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The Travel Diaries of Swedish Engineers of the Eighteenth Century as Sources of Technological History

BY

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The technical advances in industry in the period after 1760 were spectacular and are now well known. It is not quite so generally appreciated, on the other hand, that in the century before 1760 a great deal of valuable technical progress was made in England. A spirit of enquiry into the mysteries of the natural sciences, fostered and guided specifically in the direction of industrial research by the Royal Society, helped to produce a crop of developments in the sphere of technology which laid the foundations of the Industrial Revolution. Mention of the names, for example, of Savery, Newcomen, Darby, Kay, Paul and Smeaton is sufficient to remind us of the lead England was giving to the world in the century after 1660. Professor P. M. S. Blackett has recently made the point that before the middle of the eighteenth century, technological progress came largely as the result of the empirical strivings of craftsmen and industrialists, and that before that time pure science was not sufficiently developed or suitably orientated to give a lead in material progress. Thus the interchange of technical "know-how" in this period was to be made at the level of the craftsmen or technologists, rather than by the scientists or theorists.

It is not surprising, then, that England became something of a Mecca for the technicians of other European countries during the eighteenth century.[1] There were, in those times, virtually no technical journals, and the only method for the interchange of technical ideas and information was through personal contact. Some of the foreigners who came to study English techniques at this period are well known. Perhaps the best-known of all was Peter the Great of Russia, but on the level of pure technicians, Gabriel Jars[2] and Marchant de la Houlière[3] are perhaps best known. This traffic in technicians in search of information was two-way, of course, for many Englishmen travelled abroad with the same aims. Sir Ambrose Crowley sent his younger half-brother, Benjamin, to Sweden in 1701, with a detailed schedule of points concerning iron manufacture which he was to investigate in the course of a visit of nearly 12 months,[4] while the visit of Samuel Garbett's son to Sweden for similar purposes in 1763 is better known. Garbett claimed that his son made "important

[1] See A. Birch, "Foreign observers of the British iron industry during the eighteenth century," *Jour. Economic History*, XV, 1955, pp. 23–33. I wish to acknowledge much valuable assistance from Dr. Birch, former Member, now of the University of Sydney. By his examination of Angerstein's journal in the *Jernkontor*, Stockholm, Dr. Birch opened up this important field of research.

[2] Gabriel Jars, *Voyages Métallurgiques*, 1779. See also J. Chevalier, "La Mission de Gabriel Jars dans les Mines et les Usines Britanniques en 1764," *Transactions*, XXVI, 1947–49, pp. 57–68.

[3] W. H. Chaloner, "Marchant de la Houlière's Report to the French Government on British Methods of Smelting Iron Ore with Coke . . .," *Edgar Allen News*, Dec. 1948 and Jan. 1949.

[4] Directions given to Mr. Benjamin Crowley, 3 November 1701. MS. in possession of Mr. Humphrey Lloyd, Marlow, Bucks.

discoveries" during this visit "which have already been put into practice, and will prove a national advantage."[1]

In the eighteenth century, the flow of technical visitors to England appears to have been greater from Sweden than from other European countries. The links between Sweden and England were many and strong, and help to explain why there should have been such an astonishing series of visits from eminent Swedish technologists and engineers. The resources of the two countries were such that a trade of great value to both countries was well established by the eighteenth century, Sweden sending her bar-iron, copper and timber in return for England's woollen cloth and other manufactures. Sweden was a country with an ancient culture and an eminent university at Uppsala, and the awakening of interest in scientific research associated with the foundation of the Royal Society brought many Swedes to London. Equally important was the fact that many of the leading commercial and industrial figures in Sweden at this time were of English, Scottish or Irish extraction, forming a permanent close link with their homelands.[2]

Most important of all, however, was the link provided by the iron industry. In the early eighteenth century, only about half of the needs of this country for bar-iron was met by the native industry, and there was therefore a considerable and growing import of bar-iron. Most of this came from Sweden. The failure of the English industry was not due so much to scarcity of resources in this country as to the relatively high cost of labour in England compared with Sweden. A Sussex jury of 1661 which complained in a petition that "the vast quantities of woods and iron mines which the Swedes have in that Kingdome, togeather with the cheapnesse of the workemen, enables their making of iron at much lower rates than can possibly be done in any parts of this nation," was not far from the truth.[3] This export trade in bar-iron was, in fact, Sweden's economic lifeblood. By the middle of the eighteenth century, bar-iron comprised about 60 per cent. of Sweden's total exports, and of this, 55 per cent. normally was sent to England.[4]

