kept running for a good many years after the general adoption of the rolling method. But nowhere did the controversy last as long as in Sweden. In the 1850's and 1860's discussion had become particularly widespread. The hammer-masters, however, realised in time that there would have to be an end to the large number of small works, and that production would have to be concentrated on fewer units, provided with rolling-mills for mass production. Prejudice against rolled iron came mostly from buyers abroad. They thought that hammer treatment forced bad substance out of the iron, whereas rolling pressed it into the material. Opposition was manifest, particularly in Denmark, England and the United States.

Here should be mentioned the Motala Engineering Works, about which more information is given in a later chapter. D. Fraser, a British engineer employed as manager, proposed that the machine section should be extended so as to include the production of bars and plate. A British expert, T. Jones, then superintendent at a rolling-mill in Monmouthshire, was engaged in 1841. The new plant was ready in 1843; it included three puddling-furnaces with a mumbling-hammer, and a rolling-mill with four pairs of rolls for heavy plate and bars. The rolling-mill frames were of what was known as the English pattern. Gradually larger and heavier plates were required, and Carlsund, a prominent engineer who succeeded Fraser, rebuilt the ironworks and installed heavier machinery in 1855-57. The equipment of the works included one duo-mill with three sets for bars, one duo-mill with two sets for medium bars, one duo-mill with one set for small bars and one trio-mill with two sets also for small bars. At the time, this was the largest rolling-mill in Sweden. Waterpower was used with a large water-wheel having rolling-sets on both sides. The 3-high grooved set was the first of its kind erected in Sweden, although 3-

high mills were nothing new, for instance in England. Broling had seen a 3-high in a rolling-mill near London in 1829. Drawings of this 3-high mill were published in Jernkontorets Annaler in 1831.

The famous Owen machine works at Kungsholmen come under a different heading. They were the first modern engineering establishment in Sweden. After a number of useful pioneering years, however, Owen had to go into liquidation. The reason why he ultimately failed economically is considered to be that although he was a great mechanical engineer he did not possess the necessary metallurgical knowledge. He could not compete with Nyby in plates, for example. Owen's rolling-mill products were to a large extent made from scrap-iron, and the result was an uneven quality. There was also competition from other makers. Iron-works were built at Nyköping, for instance, in 1842 with puddling-furnaces and a rolling--mill mainly for boiler and ship plates. Although Nyköping failed in 1844, it had nevertheless affected the business of the Kungsholmen works. The equipment at Kungsholmen consisted, when completed, of two large pairs of rolls for plate, and two small pairs which were grooved, also a mumbling-hammer of unusual size, an ordinary small forge-hammer, a pair of shears and other small machinery. A puddling-furnace was also installed, but Owen used imported coal instead of wood, as they did at Nyby for example. A 30 h.p. steam engine completed the plant.

Grooved Rolling-Mills

Christopher Polhem's use of grooved rolling-mills early in the 18th century has already been referred to. With regard to the introduction of the grooved mill into Sweden at a later period, it may be mentioned that Broling, the metallurgist, had seen them installed in the works of Joshua Walker at Rotherham in 1798 during his first visit to England. They were provided with five tracks. He also studied these rolling-mills in 1820. The general controversy in Sweden over the supposed demerits of a rolling-mill in dealing with wrought iron has been mentioned before.

Among the early forges with a grooved rolling-mill was Furudal, in southern Norrland. Since 1808, chains had been made here from rounds produced by hammers from German hearths. It was necessary to improve the chains for the Navy, and the owner received the necessary charter in 1827 for a grooved rolling-mill.

The machinery was ordered from Samuel Owen. At the end of 1829 the works were ready, and in January 1830 the Swedish Navy placed an order for heavy anchor-chain. A wood-burning heating-furnace was used. The rolling-mill consisted of two sets of two rolls. A water-wheel was used, and the flywheel had a diameter of 17 ft. The rolling-mill was geared up to 6.8 times the speed of the water-wheel. The dimensions of the rolls were 42" x 15". One set had 12 round grooves, and the other 12 closed grooves for flat and square bars.

Rails

In 1853 Carl Ekman, of the well-known family of industrialists, started the rolling of U-rails at Finspong, his headquarters in the south of Sweden. The equipment was ordered from England. The rails were made from Lancashire iron. At Motala, rails were rolled for the first time in 1860, and consisted of light sections. Soft puddle-iron was used. In 1867 a heavier rolling-mill was installed, and rails were supplied to the State Railways. They consisted partly of puddle-iron. A rail-rolling mill was started at the Smedjebacken Ironworks in 1870; it worked well and turned out rails for quite a long time. At the Degerfors Ironworks, too, light rails were rolled at that time.

C. P. Sandberg, well-known later in England as an authority on rails, holding a Jernkontoret scholarship in 1862 for studies abroad, proposed the erection of a rolling-mill in Gothenburg for the production of rails of British sections and type. This is mentioned because Gothenburg has several times been proposed as a suitable place for a modern steel plant.

Tubes

The making of tubes in Sweden was started at Motala. O. E. Carlsund had in the 1840's studied the manufacture of lap-welded tubes in England, at the Smethwick Tube Works near Birmingham, and his mill was probably supplied by British makers. The type of construction was that normally used in England: four rolls, two vertical and two horizontal, coupled to gear wheels. Mostly boiler-tubes were made at Motala, but at the beginning of 1860 the production had to stop as it was not possible to compete with the imported material. The Motala tubes had, of course, welded seams. They were made from puddle-iron. Later came the rolled tube: seamless tubes were made at Fagersta and Sandviken, for example.

Tinplate

It does not seem out of the way in this connection to mention an early pioneer in the manufacture of tinplate, the all-powerful firm of Finlay & Jennings. Robert Finlay, together with Frans Jennings, bought Forsmark, an estate in northern Upland, in 1751. A forge was built at a place called Johannesfors on this estate, and an expert by the name of Samuel Söderstierna was engaged as technical adviser. He had studied a plant equipped with rolling-mills for tinplate in Staffordshire. At Johannesfors he also installed a slit-mill and, what is more interesting, a tinplate plant "on the Saxon and English model." Söderstierna claimed that this was the first place in Sweden where tinplate was being made from rolled material. Rolling continued for some 12 to 15 years from 1751 onwards. There were the same old obstacles again to face: hammered plate was wanted.

While dealing with British-built rolling-sets in Sweden, it may be of interest to mention a British-owned rolling-mill, a plant which, by the way, remained for nearly half a century the most northerly rolling-installation in the world. Towards the end of 1860 two Englishmen, Giles Loder and his son Robert, invested capital in the iron mines of Lapland. In order to deal with the blooms from hearths on the mainland, the Loders built a small rolling-mill on a rocky islet off Luleå, called Altappen, situated at a latitude of approximately $65^{\circ}30'$. Mo-i-Rana, a rolling-mill in Norway, built a few years ago, is only some miles further north, whereas the planned Russian works in the Vorkuta mining district by the Kara Sea, near the Siberian border, will be about 150 miles north of Altappen - if and when they are finally completed. The big steelworks belonging to the Swedish Government on the mainland near Luleå are only a few miles away from the place where the historic little rolling-mill of the Loders was built. x)

x) Most of the data and general information in the above chapter have been gathered from literature published by the late Dr. Carl Sahlin, a leading authority on the history of iron and steel in Sweden. He was also an ironmaster and a prominent industrialist. Reference is particularly made to: Valsverk inom den svenska metallurgiska industrien intill början av 1870-talet (Rolling-mills in the Swedish Iron, Steel and Metal Industries before the 1870's. With a chronological summary in English), Jernkontoret, Stockholm 1934. Bröderna Lagerström, Stockholm, Printers. Among other authors consulted may particularly be mentioned V. J. Sunström.

IRON FOUNDRIES

Casting from blast-furnaces was practised in Sweden from the middle of the 16th century, and probably earlier. German foremen were engaged at the beginning, first of all for ordinary castings. This was followed by the casting of cannon, also direct from the blast-furnace - a production which was carried on in the 17th century on a comparatively extensive scale. In other countries, particularly in England, casting was in due course transferred to separate furnaces. This was of course known in Sweden, but it was above all Thomas Lewis who brought the new method into use there.

Lewis was born in Scotland in 1747 or 1748, and it is thought that his father was employed by the Carron Company. When Lewis applied to the Swedish authorities for employment he referred to his work as a foundry master at Carron. These works were founded in 1759 and became famous for cast-iron goods, especially, of course, for their cannon (carronades). It was at Carron, by the way, that the cast-iron parts of James Watt's first steam engine were made. It is not surprising, therefore, that foreign firms tried to employ workers and foremen from Carron.

Lewis came to Sweden probably in 1766. Together with some countrymen of his, he was engaged by Johan Cahman, a Gothenburg merchant who had received a charter to erect a "cauldron foundry on the English style with reverberating furnace". Lewis stayed with Cahman for 18 months. The introduction of the reverberating furnace in Sweden actually took place in 1762, when an English foundryman, Evans by name, came to Stockholm via Amsterdam to run such a furnace erected at the Meyer Foundry.

Casting cannon from a blast-furnace, by the way, went on in Sweden long after it had been abandoned abroad and replaced by reverberating furnaces, the main reason being certain properties of the Swedish pig-iron, which made it particularly suitable for this kind of work.

It should be mentioned that it was Lewis who introduced an important improvement in foundry practice: he replaced the costly and cumbersome clay blocks with sand moulds.

At the Cahman foundry, which closed down in 1823, several British workers were employed - John Alland, Peter Clerk, Adam Mercer among others. Lewis left Cahman in 1768. Evidently he did not get on with his employer, and complained that his terms were highly unsatisfactory. He now went to Stockholm and submitted at the beginning of 1769 to the Board of Mines an application of his own for permission to establish in Stockholm or its vicinity a foundry with a reverberating furnace.

Lewis had no money of his own and turned for financial assistance to a countryman of his, Robert Finlay, an influential industrialist and merchant. Finlay was connected with Finlay & Jennings, the most important firm of merchants and iron exporters in Sweden at that time, not to say of that century. Their properties included eight ironworks in Sweden and six in Finland. Finlay transferred to Lewis a water-front property which he owned on the outskirts of Södermalm, a southern suburb of the capital. It was named Bergsund. Through Finlay, a government loan was also arranged. At Bergsund, Lewis now erected a large foundry and other necessary buildings. Fire-bricks were brought from England, sand from England and France, tools and implements as well as patterns were bought abroad. The foundry had only just started, however, when Finlay & Jennings went bankrupt (1771). This was a serious blow to Lewis, who had to go into liquidation the following year. Economic conditions in Sweden were strained, and it was not easy to raise fresh money. Lewis had, however, in 1774 married the daughter of a wealthy ironmaster, Hans Jakob Gahn[x)], and with his aid new capital was raised. It was possible to keep the foundry going, and Lewis then had a few years of undisturbed activity.

In the price-lists, Bergsund was called "the English Foundry owned by Thomas Lewis", and among the articles offered were pots and pans of many shapes and sizes, cauldrons and kettles for household use, grates and ovens for sugar refineries, cash boxes, cog-wheels, anvils, ballast iron, cannon-balls, rollers (plain and turned), water-pipes, fences, flower-pots, cauldrons and pots for chemical

x) The forbears of this well-known family came from Scotland and the gradual transformation of their name may be of interest to linguists: Colquhoun - Cahoon - Ga'hoon - Gahn

works. Cannon are also mentioned.

However, it proved impossible to obtain Swedish pig-iron suitable for commercial foundry purposes. The Swedish blast-furnaces could not yet produce a suitable foundry pig. Lewis therefore decided to make his own pig-iron. In 1780 he bought a blast-furnace called Nyhyttan, in the province of Västmanland in central Sweden. It was his intention not only to make grey pig-iron for Bergsund, but also to turn out heavier pieces by casting direct from the blast-furnace. He also intended to supply cast-iron goods that required turning and grinding. Among the improvements he introduced in this connection was a blowing-engine, which attracted considerable attention. During this period a good deal of money was spent on furnace experiments, which undoubtedly caused Lewis no small losses. He was not a metallurgist, and evidently relied too much on his own experience as a foundryman.

Not a great deal of information is available about the various activities at Bergsund during the first ten years of its existence. This was the infancy of the Swedish engineering industry, a fact that should be remembered when considering the merits of the various constructions brought out by Lewis.

Lewis maintained in Sweden his connections with Carron and with his friends there and elsewhere in Great Britain. The development of Watt's steam engines interested him greatly and he seriously considered the possibilities of making them at Bergsund. These ideas did not materialise until 1807, nearly 25 years after his death, when the works he had founded supplied the first Watt engine made in Sweden.[x)] With Quist, the Swedish metallurgist who built a crucible steel plant in Stockholm - probably the first of its kind outside England - he had close relations. Lewis died in 1783 at the early age of 36. He had built for himself a home at Bergsund, a peculiar, tall and narrow building, which stood out among the other houses in the vicinity. It was pulled down only a few years ago.

His wife carried on the business for a short time, after which it changed hands several times, in due course becoming one of the leading engineering-works in Sweden. In 1806, Samuel Owen was engaged as a foreman in the pattern shop. He remained until 1809 and then opened a

x) The first steam engine built in Sweden was of Newcomen design; it was made under the direction of Mårten Triewald and delivered in 1728 to the Dannemora mines.

machine shop of his own at Kungsholmen, about half a mile nearer the centre of the town. His life and work in Sweden are dealt with in a later chaper.

As we have seen, Bergsund was at first a foundry. After some time, especially after the engagement of Samuel Owen, the production of machinery in general was added. It has already been mentioned that the first modern steam-engine in Sweden was built at Bergsund. In 1808 a large threshing-machine "on the English model" was supplied to an estate outside Stockholm. In 1809 the first two rolling-mills for thin plate made in Sweden were supplied to the ironworks at Kloster and Skebo. They were constructed by Owen.[x)]

The land where Thomas Lewis once built his foundry and later the Bergsund Engineering Works and shipyard, which grew into an undertaking of considerable importance, is now occupied by imposing blocks of five-storey middle-class dwellings in topographically attractive surroundings. When the works were closed, shipbuilding was transferred to the Finnboda Yard, at the other end of Stockholm so to speak, where more water space is available.

x) Most of the information contained in this section has been gathered from an article by Carl Sahlin in the Journal of Jernkontoret (Jernkontorets Annaler) for 1928, pages 535-564, entitled Thomas Lewis och hans insats i den svenska gjuteriteknikens utveckling (Thomas Lewis and his contribution to the development of iron casting in Sweden). Reprint 1928 by Almqvist & Wiksell, Upsala.

IRON-ORE MINING

Extraction of iron-ore has from early times occupied a central place in the Swedish economy. Iron-ore is one of the country's most important natural assets, and Sweden is today the world's leading exporter of iron-ore. Production was for a long time entirely reserved for domestic iron-making and only in the second half of the 19th century was export permitted. In any case the heavy transport costs acted as a natural deterrent. It was in overcoming these difficulties that British influence came to play so essential a part, while the export trade itself was financially supported from British quarters over a period that was to prove of the greatest importance to Sweden. For it happened just when the phosphorous Swedish ores, through the employment of the Thomas method, proved their great value in the world's steel production.

Neither should we forget the dauntless British pioneers during the middle years of the last century who worked to find a solution of the ore and transport problems of Lapland, in some cases with disastrous financial consequences to themselves, and who followed in the footsteps of still earlier explorers - Swedish mine-owners and iron-masters such as Steinholtz, Meldercreutz and Hermelin.

Central Sweden - Grängesberg

The principal iron-ore deposits in Sweden are found in two regions: the central mining-belt and northern Lapland. The ores of central Sweden have been the main basis of iron-making since the early middle ages - beginning with "Osmund iron", then wrought iron and later steel.

In central Sweden, the ores are both of the low-phosphorous (0.002 - 0.1% P) and the high-phosphorous types. Most of the former ores hold less than 0.01% P. The high-phosphorous ores contain as a group more than 0.3% P. They are quantitatively the more important deposits of the two, and occur principally in the area owned by the Grängesberg Company. Their high P-content, however, makes them unsuitable for the higher grades of Swedish steel, although it is possible to dephosphorise them by a process of concentration and acid-leaching.

The deposits in the Grängesberg area, by far the largest in central Sweden, are in part owned by the Grängesberg Company. Their mines in this region have an annual production of about 1.2 million tons of lump ore for export, besides concentrates for domestic consumers. The ore consists mainly of magnetite with a fair admixture of haematite. What is known as "Grängesberg lump grade" contains approximately 59.9% Fe and 0.94 P. It was from the mines of Grängesberg that the first exports of ore from Sweden on a major scale were started. The shipping port was then, as now, Oxelösund, on the Baltic, a distance of about 150 miles by rail. Here the Grängesberg concern is now building steelworks for an annual production of 300,000 tons of commercial plate.

The parent company in this area, Grängesberg Grufve-Aktiebolaget, was formed in 1883 and gradually acquired most of the ore--deposits in the neighbourhood. To co-ordinate mining operations with railway transport, a new company, Trafikaktiebolaget Grängesberg-Oxelösund, generally called TGO, was formed in 1896. This concern became the owner of the Grängesberg mines, as well as the main line to the port of Oxelösund and a number of local railways.

In these transactions a dominating role was played by the British banker, Sir Ernest Cassel. He is of course known for his many financial operations in various parts of the world, but he gave very special attention to Sweden and made a substantial proportion of his great wealth by his capital investments in that country. It was while he was engaged in placing loans for building the Swedish State Railways that he came to realise the importance of the Grängesberg mines. The ores from these mines were of lower value because of their high phosphorus content, but Cassel drew attention to the Thomas-Gilchrist method, by which they could be made much more valuable. He played a very active part in the formation of the TGO railway company and the related consolidation of mining concerns in the Grängesberg region. In connection with the Lapland ore deposits, the reader will learn how the TGO in 1903 acquired control of the Gellivara (Malmberget) and the Kiruna mines. In this transaction also Cassel was one of the central figures.

The fortune which Cassel accumulated as one of the leading bankers of the world was very large - estimated at £6 million. His donations for educational and other purposes, nearly £2 million,

showed his great munificence. In Sweden, too, he bequeathed substantial sums for education and for the benefit of the workers at Grängesberg and Kiruna.

Lapland

The Lapland ores are among the richest in the world. They contain from 60 to 70 per cent iron, whereas most of the deposits now being mined elsewhere yield not more than 30 to 50 per cent. The Lapland as well as the Grängesberg ores are of a predominantly phosphorous type, which in combination with the high Fe-percentage, is hardly known to exist anywhere else. In all three of the large ore-areas of the TGO (in common parlance called Grängesberg) the principal deposits consist of typical Thomas ore, with 1-2 per cent P; in some cases with as much as 3-5 per cent. At Kiruna and Malmberget there are also considerable quantities with a low P-content.

The two main areas of ore deposits in Lapland are situated at a high latitude: Kiruna a little below 68°N and Malmberget at the same distance north of 67°; consequently both are well within the Arctic Circle. The distance between these two mining centres is 50 miles.

Kiruna, including the nearby mine at Tuolluvaara, is the name of one of the world's most important deposits of rich magnetite ore. The bulk of this ore, known as D-type, contains 60 per cent iron and 2 per cent phosphorus. There are, besides, pockets of a still richer ore enclosed in the main body, with a higher iron and a lower phosphorus percentage (Kiruna A-grade contains 68 per cent Fe and 0.024 per cent P). The low-P ores for export are divided into the following four groups:

	% Fe	max. P %		% Fe	max. P %
A	68.0	0.03	C	66.0	0.35
B	67.0	0.01	C^2	64.0	0.90

The present capacity of the two mines is 14 million tons. At Kiruna, open-cast working is being gradually replaced by underground operations. This mine, with a capacity of 12 million tons a year, will be the largest of its kind in the world. The total planned capacity of the two Kiruna deposits will be 18 million tons a year. If an increase is called for it may be raised to 20 million tons. Subject to normal industrial development, there is every reason to believe that the upper limit will be applied. It is estimated that in 1965 the consumption of

steel in the six countries of the European Coal and Steel Union together with Great Britain will have reached between 70 and 77 million tons. Last year it was 46 million.

The Malmberget deposits consist of 80 per cent magnetite and 20 per cent haematite. The ores of the main body are high-phosphorous and contain on an average 1 per cent P. One mine contains magnetite only with a high percentage of Fe and, in part, a low P-content. The production at Malmberget and the adjacent Koskullskulle is at present about 4 million tons a year and will gradually be increased to 5 million tons. The ore is submitted to mechanical classification only, i.e. it is crushed and concentrated. Below are given the Fe- and P-contents of the different grades of ore from Malmberget:

	% Fe	max. P %		% Fe	max. P %
D	61.5	0.85	A concentrate	70.2	0.026
C	64.0	0.36	A^{10}	71.5	0.010
			Fine concentrate	71.7	0.007

It is shipped from the port of Luleå on the Gulf of Bothnia, 125 miles SSE by rail. This port is ice-bound from the beginning of December until the middle of May. The ores from the Kiruna district, on the other hand, are sent to the ice-free port of Narvik in Norway. The distance from Kiruna to the Norwegian border is 80 miles. From there to Narvik the haul is a bare 18 miles.