This mutual dependence by both England and Sweden upon each other created dangerous tensions in both countries. The dependence of English manufacturers upon imports for so important a raw material as iron offended economists, ironmasters and politicians alike. "It would be a strange imprudence in a martiall nation," petitioned the Sussex jury of 1661, "whom God and nature have armed with this martiall mettall, to surrender up their owne stock of ammunition and to depend on the seas and forrainers for it."[5] Iron was a strategic import and there were risks involved in relying on imports from a single foreign country. In the seventeenth and eighteenth centuries, Sweden was continually involved in wars in northern Europe, and there were many interruptions to trade in the Baltic. Relations between the two countries were not always good and in 1717 the two countries came so near to war that all trade was suspended for 2 years. Moreover, iron was the most important item in the trade with Sweden, which showed a deplorable lack of balance. Imports from Sweden in 1696–97 were valued at £150,000, against which exports of only £40,000 could be set, a disproportion which persisted for long periods.[6] Thus, from the late seventeenth century on, there was a strong incentive to look elsewhere for their supplies of imported bar-iron. There were three possible alternatives—Spain, the American colonies, and Russia. By the middle of the

[1] *Calendar of Home Office Papers*, 1760–1765, No. 1359.

[2] Among the most important in Stockholm were Jennings and Finlay, Richard Adamson, Charles Tottie and Nicolas Fenwick. See K. Samuelsson, *De Stora Köpmanshusen i Stockholm*, 1730–1815, Stockholm, 1951, p. 44. For a detailed examination of the role of the Scots in Swedish industry, see G. Bodman, "Scottish family names in Swedish industry and technics," *Daedalus* (yearbook of the Technical Museum, Stockholm), 1948, pp. 77–88; also T. A. Fischer, *The Scots in Sweden*, Edinburgh, 1907.

[3] British Museum, Add. MSS. 33,058.

[4] G. A. Montgomery, *The Rise of Modern Industry in Sweden*, London, 1939, p. 10.

[5] British Museum, Add. MSS. 33,058.

[6] G. G. Dixon, "Notes on the records of the Custom House, London," *English Historical Review*, Vol. 34, 1919, p. 78.

eighteenth century, Russian iron was, in fact, supplementing Swedish imports in substantial quantities.

So far as Sweden was concerned, the important point was that technological effort in the English iron industry was constantly being directed towards the elimination of the Swedish iron imports. Quite apart from the problem of supplies of ordinary bar-iron, limitations of technique, particularly in the steel industry, made imports of the high-grade Swedish Oregrund iron essential for certain processes. Naturally the Swedes were concerned to know what progress was being made by the English which might ultimately enable them to dispense with Swedish imports. Much of the Swedish interest in English technological progress, which forms the subject of this paper, was directed towards this particular problem. The Swedes were also very watchful of the progress of their Russian competitors. By the middle of the eighteenth century, English imports of Russian iron began to equal those of Swedish iron; but though Sweden's share of the trade was falling, her exports to Britain did not fall off absolutely until the very end of the century. As early as the 1720's, a Swede, A. D. Schönstrom, had produced a report based on a tour of some of the Russian iron-works.[1]

For these varied reasons, then, many Swedish engineers and metallurgists came to England during the eighteenth century. Some stayed for some time in London, making the acquaintance of the great scientists of the young Royal Society; others travelled extensively round the country, visiting between them every industrial site in the country of any interest. Some works had a succession of these Swedish visitors throughout the century. Fortunately for us, they were assiduous in recording their impressions and their newly acquired knowledge in a series of travel-diaries which forms a unique and valuable source of technological history. This source has, it is believed, scarcely been touched by English historians of industry and technology so far,[2] and the object of this paper is to offer a brief account of some of the more valuable of these travel-diaries and to give some indication of the sort of information which historians may expect to find there.

There are, unfortunately, many difficulties confronting anybody wishing to make use of this material. Firstly, apart from one or two isolated instances, the journals are all written in Swedish, a language which not every historian has at his command. To make matters worse, Swedish spelling has been radically revised during the nineteenth century, so that the spelling of these eighteenth century journals is puzzling even to those acquainted with modern Swedish. Moreover, the mis-spellings of English proper names at times defeats the modern reader, while the diarists' attempts to render English technical terms into their own language are not now readily translatable. An additional difficulty is that the handwriting of the manuscripts (for only one or two have been printed) is a form of Gothic resembling German *schrift*, which English readers find particularly difficult to read. When I say that Swedes themselves today have considerable difficulty in reading these manuscripts, you will appreciate the obstacles that stand in the way of the English historian. Finally, these manuscripts are, of course, kept in Swedish libraries—mainly the Riksarkiv (the equivalent of our Public Record Office), the Royal Library (Kungliga Bibliotek) and the Library of Uppsala University. This means that for normal purposes the English reader must work from microfilm or Photostat copies.