Historical Notes on British Activities in Lapland. It is not generally known that the iron-ore deposits in Lapland were known as far back as the beginning of the 17th century, and that even then they gave rise to an iron industry. The Junosuando iron-ore field in the valley of the Torne River, which forms the boundary with Finland, was the first to be worked. This was at a place called Kengis, where blast-furnaces were built on the river. A waterfall with a 60-foot head in the vicinity was one of the reasons for choosing this site. In addition there were the transport facilities to the sea offered by the river. The forge here was kept working - irregularly, one must assume - until the beginning of the 1880's, but production was small, probably not more than 9,000 tons of pig-iron and 4,000 tons of bars in the entire period from 1646 to 1870. During the 1740's, several iron-works were built in the Råneå area north of Luleå, not far from the coast. Activities here until 1890 were on an appreciably larger

scale than at Kengis. In the 19th century, more ironworks were built, these also in the Luleå and Piteå region, but all of them ceased production in the latter part of the century, the last - Selets Works - in 1896. These forges had of course great difficulties with the transportation of the ore from the mine at Gellivara (Malmberget) down to the coastal region, a distance of some 100 miles. The leading forge--owners during the period referred to - the latter part of the 18th century - were the Meldercreutz and Hermelin.

The Malmberget deposits had at this time begun to receive wider attention, but production difficulties in general were enormous, and the forge-masters suffered heavy losses; Hermelin, "the King of Lapland", went bankrupt in 1812. Then a new period began. Charles XIV John, the first Bernadotte on the Swedish throne, and earlier one of Napoleon's generals, began his reign in 1818. He was an enterprising monarch in several respects and had a very high opinion of his own financial acumen. After a time he began to acquire land in Lapland, and subsequently his estates covered an area of some one and a quarter million acres. The King had an eye to future possibilities, and at one time planned to dispose of a portion of the property to British investors. All of it passed, however, at his death in 1844 to his son Oscar I. Various foreign groups had already examined the possibility of ore exports from Lapland, but in 1857 the royal domains were acquired by a newly formed Swedish-Norwegian company. The price paid was equivalent to £80,000 sterling. The new owners tried to dispose of the property to both French and British financial groups, and finally it was sold in 1864 to a British concern formed for the purpose with a capital of £500,000, named the Gellivara Co. Ltd. After only three years, however, the new owners had to go into liquidation. Another British concern, The New Gellivara Co. Ltd., formed in 1869, then stepped in. More information about subsequent events and the two Loders, father and son, who were leading men in the latter concern, is given in the following.

The Loders. We have seen above how the vast properties in the coastal area of Norrbotten and in Lapland, after changing owners twice in a short period, passed into the hands of the New Gellivara Co. Ltd. in 1869. The price paid at the bankruptcy sale was only £40,000. The purchase did not, however, include the Gellivara mines. The leading men in the new company were Giles Loder (1786-1871) and his son Robert (1823-1886). The mines were acquired by the Loders as their

personal property.

The new owners took a keen interest in the development of the vast estate. The small ironworks belonging to the property had been closed since 1859-60, and efforts were now made to restore them to working order. The Avafors blast-furnace, not very far from the coast in the Luleå district, was repaired and restarted in 1873-74 after 14 years of idleness. The Selet blast-furnace, in the same district, was put in order and fired in 1874. In the same year the forges at Melderstein, also in this area, and at Selet were rebuilt and enlarged. In place of the German hearths, the Franchecomté process was introduced. In 1876 these two forges were again rebuilt and the Lancashire process adopted. At the Alter forges, reheating hearths were installed on the adoption of the Lancashire process, since real reheating-furnaces were considered too expensive to build. The production consisted of hammered bar-iron and was mostly sold for export.

The blast-furnaces were in the main supplied with ore from mines as far away as the island of Utö, off Stockholm, and from deposits in central Sweden. They were originally intended for the use of Gellivara ore, but it was found that the type mined gave a cold--short iron. Therefore a charge with less phosphorus had to be used, although a limited quantity of Gellivara ore was still added.

A clerk who had been employed at the Melderstein forge describes the impression made on a new arrival by the long procession of reindeer--drawn flat-bottomed sleighs, transporting ore over the snow-covered wastes from Gellivara to the blast furnaces not far from the coast - a distance of some 100 miles. The load of each sleigh weighed about 200 lbs.

From 1870 the use of Gellivara ore gradually increased; it was possible to make a better selection. Production at the Loder works was, of course, very modest: two blast furnaces and three forges were kept going. The aggregate number of working days a year for the two furnaces varied considerably - from 50 to 200; and so did production: from 400 to 1,000 tons a year. The furnaces were very small; at Avafors the flue was only 33 feet high.

In 1877 Robert Loder took up the question of building a rolling--mill somewhere off the coast. His idea was to gain a few weeks of additional open water, as the forges were some 15 miles inland from

the ice-bound coast. He bought a rocky little island called Altappen, a few miles off Luleå, for the proposed mill. This island, by the way, has already been mentioned under "Rolling-Mills". The new plant was started in 1879. The equipment was supplied by Swedish makers and consisted of two rolling-sets, two reheating-furnaces with gas-producers, a machine-shop, a small foundry and two steam-engines producing together 85 hp. These also supplied power for the sawmill which the Loders had previously put up on the island. After rolling had started at Altappen, the hammer works at Alter, Selet and Melderstein were closed down. The production at Altappen consisted of bars, round, square and flat, also rods for wire and strip. Since double entries occur regularly, the Altappen journals supply no exact figures for the annual production, but it was, needless to say, very small.

In 1890 the rolling-mill burned down. It was not rebuilt, for the price at which bar-iron could be produced was too high under the very unfavourable conditions which the owners had to face. Furthermore, the Gellivara mines had entered a new period of development. In 1887 the first locomotive arrived at the mining centre from the coast, and the whole situation changed. New owners took command.

Robert Loder (who in due course was knighted) took a great personal interest in the improvement of social conditions among the employees (about 200) and their families (500 persons all told) at their place of work - at the outset nothing but a bare and desolate little island. Apart from the unloaded ballast of arriving ships, soil was brought from the mainland in large quantities, trees and shrubs were planted in great number, and, thanks to judicious manuring, vegetables were grown in an abundance quite unknown before at that latitude. Photographs from the time give a good idea of the pleasant little community which Robert Loder built up on his island at $65^{o}3''$N. x)

Transport problems. Some data have previously been given to show the difficulties successive pioneers had to face in their efforts to make use of the great natural resources of Lapland. When the New Gellivara Company had left the scene, new investors came forward. The building of the railway between Gellivara and Luleå had started in 1884, but soon fresh capital was needed. The North of Europe Railway Co. Ltd. was then

x) Literature: Carl Sahlin: Altappen, published in Blad för Bergshanteringens Vänner, Stockholm 1934.

formed, "the most northerly railway in the world", as it was described. This concern was succeeded already in 1888 by a new group, the Swedish and Norwegian Railway Co. Ltd. In that year the line to Luleå was provisionally completed, and freight from Malmberget could at last be shipped. The British company responsible for building the railway could not, however, bring the costly undertaking to a final conclusion but was compelled to go into liquidation. The Swedish Crown then declared the concession forfeit and bought the property in 1890. What remained of the line between Luleå and Gellivara was then fully completed. By 1893 about 300,000 tons of ore a year were produced and at the end of the century this figure had risen to some 950,000 tons.

The obvious question of continuing the line to the ice-free port of Narvik had of course been discussed before that. Luleå, as has been said, is ice-bound in winter, and with the expected sharp increase abroad in the production of steel by the Thomas method, a rising demand for the phosphorous Lapland ores could confidently be anticipated. Private groups of financiers applied - without success - for a concession to build the extension of the railway to Narvik, but in 1898 the Government decided that the State should build the line. Narvik was reached in 1902, and the first ore-load was despatched in January of the following year.

The Twentieth Century. The owners of the Lapland mines towards the end of the 19th century had to contend with great difficulties and were, as has been stated several times in these pages, in constant need of funds. Credit facilities became more and more strained, and one quite important ore deposit had in fact to be sold in 1897 to a Bohemian steel company.

Mention has also been made earlier of the consolidation of the mining concerns in the Grängesberg region, and how TGO, the combined mining and transport company, rose to dominance. It was obvious that such an undertaking would pay attention to developments in Lapland and not least to the financial troubles constantly impeding progress there. The two Lapland ore companies, Luossavaara-Kiirunavaara and Gellivara, had been founded in 1890 and 1891 respectively. The shortage of capital referred to above proved in time so intractable that the majority of their shares was in 1903 offered through Deutsche Bank to a consortium of German steelworks. At that time a Swedish financier, G.E. Broms, held a dominating position in the companies, and with him TGO began negotiating in the same year (1903) to acquire control. The transfer

was finally concluded in 1904, and so TGO became owners of both Luossavaara-Kiirunavaara and Gellivara.

In order to avoid the risk of future interruptions in working these mines, which represented some of the most important national assets and were also situated on Crown land, and to ensure that the ore could be carried by the railways owned by the Crown, it was necessary to come to an agreement with the State. This was done in 1907. By virtue of this Ore Agreement, as it was called, the Government secured half the ownership rights in the Lapland mines and a half share in the profits. Under a new agreement in 1927 and subsequent amendments the greater part of the Luossavaara-Kiirunavaara Aktiebolag (LKAB) profits was secured to the State, and about 80 per cent of the profits from the Lapland ore-fields went to public (government and municipal) authorities in the form of taxes, rates and dividends, whilst 20 per cent accrued to the TGO parent company. In 1950 the LKAB bought all the shares in the Koskullskulle mine near Malmberget which, as stated above, had at one time been sold to Bohemian interests.

Nationalisation of the Lapland Mines. On October 1st 1957 the Luossavaara-Kiirunavaara Aktiebolag[x)], owners of the mines and ore deposits at Kiruna (with Luossavaara) and Malmberget (Gellivara) passed in its entirety into government possession. This transaction took the form of an acquisition by the State of the ordinary shares in LKAB, which were held by the TGO Company. The LKAB, now a government concern, and the TGO which, of course, still own the Grängesberg mines in central Sweden, are partners in equal proportions in a joint sales company. They will also continue to collaborate in respect of ore shipments. In fact, all shipments are managed from the TGO head office in Stockholm. At the end of 1963 the TGO fleet consisted of 33 ships with an aggregate tonnage of 630,515 t.d.w.

The output during 1963 from Kiruna and Malmberget totalled 17,300,000 tons. Exports amounted to about 16,600,000 tons. Of this quantity West Germany purchased about 6,800,000 tons, Belgium-Luxembourg about 4,750,000 tons, Great Britain about 3,100,000 tons and Poland about 370,000 tons. LKAB employed about 7,500 people in 1963.

x) These strange-looking words are the native names of the neighbouring two mines; vaara means "mountain", luossa "salmon" and kiiruna "snow-grouse".

The Government Steel Works in Norrland

The existence of transport facilities for the ore from the mines in Lapland to a Swedish port did of course provide opportunities for large-scale ironworking in the area. But it needed quite a long time for progress to be made by action of a permanent character. Meanwhile a number of more or less half-hearted efforts were made to establish works for the production of pig-iron and commercial steel near Luleå.

Finally a modern plant came into existence on the initiative of a socialist government. In 1945 the first part of the new works, the electro-steel section, was opened. The equipment for the production of pig-iron now includes: 3 electric furnaces with a total production of 90,000 tons a year, and one coke blast-furnace with an annual production of 280,000 tons. Then there are for steel-melting 3 basic Bessemer converters and 4 electric furnaces. The annual production of rolled material is at present 300,000 tons. A programme has recently been placed before the Government for a four-stage extension, which in four years' time would bring the production up to the respectable volume of 580,000 tons of commercial steel. x)

x) In the compilation of this chapter the author has had the benefit of valuable assistance from several members of the TGO management in Stockholm. Useful literature has also been placed at the author's disposal. Particularly to be recommended is a well documented review of the TGO Company's activities which also contains historical notes. Its title is The Mines of the Grängesberg Group, the author Dr. B. Högbom and it was published in 1951 by AB Hasse W. Tullberg.

RAILWAY BUILDING

In the field of railway construction, Sweden like so many other countries received the first impulses from Britain. That applies both to the building of the railways and to the manufacture of the material for them. And it did not stop at the impulse: when the experience gained in Britain came to be transplanted in practical terms on Swedish soil, British capital gave much help.

The Royal Swedish Railway Company

It may be mentioned by way of introduction that the first railway line in Sweden, that between Örebro and Arboga - two market towns in central Sweden - was opened to traffic in August 1857. This railway, with a length of 30 miles, was built on the initiative of Count A. E. von Rosen and formed part of a large scheme for connecting Stockholm and Gothenburg. This scheme was not, however, carried out until some years later, and then under government direction and over a different route.

Count von Rosen had in 1845 obtained a charter to build railways in Sweden over the following twenty years, and he commissioned a prominent British civil-engineer, Sir John Rennie, to make surveys for the line between Stockholm and Gothenburg. For those days, this was an enormous undertaking that could only be carried out in stages. The acquisition of the capital needed met with serious difficulties, and the promoters had to content themselves with the Örebro-Arboga section as a modest start. Von Rosen fully realised that without British capital no protracted railway construction could be undertaken. The company that was to carry out the building project was styled Kongl. svenska och engelska aktiebolaget mellan Örebro och Hult (Royal Swedish and English Company between Örebro and Hult). Hult was a small place on the eastern shore of Lake Vänern, and the intention was to carry passengers and freight by boat across the lake until the railway between Stockholm and Gothenburg were completed.

Sharp cleavages of opinion - political, geographical and economic

in character - supervened, and after a few years the style of the company was changed to Kongl. svenska aktiebolaget för jernväg mellan Köping och Hult (Royal Swedish Company for a Railway between Köping and Hult). In 1852 was held the first company meeting, at which Sir John Rennie was appointed chief engineer and Charles Henry Edmonds the company's representative in London. Von Rosen was made managing director of the company. The share issue in London went forward satisfactorily, and the company achieved a good rating in financial circles. Among its board members may be mentioned John Sadleir, John Masterton junior, James Rhodes and Robert Gillman, and the above-mentioned Charles Henry Edmonds, who was the company's solicitor. A contract was concluded with one of Britain's best known railway contractors, George Burge, to carry out the entire project and to acquire all the rolling-stock needed. Space is not available here for details of the financial agreement then made.

Financial troubles began to be experienced after a time, and the work took a good deal longer time than had been foreseen. Finally traffic was opened in August 1857 between Örebro and Arboga as mentioned above. Gradually the railway was extended in several directions and after some years part of the system was taken over by the State, part of it by Trafik AB Grängesberg-Oxelösund (TGO), the great railway and mining concern mentioned in the chapter on "Iron--Ore".

The Swedish Central Railway Co. Ltd.

Towards the end of the 1860's, British interest was increasingly being shown in the Swedish groups who were discussing plans to build a railway south to north through the mining and iron-producing areas of central Sweden. It would run from the junction of Frövi on the existing line to the town of Falun in Dalarna, a distance of 110 miles, and would link up with a new line to an ice-free port on the Baltic, south of Stockholm.

Several years elapsed before things began to move. Nothing was heard from the British side for a long time, but during the winter of 1868-69 certain individuals, among them the Secretary of the British Legation in Stockholm, Audley Gosling, began negotiations with financiers in Britain with the object of applying for a concession to build a railway between Frövi and Ludvika, with a possible extension to Falun.

Leaving aside the details of the proceedings it should be stated that the concession obtained by Gosling was transferred in 1869 to a company founded under English law in Britain, styled the Swedish Central Railway Company Ltd. There was, however, to be a permanent manager in Sweden residing near the line. A contract was drawn up with Wythes & Longridge, a firm of contractors, to build the line. The capital, however, was insufficient, and two mortgage loans had to be obtained. Walmsley Williams, an engineer, was engaged to take charge of the work and arrived in Sweden in 1869. In the autumn of 1873 the railway between Frövi and Ludvika was ready, at least for provisional traffic.

The railway had been built and was owned by British interests, the most important being the banking firm of Bischoffsheim & Goldschmidt, the merchant house of J. Thomson, T. Bonar & Co., and the railway contractor Geo. Wythes. The board of directors, domiciled in London, comprised in 1875 H. L. Bischoffsheim, chairman, C. Weguelin[x)] (head of J. Thomson, T. Bonar & Co.), George Wythes, and George Goslett, a director of the Nässjö-Oskarshamn Railway Company, a line that was also built on British initiative.

But it proved uphill work to get the new railway to pay its way. It was soon realised that an interest had to be acquired in mines and other industries adjacent to the line. To bring this about, Weguelin took the initiative in 1875 in forming the Swedish Central Association in London. Weguelin's representative in Sweden was C. F. Liljevalch junior, a merchant banker of great influence. He succeeded in acquiring valuable territories comprising mines, blast-furnaces and forges, covering an area of about 90,000 acres. The purchase deed was transferred to the Swedish Central Association or, in effect, to the three interested parties referred to above. At the office of one of these - Bischoffsheim & Goldschmidt - was employed a young departmental manager, Ernest Cassel, and it was probably at this time that his name was first heard of in Sweden. It was not long before it was found desirable to reorganise the financial structure: the major Swedish interests ought, it was realised, to be under joint administration, and to this end a company

x) In the chapter on "Sulphite Pulp" mention is made of the important role played by Christopher Weguelin in the experiments made at the Bergvik mill in Norrland with the boiling of cellulose, which led to the first production on a commercial scale of sulphite pulp.

was founded in London in 1877 called the Swedish Association, with a share capital of £715,000. The assets were shares in the Swedish Railway Company Ltd., in the railway previously mentioned from the mining district in Oxelösund and the mining companies.

Cassel now joined the Swedish Association as representative for Bischoffsheim & Goldschmidt, and shortly made a proposal for purchasing phosphorous-ore mines in the Grängesberg area. The proposal was accepted and quite a number of mines were bought at fairly advantageous prices. The management of these new acquisitions was placed in the hands of a company founded for the purpose in 1883, Grängesberg Gruv AB (Grängesberg Mining Co.). That, then, was the origin of an undertaking whose name would in a few decades become one of the most widely known in Swedish industry.

In 1879 the Frövi-Ludvika railway was given a new head. He was John Johnson, a machine engineer. One can without question ascribe to the foresighted new chief a great deal of the credit for making the line a paying proposition. John Johnson was in his time one of the most well-known and best-liked Englishmen in central Sweden.

In 1900 the railway was leased for fifty years to Trafik AB Grängesberg-Oxelösund (TGO) which thereby acquired the means for its subsequent attainment of a dominant position in Swedish ore-production. The transfer meant that the Swedish Central Railway Co. no longer conducted a railway service. In 1925 the company's entire assets were taken over by TGO.

The Railway to the Port of Oxelösund

The distance from Frövi - which one might say is the southern terminus of the "ore line" - to the port of Oxelösund is 106 miles. Articles of Association for the company that was to build this railway line were adopted in 1872. On the board were found the names of W. Stanley, J.A. Longridge and C. Weguelin. The contractors appointed were G. Wythes and J.A. Longridge, to whom reference has been made earlier in these pages. Shortly afterwards the British shareholders decided that the railway company itself should take over the line from the contractors. The railway ran at a loss in its early years, and it was natural that efforts should be made for co-operation with the line through the ore-bearing districts higher up the country. The Swedish Association, by successive agreements in the early 1880's brought such co-operation about. In the year 1900, TGO took over the administration of the whole Oxelösund line.

FOREST INDUSTRIES

Timber

Partly for strategic reasons, partly under the influence of mercantilistic concepts, Britain very largely excluded imports of European timber in the early decades of the 19th century and obtained her supplies from Canada. The object was on the one hand to safeguard timber requirements in the event of war, and on the other to help Britain's colonies. Woodgoods from Europe were saddled with almost prohibitive customs duties, while the colonies escaped with substantially lower rates. British tariffs were gradually being reduced but not until 1851 had this process gone far enough to have decisive effects. By 1861, however, the duties on European wood had become for practical purposes nominal.

During the first half of the 19th century, difficulties accumulated for the Swedish iron-export trade; The Gothenburg export-firms tended to concentrate more and more on woodgoods, alongside - and sometimes in place of - bar-iron exports. In the early years of that century, several British wood-exporters came forward, notably Hichens, Carnegie and, above all, the Dickson concern. During the previous period, i.e. in the closing years of the 18th century, the leading position had been occupied by the well-known British Gothenburg firm of John Hall & Co., whose shipments of planks from Gothenburg in 1790 and 1800 for example amounted to 70 per cent and 50 per cent respectively of the total exports of this class of goods from that port. John Hall & Co. owned no less than eight sawmills at the Lilla Edet waterfalls, 30 miles up the Göta River from Gothenburg. In those days a sawmill was, of course, an establishment of very small dimensions with extremely simple equipment.

The pioneer concern among the Gothenburg merchant houses in the timber trade was without question the Dickson firm. They bought forests and felling rights in North Värmland, where the statutorily privileged iron-industry did not stand in the way of providing the sawmill's raw-material needs. They obtained possession of the large water-power sawmills at Munkfors, Dejefors and Edsvalla, which are now the sites of great

industrial undertakings (steel, paper and pulp). And in a short time the firm extended their production to Norwegian territory.

Early in the 1820´s, the Dicksons also began buying forests and sawmills in Norrland, in some cases at exceptionally low prices. The Matfors sawmill and the Svartvik loading-site were joined to the Dickson concern at the beginning of the 1830´s, Baggböle in 1838, Husum in 1846. The investments in Värmland were successively and very profitably liquidated in the course of the 1850´s.