The picture, however, is not entirely black, for there has recently been published a book by a modern Swedish historian, Dr. Sven Rydberg, which is a most comprehensive guide to these travel-diaries, through which it is possible in a great many instances to locate to the exact page the reference

[1] E. F. Heckscher, *Sveriges Ekonomiska Historia*, Stockholm, 1949, II, Pt. 2, p. 413.

[2] The only instance I can recall of previous reference to any of these diaries (apart from the work of Dr. Birch mentioned above, and of Dr. H. S. K. Kent, mentioned below) is a mention of Angerstein's journal by Rhys Jenkins in a discussion after a paper read to this Society. In spite of a careful search, I regret not having been able to trace this reference in the *Transactions*.

in a journal to a visit to a particular place or works. Dr. Rydberg's book is therefore the indispensable and invaluable guide for anyone wishing to make use of these travel-diaries. I need hardly say that this paper would not have been possible without extensive use of Dr. Rydberg's book.[1]

One of the earliest of the Swedish visitors to England with an interest in technology was Erik Odhelius. He travelled extensively in Europe, and was in England between October 1691 and March 1692. The very substantial journal of his travels is much admired in Sweden, and a modern edition of it is being prepared.[2] Odhelius devoted some 56 pages of his journal to England, about a quarter of which concerned the iron industry. There are also chapters on English lead- and tin-mining, and another on vitriol and alum-boiling.

The first quarter of the eighteenth century brought three Swedish travellers of outstanding importance and interest to England—Triewald, Alströmer and Kalmeter. Marten Triewald is already well known to members of this Society, which has the distinction of having published a translation of his account of the Newcomen engine.[3] Triewald, unlike most of the other Swedes who visited England in the eighteenth century in quest of technological information, did not compile a travel-diary, but he left a number of other records which give some indication of his interests and activities in this country. Arriving here in 1716 at the age of 25, he settled for a time in London, where he became acquainted with the scientist Desaguliers. He also struck up friendships with the Swedes, Kalmeter and Alströmer, who visited England for long spells at the same period. Triewald's main concern was with mining, and this led to his interest in the Newcomen engine, then very much of a novelty. He was also interested in the ventilation of mines.[4] In 1717, Triewald was commissioned by Nicholas Ridley, the Newcastle coal-owner, to assist Samuel Calley to erect a Newcomen engine in one of Ridley's mines. Samuel Calley was the son of John Calley, the partner and assistant of Thomas Newcomen. It is now known that John Calley was still alive at this time, so that there is no reason to suppose that Samuel Calley held any kind of rights in connection with the Newcomen engine.[5] Triewald's connection with Calley lasted several years, for in 1723 Kalmeter wrote to Alströmer that "Mr. Triewald . . . is now settled here and in partnership with the son of the inventor of the fire engine."[6] (This referred, of course, to Calley's son, not Newcomen's.) Various Swedes in official positions were anxious to have a Newcomen engine set up in Sweden, and Alströmer had approached Kalmeter, then in London. "Mr. Törne has writ some time ago to Mr. Rönling," wrote Kalmeter to Alströmer, "to get a man over to Sweden that could erect a fire engine here of the same kind as at Newcastle and otherwhere. He has with the last post iterated the same and recommended a great deal of secrecy, and at least desired to have a modell of the engine. I think both will be impossible, few or none of the workmen being let into the secret of building it. But as Mr. Rönling has [written] to me about it at the desire of Mr. Törne, I'll see to send a draught of the machine to him, if that will do, as it may in a great

[1] Sven Rydberg, *Svenska Studieresor till England under Frihetstiden*, Uppsala, 1951. The book has a short summary of each chapter in English at the end. I also wish to acknowledge much valuable personal assistance from Dr. Rydberg in several aspects of this field.

[2] The original of Odhelius's journal has been lost, but manuscript copies exist in several libraries, notably the Kungliga Bibliotek, and Uppsala University. The modern edition is being prepared by Dr. Nils Zenzén, to whom I am indebted for information about Odhelius. Further information may be found in Rydberg, pp. 140–147.

[3] M. Triewald, *Short Description of the Atmospheric Engine*, trans. Are Waerlund, Cambridge, 1928. For biographical details see Are Waerlund, "Marten Triewald and the first steam engine in Sweden," *Transactions*, VII, 1926–27.

[4] There is a printed description of a ventilation machine submitted to the Royal Society by Triewald in 1742. Another manuscript communication to the Royal Society of 1736 refers to experiments in ventilation. (Royal Society, Classified Papers, 1660–1740, III (2). I am grateful to the Society and its librarian, Mr. I. Kaye, for facilities to consult these and other papers.