The prices sometimes paid in the first half of the 19th century for forest land in, for instance, upper Norrland, now appear so incredibly low that the author refrains from even giving examples.

It seems to have been a widely held opinion in timber circles of the 1860´s and 1870´s that the Dicksons had been pioneers in almost every sphere of the sawmill industry and had shown the way that others were to follow - it is hard to say with what justification. Nevertheless, remarks by critically-disposed competitors indicate that there were probably solid grounds for these estimates. The Dicksons possessed remarkable business acumen, ruthless tenacity of purpose and astonishing prescience. Their keenness and general adaptability were strikingly exceptional for the period.

There is a good deal of evidence that the changeover at this period from water-wheel to steam-power sawmilling was enforced by the demands of the increasingly dominant British market. Steam-power first broke through in the Härnösand-Sundsvall district, where it came into use in the 1870´s. The steam-engines and frame saws needed were obtained mainly from Swedish engineering-works, such as Bolinders, Motala and Bergsund.

The technical aspect of sawmill owning or sawmill financing in the golden days of the great Gothenburg houses was of very simple structure and is hardly a major subject for investigation or review. Water-power mills, often located up-country, gave place gradually to steam sawmills built near a port. Thin-bladed saws came increasingly into use, and later on a beginning was made with mechanical processing of the sawn timber. This was the period when the Gibson Works at Jonsered made a name for itself in the engineering industry.

The Dicksons did not escape criticism for their exploitation of the Norrland forests, but on the other side of the Atlantic examples of

the same kind were, as we know, also very numerous. Several members of the Dickson family gave large amounts for scientific, cultural and social purposes. The best known of their acts of munificence was the provision by Oscar Dickson of funds for the expedition through the North--East Passage made in 1878-1880 by the explorer A.E. Nordenskjöld. x)

Pulp Making

When the chemical-pulp industry made its appearance in Sweden it was relations between Britain and Sweden that proved to be the most important. The production of chemical pulp, or cellulose, is based on the principle of boiling wood in chemicals so as to dissolve the binding substance, the lignin, thereby freeing the cellulose fibres.

According to the chemical elements used, the production of wood cellulose is divided into two groups: alkaline and acid. The former has the alkaline metal sodium, the latter sulphur, as its base. The alkaline processes were the first chemical methods of producing wood pulp to be attempted. The original soda-processes have now been almost entirely replaced by a derivative, known as the sulphate treatment, in which sodium sulphate, in the commercial form known as "saltcake", is used. Sulphate pulp is often called kraft.

Without going into detail it may be said that the acid, e.g. sulphite (or bisulphite), process is a good deal simpler than the sulphate method: lime is added to a solution of sulphur dioxide in quantities insufficient for complete neutralisation. A modification has in some cases been adopted by the use of a magnesium instead of a calcium base.

The Alkaline Process. The first soda-process pulp mills in Sweden were in the early stages nearly all based on British techniques, and three separate processes have been indentified. The financing of the new undertakings, on the other hand, was largely effected from domestic sources, although British investments of capital did occur - certainly in one case and probably in another. The three production-processes which it has so far been possible to segregate with reasonable certainty are described below.

x) Among literature consulted should in particular be mentioned Svens Trävaruexport under Hundra Ar by Ernst Söderlund (Swedish Wood Exports through a Hundred Years), Stockholm 1951, Almqvist & Wiksell.

The F. B. Houghton process, completed by J. A. Lee, was applied at the following mills: Alstermo 1870, Delary 1872, Värmbol 1872, Krontorp (Bäckhammar) 1873 and Brusaholm 1873; probably also at Borkhult. The mills at Delary, Värmbol, Krontorp and Brusaholm were built on the initiative of Count Sten Lewenhaupt, a prominent Swedish industrialist. He went to England primarily to study the Sinclair method, but found that the Houghton process was preferable. Houghton's basic British patent is dated as early as 17th February 1857 - No. 467 - and his name was later associated with new patents right up to 1873. Lee also has a number of patents to his name during the period 1868-73.[x] The Alstermo mill went into bankruptcy in 1874 or 1875, but the pulp made there had been usable. The Borkhult mill also went bankrupt.

The George Sinclair process was made known in Sweden in 1870-71 by a prospectus distributed by Frederick D. Blyth of 131, Fenchurch Street, London. Among the first to introduce this process was G. A. Engelbrektson, an industrialist of Örebro in central Sweden, who built a mill at Gustafsfors in Södermanland, some 60 miles southwest of Stockholm. This process had previously been investigated by a Swedish engineer, Wilhelm Wenström, at mills in Chirnside (probably started in 1870) and Musselburgh in Scotland. He had also visited Sinclair's machine-shop in Leith, together with other workshops in the same town. Sinclair was an experienced steam-boiler constructor. At Gustafsfors, Engelbrektson made a number of changes, among them some to the Sinclair boiler. To judge by several patents granted up to the end of 1880, Sinclair showed much interest in the development of cellulose production.

At a place called Kymsberg, in the province of Värmland in the western part of central Sweden, a cellulose mill based on the Sinclair method was also built in one of the early years. Blyth undertook to obtain a plant and a British expert to get the mill under way and to act as purchasing agent for chemicals etc. and as sales agent for the pulp. The first consignment of pulp for London was

x) At his machine-shop in Lydney, Gloucestershire, Lee made the equipment for the above-mentioned mills. This shop was situated not far from the Cone Mill, a soda pulp factory (built in 1866) visited by several Swedes who wanted to study the new industry. It is stated that Lee himself went to see several of the Swedish mills where his machinery had been installed.

shipped in January 1872. This was the first cellulose to be exported from Sweden. It was wet pulp packed in wooden packing cases. The owner of this mill, Drakenberg by name, left in 1874, a ruined man. The whole place was burnt down in 1875 and was not rebuilt.

At about the same time as Kymsberg, a soda-mill on the Sinclair system was built at Götafors, a place close to Korndal, not far from Gothenburg, and later an important industrial centre. The Sinclair system was likewise used at a mill outside Gävle, 100 miles north of Stockholm, built by an enterprising pharmacist of that town, who like so many of the early leaders in due course went bankrupt.

Count Lewenhaupt, an untiring and resourceful industrialist, has previously been mentioned. His interest in the Sinclair process had been aroused, and in 1871 he went over to England to investigate it, but he came to the conclusion that the Houghton process was preferable. Through Torsten Nordenfelt, the Swedish inventor and armament manufacturer, he met in London a wealthy broker named Ricardo. Lewenhaupt's project included factories at Värmbol and Delary. Nordenfelt extended this with a programme of his own which embraced old ironworks at Brusaholm and Hörle in Småland, Krontorp near Björneborg, later Bäckhammar, Skagersholm near Laxå and Frötuna near Tellingsborg. These were all bought on British credits obtained from or through Ricardo. The plans for Hörle, Skagerholm and Frötuna soon had to be written off and the properties sold, but at Värmbol, Delary, Brusaholm and Krontorp building was got under way. Lewenhaupt is said to have been the unifying factor in the enterprise, and so he became the most prominent Swedish pioneer in the new industry.

The mills at Delary, Värmbol, Krontorp and Brusaholm had all obtained their plant from Lee's workshop. Unfortunately it was found almost immediately that the manufacturing method was far from being as thoroughly worked out as Lee had asserted, and many difficult problems were encountered. Technically the process had not been properly investigated. Great financial difficulties also ensued. Later, on completion of the mill at Borkhult, trouble was encountered there also.

A mill in the Sinclair group that should not be omitted is Tidaholm in the south of Sweden, now a famous match-centre. The Tidaholm pulp-mill and the Sphinx paper-mill were built by Baron H. H. von Essen, probably aided by British capital. The leading person in this undertaking was the Rev. Dr. James Blackwood, who had become related to the Essen family through his marriage to a daughter of the Earl of Cavan. Blackwood

was a chaplain in the Crimean war, lived at Tidaholm for a year at the beginning of the seventies and then went to live at Boxmoor in Hertfordshire. As an assistant he had engaged a British engineer by the name of Calvert. As indicated above, the pulp factory was combined with a paper mill. It would appear that the cost of building and starting up the latter mill was so heavy that the whole business had to be wound up before any pulp was made.

The third alkaline method was based on a patent, No. 1974, dated 13th July 1870, granted to D.A. Fyfe and later bought by Johan Ekman. Ekman belonged to a well-known family of successful merchants and iron-masters. His father, Gustaf Ekman, has already been mentioned in connection with the introduction of the Lancashire wrought-iron process. The Ekman family's venture on pulp manufacture at their Gustafsfors estate in the province of Dalsland in the western part of central Sweden brought many years of worry and trouble - the period, to be exact, between 1872 and 1880. Johan Ekman had made a long journey on the Continent and to England, and the ultimate choice was Gustafsfors for a pulp-mill employing Fyfe's patent. During his visit to England, Ekman had inspected among other mills the Cone Mill near Lydney, mentioned before in this chapter.

In Fyfe's method the wood was disintegrated into thin-fibred shavings, which were then treated alternately with a chlorate of lime solution and a weak alkaline lye under low pressure. Houghton and Sinclair, on the other hand, used fairly thick shavings, strong lye and a high boiling pressure, which is still adhered to. Fyfe's method had certain theoretical advantages, but it failed in practice. In consequence, another method was worked out at Gustafsfors, closely related to those of Houghton and Sinclair but with more suitable boiling equipment. After more or less regular working had started at the end of 1878, Johan Ekman was able a year later to satisfy himself that his mill had successfully passed its trial period. No other pulp-mill owner could at that time say the same. In England Fyfe's method had been tried in a mill at Ramsbottom near Bury in Lancashire, but proved no more practical there than at Gustafsfors.

The Sulphite Process. The distinction of first manufacturing cellulose on a commercial scale by the sulphite method goes to a Swedish chemist, Carl Daniel Ekman - not related to the two industrialists previously mentioned. In this case too there was close co-operation with Britain,

for it was at the request of a British firm, J. Thomson, T. Bonar & Co., that Ekman carried out on a larger scale the experiments he had already started, and it was thanks to the same firm that he ultimately saw in action a full-scale mill, the first sulphite plant built anywhere. Small specimens of Ekman's pulp were sent to London on 31st October 1871, and were stated to be "very satisfactory".

The actual production was started in November 1874. The factory was built on the site of the Bergvik sawmill in southern Norrland, some 150 miles north of Stockholm. This mill was represented in London by J. Thomson, T. Bonar & Co., one of the leading firms in the Baltic trade with, by the way, a branch office in St. Petersburg. Besides their interest in Bergvik, they were financially engaged in several other Swedish sawmills and industrial concerns, Sandvikens Ironworks for instance. At the time in question the firm was owned by the Weguelin family, city merchants of considerable prominence. The head of the family was Thomas Mathias Weguelin, born in 1809, but his son Christopher became managing director in 1868. Both were men of outstanding qualities, and it was thanks to their foresight, keenness, untiring interest and liberal provision of funds that the experiments at Bergvik were carried through to the final stage of a full-size sulphite mill. The younger Weguelin in particular appears to have had a keen eye for technical and industrial progress. He was born in 1838, had studied at Cambridge, and was a Deputy Lord-Lieutenant of the County of London. His father, by the way, had been a member of the court of the Bank of England since 1838 and became Governor in 1855. In 1857 he was elected to the House of Commons as a Liberal. He was on the board of many shipping and financial concerns, one of the biggest being the Trust and Loan Company of Canada. x)

The sales in London of the output from the Weguelin sawmill interests in Sweden, Bergvik included, were under the management of George Fry (1843-1934). Here we meet what may be called a technically-minded timber agent. Fry had set up a laboratory at Arundel, where one of his occupations was a search for some kind of solvent for wood. In 1869 he applied for a patent covering "Improvements in the

x) Ample information about the two Weguelins will be found in Männen kring Carl Daniel Ekman (The Men of C. D. Ekman's Circle) by George Spaak, Stockholm 1917, published by the Swedish Cellulose and Wood Pulp Association.

treatment of wood for obtaining fibre for the manufacture of paper etc." The patent claims included "the production of fibres suitable for paper manufacture with the aid of hot water alone". Perhaps the basic idea was the utilisation of sawmill waste.

Weguelin discussed this question with Fry and said inter alia: "I have a strong idea that it may prove worth our while before long to erect at Bergvik a mill for the production of paper pulp from wood. Mr. Fry and I are now looking into the question very carefully." Some students of the period say that Weguelin or Fry, or both, may have visited the Houghton-Lee soda pulp plant at Cone Mills in Lydney, Gloucestershire, one of the first of its kind in England. The erection of the contemplated mill was duly started and pursued with great energy. Some machinery was supplied by Swedish engineering-works, some came from England. So did, by the way, the bricks for two of the three new houses required.

In 1871, on one of his trips from London to Bergvik, Fry happened to meet the young Ekman, then an up and coming chemist, in Stockholm, and most likely the problems which had arisen at the new mill were discussed. Ekman had graduated from the Royal Institute of Technology in Stockholm, and there is evidence that he had been interested in wood-pulp experiments since 1868. Ekman accompanied Fry to Bergvik, and in August of the same year, 1871, was engaged at the mill as a chemist. As such he was provided with complete laboratory equipment for his experiments.

After a comparatively short time a sample of his pulp was sent to London, and the famous telegram worded: "Small specimen sent 31st Oct. very satisfactory", was received at Bergvik. That was on 7th November, and there is no doubt that the "specimen" was sulphite cellulose.

After many tribulations, Fry's factory was finally started early in 1872, but the pulp was not a success: it could only be used for very coarse papers and was more like ground wood. The factory was, however, worked on an industrial scale until March 1873, and about 1,000 tons of pulp was produced.

As Ekman's experiments had now proved successful, it was decided in 1873 that a new plant should be constructed, based on his method. This plant, which consisted in part of the Fry mill, was completed in the latter half of 1874. Actually it was in November

1874 that the production of sulphite pulp on an industrial scale may be said to have started, and on the 25th of that month the first shipment of 61 bales was exported to England. It was at a paper mill at Ilford near London, controlled by the Weguelin interests, that the first perfect paper was made from sulphite pulp alone. For a considerable period thereafter, sulphite pulp was the principal raw-material for paper making. In 1883 Ekman left Sweden and settled at Northfleet in Kent, where a new sulphite mill, using his method, was built. He died in 1904. x)

Thus British-Swedish industrial relations were of exceptional importance in the rearing of the Swedish cellulose industry, and some of the early pulp-mills were financed by British capital. Nor were the commercial relations between Sweden as a producer and Great Britain as a buyer of cellulose and mechanical pulp less vital in the history of the Swedish forest industries. The production of chemical pulp, both by the sulphite and the sulphate process, has now reached a huge volume. For the world as a whole the annual output is now about 42 million tons, the Swedish share amounting to no less than 4 million tons, or about 10%. xx)

In the application of these various pulp-making methods to Swedish conditions, the pioneers on both sides met with many reverses, disappointments, and in several instances also with financial difficulties or disasters - the frequent fate of pathfinders in all industries and all countries - but it should be remembered that it was to England that the founders of the now so important alkaline-pulp industry first went to receive guidance.

x) The Swedish Cellulose Association, in co-operation with the Society of Swedish Engineers in Great Britain, erected in 1934 a stone memorial on his grave at Northfleet.

xx) The leading writer on the Swedish pulp and paper industries is Elis Bosaeus. His chef-d´oeuvre is Molae Chartariae Suecanae, an outstanding achievement, possibly without an equal in the literature of any other country. Bosaeus himself held for many years a prominent position in these industries. George Spaak has already been mentioned in another footnote. He was the technical head of Bergvik over a long period and has written a great deal on Ekman and his days.

Paper Making

The idea of producing a continuous sheet of paper on a moving endless wire cloth hails, as we know, from France, where a patent was granted in 1799 to Nicholas-Louis Robert, originally a book-keeper and proof-reader. It was in Bermondsey, however, then a country district of low-lying fields and open spaces south of London, that the first paper-machine of commercial value was constructed. The name of the firm who built it, Bryan Donkin & Co. Ltd. (founded in 1803), occurs of course in every guide to industrial history. From that shop the first paper-machine erected in Sweden was supplied in 1832, the initiative being taken by S. M. Sönnerdahl, the owner of one of the oldest handmills in the country, Klippan, situated in Skåne, the southernmost province of Sweden.

One of the Donkin paper-machines had been installed outside Copenhagen in 1829, and the competition on the Swedish side of the Sound was being increasingly felt. The Klippan machine, which by the way had 92 as its shop number, was naturally a small affair, 50" wide and 40 feet long, as against the width of well over 300" and the length of some 300 feet of a modern newsprint machine.

The next six paper-machines installed in Sweden were also supplied by Donkins. The mills concerned were Lessebo, Grycksbo, Holmen, Nykvarn (two units) and Korndal. Towards the end of the century - after 1875 - another British engineering-concern came to the fore, Bentley & Jackson Ltd. of Bury near Manchester. They have supplied in all twenty-five paper-machines to Swedish mills.

When the French patent was brought over to London, contact was established with a prosperous firm of stationers, Walker, Bloxam & Fourdrinier. Henry and Sealy Fourdrinier, the two leading partners, took the patent in hand, and after a few years an efficient paper-making machine was completed. (At Frogmore, Herts, in 1804.) There is little doubt that to Donkin alone should go the credit for having brought the crude machine of Robert to a state of industrial usefulness.

The enterprising Fourdrinier brothers suffered great financial reverses during their many years of international activities, but a paper-machine with a continuous wire web is still called a "Fourdrinier" the world over wherever the English language is used. The Bryan Donkin firm moved to Chesterfield in 1902, and is now a concern of many-sided engineering activities.

MECHANICAL ENGINEERING

For British readers it should be of interest to know that the founders of the first two Swedish machine-shops in a modern sense were both British: Samuel Owen, who built the Kungsholmen Works in Stockholm, and David Fraser, who established extensive engineering works at Motala, a town on the eastern shore of Lake Vättern in the south of Sweden.

Samuel Owen may in a sense be called the founder of the Swedish mechanical engineering industry. His importance for its development in Sweden can scarcely be overestimated. His work was not confined merely to the pioneering of new products and methods but was equally evidenced by the first-rate technical training he gave to a whole generation of adepts.

Before proceeding with a review of Owen's technical and industrial achievements in Sweden, I offer here some personal data. Owen was born in 1774, the son of a poor farmer in the village of Norton, near the town of Market Drayton in Shropshire. He received practically no education and worked on the farm until he was seventeen. Then he first became a drayman's and later a carpenter's mate, off and on attending an evening school. At the age of 20 he became a joiner in the shop of Boulton & Watt, then erecting larger premises near Birmingham for the production of James Watt's steam-engines. After a while he turned machinist, and later went to Marry & Wood in Leeds, also makers of steam-engines.

A Swedish official named Edelcrantz, who had ordered three steam-engines from Marry & Wood, engaged Owen as an erecting engineer. (One engine at Lidingö set up in 1804, one at Ladugårdsgärde, one at Kungsholmen). These engines were a great success and a fourth was ordered for the famous Eldkvarn flour-mill (also in Stockholm). This last engine was too small, and another was ordered to replace it. The other one went to the Dannemora mines. Owen then returned to England. In 1806, Edelcrantz asked him to come back in order to erect a fifth engine which had also been bought in England. At that time the Bergsund Machine Works (built by Thomas Lewis) had passed into the hand of a Stockholm firm, Erdman & Wilke, who decided to specialise in modern

steam-engines. Owen was engaged as a foreman at Bergsund. Here the first condensing engine in Sweden was built, in 1807, and Owen also carried out the erection at the Kloster Ironworks, situated in the mining belt of central Sweden, of the first really modern sheet-rolling mill in the country. It began operations in 1809. The earlier rolling-mill at Kloster, for tinplate, erected in 1806, had not come up to expectations.

In 1809, Owen started on his own by buying a plot of land in a well-known thoroughfare called Hantverkaregatan, more or less in the centre of Stockholm. His capital was limited, but there in due course he built up a well-equipped establishment of impressive size for that time. About this shop some details are given in the chapters dealing with rolling-mills and shipbuilding. Late in life, in 1848, Owen wrote: "This was the first mechanical workshop in Sweden and now there are 26. Have up to now made 60 steam engines, over 1,000 threshing machines as well as flour-mills and other machines." Many projects engaged Owen's attention, and it should be mentioned that as early as 1802 be began experimenting with steamship building. He first tried out the propeller drive but found the paddle wheel preferable. And so it came about that he built Sweden's first passenger steamer, the Amphitrite. Its first trip was to Västerås, an important trading centre on Lake Mälaren, in 1818. One of the largest steam-engine aggregates constructed by Owen was the pumping plant in the Ryd shaft at the Höganäs mines in 1832. It was made up of two sets with beam engines of the Boulton and Watt type. They had a capacity of 100 hp each and were working till 1901 and 1903 respectively. One of them now forms the pièce de résistance of the main hall of the Science Museum in Stockholm.

Owen ran his engineering works for thirty-three years, but in 1843 he was forced to go into liquidation. He everywhere enjoyed great respect and a high reputation. The Swedish Riksdag in 1829 had granted him a substantial pension (2,000 riksdaler), and Jernkontoret contributed 500 riksdaler per annum. During his active years loans had been granted to him both by the Government and by Jernkontoret, but the establishment was not a paying concern. Owen was not a metallurgist and suffered losses through his metallurgical mistakes. He was elected a member of the Royal Academy of Science, took a great deal of interest in social work, and was an ardent temperance-reformer.

Deeply religious, he was very active in opening Sweden to the methodist movement. He died on 15th February 1854. His creditors were for various reasons in 1848 unable to keep the works running: they were closed down and the valuable machinery was dispersed. The site was subsequently occupied by the Royal Mint (in 1849).

Motala. The first establishment in Sweden that could be called a mechanical engineering works was, as we have seen, set up by Owen in Stockholm in 1809. The second was the undertaking founded in 1822 by Count Baltzar von Platen, a very prominent civil engineer who built the Göta Canal, the well-known waterway of lakes, rivers and excavated channels which links Stockholm with Gothenburg. It is interesting to note that the great Thomas Telford acted from 1808 to 1813 as expert and collaborator with von Platen in preparing the plans for the Göta Canal. Von Platen needed a workshop for repair of equipment, and thought it best to employ an Englishman to run it, as skilled mechanics were hard to find in Sweden at the beginning of the century.

The manager of the works during the first 21 years was Daniel Fraser, who at the start had three assistants known as "the English foremen". Fraser was born at Ancrum, Roxburgh, in 1786 and came from a farming family. The father was a carpenter and flour-mill builder and his son very early showed his mechanical aptitude. In 1809 he was taken on by Bryan Donkin & Co. in London, a firm that later was to become the world's foremost paper-machine makers. Fraser stayed on till 1822, in which year he went to Motala to assemble a British-made dredger. He remained at Motala until 1843.

Fraser had some ten of his countrymen in his employ, among them Braid for the boiler and sheet-working shop, Malcolm for the foundry, Thorn for the machine-shop and Jones and Fletcher for the ironworks.

Fraser had a worthy successor in O.E. Carlsund, who proved to be one of the country's finest works-engineers. Motala became in time Sweden's foremost industrial concern. In the 1880's the total labour force in the various shops was at times nearly 3,600. Carlsund had for some time after 1839 been employed by the well-known British firm of Braithway & Co., first as a mechanic, later as a designer. At Motala the first Swedish propeller-driven ship (1844) and the first iron ship were built. In 1840 it was decided to build an ironworks adjoining the workshops and this became progressively very large by the standards

of those days. It may be of some interest to students of industry to learn what comprised the main equipment in 1857: 2 double and 6 single puddle-furnaces, 6 welding-furnaces with draught control, 13 welding-furnaces with blasts, a bar-iron mill with three pairs of rolls, a medium mill with two pairs of rolls and a finishing mill with two sets of three rolls, 9" diameter, and one set of two rolls, also 9" diameter. The two rolls on the heavy plate--mill measured 21" x 62", the sheet-mill had three rolls, 61" long and a diameter of 21", 9" and 21" respectively. By 1875 the number of furnaces had grown to twelve for the puddling shop and six for the plate-mill, apart from eleven ordinary welding-furnaces. Rails were rolled for a short period, and wire-rolling began in 1890. Fraser's reason for erecting the ironworks was that Motala should make its own iron to be on the safe side both economically and qualitatively, an argument that was undoubtedly well founded at the time and for a good many years to come.

After several periods of change, the Motala works finally became part of A. Johnson & Co., one of the largest concerns in Sweden, well--known internationally as shipowners, shipbuilders, mine owners, steel-makers, mechanical engineers and oil refiners.

The Keiller Family have been prominent for several generations. The founder, Alexander Keiller, was born in 1804 in Dundee, of old Irish stock. His ancestors had moved over from Ireland several centuries earlier. The father of Alexander Keiller, James, was a shipowner and timber merchant who had a flourishing business with Sweden. Alexander Keiller came to Gothenburg in 1826 in connection with his father's timber trade. One of his earlier business connections was William Gibson, a prominent merchant. They joined hands in several ventures. For example, in the suburb of Majorna they built a weaving--shop for sail-cloth. Later, in 1832, they built at Jonsered, outside the town, a larger factory for sail-cloth, a spinning-mill for jute and linen and a machine shop, primarily for their own use.

Keiller was a strong personality and had the reputation of possessing an unbending will. The two partners did not get on particularly well together, and separated in 1839, whereupon Gibson alone became the owner.

A few years afterwards, in 1841, Keiller built a machine-shop and foundry in Gothenburg, in a part of the inner town called Otter-

hällan. A small shipyard was also laid out in the same place. There was no room for expansion on the town side, and in 1855 Keiller laid out a new machine-shop on the opposite side of the Göta River, on the island of Hisingen. Later a shipyard was added to the new establishment, and the first steamer was launched from it in 1868. The Keiller concern was later turned into a public company under the name of Göteborgs Mekaniska Verkstad. The eldest son, Alexander junior (1832-1918) had become a partner in 1858; the second son James, who had a pronounced mechanical bent, later became the managing director. In 1898 the place was seriously damaged by fire, but was rebuilt under the direction of James Keiller junior. The number of workers was 325 in 1867, 530 in 1877, and 917 in 1900. The Keiller shipyard and machine-shop are the origin of the now famous Götaverken (from 1906), the largest shipyard in Scandinavia, with an annual output of about 300,000 tons d.w., including a rather substantial displacement of naval vessels. The number of employees is now about 7,000.

The Jonsered Machine Works. This well-known concern has from its foundation been connected with the Gibson family. William Gibson (1783-1857) was born in Scotland and came at the age of 14 to Gothenburg, where he remained. Together with Alexander Keiller (see above) he bought in 1833 the Jonsered estate some miles from the town. There the two partners built a textile-mill and a machine-shop, as already related. When Keiller had left the company, Gibson became sole proprietor. William Gibson the younger (1816-1865) took a special interest in the shop and started making wood-working machinery, of which he made a notable success (first prize in London 1862). William Gibson the third (1848-1917) continued the expansion of the factories. The Jonsered Works now comprise hemp and jute spinning-mills, weaving-mills, bleaching and impregnation plant, together with the factory for wood-working machinery. The latter group has gained a very high reputation everywhere in the world.

The Malcolm Machine-Shop in Norrköping. Alexander Malcolm established a mechanical engineering works at Norrköping in the early 1830's. About the same time a paper-machine was being assembled for the great Holmens Bruk concern by the makers, Bryan Donkin & Co. of Bermondsey, London. In connection with that installation, Malcolm secured quite a number of orders from Holmen. Alexander had a brother, Andrew, who was employed at Motala, and a good deal of work for Holmen went there also at the time.

Malcolm of Norrköping built several of the early textile-mills in Sweden, such as Strömma at Karlshamn at the beginning of the 1830´s, Trollhättan in 1840 and Torskog in the same year. But it was of course difficult, not to say impossible, for an engineering works with the modest resources Malcolm had at his disposal to compete with the large British engineering firms, and he was constantly faced with financial and other troubles.

SHIPBUILDING

British influence on Swedish shipbuilding made itself felt at a relatively early stage. The first prominent name we have to consider in this context is that of Sheldon.

The Sheldons were a family who had come over from England, and they occupy one of the foremost places in the history of Swedish shipbuilding. The first Sheldon of whom we have knowledge is Francis, who had to leave England for political reasons, and settled in Sweden in 1685. In that year, too, he was appointed Naval Architect to the Fleet. He had two sons, Francis (d. 1692) and Charles (1655-1739) who successively became naval architects.

Gilbert Sheldon (1710-1794), grandson of the first Sheldon, was in 1733 given a post as Assistant Naval Architect. On his father's death he became Chief Architect and in 1748, when the Shipbuilding Corps was reorganised, he was appointed Captain in the Naval Engineering Corps. In 1756 he was made Chief Naval Architect with the rank of Lieutenant--Colonel. He designed no fewer than 69 men-of-war during his service in the Swedish Navy.

Francis Sheldon (1755-1817), great-grandson of the first Francis, became in 1778 Naval Architect at the Army's Naval Squadron in Stockholm; in 1795 he was appointed head of the Engineering Department at Karlskrona and in 1799 Lieutenant-Colonel in the Engineering Corps. Later he served at the Engineering Office in Stockholm, and was promoted full Colonel and second-in-command of the Engineering Corps in 1814. He was ennobled in 1817.

Fredrik Henrik af Chapman (1721-1808), Chief Naval Architect and Vice-Admiral, was born in Gothenburg and came of an English family. His father, Thomas Chapman (1679-1770), received at Stralsund in 1715 a captain's commission in the Swedish Navy and ended his career as holm-major in Gothenburg. In his youth Fredrik Henrik worked at various times in the Crown Shipyard in Gothenburg, at private yards in Stockholm and at British, Dutch and French yards. Simultaneously with his practical

training he devoted a good deal of time to theoretical studies, particularly in mathematics and physics. Having declined an offer in England of employment in the British Navy, he returned in 1757 to Stockholm and was appointed Assistant Naval Architect in the Swedish Navy. He was sent to Pomerania, then a Swedish possession, to build small naval craft during the war in progress at the time. Later he went to Finland, where he was also engaged in ship designing. In 1764 he was appointed Chief Naval Architect of the army's Naval Force and in 1783 he was made head of the Shipbuilding Department at the principal Swedish Naval Shipyard of Landskrona. While there he took an active part in the reorganisation of the Navy. The Karlskrona Yard was greatly expanded, and a large number of ships of the line and frigates were built. Chapman remained in Karlskrona for ten years.

Af Chapman, as he was called after being invested with an hereditary knighthood, was a man of unusual gifts who became internationally famous. Not only was he a great shipbuilder, with thorough theoretical knowledge; he also possessed unusual artistic talents. He became an authority as a writer on shipbuilding and his Architectura Navalis Mercatoria was studied everywhere. Last but not least, he had a great capacity for work and was indeed a remarkable person altogether. It need hardly be added that he was a member of the Royal Swedish Academy of Science.

Samuel Owen is known in Sweden not only as the founder of modern mechanical engineering practice, but also as the builder of the first steamship. He started experiments with a small sailing-vessel, really nothing but a local smack, and put in a primitive propeller of enormous diameter. His little steamship proved unmanageable, however, and he had to resort to the old reliable paddle-wheel of his other ships. This was in 1816, and the name of the ship was Witch of Stockholm. In 1818 the Amphitrite was launched. She was, naturally, quite a sensation in Stockholm and could take no less than 182 passengers. In 1840 Owen built the first iron steamship in Sweden, the Samuel Owen. Her dimensions were 120 feet long and 15 feet wide with a draught of 2 1/2 feet. Her maximum speed was all of 13 knots.

From Owen's works were supplied some thirty engines for steamers of various kinds. Additional details about Owen as a shipbuilder will be found in the chapter on mechanical engineering.

On the activities of the Keiller family and how they built a yard in Gothenburg which was to become the foundation on which Götaverken, the largest shipyard in Scandinavia, later grew up, information will also be found in the chapter on mechanical engineering.

George Douglas Kennedy (1850-1916) built ships at a yard known as Gamla Varvet on the outskirts of Gothenburg, by the Göta River. This was in the palmy days of the big sailing-ships, of which he built several. He was, moreover, prominent in Gothenburg business circles and had wide interests in shipping and kindred trades.

STEAM-ENGINES

The expansion of the engineering industry in Sweden, as in other countries, began with the building of really workable steam--engines. In Sweden this happened around the beginning of the 19th century, but some time before this a simple type of steam-engine had been built in the country by a Swedish engineer, Mårten Triewald (1691-1747). Among Swedish engineers in the first half of the 18th century his name is outstanding, but it is not only for that reason that a special section on steam-engines is included in this survey: it is also because Triewald, as a resident in England for many years, was very active in maintaining industrial and cultural relations with Britain.

In Triewald, consequently, we have one of the first Swedish engineers to establish connections with the industrial life of Great Britain, and to draw inspiration from it wherever it might benefit his native country. He was, to take a single example, the first to familiarize Swedish miners with British coal-mining, in which he had himself been engaged for a number of years. His stay in England lasted for ten years. He came over at the age of twenty-five, and after a while found work as a supervisor at a coal mine near Newcastle. Here he had the opportunity of studying the Newcomen engine. Afterwards he became an assistant to the inventor himself.

Thomas Newcomen (1663-1729) was of course the famous British engineer who constructed the forerunner of the actual steam-engine. His engine was primarily used in mines for pumping water. It was first erected in Staffordshire in 1712 to draw water from the mines, and was then called a "fire machine".

During his ten years in England, Triewald made a close study of the industrial life of the country. In 1731 he became a member of the Royal Society, and was one of the founders of the Royal Academy of Science in Sweden.

On his return to Sweden, Triewald erected in 1726 a Newcomen engine for pumping at the Dannemora mines, some 150 miles north of

Stockholm, the first steam-engine to be built in the country.

In 1734 Triewald published A Short Description of the Fire- and Air-Machine, i.e. the Newcomen Engine. The Dannemora engine was the largest built anywhere prior to the issue of this book. With the exception of the cylinder, the metal parts were sent over from England. The cylinder, which was made of brass, had a diameter of 36" and a length of 9 feet. It was presumably cast in Vienna. The engine worked without actual pressure, the power being produced through condensation under the piston by means of water. In the course of his years in England, Triewald had gained wide experience in many fields. He was very active in Sweden as a lecturer on mechanics and the physical sciences, and held the position of Director of Machinery and Mechanics at the Bureau of Mines. His book was translated in 1928 into English and printed for the Newcomen Society.

The Newcomen engine at Dannemora was difficult to run owing to the lack of experienced men, and it had to be repaired far too often. It also consumed an unexpected quantity of fuel. The owners therefore decided after some time to return to the use of the well-established horse-whim.

The fact that two more Newcomen engines were installed in Sweden at a later date and that they were actually working is hardly known outside a narrow circle of specialists on mining history. Yet this happened in two mines near Persberg in the western part of the central Swedish mining district. The first Newcomen engine was ordered in England through the well-known ironmasters and merchants Finlay & Jennings of Stockholm, and arrived in 1766. It was difficult to run, however, and was shut down in 1772. The consumption of fuel, which of course consisted entirely of wood, was more than the mine-owners could afford. The second Newcomen engine, made at the Carron Works in Stirling, was erected by Ebenezer Grieve, a mechanic sent over by the makers. It too was shut down in 1772, the cost of the wood fuel being prohibitive also in this case. Besides, there was no mechanical experience available and the recurring repairs caused the owners a good deal of trouble (see Persbergs malmtrakt by Harald Carlborg).

Apart from the units brought over from England in the early days, steam-engines were built in Sweden either by British residents or, to a considerable extent, by Swedish engineers who had gained experience

in Britain. The first steam-engine was constructed at the Bergsund Works in Stockholm. Samuel Owen's role is mentioned in the chapters of this survey dealing with mechanical engineering and shipbuilding. Then there were the Motala Works, where O.E. Carlsund, who succeeded David Fraser, the founder, and who had working experience from England, built a great number of steamship engines known for their high degree of structural elegance.

TEXTILES

Introduction

The substantial British influence on the development of the Swedish textile industry is confined, as is fairly generally known, largely to the spinning and weaving of cotton. In respect of wool and woollens Germany played the principal role.

Generally speaking, the early foreign infusion into Swedish textile production was limited to simple plant for making such fabrics as lay nearest to hand, i.e. sail-cloth and rope. It is probable that the Dutchmen who came to Gothenburg at the time of the city's foundation started to make these materials. Holland herself was for long a major supplier of sail-cloth to Sweden.

At the beginning of the 18th century, noteworthy impulses towards higher technical standards and a wider range of production in the Swedish textile-industry were diffused by the prominent industrialist Jonas Alströmer (1685-1761). These impulses derived from his own experience in the course of many years of business activities in England and from extensive studies of these industries. Alströmer began his career as a junior clerk in London in 1707, and eventually succeeded in amassing a not inconsiderable fortune there. He acquired British nationality in 1710, and returned to Sweden in 172

England had of course from the outset taken an undisputed lead in the textile industry, which meant that Swedish requirements textile products had to a large extent to be supplied from British sources. This circumstance led Alströmer to investigate very clos the feasibility of expanding the domestic industry, to ensure reduced dependence on imported goods.

We should here recollect that Sweden had during an earlier epoch established a textile industry, at that time also on foreign initiative. This happened when the Dutch banker and industrialist Louis de Geer found time among his manifold interests to set up a

woollen-mill at Norrköping. Its immediate and main justification was the Army's need of uniform cloth, and later on, in the reign of Charles XI (1660-1697), the industry had advanced so far that the Swedish Army could be almost entirely clothed with material produced within the country.

After his return to Sweden in 1724 Alströmer started, with government support, a company in the small town of Alingsås, 30 miles north-east of Gothenburg, which was destined to develop into an entirely new textile industry. By 1729 production was in full swing with braid, tape and dress-fabric weaving-mills, calico printing, hosiery factories, hat makers, dye-works etc. Tobacco was grown and this was combined with tobacco spinning. At that time the labour force totalled about 400, and by 1746 it had grown to 880-135 men and 745 women. If all sections of the industry are included, no fewer than 1,500 people were employed in the locality in 1761, an impressive figure for the period. Included among them, however, were the countrywomen who wove and knitted in their homes.

It should be mentioned in passing that Alströmer, during his years in England, also studied sheep-farming and was able on his return to bring with him some breeding stock, despite the strict export regulations then in force. Export of textile machinery was completely prohibited, and this obviously created a large crop of difficulties when it came to expanding the factories in Alingsås. The British craftsmen needed at the beginning had been brought in by Alströmer from Holland.

However, in this little town had grown up what was for Swedish conditions quite a substantial industry, and Alströmer had unquestionably played a very important part as one of the nation's industrial creators and innovators, even if this part has at times been exaggerated. He was fundamentally a man of ideas and initiative rather than an economically conscious industrialist; he evidently lacked a sense of proportion and was apt at times to set off on new enterprises without adequate preparations.

But while Alströmer's equipment for industrial leadership revealed shortcomings, he lacked nothing in political astuteness. He was able without difficulty to secure from the Riksdag wide-ranging privileges: government loans, premiums and tariff protection. But others beside Alströmer were able to get help - too much and too easily. In fact industry was spoiled and achievements were nowhere near commensurate

with expenditure. The goods produced were often of poor quality and their variety too great. Yet, although demonstrable results were far from gratifying, a multitude of initiatives had been taken which were to prove rewarding in the future.

With the political, economic and technical changes that gradually permeated the Swedish community, the conditions under which the Alingsås industry had grown up were dislocated. Progress slackened, confidence dwindled, and by the beginning of the 19th century the various activities were in a state of decline.

The factories had, as earlier indicated, to overcome great difficulties in obtaining their machinery from the manufacturing countries. In a large measure recourse was had to smuggling, with resultant high costs; this smuggling was most extensive via Holland.

In the inception and expansion of the Alströmer undertakings at Alingsås, an important role was played by the British industrialist Stephen Bennett. He was born at Rearsby in Leicestershire in 1691 (died at Mo in the province of Hälsingland in 1757), the son of Thomas Bennett, a farmer. He was trained as a wool-weaver, and settled for a time in France, where he met Alströmer in 1723. Alströmer engaged Bennett as supervisor of his projected factory at Alingsås. In this capacity he had over a period of years a responsible and onerous task from which he emerged with the reputation of a capable and skilful industrial executive. Alströmer himself had many and great political interests to look after, and therefore spent most of his time in Stockholm. The decline that was later suffered by Alingsås certainly cannot be blamed on Bennett: the basic cause of this decline was rather the artificial, complicated and intractable combination of politics, backroom intrigues and government subsidies.

Bennet took up his post at Alingsås in 1726. After ten years at the factories there he was transferred by Alströmer to the province of Hälsingland in southern Norrland, for the purpose of reorganising the old linen industry of the coastal areas. He made his headquarters at Flor, in the parish of Mo, twelve miles west of the seaport of Söderhamn, situated 150 miles north of Stockholm. More information about this part of Bennett's work in Sweden will be found in the section dealing with linen.

Sail-Cloth, Rope and Jute

The manufacture of sail-cloth and the spinning of rope were in the

early days often carried on at the same place. The shed of a rope-walk and the whirlers for twisting the yarns of a rope were an establishment that was simple and inexpensive to set up. Such little factories were not uncommon in various parts of the country. With regard to early British makers of sail-cloth and rope, the following is taken from notes made by Bodman. In 1646 Hans Mackler is mentioned as having been granted a charter in Gothenburg for the manufacture of sail-cloth and rope. This is the first reference available concerning British activities in these particular sectors of textile manufacture. In 1680, also according to Bodman, one Hamilton started to make sacking and sail-cloth at a place called Rodga in the province of Östergötland, not far from Norrköping. This is probably the same Hamilton who, according to Helmfrid, had a linen factory at Rodga. In Örebro there was a Hamilton who, in 1771, owned a small plant for making rope and sail-cloth. In 1799 A. & N. Clayhill were granted a charter for a factory in the town of Lovisa in the southwestern part of Finland, which was then Swedish territory, and one Marshall started the making of sail-cloth in Gothenburg early in 1800. Two other men, T. Gavin and Gordon, received a charter in 1816 for the manufacture of rope in Gothenburg.

One of the pioneers in the manufacture of sail-cloth and cordage was William Gibson. (For personalia see notes under "British merchants and industrialists). William Gibson had come to Gothenburg as a young man from Arbroath in Scotland, and very soon engaged in business and industry. In 1810 he bought the Vädersågen estate on the Göta River in the suburb of Majorna, where there was a sawmill and ropewalk. To rope-spinning was added (probably in 1825) sail-cloth making and also an iron foundry. For his sail-cloth Gibson had to use handspun yarn, as mechanical spinning was then unknown in Sweden. More accommodation was needed and Gibson, who had entered into partnership with another rising British industrialist, Alexander Keiller, obtained in 1826 permission to build a small flax-spinning mill at the old Gothenburg "lock weir" (a waterfall in the middle of the town). Later a weaving--mill and a bleaching-mill were added.

But the two partners needed still more space and also more power, and so they moved both the sawmill and the weir plant as well as the foundry to the waterfalls at Jonsered, a little place 12 miles northeast of Gothenburg.

Skilled operatives were brought in from Scotland and England,

and quite a substantial production was achieved of sail- and tent-cloth and cordage. In the 1850's, cotton was added to linen and hemp as a major product at Jonsered, and another important mill was built for jute weaving. Calico, curtain- and furnishing-fabrics from Jonsered had an important place in the supply to the whole country, and the Jonsered mills still occupy a leading position in Sweden's textile industry. The famous engineering works at this place also belong to the same concern, and are referred to in the chapter on mechanical engineering. It should be added that Alexander Keiller retired from the business quite early in its career.

Cotton

In Sweden three areas are regarded as predominantly concerned with the textile industry. Their central points are Gothenburg and Borås for cotton, and Norrköping for woollens. The last named town lies 80 miles south of Stockholm, and Borås is 36 miles east of Gothenburg. The countryside round Borås has old traditions of home knitting and weaving, and it is ultimately on this that the local factory complex has been gradually built up. The atmospheric conditions in this part of the province are favourable to the industry. Borås, with an annual rainfall of 36", has the reputation of being the wettest town in Sweden. For comparison it may be mentioned that the annual precipitation in Gothenburg is 29", in Stockholm 22 3/4" and in Manchester 31 1/2". On the grouping of the pioneers of the cotton industry, here is what Gårdlund says in his Industrialismens samhälle (The Community of Industrialism), Stockholm 1942: "When the mechanical cotton-spinning mills were imported, out of the fifty to be built in the first three decades of the 19th century fifteen were owned by Gothenburg merchants, six by merchants in other towns and nine by craftsmen."

Owing to the export prohibition of textile plant imposed at that time in Britain, Swedish textile men had at the outset to resort to smuggling where British machinery was concerned, or to buy what they needed from the Continent. In this connection an Englishman, William Cockerill, played an important part. Cockerill was born in England in 1759 and died in 1832. He went first to Belgium as a simple mechanic. In 1799 he constructed at Verviers the first wool--carding and wool-spinning machine on the Continent. At Liége he founded in 1807 a machine-shop which became very important and which attracted orders from all over Europe. At Seraing, too, he

had a large establishment and the Société Cockerill de Seraing gradually grew into one of the largest engineering works in Europe. J.T. Berg, who is well-known as the founder of the early Nääs cotton-mill near Alingsås, ordered for instance in 1833 the equipment for his establishment from Seraing.

Of the various sections of the textile industry it was emphatically the cotton industry that led in the advance; in the wool industry it is hardly possible to talk of any real mechanical production until the middle of the 19th century; and for linen there was, apart from the sail-cloth mill at Jonsered, only the Almedal flax-spinning mill - built in 1847.

The pioneer in the cotton industry was Fredrik Hummel with his mill, Gamlebokullen, at Lerum (generally known as Kullen), 12 miles from Gothenburg. This was built and equipped by C.H. Strimberg in 1795. Hummel remained the only manufacturer for twenty years. Next came A.W. Gyzander, for whom Strimberg in 1814 erected a mill at Sjuntorp in Upphärad about 30 miles north of Gothenburg, near Trollhättan. In fact Gamlebokullen was the progenitor of several more mills. Strimberg, who had learnt his business at a new mill in Copenhagen, settled at Sjuntorp and was regarded as a great authority in this field.

In referring to Kullen as the first modern cotton-mill in Sweden and to Hummel as its founder, the circumstance must not be overlooked that the initiative for the spinning-mill had been taken by the William Chalmers of whom mention has already been made in previous chapters of this survey. He, together with another British merchant named Henry Greig, in 1795, had obtained a licence to erect "a cotton spinnery and weaving-mill". But Chalmers was so fully engaged on other projects that he very soon assigned his licence for Kullen to Hummel. As in the case of so many of the other early textile mills, Kullen had to face great difficulties at the start, which led to the mills being taken over in 1818 by the creditors, of whom the principal was Alexander Barclay, a British merchant in Gothenburg. The mill was destroyed by fire in 1846 and not rebuilt. At its opening it was stated to have been equipped with "machinery of the newest English contrivance". What has now been said shows that the first licence to set up a cotton--spinning mill in Sweden was obtained on British initiative - a fact of obvious interest in the context of the present survey.

As the notes at the end of this chapter show, a small experimental spinning-mill was in operation at Norrköping for a few years.

Its machine equipment had been designed and made locally, the designer being a Norrköping mechanic named Johan Carlström, who got the plant started in 1801. After his death, the Holmen concern worked the mill from 1812 to 1818.

About 1830 the erection began of several of our now well-known cotton-mills: Mariedal in 1829, Anderstorp in 1830-31, Rosendal and Nääs in 1833, Stockholm´s "old" in 1834 and finally Rydboholm´s art--weaving mill, the first mechanically operated cotton-weaving mill in Sweden, with the plant supplied by Cockerill, be it noted. British operators were brought in for the skilled work. Later mills to be added were Rydal in 1853, Viskafors Works in 1854, Strömma at Karlshamn in 1867, the Svaneholm weaving-mill etc.

One of the best-known manufacturing concerns in the textile industry, Borås Wäfveri A. B., owes its origin to an Englishman, Edward Davies, who founded the Wiskafors Väfveri at Borås in 1857. Davies´ financial position was not strong enough for him to bear the cost of equipping the mill himself, and he therefore joined forces with two compatriots, Charles Hill, who had been active before in Norrköping, and William Robertson of Gothenburg. To these were subsequently added two other Britons, Edmund Hill and James Robertson, before finally application was made to register the Wiskafors A. B. in 1859. This company, too, had a great many troubles to overcome in its early years.

One of Sweden´s largest concerns in the textile field is Norrköpings Bomullsväveri A. B., founded in 1852. Charles Hill (1816-1889), who was a British resident of Gothenburg and by that time prominently identified with the industry, was engaged as technical and financial adviser in planning the undertaking. His name appears on the share subscription prospectus issued in 1852. He was described as "textile-mill engineer and works manager". Among Hill´s many other undertakings should be mentioned Alingsås Bomullsväveri A. B., which was founded by him in 1866 and is now a member of the Nääs group. It is worth remembering that the British export embargo on textile machinery had been removed in 1842.

Persistent efforts were made in the mid-19th century to establish a textile-machinery works at Norrköping on the British model. The active spirits here were the brothers Andrew and Alexander Malcolm

and the former's sons, all of whom were qualified mechanics and draftsmen. They brought out new ideas, working methods and plant designs, and supplied over a period of years a number of new textile-mills with their mechanical equipment. x)

The Malcolms built for example the entire plant for the newly started Norrköpings Bomullspinneribolag (later styled Bergs A. B.). After the death of Andrew Malcolm, his brother Alexander built an engineering works at Norrköping where he made textile plant, water turbines and other engineering products.

When in 1854 the great Holmen concern at Norrköping began to make plans for what was intended to be the country's largest cotton--spinning mill, there was a good deal of valuable experience available close at hand. At the Malcolm works, plans and designs were worked out for a factory with 18,000 to 20,000 spindles. The machines themselves were to be imported from the United Kingdom, as Malcolm had no means of competing with them. The drawings were sent to Platt Brothers and passed by them.

On number of spindles it should be remembered that the general goal in the 1830's and 40's was about 2,000. Kullen, the first spinning--mill in the country, had 500 in 1805. By 1814 it had reached 2,000. The more ambitious undertakings founded in 1850 - such as Rosenlund, Strömsbro and Rydal - kept the number somewhere in the region of 15,000.

The Malcolm family's business at Norrköping had an uphill fight. Although their works were situated in an important textile centre, they had to compete with firms of world renown in Britain, and they were in the long run unable to hold their own. The member of the family who was at the head of affairs in 1868 gave up the unequal contest and closed down the works. This man, A. Malcolm senior, presented his views in a number of brochures, among which were: Om den maskintekniska utvecklingen inom i synnerhet Norrköpings textilindustri på 1830-60-talen (On Engineering Development especially in the Textile Industry of Norrköping in the 1830's to 60's), Berättelse

x) On the subject of Norrköping industries reference is made to Björn Helmfrid's historical work: Holmenöden under fyra sekler (Holmen Fortunes through Four Centuries), Norrköping 1954.

om min verksamhet i och för upprättandet och vidmakthållandet av en maskinverksamhet i Norrköping åren 1842-1868 (Report on my Activities in Connection with the Establishment and Maintenance of Machine Manufacture at Norrköping during the Years 1842-1868), Linköping 1869, and Faktiska bevis att fabriks- och industriväsendet inom Sverige icke är lika tacksamt som i andra länder (Factual Proof that Manufacturing and Industrial Conditions in Sweden are more Thankless than in other Countries), Linköping 1869-70. These brochures tell of the disappointments he met with in a life filled with hard work and many-sided enterprise.

Wool

On the whole, the influence of British manufacturers and merchants on the development of the wool industry in Sweden is not particularly noticeable. The Germans took the lead and maintained it.

As was the case in all other countries, Sweden had for generations been accustomed to the production of hand-made textile products by a cottage industry both for the family's own use and for sale. It was not until the reign of Gustav Vasa that anything like large-scale manufacture of textiles was initiated, and then under the guidance of skilled foreign workers. In the first place it was the Army's needs that were considered, and imports on quite a large scale had to continue.

Mention has already been made elsewhere in these pages of the important contribution made by the famous Louis de Geer in the development of cloth weaving at Norrköping. During the 18th century a "violent flowering" (as some contemporary sources describe it) ensued in the cloth-weaving industry. In the 1780's there were 40 mills with 140 looms, 200 master weavers and 1,000 other hands. One has to assume that this industry had a marked German emphasis, but one Briton, the industrialist Spalding, is mentioned in the industrial records as the owner of a woollen--mill.

In Stockholm we find towards the end of the 17th century a man from the British Isles by the name of Young. A pushful Scot, he came to be closely engaged in the textile industry of the city. He was reputed to be a member of an old family whose head was a baronet and whose earliest known forebear had been Vice-Admiral Malcolm Young, in the latter half of the 16th century. His grandson, Daniel Young, a merchant who also called himself Junge, came to Sweden from Lübeck and was ennobled in 1666, taking the name of Leijonancker. His progeny in most cases adopted a military career.

Daniel Young was born in Scotland in 1627 and died in Stockholm in 1688. In 1649 he was admitted a burgher of the city as a spice--merchant, worked his way up to become in time one of the most prominent personages in the commercial field, and had large business dealings with the Government. He was engaged in a good many trades, but was best known as a successful textile manufacturer and may be regarded as a pioneer in the manufacture of cloth. In the later 1660's he started a cloth-weaving mill at Barnängen, at that time a sparsely-populated district in the southern part of Stockholm. He also operated a linen-mill.

Young, as already indicated, was a highly enterprising person. Somewhat quarrelsome, it was not easy for him to avoid difficulties, both personal and financial, but at the same time his services to the development of the early Swedish wool-industry must unhesitatingly be acknowledged.

Linen

There had been production of linen material for generations as a cottage industry in southern and central Norrland, in the provinces of Hälsingland and Ångermanland, some 150-250 miles north of Stockholm; by the time - in the 1680's - a beginning was made with intensified cultivation of flax in the area. Three villages led the way: Färila, Järnsö and Ljusdal.

In the general scheme of "rationalising" the Swedish textile industry, plans for effecting changes in these far-off districts were also undertaken by Jonas Alströmer. To promote these he sent in 1736 Stephen Bennett, his textile manager at Alingsås, of whom we have heard before, to a little place in Hälsingland by the name of Flor, six miles inland from Söderhamn, about 150 miles north of Stockholm. This centre was opened in 1729, in an old flax-growing area. Bennett's contributions were of great value. He opened a spinning-school and set about instructing the country-folk generally in the business of spinning and weaving. The result was the establishment of a not inconsiderable weaving-industry. It has to be borne in mind, however, that the work was to a large extent dependent on state support. But Bennett's initiative did much to improve flax-cultivation and efficiency in processing, which had repercussions far into the 19th century. He was much in demand as adviser to other mills in Norrland, and the Government also made use of his services when industrial problems had to be solved.

During the whole of the 18th century and the first half of the 19th, flax-cultivation steadily advanced as an ancillary industry; after that time a slow decline set in.

Towards the end of the last century, under the guidance of Axel Leman (1871-1957), a revival of flax-growing and linen manufacture took place in the district of Hälsingland previously mentioned. Leman was no textile expert and had no textile connections or interests, but as a young man he happened to be visiting the linen districts. His interest was awakened in the movement then afoot among the farmers to re-establish flax-growing and then to build an up-to-date factory for spinning. To do this it was necessary to study conditions in linen-manufacturing districts abroad and, above all, to learn something of the production of machinery - first and foremost in Northern Ireland. It was here that young Leman's knowledge of English came in. He was sent over to Belfast, and the connections he built up there were to prove of the utmost value to the new spinning company that was eventually formed: Hälsinglands Linspinneri A. B. He became its managing director in 1898. The modern spinning-mill that was built in the parish of Forsa became the origin of a combine of five factories which is responsible for the greater part of Sweden's domestic production of linen fabrics. In this combine, at first styled Holma-Hälsinglands Linspinneri & Väveri A. B., Leman was in 1916 appointed managing director. The remaining mills are located in the province of Västergötland.

The important Jonsered industrial concern, old headquarters of the Gibson family, is also a large consumer of flax in its weaving--mills, but is not connected with the combine.

The renewed cultivation of flax in Norrland which started under Leman could not be maintained. Swedish flax-growing is now principally carried out much farther south, in the western and southern section of the province of Skåne. Apart from other factors, the climatic conditions are more favourable; first and foremost these parts of the country have the rainfall necessary for the successful raising of flax crops.

Sundry Notes on British Activities in the Textiles Field

At Gothenburg, plans had been put forward as early as 1651 for the manufacture of broadcloth, and a few years later Maccabeus Thornton established together with the Gothenburg merchant Henrik

Braun-Johan a cloth manufactory in the city. In 1687 one Daniel Crokat, said to be an Englishman, proposed sending for master weavers from England in order to utilise more effectively the native labour force available at Mark, Bollebygd and other places near Gothenburg. Nothing came of this plan, however.

Over the years one finds mentions of textile-mills of various kinds, and in various parts of the country, started by industrialists of British descent. The following notes bearing on the subject are taken from Bodman's Excerpts.

Towards the end of the 18th century members of the Feiff family are mentioned as owners of textile-mills, probably woollen. The family hailed from Scotland, and the oldest known progenitor, Alexander Fyf, kept a shop at Montrose towards the end of the 16th century. Four of his sons settled in Sweden. One of their descendants was ennobled, another became a shopkeeper in Stockholm, a third a goldsmith, a fourth a hatter and so on.

A member of the Duwall (MacDougall) family founded in 1734 a woollen-mill in the town of Karlshamn, in the province of Blekinge, south Sweden. The name of Helleday is met with in Stockholm in 1700 in various branches of the textile industry.

In 1740-1760 four members of the Springer family were the owners of textile factories, but names of localities are not given.

In 1740 one Strang was the owner of a woollen-factory in the town of Köping, in central Sweden.

Harweck & Brothers were granted a charter in 1744 for "preparing silk" in a factory in Stockholm.

A charter was granted to one Bennet in 1761 for "cloth printing and dyeing" in Gävle. He later obtained a charter for the same purpose in Stockholm and in Åbo, Finland.

In 1799 A. & N. Clayhill were granted a charter for setting up a cloth-factory in the town of Lovisa in Finland.

At Gustafsfors, in the province of Småland, southern Sweden, a member of the Lowrie family (ennobled Lagergren) was in 1806 the owner of a woollen-factory.

Lancefield & May obtained a charter in 1829 for cotton-spinning in Lindome, about 10 miles south of Gothenburg.

James Lancefield was granted a charter in 1834 for the manufacture, at Färsberg outside Gothenburg, "of cloth from cotton, wool and silk". In 1839 he obtained a charter for starting a "ribbon and net factory".

A. Robertson received a charter in 1839 to start a "weaving-shop" in Gothenburg.

W. Robertson obtained a charter, also in 1839, for a factory for producing "wool, linen, cotton and silk goods".

C. J. Hallwell was given a charter in 1840 for a rope factory.

Members of the Tottie family are also on record as having been interested in various textile factories.

In the various sections of this survey dealing with textile products, as with most other sections, only a limited number of technical details is recorded. This has been intentional throughout to avoid overloading. On the other hand, genealogical data and details of personal history have here and there been given fairly fully. It should be acknowledged that this source-material has been extracted, often verbatim, from a number of publications such as Svenska Män och Kvinnor (Swedish Men and Women) and Svensk Uppslagsbok (Swedish Encyclopaedia).

Notes on an Early Swedish-designed Spinning Machine

It is hardly known outside a narrow circle of industrial historiographers that cotton yarn was made on a machine of Swedish design as early as 1801.

In the probate inventory after the death of the "instrument maker and mechanicus" Johan Carlström of Norrköping in 1812 there is the following entry: "a cotton-spinning machine, drawn with water, consisting of eight spinning-jennies totalling ninety-six spindles". It was bought by the Holmen concern. Carlström had himself built this machine and also got production under way in 1801. It was a very small business, only six persons being employed.

As far as is known, Carlström´s was the first workable Swedish-built spinning machine. In purchasing the machine in the autumn of 1812 and resuming production with it (on a modest scale, ending in 1818)

Holmen joined the band of pioneers in the field of mechanical cotton--spinning. Kullen's spinning-mill was earlier, having been founded in 1795, while Carlström was engaged on his experiments, but as has been stated elsewhere, all essential parts were brought to Kullen from Copenhagen.

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TANNING

There are sectors of Swedish industry where English influence at an early stage is taken for granted, others where it is fairly common knowledge and others again where it is practically unheard of outside the trade circles concerned. To the first group belongs tanning, such as it was when it was developed in Sweden during the first decades of the 17th century, and it is significant that for many years the term "English tannery" was a description generally adopted. Later, the original English method was modified several times but the old name was retained.

Oak bark, as being by far the richest in tannic acid of all common species of bark, has been used in Europe at least since the Middle Ages, but not before the middle of the 17th century were its superior qualities for curing sole leather and the rougher kinds of upper leather sufficiently recognised in England for the tanners of these kinds of leather to receive certain privileges on condition that they used only oak bark.

In Sweden the great wars in the 17th century caused an increased demand for leather, and the tanneries received special guild privileges. In 1662 and Englishman by the name of Charles Howard, of "noble English birth", received special facilities for tanning leather according to a new method, and from then on the term "English tanneries" came into general use. Apart from Stockholm such tanneries were set up at Malmö, Landskrona and Kalmar. It was not perhaps fully understood what was meant by "English tanning" but everybody knew that oak bark alone could be used for it. The smaller tanneries made use of birch and spruce bark. At the English tanneries only sole leather and heavy upper leather were made; in time however, their method went out of use, for despite privileges it could not be made economically viable.

In about the middle of the 18th century, efforts were made to renew the use of the English tanning methods. Jonas Alströmer,

often mentioned in this survey, called in English tanners not only to do the tanning in the English fashion but also to show how oak bark should be gathered and prepared. Tanning now flourished anew, and in the 1760's Stockholm had 28 tanneries, while 15 were to be found in the provinces. There were of course also many shops where tanning on a small scale was done in connection with shoemaking.

In the 18th century, the tanning industry was again encouraged by being given special privileges. It was, for example, freed from the trade-guild obligations and placed under the factories. But the real "English method" could not in the long run be maintained - the demand for leather rose, the number of tanneries grew, and the supply of oak bark proved in time too limited.

GASWORKS

In the first twenty years of the 19th century, gas technology had advanced so far that gas illumination was quite common. The building of gasworks to produce gas for lighting purposes had been found a very lucrative undertaking, and it was not long before British financiers decided to exploit the invention and technique abroad. Their eyes were soon turned on Sweden, in the first place Stockholm. In 1824 a consortium was formed in London to engage in the foreign side of the business; it was given the name of "The Imperial and Continental Gas Association". Its object was to secure monopolies in the large cities of the Continent, either direct or by acquiring control of national companies. It was explicitly understood that every effort should be made to avoid wounding national feelings anywhere.

The Swedish Minister in London sent home in 1824 a proposal received from the above consortium for taking over the "illumination by gas" of Stockholm and a number of other towns. The offer was made on the basis of a 21-year monopoly. There proved to be very little interest in Stockholm for the proposal, and the plans put forward were discarded. The matter was taken up again for discussion later, but a good many years elapsed before the lighting problem was solved. In the end, the City itself formed a company for the purpose, and the first gas street-lamps were lit in 1853.

The lighting of Gothenburg began to be discussed in the early 1840's, and in 1843 the well-known industrialist Alexander Keiller submitted a fully considered proposal on the subject. He had had personal experience, for already in 1834 a gasworks had been built by him at the sail- and tent-canvas factory owned jointly by Keiller and James Gibson, another leading townsman, at Jonsered just outside Gothenburg. Another gasworks was built under Keiller's supervision at the Rosenlund textile-mill, also near Gothenburg, in 1847.

But in Gothenburg, too, there were delays in getting the gas question settled. Enquiries were made in Hamburg, where the

British consortium had secured a 30-year monopoly. It may be mentioned in passing that the concern had built gasworks in Berlin and Hanover in 1826, in Dresden in 1828 and in Leipzig in 1838. Among the tenders received by the City Council was one from Hamburg, in 1845, signed by one James Malam. He finally obtained the contract for both gasworks and lighting. This contract was, however, transferred in 1850 to the Gothenburg Gas Aktiebolag, whose shares were held in Hamburg. Eventually, however, ownership was taken over by the City of Gothenburg. Malam was also engaged in Norway, and in 1846 he obtained a concession to build a gasworks in Christiania (now Oslo). This was completed in 1848. Another gasworks was erected at Trondhjem. Towards the end of 1850 Malam laid the foundations of a third Norwegian gasworks, at Fredrikshald, but he died shortly afterwards at the early age of 48.

Although Keiller did not have the success he had expected in his home town, he was to play a very prominent part in the introduction of gas lighting in other Swedish towns. For example, he secured the contract for a gasworks at Norrköping for which his old competitor, Malam, had also submitted a tender. Gas was turned on there in 1851. The work had been carried out by J.A. Andersson, an engineer in the service of Keiller's own firm. This means that Keiller had trained Sweden's first gasworks engineer. Andersson later built on his own account as contractor several other gasworks, for example at Ystad, Linköping, Jönköping and Nyköping. The Keiller family were then owners of the Gothenburg Engineering Works (Göteborgs Mekaniska Verkstad) and one may assume that there was co-operation in the supply of equipments as before.

At Malmö an Englishman, H.A. Milne, had in 1852 secured from the City a concession for lighting and a contract for setting up some 190 street standards in the community. Gas lighting was first turned on there in 1854. To begin with, a private company was responsible for light maintenance but the City of Malmö took over in 1884. The moving spirit in the introduction of gas lighting here was Frans Henrik Kockum (1802-1875), the leading industrialist in that part of the country in the middle of the 19th century. At its foundation he owned the controlling interest in the gas company, and it would appear that a firm of engineers and iron founders at Smethwick, near Birmingham, by the name of Fox, Henderson & Co., which was responsible for the erection of the gasworks, also supplied part of

the necessary capital by taking up a number of shares. Milne was employed in Hamburg by the Imperial and Continental Gas Association and built the gasworks in that town. He had also erected the gasworks of Copenhagen.

In co-operation with Kockum, Milne later on built gasworks at Landskrona and Halmstad, two towns in the south of Sweden. Finally he was also responsible for the building of gasworks in the towns of Kristianstad, Gävle and Höganäs. Later on Milne became the manager of a copper mine in the south of Sweden, on the Baltic coast. This property, which was owned by the Kockum concern, had been acquired by a British syndicate, The Swedish Copper Company, but the mine was difficult to work and the venture was not a fortunate undertaking for the Birmingham financiers concerned.

Another British gas-pioneer during the period here discussed was Henry Beatley. Three gasworks were built by him: in Majorna (a suburb of Gothenburg) and in the towns of Västerås and Eskilstuna. Beatley held a Swedish patent for a miniature gas-producer, which could be placed alongside the kitchen stove and provide both heat for cooking and gas for illumination. Incidentally, he also held a Swedish patent for a "portable water closet".

COAL MINING

The Swedish coal deposits occur in a limited area of the north-western part of Skåne, the southernmost province of the country. They are insignificant in extent and, of course, also in relation to national requirements. They were first mentioned in print in 1571, when the King of Denmark granted privileges to work coal deposits in Skåne, then Danish territory. In 1638 a mining foreman from Leith, Robert Wricht, as his name was then spelled, was brought over to examine the coal deposits of the island of Bornholm in the southern Baltic. There was no coal on the island and Wricht, who was accompanied by six Scots, went over to Skåne. Here coal mining of a kind went on for a few years under government control.

Later, when Skåne had become a Swedish province, coal mining was carried on by an enterprising woman landowner in the neighbourhood. Coal was supplied in respectable quantities to the lighthouses on the west coast. But the difficulties of coal-getting were too much even for this energetic lady, and mining came to an end in 1680.

Nothing then happened until 1738, when Jonas Alströmer, the industrial pioneer, was granted privileges to take up mining. He had been in England, and had there come to appreciate the speedy rise in importance of coal. But the attempt proved unsuccessful, and was discontinued in 1785. When coal mining was resumed in a more businesslike way at the beginning of last century a British engineer, Thomas Stawford, was engaged as superintendent.

Stawford was born in 1766 in County Durham. He appears to have been a many-sided technician, but he specialised in coal mining and glass manufacture. It was in this latter capacity that he came to Sweden at the request of a prominent industrialist and merchant, Carl Bagge, in order to introduce coal instead of wood firing at the glassworks. Stawford arrived in September 1795 in Gothenburg, where he remained till November 1796, being engaged on improving the glass-making processes and other tasks.

Bagge and a wealthy landowner in Skåne, Count Erik Ruuth, owned the principal coal deposits in the district referred to above, and in the summer of 1797 these two men together with Stawford signed a contract whereby the latter became associated with the Gustaf IV Adolfs Stenkolsverk (coal-works) at Höganäs. Even at that stage it was decided to adopt what was known as the Newcastle method to win the coal. Stawford remained at Höganäs until his death in 1831. The present Höganäs Company still has in its archives a number of journals from the years 1796-1831, written in English by Stawford, his son John and his nephew Robert. These journals or diaries have been translated into Swedish, and give very interesting descriptions of work at the mines and life in general in that part of the Swedish countryside.

Coal-getting was, of course, conducted on a very small scale at the outset. Stawford had great difficulty in finding workers, and he was boycotted by the farmers. At one time he even had to fetch men from Norway. They were, as he says, a particularly tough lot of desperadoes, much given to fighting and drinking. The first owners had a good deal of financial trouble, which lasted until the working of the existing clay deposits was properly under way. Layers of coal and clay alternate, and it is doubtful if coal-getting would have paid at all in the absence of clay.

In 1826, when the working of the coal and fireclay deposits was running smoothly, about 100 coal-miners were employed. The coal seams are very thin and consequently difficult and costly to work. The primary material is fireclay. Production now includes, apart from refractory goods in general, glazed stone-ware and tiles of various kinds. Sponge iron and iron powder, silicon carbide and emery products have of late formed highly important elements in the manufacturing programme. A separate company has also lately been founded for the manufacture of plastics. About 300,000 tons of coal are mined a year. Owing to the need for coal by the various refractory processes, very little of it was formerly sold to other consumers and generally only in times of emergency, such as the first World War. This sale has, however, lately grown considerably, owing to the increased use of oil in the manufacturing processes. The total number employed at Höganäs and its vicinity is about 3,000, 1,500 of them in the town itself. In addition to the various establishments in this particular district, the company operates four works in other parts of the country.

PORTER BREWING

A German merchant by the name of Abraham Robert Lorent, who had spent some time in the U.S.A. and made a fortune there, settled during the Napoleonic wars in Gothenburg. Apart from his commercial ventures, he started a sugar refinery in the city (about 1810) and a porter brewery (in 1817). As a result of the general depression following the war period Lorent found himself in difficulties, and after some changes in the management his firm went into liquidation (1833). David Carnegie junior became the new owner, and the two properties were managed by his firm after 1836.

While the sugar refinery made considerable progress, the brewery made little headway for quite a number of years. From about 1850 some extensions were made, but they were not of any particular importance. Four grades of beer were made: brown stout, porter, ale and draught porter. Competition on a small scale was started by another brewery in Gothenburg, but it was not serious and did not survive for more than a few years. The brewing-masters at the Carnegie brewery naturally came from Britain: David Waller was engaged in 1845; after him came David Wemyss for a short period, followed by John Lyell in 1868. During the 1860's production rose considerably and the progress then begun continued right up to 1907. Production had then reached a volume of 105,000 gallons a year. Some competition had arisen, but in 1905 for example the Carnegie porter production amounted to roughly 70 per cent of the total quantity made in the country. At present there is another porter brewed in Sweden. The brewery gave "quite favourable financial results", as it is so briefly expressed in source documents. John Lyell was the brewery manager for a long period (1868-1896). Arvid Uddenberg succeeded him and was the first Swedish brewing master to be employed by Carnegie. In 1907 the whole Carnegie business was reorganised and the brewery was taken over by a separate company, still bearing the name of the former owners. It was called Porterbryggeriet D. Carnegie & Co.

Before the first war Carnegie's porter had an alcoholic strength of 6 per cent by weight. After the war great changes were made in the production and sale of beer and alcoholic beverages in Sweden. In 1920, for instance, the government monopoly took over the Carnegie Brewery and the production of strong porter came to an end. In 1928 the monopoly sold the brewery to a syndicate consisting of the two leading breweries in Stockholm and Gothenburg, as well as some minor breweries in the provinces. In 1938 the venerable Carnegie brewery was taken over by the well-known Gothenburg beer brewers, Pripp & Lyckholm. The output is at present about 70,000 gallons. In Sweden the proportion of porter (or stout) in the total consumption of malt beverages is, of course, much lower than that reached in Great Britain.

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SUGAR REFINING

The preceding chapter tells how a German merchant, who had settled in Gothenburg after some years in the United States, started a sugar refinery and a porter brewery, about 1810 and 1817 respectively; also how he got into financial difficulties in 1833 and had to dispose of these two properties to the Carnegie interests, who took over possession in 1836. In this transaction a well-known British merchant, William Robertson, participated with one-half of the capital. Soon steps were taken to modernise the refining processes, first of all by the introduction in 1838 of the vacuum method, which had not been used in Sweden before. Carnegie´s refinery was of course based on imported raw material from the tropics, but after the middle of the century an important production of beet sugar arose in the southern province of Skåne. The Carnegie works, however, kept their leading position for a considerable time. At the beginning of the 1880´s great changes took place in the sugar industry, brought about by the incipient ascendency of beet sugar over can sugar. For the Carnegie Company this implied difficult technical problems. But they were successfully solved, and the company became at the same time engaged in the Skåne beet-processing industry. Apart from the consequences of this co-operation, the Carnegie refinery had begun to use raw beet sugar from Germany, and in 1885 this already represented more than 50 per cent of the raw materials used by the company. Up to 1889 cane sugar continued to be used, but from 1890 the production was based practically on beet sugar only. The total output of sugar in 1907 reached 18,000 tons. In connection with certain plans for reorganisation it was decided in 1957 by the Sugar Combine to close for good the Carnegie refinery, that monumental building with its dominating position on a high plateau at the entrance to Gothenburg harbour.

BRITISH MERCHANTS AND INDUSTRIALISTS IN SWEDEN'S PAST

Campbell, Colin (1686-1757)

The Argyll branch of the Campbell clan sired many of the warriors who came to Sweden in the reigns of Charles IX and Gustav II Adolf. The Swedish family was fairly large, mostly made up of officers in the junior ranks, but it died out eventually. In the 18th century Campbells were merchants in Stockholm as well as in Gothenburg. Of members of the family in the latter city, Colin Campbell had settled there in 1731. He was born in Edinburgh in 1686, where his father was a lawyer. Campbell had in his younger days seen a good deal of the world, principally in the East Indies. Before the year of his arrival in Gothenburg had ended, he became a director of the Swedish East India Company. Both he and his brother Hugo were naturalised and ennobled, the former in 1731 and the latter in 1736.

Campbell and Nicolas Sahlgren, a leading Gothenburg merchant, were the two men who organised the Swedish East India Company as the powerful and famous undertaking it became. Sahlgren, whose mother - Sara Hervegh - was English-born, had met Campbell in Amsterdam, which city he had used as an observation post to watch the trading activities of various European countries on India and China. Campbell suggested in the course of discussions in Amsterdam that a Swedish East India Company be founded. When this came to pass, Campbell was made supercargo on the first ship to leave Gothenburg for Canton. He carried credentials in Latin as the King of Sweden's Minister Plenipotentiary to the Emperor of China. This first ship set sail in 1732, and the last departed in 1803. Campbell left a large fortune and made substantial gifts to city institutions, the Gothenburg Orphanage among them.

Carnegie

The firm of D. Carnegie & Co. in Gothenburg, which was founded in 1803, goes back to George Carnegie (1726-1799), who joined the Pretender in Scotland. Like so many thousands of the Stuart supporters, George Carnegie left Scotland after the battle of Culloden in 1746. He

went to Gothenburg. There he received his warrant as a merchant in 1758 and engaged in foreign trade. From England he imported barley, coal and butter, from the Baltic countries rye and flax. Exports consisted of iron and sawn wood, which were sold mostly to Britain, but also to Spain and Portugal.

Carnegie returned to Scotland in 1769 and there bought the family estate Pitarrow and also Charleton, another property near Montrose.

George Carnegie´s son, later David senior (1772-1837), was sent to Gothenburg at the age of 14 to receive commercial training from his father´s friend, Thomas Erskine (who had been British consul there since 1775). For this purpose David senior was in 1776 set to work in the office of John Hall & Erskine, a firm established in 1765. Another Scot, David Mitchell from Montrose, was a partner in 1798 of this Erskine in the firm of Thomas Erskine & Co. Erskine returned to Scotland in 1799, on succeeding to the earldom of Kellie, and David Mitchell continued trading under the style of Thomas Erskine & Co.

In 1790 a very able young Gothenburger, Jan Lamberg (1771-1834), joined the Hall firm and was appointed by Erskine assistant to David Mitchell in 1798. The latter died in 1803. In the middle of that year David Carnegie together with Lamberg took over the Mitchell business and property and carried it on under the name of D. Carnegie & Co. It soon developed into an important trading-house. From the Baltic countries they imported at the beginning mainly flax, while other imports consisted chiefly of salt, wine, sugar, coffee, cocoa and tobacco. Exports included cured herrings, pitch and tar, and some sawn wood.

The firm grew rapidly, principally as exporters of iron and wood, above all of iron. But Carnegie & Co. was not one of the really large exporters of iron in Gothenburg. These were A. Barclay & Co., Olof Wijk & Co., James Dickson & Co. and John Hall & Co. From the middle of 1810, when the trend of the trade changed and the USA became a large buyer of iron from Gothenburg, Carnegie & Co. sent some quantities to America, but they kept up their sales to England. During the 1810´s, 1820´s and 1830´s the large exporters, such as A. Barclay & Co. and Olof Wijk & Co. sent most of their iron to the U.S.A.

The iron exported by Carnegie & Co. consisted mostly of bars, with some quantities of bands, and in addition some blister steel. Like the other exporters, Carnegie & Co. received the iron from the producers both on commission and as outright purchases. They had about

twenty suppliers of iron, and ten of steel alone. The names of the principal exporters of iron in Gothenburg during the period from 1800 up to 1850-1860 are given below in alphabetical order:

A. Barclay & Co.	Jos. & O. Hall
D. Carnegie & Co.	Low & Smith
James Dickson & Co.	C.A. Murray
Rob. Dickson & Co	James Sinclair
W.G. Gordon	Laurent Tarras
John Hall & Co.	J.W. Wilson

John Hall & Co. went bankrupt in 1807, and D. Carnegie & Co. then developed into one of the leading houses in Gothenburg. The dominant person was David Carnegie senior. In 1836 his nephew, David Carnegie junior, joined the firm as a partner.

David Carnegie junior was born in 1813, the son of James Carnegie, a sea captain, who mostly sailed to India but who came to Gothenburg off and on. His son, who was then 17, was sent to Gothenburg in 1830, and placed in the office of his uncle. At the age of 20 he received his warrant as a burgher and from 1836, when 23 years old, he was number three in the firm. In the same year he bought at a bankruptcy sale the Lorent porter brewery and sugar-mill at Klippan, near Gothenburg, aided financially by his uncle David and his cousin William Robertson. The history of the Carnegie sugar factory has already been dealt with.

In the Carnegie trading firm there was nothing unusual in the way of sales organisation. Sales, to deal for a moment with the subject, were made either direct to firms in the iron trade abroad, through representatives or through established direct connections. Among the latter were R. & W. Crawshay & Co. and Rew Prescott & Co. in London, and A. Hay in Antwerp. One unusual method, however, was employed. The master of a ship was sent to a certain port and instructed to act as salesman on the spot for the cargo or part of it. In certain cases he also acted as buyer of the local produce offered. Among financial connections abroad were large merchant bankers, Jos. Denison & Co. of London and Parish & Co. of Hamburg being of the first importance. During the time of D. Carnegie junior - say at the beginning of the 1840´s - new connections were established: in London there were Reid Irving & Co., Westphal & Rist, Edward Sieveking, Engeström, Parkins & Co. and others.

In common with other iron exporters in Gothenburg and Stockholm, D. Carnegie & Co. tried to gain influence, not to say dominance, among the forge-owners in central Sweden. The exporter would advance money and the producer gradually paid off through deliveries of iron. Capital was necessary for the purchase of charcoal as well as of pig-iron, since this was in many cases not made by the forge owner. This is not generally known, and it has been mostly assumed that the hammer-works were equipped with blast-furnaces. Iron was, as a rule, bought by the exporters once a year, and this was generally done at the "fair" in Kristinehamn, a town in the province of Värmland in western Sweden. Some of the forge owners then bought grain, salt and salted herrings from the Carnegies and other Gothenburg houses. Now and then it would happen that iron was not supplied in sufficient quantities to pay off the advances received, or at the rate agreed on. Mortgages would follow or in some cases bankruptcy, whereupon the exporter would take over the business as actual owner.

Returning to the Carnegie activities, there were for six years two Carnegie firms: D. Carnegie & Co., engaged in shipping and trade (principally iron and timber), and D. Carnegie junior, concerned with porter-brewing and sugar-making. In 1842 the two firms became one: D. Carnegie & Co. In 1845 the trade in iron and timber came to an end, and only a little shipping was kept going; sugar took chief place in the firm´s business, and then there was, of course, the stout or porter. In the history of Swedish sugar manufacture the Carnegie firm played an important part, as will be seen from the data given under "Sugar Refining". David Carnegie junior retired in 1841 to Scotland, but still directed his firm´s business. In Gothenburg the head of the firm during the period 1836-1845 was John Nonnen, a relative of the Carnegies, and after him came Oscar Ekman, one of the leading businessmen of Gothenburg in the latter part of the 19th century. David Carnegie junior died in 1890, a very wealthy man. In his will he remembered by large donations the city in which he had acquired his fortune; for example, he gave a very large amount to the Gothenburg University College. When the Carnegie firm was dissolved in 1907, the manufacture of sugar at Klippan was taken over by the Sugar Combine. This has already been dealt with in the chapter on that subject.

D. Carnegie & Co., as previously mentioned, were also shipowners. They had their own fleet varying from four to seven vessels, and acted besides as agents for a considerable number of owners. x)

x) The main source of information consulted for this part of the chapt is D. Carnegie & Co, 1803-1953, an impressive volume published in 1953 in Gothenburg. The author is Arthur Attman, professor of economic history at Gothenburg University.

Chalmers, William (1748-1811)

William Chalmers was born in Gothenburg of British parents. The father, also named William, was a Scottish businessman. The son was resident in Canton from 1783 until 1793 as representative of the East India Company and made a large fortune there. After his return to Gothenburg he became the principal director of the East India Company.

During his Gothenburg period, Chalmers was keenly interested in municipal and social matters. He founded the first craft-training school in the city, where poor children could learn to card and spin - it was regarded at the time as an entirely needless scheme. His great interest in raising the standard of craftsmanship is reflected in his munificent bequest - one half of his fortune - for the establishment of the well-known technological college which still bears his name. The other half of his estate was given to the hospital founded by his old friend Sahlgren.

It is perhaps not widely known that he did a great deal to promote the plans put forward for canalising the waterfalls of the Göta River and thereby making the vast inland territories of south-western Sweden accessible from the sea through the port of Gothenburg. Chalmers was one of the leading men on the commission dealing with these problems. He was a pioneer in the Swedish textile industry, founding in 1795, together with Fredrik Hummel, the country's first mechanical cotton-spinning mill at Lerum near Gothenburg.

Kullen, as the mill was called, became the model for many other spinning-mills around Gothenburg and elsewhere. The privilege he secured for the mill he transferred after six months to others. Chalmers' name is later found to have been associated with the development of the coal-mines at Höganäs.

Chalmers' activities brought him into contact with many of the notable men of his time. Banking was a particular interest of his, and he took a prominent part in the prevailing discussions on its reform.

As a bachelor, Chalmers was much seen and welcome in the social life of Gothenburg, and he was one of the founders of the Bachelors' Club, at that time a very exclusive institution.

Dickson

The Dicksons came from the town of Kelso on the Tweed, in southern Scotland. One James Dickson settled in the 1770's as a merchant at Montrose, a small port 25 miles north of Dundee on the east coast. Two

of his sons, Robert (1782-1850) and James (1784-1855), moved to Gothenburg in 1802 and 1809, starting business independently. In 1816, however, they joined forces and established the firm of James Dickson & Co. They fully understood how to take advantage of the highly favourable conditions ensuing after the Napoleonic wars, and the firm quickly rose to share with D. Carnegie & Co. the status of the largest and wealthiest trading-house in Gothenburg, with large-scale export of timber and iron as well as import of colonial produce.

The most successful period of the House of Dickson was just before and during the Crimean War, when the capable though ruthless James Robertson Dickson (1810-1873) was at the helm. In the course of time James Jameson Dickson (1815-1853) and Oscar Dickson (1823-1897) became partners. The former served from 1837 to 1840 as head of a branch in London, trading under the name of Dickson Brothers. During his residence in Gothenburg he took the initiative in the formation of the Bergslagsbanan railway, the most important link between the timber and iron districts of central Sweden and the port of Gothenburg. In its early days the firm had been substantial shipowners with Sweden's largest fleet of sailing ships, but they gradually withdrew from this part of the business to concentrate on export, mainly of woodgoods which they shipped in British and Norwegian vessels.

To begin with, the firm's timber interests were centred in the province of Värmland, north-east of Gothenburg (with sawmills at Edsvalla, Höglunda, Forshaga and Dejefors), but they were transferred during the period of the Crimean War to Norrland, where enormous forest areas in the rafting districts of the rivers Ljungan and Ljusnan were purchased and sawmills built (Matfors, Sandarne, Baggböle, Svartvik and others).

Oscar Dickson acted as manager of the forest properties and sawmills in Norrland. He, incidentally, paid one-third of the cost of Nordenskölds famous North-East Passage along the north coast of Europe and Asia in the sailing ship Vega. He also gave large sums to various geographical and botanical expeditions. In fact, all the members of the Dickson family became known as liberal donors to many causes. Details of Oscar Dickson's activities in the woodgoods industry will be found in the chapter on timber.

Finlay & Jennings

One of the most remarkable firms in the history of Swedish trade was Finlay & Jennings. In the usual books of reference it is stated that the founders, Robert Finlay and John Jennings, came from Ireland. This

is undoubtedly so, but the Jenningses were certainly descendants of the old English noble family of Jenins, who at the end of Elizabeth I´s reign moved from Somerset to Ireland.

Frans Jennings came to Sweden from Belfast, set up as a merchant in Stockholm and was naturalised into the Swedish nobility in 1742. Of his sons one, John, became a financier, mill owner and politician, and the other, Frans, went into the Army. The principal interest of the elder Jennings was iron production, and by virtue of his good connections in Britain he financed ironworks on an extensive scale. Thus he owned Gnarp and Antskog in Sweden as well as Koskis, Fiskars and Kulla in Finland. John Jennings, the son, died in 1773 on his superb estate, Forsmark, in the northern part of the province of Uppland.

The firm of Finlay & Jennings had been dissolved in 1761. Apart from his far-reaching commitments in politics, finance and industry, John Jennings devoted much energy to canal and lock construction. He was one of the directors of the Trollhättan Lock and Canal Office, and was very influential politically, obtaining large loans for his firm from the Riksdag. His partner and associate, Finlay, went bankrupt in 1771, after which the greater part of their properties was transferred to Jennings, who left a substantial fortune.

Robert Finlay was born in Dublin in 1719 and spelled his name Finlaij on being ennobled in Sweden. Like so many others of his time, he was an immigrant of old Scottish aristocratic stock, and was prominent in the influx of technicians and businessmen to Sweden from Britain at the beginning of the 18th century.

The financial crises of the 18th century hit Finlay much harder than Jennings, and in 1771 he was, as already stated, forced into bankruptcy - ten years after the dissolution of the firm. After a time he left the country and died in Bordeaux in 1785. The firm´s iron production had nevertheless been the largest in Sweden. Jennings showed an interest in the technical development of the works that was very unusual among merchants of that period; he paid particularly great attention to the improvement of blastfurnace design. He was honoured with a gold medal by the Swedish Iron-Masters´Association, of which institution he was for a time a delegate.

Gibson

William Gibson (1783-1857), the first of that name to make an impact on Sweden, was born at Arbroath in Scotland. The father, also named William, was a sail-cloth manufacturer and shipowner. At 14 years of age

the son was sent to Gothenburg, where he worked at first as an ironmonger's assistant. At the age of 23 he was admitted a burgher of the city and had by then established his own business. He began by running a vinegar-factory but very soon, thanks to the favourable conditions ruling after the Napoleonic wars, he went further afield and made substantial profits. He built a sail-making mill and a rope works in the Gothenburg suburb of Majorna, and afterwards a linen mill and an iron foundry, said to have been the first of its kind in Sweden. The same was in fact said of the linen mill, which was intended to be mechanically driven but seems in fact to have been manual. But there is some doubt whether the distinction is due to the Majorna mill or to a similar plant at Norrköping.

In both places water-power soon replaced manual operation. Gibson obtained in 1828 permission to erect a small flax-spinning mill at the old lock weir in Gothenburg, and to this was later added a weaving- and bleaching-mill. In partnership with another rising British industrialist, Alexander Keiller, Gibson moved the weir plant and the foundry in 1834 to a site by the waterfalls of Jonsered, 12 miles north-east of Gothenburg. Skilled operatives were brought in from Scotland and England, and the production of sail- and tent-cloth and of rope work was greatly expanded. In the 1850's cotton developed into an important raw material at Jonsered, side by side with flax and hemp. The production of calico, curtain- and furnishing-fabrics, towelling and sheeting rose to a position of importance in the country's internal economy. The reader may here be reminded that Jonsered was where Keiller in 1834 built his own gasworks - the first in the country.

Mention must also be made of Gibson's enduring social interests. He built a church and an almshouse and established an institution for poor children. For further information about the Jonsered business the reader is referred to the chapter on mechanical engineering. William Gibson the second (1816-1865), son of the founder of the business, was particularly interested in the mechanical section of the growing establishment at Jonsered. This factory grew rapidly, and its wood-working plant became well-known in the trade. Like his father, the second William was also interested in social matters.

William Gibson the third (1848-1917), an engineer like his father, continued the expansion of the wood-working plant section. The Jonsered machinery became world famous. He added to the textile department a large jute-weaving plant. The family traditions of social welfare were maintained.

Additional Notes on the Gibsons. In the 1790's there was in Gothenburg a Scottish firm, James Christie, engaged in export and import business with Britain. Christie's premises were located at Masthugget, on the outskirts of Gothenburg, and in 1797 a boy of 14, named William Gibson, was taken on soon after his arrival in the city from his home at Arbroath. The boy's father was a shipowner at that place and also ran a small sail-cloth factory. At Christie's, young Gibson met Olof Wijk, three years his junior, who in time became a prominent merchant in the city and also Gibson's brother-in-law. Christie died in 1806 and in that year and in 1810 Gibson bought from a shopkeeper, Johan Schutz, a large site known as Vädersågen, at Majorna, with sawmill and rope-works. This site is on the Göta River, north and east of the hill on which the Carl Johan Church now stands. The textile production then carried on there developed in course of time into the great Jonsered Works. At the time there was a rope-making plant, a timber business, a shipping wharf and, a little later, a sail-cloth mill. There are some indications that an iron foundry was also set up there.

The sail-cloth mill seems to have been established some time during 1825 and in April of the following year Gibson & Co. submitted for the first time their accounts of this production to the Hall Court of Gothenburg. In 1828 corresponding accounts were lodged by the firm of Gibson & Keiller. Mechanical spinning was not then known in Sweden, and Gibson had to use handspun yarn. Nor was the weaving-mill mechanised.

Gibson then approached Keiller with a request for his cooperation in building a mechanical spinning-mill, and Keiller helped Gibson to plan this mill, which was erected in 1828 at the lock in Drottningtorget square in Gothenburg.

There were many difficulties in the way of equipping this mill. The plant had to come from Scotland, but there was a British embargo on the export of such machinery, and it was in force until 1842. And for the factory building, which occupied the space now taken up by the bridge from the Hotellplatsen square over the harbour canal, space was very cramped.

The Jonsered estate was purchased in 1831. Olof Wijk, Gibson's brother-in-law, was the buyer, but he transferred the property to Gibson & Keiller, who were registered as owners on 18th October, 1833. The principal reason for the acquisition of Jonsered was the presence there of water-power from the Säve River.

It is not now possible to say in which order the factory buildings

were erected, but those farthest east came first, i.e. the flax-spinning and weaving-mills. They were probably built at about the same time - the spinning-mill no doubt first. In 1835 the first rolls of cloth were delivered from the new mill. Joint production at the Sågen weaving-mill and the spinning-mill in Gothenburg was continued for some time, but in March 1836 the whole textile business was concentrated at Jonsered, apart from the ropeworks which remained at Sågen.

Relations between the partners began to deteriorate, and it was decided to separate. Gibson and Keiller both married sisters of Olof Wijk. Wijk stepped in as mediator and arranged for Keiller to be bought out from the firm, which was then taken over entirely by Gibson, who ran it under his own name. Keiller, with his wealth of ideas and forceful nature, made himself an honoured name as the founder of Keiller´s Engineering Works - the present Götaverken.

Hall

The forebears of the Hall family were British, and in the first half of the 18th century the brothers Benjamin, John and Robert Hall settled in Gothenburg as merchants. John was admitted a burgher in 1752 and his firm, Wilson & Hall, was the city´s most highly rated trading-house. In the period of the East India Company´s third charter, the firm ranked as the second largest shareholder. John, however, left Sweden in 1768. Robert Hall was born at Hull and obtained his Gothenburg franchise in 1753. He died in 1763. Benjamin Hall gained admission as a burgher in 1735; he died in 1755. He had two sons, John Hall senior and Benjamin Hall (d. 1768). Both were merchants. The former´s son, John Hall junior, was a mill owner as well as a merchant.

In 1764 George Carnegie (see chapter on the Carnegie family) had three clerks: Thomas Erskine, John Hall and James Carnegie. George Carnegie returned to Scotland in that year and bought the family property, Pitarrow, and an estate known as Charleton, near Montrose. Together with other British merchants in Gothenburg, George Carnegie put money into the Hall firm and was one of its founders. The company was called John Hall & Erskine. The latter was a partner in another firm with David Mitchell, called Thomas Erskine & Co., which was engaged in herring curing and fish-oil extraction. They were also shipowners and dealt in tea and other products from China on commission.

John Hall & Co. were large exporters of iron and timber. They were owners of a considerable number of forges and ironworks in the

provinces of Värmland and Dalsland and of sawmills, mostly at the Lilla Edet waterfalls. In common with many other Gothenburg merchants they also were engaged in herring curing and fish-oil extraction. When John Hall died, 70 per cent of his fortune was placed in forges and sawmills. Of Gothenburg´s exports of planks, John Hall & Co. were responsible for a substantial portion: in 1770 for about 18 per cent, in 1777, 55 per cent, in 1790, 70 per cent and in 1800 for some 50 per cent. Hall was in his time regarded as perhaps the wealthiest merchant in Gothenburg, but his son did not possess the mental equipment or the balanced judgment necessary for "big business". His firm went bankrupt in 1803 and he himself died penniless in Stockholm in 1830.

Keiller

The contribution of the Keillers to the development of modern industry in the Gothenburg area is dealt with under "Mechanical Engineering", "Shipbuilding" and "Textiles". The first Keiller in Gothenburg, Alexander, was born in Dundee in 1805. He came to Gothenburg in 1825 and died there in 1874. Together with a countryman, William Gibson (later his brother- in-law), who had already settled in the town, he formed a trading firm under the name of Gibson & Keiller.

Alexander Keiller first established a hemp- and flax-spinning mill in the Majorna area of Gothenburg, but removed later together with Gibson to Jonsered, north-east of Gothenburg; he separated from Gibson in 1839 and built in 1841, on two sites along the Göta River, a shipyard for steamers and an engineering works.

His son, James (1836-1918) graduated from Chalmers Technological Institute, received further training in England and Scotland and was admitted a partner in Alexander Keiller & Co. in 1860. He was a very capable engineer and devoted himself almost exclusively to the technical side of the business, although he also acquired a high reputation as a businessman. He was, moreover, interested in municipal affairs and bought the beautiful Ramberget estate which forms the background of an engineering works founded by him on the Hisingen island. It is now called Keiller´s Park and is one of the most beautiful natural plantations in Sweden. He retired in 1906.

This Keiller had a son, born in 1867, who continued the development of the shipyard with great ability and energy. The original Alexander Keiller, i.e. the member of the family who came to Gothenburg from Britain, had a son, David Cable (1846-1935), the youngest of three, who also made his mark in industry. He managed the family copper-works at Kaveltorp

from 1874 to 1899 and made his home at the well-known Vedevåg Works between 1894 and 1913.

As related in the chapter on gasworks, Alexander Keiller was one of the first Swedish industrialists to pay attention to the introduction of gas lighting, and in 1843 he submitted a complete plan for Gothenburg. He had in fact, as early as 1834, himself built a gasworks at the Jonsered factory, and later on he followed this up by erecting a gasworks at the Rosenlund weaving-mill in Gothenburg. The contract for Gothenburg city was given to a large British concern that had installed gas production plant in serveral European countries. However, Keiller was able to introduce gas lighting in a number of other Swedish towns. After the Keiller firm had completed a gasworks at Norrköping, the engineer employed for the purpose by Keillers became the builder and manager of the gasworks subsequently built in various parts of the country - such as Ystad, Linköping, Jönköping and Nyköping.

Petre

This family was connected with the iron industry in central Sweden over a long period. It is traced back to Robert Petre (born 1614), who was at one time mayor of Montrose. Three of his sons, George, William and Robert, came to Sweden at an early age, and the two elder brothers settled in Stockholm. The younger (1614-1690) founded the Brattfors Ironworks at Ockelbo. Two sons of the elder brothers, Robert junior and Jacob, became traders in the town of Arboga. In this busy provincial centre their uncle, Robert senior, had already settled. All the Petres were able businessmen, and acquired in the course of time iron-industry property in the eastern part of the Swedish iron-belt.

The hammer forge at Hofors, some 20 miles from Gävle, was acquired by the family in the 1680´s. The most prominent of the proprietors was Johan Thore Petre (1793-1853). But financial difficulties arose in the course of time, and in the end the whole property was taken over by the Stockholms Enskilda Bank, owned by the Wallenberg family.

The Lancashire method had been introduced as early as 1855 and the Bessemer process followed in 1883. The works expanded considerably under the bank´s administration: rolling-mills, open-hearth furnaces etc. being added. The Swedish Ballbearing Co. of Gothenburg, parent company of the Skefco Company at Luton, acquired the Hofors Works in 1916. The 300-year-old forge has now become one of the most up-to-date quality steel works in

the world, with an annual capacity of more than 200,000 tons of ingots.

Tottie

The Tottie family, closely related by kinship and business contacts to the Arfwedson family, came from England. Their earliest known ancestor, William Totty, had his home near Leeds. Thomas Tottie, born at Jedburgh in Scotland (1664-1724), emigrated to Sweden in 1688 and established himself as a merchant in Stockholm, where he also opened a tobacco manufactory. He was the ancestor of the widely-ramified Swedish family of whom Charles Tottie (1703-1776) is the most notable member. He made his mark in many industrial fields - wood tar, iron and woodgoods being some of them. One of the Totties set up in business in London, became in time Swedish Consul-General there and enjoyed the highest repute. The firms of Tottie & Arfwedson and Finlay & Jennings were two of the most remarkable trading and industrial concerns ever to flourish in Stockholm. It may be as well to remember, however, that the works owned by these firms were not, measured by later standards, individually of very great importance.

General Remarks

Tom Söderberg, in Bergmän och brukspatroner i svenskt samhällsliv (Mining Men and Ironmasters in Swedish Community Life, Gebers, Stockholm, 1948) writes as follows: "The number of works and metal-manufactories in Sweden appears towards the end of the 18th century to have been near the 500 mark, of which three-fifths or close on 300 were bar-iron forges." This tallies pretty well with the information provided by Bertil Boëtius in his Gruvornas, hyttornas och hamrarnas folk (People of the Mines, Foundries and Hammer Forges) as seen below:

	1695	1748	1803
Number of works	324	352	340
Number of forges	110	93	71

None of these works, of course, could have reached any great size, considering that in the mid-18th century Sweden's entire iron export amounted to no more than 40-50,000 tons. Of this, 60-62 per cent was shipped from Stockholm and 25-27 per cent from Gothenburg. The changes from time to time in exports from these ports have been referred to several times in these pages.

During the 17th and 18th centuries, the bulk of Swedish iron was exported from Stockholm. The export agents in the capital, who were mostly members of the Stockholm Iron Exchange, were in many cases, say during the last 30 years of the 18th century, owners of the forges they represented. Tottie & Arfwedson were then the largest exporters and represented in 1794 no less than 45 forges, most important of which was the Dannemora group. Gradually there was a change in the relative position of the two leading ports. Already in 1815 exports of iron from Stockholm and Gothenburg were of about equal importance.

Iron exports from Sweden amounted to 40-50,000 tons a year from the middle of the 18th century, as has already been stated. It was, of course, mostly bar-iron. During the second half of the century, exports of bar-iron from Gothenburg were concentrated on a few large firms. In 1777, John Hall & Co. shipped 4,000 tons out of a total of 13,400 tons. In the 1790´s the figures were 10,000 and 13,900 tons respectively, in 1800 they stopped at 5,200 and 10,800 tons. In 1810 iron exports from Gothenburg amounted to 18,655 tons, but by then other firms had taken the lead.

Throughout this survey there is clear evidence of the powerful influence wielded over a large period by British merchants on the business life of Gothenburg. There has been no occasion here to enter generally into the question of the city´s topography, but one fact should be borne in mind. This is that during the earlier days of the British build-up in Gothenburg the place was small, measured by British and Continental standards, and its considerable importance as a trading centre bore little relation to the size of its population.

Sweden was then, as it is now, a sparsely-populated country. In 1750 the population of Gothenburg was only 9,500, with 12,500 at the beginning of the 19th century. In 1760 Stockholm showed a figure of 71,860, in 1800, 75,520. Today, the population of the two cities, including suburbs, is about 1,000,000 for Stockholm and 500,000 for Gothenburg. The total population of the country is almost eight million.

It may be mentioned that the number of British residents in Gothenburg is at present put at approximately 300; in Stockholm the figure is 800.

SUNDRY INDUSTRIES

Miscellaneous Notes on British Activities

As a primary guide for this section the author has used a large collection of extracts made by Professor Bodman from a considerable number of publications, differing widely in purpose and character [x]. A comparatively small number of names from other sources has been added. Certain firms have already had their chief activities referred to under some of the main headings and are included here only by reason of some additional type of manufacture.

The names are placed in alphabetical order, and give an idea both of the large number of small and moderate-sized British manufacturers active during the period in question and of the great variety of commodities which these pioneers produced.

Baker, John. Charter received in 1834 for a machine-shop in Stockholm.

Barclay, Alexander. Started in 1842 a sugar-mill and in 1847 a cotton-mill in Gothenburg.

Baxter, H. R. (Aktiebolaget J. G. Cox, Gothenburg), Proprietor of a glue factory.

Belfrage is a well-known name in Sweden. It was first mentioned among the Scottish soldiers in 1637. In 1837 the Munkedal Ironworks belonged to the family. Fifty years later a Belfrage bought a sawmill at a place called Sandö.

Bennet. In 1761 this family started cloth printing and dyeing in Gävle, and later opened such factories in Stockholm and at Åbo in Finland A Bennet owned in 1807 a candle factory, using bleached wax, at Järva outside Stockholm.

x) Apart from some seventy works on industrial history, on topography and on geography, the material includes manuscripts in the National Archives, publications issued by government departments, and finally the principal genealogical reference books in Sweden. The results of Bodman's painstaking search into the history of Scottish families in Sweden, previously indicated, have been extensively used in this particular section; in fact they were found invaluable.

Billow, J., opened dye works in Gothenburg 1853

Bley, R. W., Uddevalla. Charter in 1856 for the Kampenhof textile works in that town: cotton spinning, weaving, bleaching and dyeing.

Blackwood, Robert. Supervisor at the Gothenburg Waterworks about 1818. Charter in 1816 for a small iron foundry in Gothenburg, "in the English style". He intended to use scrap, old castings and pig-iron.

Campbell, J., was in 1756 granted a charter in Stockholm for the cutting of steel files.

Cane, P. Brought over from England as a foreman in the famous metalware factory at Vedevåg in central Sweden; received a charter in 1757 for the manufacture in Stockholm of saddlers' hooks and eyes.

Carnegie. This name, later so well-known in Sweden, is encountered already in 1625. This early Carnegie, who had nothing to do with the famous Gothenburg family, was the owner of a flour-mill at Lilla Edet, a village by a waterfall in the Göta River, some 30 miles north-east of Gothenburg.

Chalmers, William, is mentioned in 1794, together with one Greig, in connection with a charter for a cotton-spinning and weaving-mill in Gothenburg. This is of course the famous Chalmers who was one of the leading men in the Swedish East India Company. He founded the well-known Chalmers Technological Institute in Gothenburg.

Chapman, Fr. H. The famous admiral and shipbuilder received a charter in 1740, together with P. Bagge, for a shipyard in Gothenburg. He had become partner in a shipyard built in 1735 at Djurgården, an outlying area of Stockholm, and was in due course raised to the nobility.

Christie. Playing-cards and sealing-wax were made by a Christie in a small shop in Gothenburg in 1810; he was succeeded by William Gibson & Co.

Clancey, E. Charter in 1834 for a tannery in Gothenburg.

Clayhill, A. & N. Charter in 1799 for a cloth factory, and in 1800 for a sack-cloth factory, both in the town of Lovisa in Finland.

Clayhill, C. Charter in 1737 for the manufacture of pitch in Fredrikshamn, Finland.

Clerck is a name that occurs in 1606 in connection with boat building. Later goldsmiths by the same name are mentioned (one received a Royal Warrant in 1730), and also a tanner in the village of Abbestorp, in the province of Småland.

Cooper, Robert. Charter in 1844 for a tannery in Stockholm.

Duncan was the name of a tobacco manufacturer in Gävle in 1747.

Duwall. One member of this family founded a woollen-mill in the town of Karlshamn in 1734, another was operating a sawmill at Hällsjö, in the province of Jämtland in northern Sweden. The family also owned a tannery and a sugar factory at Karlshamn during the 18th century. The first Duwall in Sweden bore the name of Mac Dougall and came over in 1594. He became naturalised and changed his name. A great many military men are found in the family.

Elder, W. Charter in 1833 for the manufacture of sulphuric acid.

Feiff. In 1628 this name is found among brewers and also goldsmiths in Stockholm, and towards the end of the 18th century among the owners of textile factories, also in the capital. A member of this family became in due course ennobled.

Finlay, Robert, of Finlay & Jennings. Charter in 1757 for the manufacture of iron and steel products at Duvenäs in Sickla, then a little village outside Stockholm. Among the foremen were E. Staunton and J. Oakley. Finlay also received a charter, in 1753, for a tannery at Kungsholmen, then as now a part of Stockholm.

Fleetwood, G. V. Charter in 1723 for producing alum at Lover, on the island of Öland; in 1725 for an iron forge at Flerohopp in the province of Småland; and in 1727 for a tannery at Stjernarp, in the province of Halland.

Fleetwood, Hedvig Charlotta. Charter in 1734 for a paper-mill in Stjernarp.

Fleetwood, Gustaf Erik. Charter for a forge in Barnarp in the province of Småland.

Forbes, A. U., is mentioned in 1756 as having received a parliamentary reward for his progress in mechanical engineering. He had, for example, constructed a very useful chaff-cutter, a model of which can be seen in the Science Museum in Stockholm.

Fraser, Robert, a brother of the well-known head of the Motala Engineering Works, was the owner of a paper-mill in the same town in 1855.

Gahn. The members of this family are descendants of two Scottish officers who came to Sweden in 1572. The original Scots name was Colquhoun. In Sweden it was originally and for some time afterwards spelt in various ways: Cahund, Khahun, Cann, Cavn and Caan. Early in the 17th century the name was finally registered as Gahn. The first Cahuns were engaged as cannon founders by the King. The Gahns became well-known in Swedish industry and were the owners of works and factories for the production of iron (Voxna and Dalkarlshyttan), sulphuric acid, metalware, tobacco pipes, preserved food and cosmetics. As early as 1867 they put on the market an antiseptic lotion which was widely sold, not only in Sweden, and their mouthwash is claimed to have been the first of its kind marketed according to what might be called modern ideas. In science also the Gahns have made a name for themselves. Henrik Gahn & Co. of Uppsala is now one of the largest manufacturers in the country of cosmetics and toilet articles.

Gardner was the name of the owners of a sail-cloth factory in Gothenburg in 1814.

Gavin, T. and Gordon. Charter in 1816 for a rope factory in Gothenburg.

Gibson, William. This prominent Gothenburg industrialist has been mentioned several times in connection with textile factories. He started a brewery in 1805, then took up the manufacture of playing-cards, sealing-wax, vinegar, rope and sail-cloth. Finally, the foundation of the big industrial undertaking at Jonsered, not far from Gothenburg, was laid (textiles and wood-working machinery).

Gordon was in 1816 the name of a rope-maker in Gothenburg.

Graveley, T. & Kronthén, J.T. Charter for a sugar-mill in Stockholm.

Greenbrough, R. Began to make varnish in 1691 and claimed that he would meet the total requirements of the country.

Greig, W., was a well-known brewer in Gothenburg in the 1840´s.

Hacker, Thomas, (ennobled Hackersköld in 1686) was a supervisor at the Åker cannon foundry some 50 miles inland from Stockholm; also an inspector of the powder factories of the country.

Hallwell, C.J. Charter for a rope factory in 1840.

Hamilton. The members of this family were originally all military men. In 1654 a Hamilton appeared in industry, when Hugo Hamilton received a charter for building a potash and a soap factory. Other Hamilton ventures: in 1680 a sack- and sail-cloth factory was bought in Rodga, a village in the province of Östergötland; in 1771 a similar factory was started in the town of Örebro; in the same year a glass factory was opened in the province of Närke in central Sweden; in 1796 a combined tannery and paper-mill x) was started in the province of Småland. Towards the end of the 19th century a Hamilton owned a sugar-mill in Karpalund, a village in the neighbourhood of Kristianstad, in the province of Skåne. Some ironworks have also belonged to the family, e.g. Gryt, Gammelkroppa, Högfors and Persbo, in central Sweden.

Harper, junior, Jacob. Charter in 1717 for a tobacco factory in Stockholm.

Harrison, Joseph. Built an oil-mill in Gothenburg in 1839.

Harweck & Brothers. Charter in 1744 for a silk-finishing factory in Stockholm.

Helleday. In 1648 a brewer by that name is found in the records of Stockholm burghers. Later the name is met with in various branches of the textile industry. In 1834 a Helleday appears among the pewterers of Stockholm.

Hollingworth, A. Began to make agricultural machinery in the town of Arboga in Central Sweden in 1880.

Howard, Charles. Charter in 1662 for an "English tannery" in Stockholm.

Jordan is a name found in 1654 among brewers and bakers in Stockholm.

Kinlock, A.J. Engaged in 1694-1708 at a government rifle factory in Norrköping, then already an important industrial town in central Sweden.

Kinnaird, Alexander. Made a name for himself as a distiller in Gothenburg.

Kinnimundt was the name of a Scottish family that came over in 1620 and is said to have had connections with various industries. The name Kinnemond was then also mentioned.

Lancefield, James. Charter in 1834 for a mill in Fässberg, near Gothenburg, "for the manufacture of cloth from cotton, wool and silk".

Lancefield & May. Charter in 1829 for a cotton-spinning mill at Lindome, in the province of Halland.

x) In those days, of course, paper was all made by hand and the mill itself was a very small affair.

Leijel (Lyel, Lyell). This originally Scottish family came to Sweden in the middle of the 17th century and soon became connected with the iron industry. They have had interests in works at Älvkarleö, Harnäs, Hammarby, Bröstorp, Norrby and Flerånge.

Lowrie (ennobled Lagergren). This name is mentioned in 1806 in connection with dyeworks, a paper-mill and a woollen-mill at Gustafsfors in the province of Småland. The Lowries came very early to Sweden from Scotland as soldiers.

Lyon. In 1839 a Lyon started making soap and candles in Stockholm.

Mackeij. In 1672 a member of this family was the owner of the Hammarby forge, not very far from Gävle. The Lögdö forge, in the province of Medelpad, in Norrland, was bought by a Mackeij later.

Mackler, Hans. Received together with Major Anckarhielm a charter in 1646 for rope works and a textile factory in Gothenburg.

Macklier was about the middle of the 17th century one of the most important merchants and shipowners in Gothenburg. Established a rope and a sail-cloth factory, one of the first textile-mills in Sweden. Was ennobled for his services to the Crown in connection with certain financial transactions with England. Traditionally the family came from old Scottish nobility (Maclean), and the name was in Sweden evidently spelt Makelér as well. Descendants took the name of Maclean in 1784.

Maister. Charter in 1691 for a starch factory and an oil-mill at Djurgården, Stockholm.

Maister, W. Charter in 1744 for metal works.

Malcolm, Andrew, Alexander, John and James (brothers). Opened in 1836 a shop for making textile machinery in Norrköping. They were granted six Swedish patents.

Marshall, J. Was in 1758 a maker of fans in Stockholm, and a Marshall started at the beginning of the 19th century a textile factory in Gothenburg, particularly for making sail-cloth.

Mesterton. In the town of Karlshamn, in the province of Blekinge, in the south of Sweden, a Mesterton received a charter for tobacco factory in 1698. It may have been the same Mesterton who some 20 years later started a tannery, an oil-mill and a soap factory in the village of Asarum in the same province.

Montgomery is a name met with in the history of a large number of ironworks and forges: Länna, Löfstaholm, Björkefors, Annefors, Rottneros, Bäckefors, Ortala and Åminne. One Montgomery was connected with copper works in the northern province of Jämtland; Montgomery's were also brewers in Stockholm, Södertälje and Köping.

Murray. About the middle of the 19th century the forge at Baggå in the province of Västmanland in central Sweden was owned by a Murray.

Nisbeth. This family came to Sweden from Scotland in 1596 and were ennobled in 1675. Military and administrative activities, but also connected with industry.

Parker, John. Charter in 1765 for a tannery.

Petre. This name is mentioned for the first time in 1675. The importance of the family in the iron industry is dealt with under "British Merchants and Industrialists", but they were also active in industries of what might be called minor importance. These were: in 1735 a paper-mill at the village of Olofström, in the south of Sweden; in 1808 a nitric-acid factory; in the 19th century a rope factory in Stockholm and a printing office at Linköping.

Ramsay. In 1824 the owner of a flour-mill and a machine-shop in the village of Kortfors in central Sweden bore the name of Ramsay.

Robertson, A. A charter for the opening of a weaving-mill in Gothenburg was in 1839 granted to a Robertson.

Robertson, W. Charter in 1839: dyeworks and a factory processing wool, linen, cotton and silk.

Robsahm and von Robson are Scottish names, and no less than 31 members of this group have been interested in Swedish industry, particularly mining and iron-making, and the Robsahms or Robsons have been connected with more than a score of forges and ironworks. They have also had interests in other industries, such as textile-mills, dyeworks, a sugar-mill, a shipyard and an alum factory.

Sinclair. This name appears in 1652 in connection with a proposal to produce salt from sea water on the west coast of Sweden. A Sinclair was the owner of a small forge called Gammelbo.

Sloane, J.J. Opened a factory for making wood-screws in 1850.

Spalding. The first Spalding came from Scotland, and was ennobled in 1678 under the same name. Another branch was ennobled under the name of Spaldencreutz. There were merchants in Gothenburg by the name of Spalding, and one Jakob Spalding came to Norrköping as early as 1649. This branch of the family was interested in the iron forge and metal-works at Gusum from the end of the 17th century until 1812. In Norrköping a Spalding owned a tobacco factory and a woollen-mill. In 1740 George Spalding, associated with a merchant by the name of Johan Forsberg, acquired the very important Holmen forges and metal-works in Norrköping from the State Bank. In the 17th century the Spaldings played a prominent part in the industrial history of Norrköping. Today Holmen is one of the largest concerns in Sweden, chiefly for paper and textiles.

Springer, J. Charter in 1742 in Stockholm for cloth preparation.

Springer, C. Charter in 1757 in Stockholm for cloth preparation.

Springer, P. Charter in 1757 in Stockholm for cloth preparation.

Springer, J.J. Charter in 1769 for making powder and starch.

Stanton, Edw. Charter for polished steel products. First worked at Vedevåg, then started on his own; later worked for Finlay at Duvenäs, near Stockholm, for some time; had other paid employment; then again on his own in Stockholm (Lilla Nygatan).

Strang. In this small family group are found in the 17th century an owner of a small forge called Nyhammar in central Sweden, and about the same time also an owner of hammer-works at Gisslarbo, in the province of Västmanland - central Sweden also. In the 1740's the name was connected with brick-works, a woollen-mill and a tobacco factory in and near the town of Köping, some 70 miles west of Stockholm. It is possible that the original name was Strange.

Stuart. Most members of this family were soldiers, but the name is also connected with industry: a paper-mill in Småland, three glass factories (Stafnäs, Långvik and Södertälje) and a tannery.

Teet (initially Teit), a Scottish family that settled in Finland very early; ennobled in Sweden 1652.

Thomaeus. A young Scottish boy who was the only survivor from a ship lost off southern Sweden in the 17th century. He was adopted by a Swedish family and later took the name of Thomaeus (presumably

from the village where his relatives lived). This name then became Thomée, and the family was ennobled in 1773 under the name of Adelsköld.

Thorburn. Started an oil-mill in Gothenburg in 1821.

Thorburn. Together with a partner named Brodie, a Thorburn established in 1824 an oil-mill at Uddevalla, a town on the west coast, north of Gothenburg. Seeds of caraway, juniper, cucumber, etc. were used. The name of Thorburn was later connected with various industries at Uddevalla: linseed boiling, paper making, cooperage and a machine-shop.

Thornton. One of the first cloth factories in Gothenburg was in 1694 owned by a Thornton (together with a partner called Manorgen).

Tottie. This family is mentioned in other connections and was at one time of great importance in Stockholm as merchants and forge owners. The first Tottie is mentioned in 1688 as owner of a tobacco factory in Stockholm. A Tottie had a tobacco factory also in Gävle. During the middle of the 18th century, members of the family were active in various fields of manufacture: snuff-boxes, playing-cards, stockings and woven garments. Later the interests of the Totties turned to the iron industry, and they were owners of a considerable number of works, such as Älvkarleö, Harnäs, Vifors, Lindsbro, Långvind and Olofsfors. A Tottie was the head of the famous Stora Kopparbergs Bergslags Aktiebolag during the latter part of the 19th century.

Turner, Robert. A shipbuilder by that name is mentioned in 1674.

Watson, William. Charter in 1688 for a tobacco factory in Stockholm.

Wessley, P. Charter in 1757 for the manufacture of gold and silver articles.

Williamson, Alexander, was the owner of brick-works in Gothenburg in 1752.

Wilson. In 1818 the records show a factory at Solna, outside Stockholm, - for making oil cloth, belonging to a Wilson. The name is at about the same time connected with a soap and perfume factory, called "Nordstjernan", also in Stockholm.

Young. A member of this family by the name of Daniel founded in the 1660's a cloth factory at Barnängen, on the outskirts of Stockholm. He received the title of commercial counsellor (kommerseråd) and was raised to the nobility under the name of Leijonancker. Members of this family became known principally for their technical and scientific activities. Daniel Young was born in Scotland in 1627.

SUNDRY BRITISH NAMES IN SWEDISH ANNALS

A considerable number of British names have appeared in the various sections dealing with early industrial life in Sweden. To the man in the street many of these names retain their historical ring. Among writers who have dealt with the subject of British soldiers, merchants, industrialists and scientists in Sweden are Birger Steckzén, Alf Åberg and Gösta Bodman.

It may seem uncalled-for to place before the reader a long list of surnames connected with the manifold activities of British residents in Sweden, but in a way it gives a picture of the comparatively large number these residents involved. The names are of course available to the student in various publications, and the list presented below does not represent the result of any thorough research work.

Gothenburg was founded in 1621 by Gustaf II Adolf. A considerable number of settlers were encouraged to come to the new town from Holland, then considered in Scandinavia to be the leading trading country in Europe, but very few British names are traceable during the first twenty years or so. In 1666 official trade relations were opened between Sweden and England, as mentioned in the introduction, and it is recorded that in 1691 there was an English congregation in the town. Freedom of public religious worship was not granted until fifty years later, so that the English congregation must have held their meetings in private. As mentioned in an earlier section the British Factory, a body of British merchants, was formed towards the end of the 17th century.

In dealing with British names we begin with the contributors to the stipend of the incumbents of the English Church in 1757:

Colin Campbell	George Bellenden	John Wilson
Charles Irvine	Robert Parkinson	John Hall senior
Thomas Anderson	John Scott	John Hall junior
James More	Robert McFarland	Robert Hall
William Chambers	Thomas Clansey	Timothy Lundie
	George Carnegie	William Williamson

The British names occurring in trade and industry in Sweden in earlier days have been gathered from the following sources:

1. Names of the treasurers of the British Poor-Box and British Factory in Gothenburg 1727-1926, from History of the English Congregation and its Association with the British Factory in Gothenburg by S. Townshend and H.J. Adams, B.Sc., Gothenburg 1846, Erlanders.

2. Gösta Bodman: Scottish Surnames in Swedish Industry and Technics, in Daedalus for 1948 - the year book of the Science Museum in Stockholm.

3. Fisher's book on The Scots in Sweden. Here is the list:

Airth	Clansey	Gibson	Jennings
Anderson	Clayhill	Glen	Johnson
Arbuthnot	Cleghorn	Gordon	Johnston
Baker	Clerck	Graveley	Jordan
Barclay	Colquhoun	Gregor	Keiller
Baxter	Cooper	Greig	Keith
Belfrage	Crafoord	Grundy	Kennedy
Bellenden	Crocket	Guthrie	Kinlock
Bennet	Dickson	Hacker	Kinnard
Benson	Douglas	Hall	Kinnimund
Bethune	Duncan	Hallwell	Krichton
Billow	Erskine	Hamilton	Lamb
Blackwood	Ennes	Harper	Lancefield
Bley	Feiff	Harrison	Lander
Briggs	Finlay	Hay	Leijel
Brodie	Fleetwood	Helleday	Lewis
Browning	Fletcher	Hichens	Lindsay
Calvert	Flint	Hollingworth	Lockhart
Campbell	Forbes	Howard	Low
Cane	Forrester	Hunters	Lowrie
Carnegie	Fowler	Hutchinson	Lundie
Chambers	Fraser	Innes	Lyall
Chalmers	Gardner	Irvine	Lyell
Chapman	Gavin	Jarrett	Lyon
Christie			

MacDougall	Mitchell	Robson	Stuart
McFarland	Montgomery	Ross	Tarras
Macfie	Moore	Rynd	Tailyour
Mackey	Mould	Seaton	Teet
Mackenzie	Murray	Seton	Thorburn
Mackler	Norrie	Scott	Thornton
Maclean	Nisbeth	Sheldon	Tottie
Maclier	Ouchterlony	Sibbald	Turner
Maister	Parker	Sinclair	Wadham
Makinson	Parkinson	Sloane	Watson
Malcolm	Petre	Smith	Wemyss
Marshall	Primrose	Spalding	Wessley
May	Ramsay	Spens	Williams
Mesterton	Reid	Springer	Williamson
Metcalfe	Robertson	Stanton	Wise
Millar	Robsahm	Stewart	Young

Most of these names belonged to families with trading and manufacturing interests, from the Gothenburg millionaire with his forges, blast-furnaces, sawmills and fleet of sailing ships, to the forgotten maker of hooks and eyes in one of the Stockholm back-streets. Other names recall men well-known in science, administration and war.

The list of names records only such British people as settled in the country, so it does not include foremen, craftsmen, instructors and others who came to carry out special tasks and then returned to Britain.

For generations Gothenburg has been called "Little London", and there is no doubt that a quite well-defined English atmosphere has invaded the social habits of the city. And this does not apply merely to the upper strata of its population, but curiously enough to the broad masses of the townsfolk as well.

Atman´s history of the Carnegie family contains the following passage, which may be of interest in this context. The well-known German poet and professor, Ernst Moritz Arndt, who visited Gothenburg in May 1804, writes in his Reise durch Schweden: "Gothenburg is Sweden´s England - English taste is the rule here right from the breakfast table until the night-gown is donned. They breakfast in English fashion, they drink stout and port, they serve toddy both before and with tea, they ride and dress just like the fashionable gentlemen in Pall Mall and Westminster."

A characteristic of the early British merchants and industrialists of Gothenburg was their interest in municipal affairs, in the improvement of social conditions among the working class, in the raising of the educational standard, the standard of health, etc. This public spirit made itself manifest through generous gifts and was maintained from generation to generation.

CONCLUSION

The author is fully aware of the fact that the surveys here presented suffer in many places from an excess of encyclopaedic aridity. Owing to the nature of the whole subject and to certain limitations of space this is unavoidable, but it is hoped that, with all its shortcomings, the compilation as a whole will serve its purpose: to give an idea of the great part that British energy and foresight have played in laying the foundation of the present industrial structure of Sweden. The British contribution to Sweden´s economic expansion in the last century was not restricted to what are generally regarded as industrial and technical pursuits. Of even greater, in fact of fundamental importance, were the impulses towards economic liberalism which came from the Island Kingdom. An industrial expansion such as Sweden and other European nations have experienced would have been impossible inside the straitjacket of the old guild system with its restrictions and rationing and its unavoidable reliance on the regulating and supporting hand of the State.

British influence has certainly continued to make itself felt in Sweden as elsewhere even after the break-through of industrialism. And it is still growing in intimacy and range. The only difference is that it now takes other forms, more difficult to pin down and localise. As technical progress has expanded, the conditions under which it is applied have become more complicated, and the industrial advances made have in a far greater measure than during the industrial revolution taken the form of gradual improvements, often arrived at simultaneously in various parts of the world.

But the Swedish people owe a debt of deep and unqualified gratitude to the English and Scots who have in the course of several centuries made such splendid contributions to Sweden´s industrial advancement.

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