[5] See J. J. Bootsgezel, "John Calley, the partner of Thomas Newcomen," *Transactions*, XI, 1930–31, p. 135.

[6] H. Kalmeter to J. Alströmer, 24 September 1723, Uppsala University Library, MS. G.130.

deal, if any one in Sweden is of humour or capacity to undertake it. Mr. Triewald, when he goes there, can best bring it about."[1] However, it was two or three years before Triewald returned to Sweden, but, as we know, he did supervise the erection of the Dannemora engine in the late 1720's.[2]

Triewald's activities during his ten years' stay in England would amply repay further investigation and undoubtedly throw much valuable light on the early history of the Newcomen engine. He finally returned to Sweden in 1726, where, in addition to setting up the first Newcomen engine in that country, he founded with the great botanist, Linnaeus, the Swedish Academy of Science. In Sweden, he described himself variously as "Director of Mechanicks in the Kingdom of Sweden" and "Captain of Mechanics and Military Architect to his Swedish Majesty." He is known to have experimented at this time with the hardening of steel for making saws.[3] He maintained close contact with his scientific friends in England, sending descriptions of his inventions and experiments to Desaguliers and Sir Hans Sloane. There are descriptions of diving-bells, experiments concerning the cohesion of lead pellets, and an account of a new type of water-powered bellows, which show an awareness of the needs of the iron industry. "This shows, I hope, very plain," he wrote to Sir Hans Sloane, "that the power required to work these Water Bellows is farr less, and consequently less water will be consum'd in working these bellows than those commonly used, and again that an Iron Furnace wch. for want of water to work the Common Bellows, cannot be kept at work longer than six weeks, tho' he be provided with all other necessarys, may by means of such water bellows as here described be kept at work at least as long again."[4] Triewald became a Fellow of the Royal Society in 1731, and made several contributions to the *Philosophical Transactions*.[5]

Jonas Alströmer came to England in 1707, settled, and built up a successful business. He took out English citizenship and became Swedish Consul in London.[6] In the years 1714–15 and 1719–20, he made extensive tours in England, and his travel-diaries of these journeys are held to be the most comprehensive and valuable of all the Swedish journals,[7] but I have not had occasion to make use of them myself. Dr. H. S. K. Kent, formerly of Cambridge University, who has made a special study of Alströmer's journal, regards it as a most valuable source, and tells me that it is particularly informative on the textile industries. Alströmer finally left England in 1723, after a stay of 16 years in the country.

The third of this trio of Swedes in England during the first quarter of the century was Henrik Kalmeter. Kalmeter spent four years in England in all, in the course of ten years of travel outside Sweden, between 1718 and 1730. His substantial travel-journal covers visits to Germany, Holland, France and England during the years 1718–26. He arrived in Edinburgh in 1719, where he spent the six months of summer, before travelling through Newcastle to pass the winter of 1719–20 in London. In 1720 he toured the South of England, and in 1721 he returned to Scotland, examining industrial sites at Bristol, Chester, Liverpool, Keswick and Carlisle on the way. During a second visit to England in 1723–25, he made a further extensive tour of the country, but by the second

[1] H. Kalmeter to J. Alströmer, 12 October 1723, Uppsala University Library, MS. G.130.
[2] M. Triewald, *Short Description of the Atmospheric Engine*, p. viii.
[3] C. Sahlin, *Svenskt Stål*, Stockholm, 1931, p. 15.
[4] Letters and communications from Marten Triewald to J. T. Desaguliers, 20 November 1728, and 1 November 1732; and to Sir Hans Sloane, 12 May 1736. MSS. in library of the Royal Society.
[5] Rydberg, p. 204. His contributions to the *Philosophical Transactions* were as follows: "Queries on the cause of cohesion" (XXXVI, 1731); "An extraordinary instance of the almost instantaneous freezing of water; and an account of tulips, and such bulbous plants, flowering much sooner when their bulbs are placed upon bottles filled with water, then when planted in the ground" (XXXVII, 1733); "An improvement of the diving-bell" (XXXIX, 1735); "Description of a new invented water bellows" (XL, 1738); "Account of the vegetation of melon seed, forty-two years old" (XLII, 1744).
[6] Rydberg, pp. 108–109.
[7] *Jonas Alströms Reseberättelser*, Uppsala University, MS. X. 376–378. (Copy in Kungliga Bibliotek, MS. M.218.) The first journey covered the southern part of England, and the second the Midlands and North.

visit he had evidently so much impressed the authorities in Sweden by his capacity for critical observation, that he came as an official representative of the *Bergskollegium* (Board of Mines). His observations during these journeys took two forms—the first, a daily journal,[1] and the second, a series of official reports which he made to the Board of Mines in Sweden.[2] Both are valuable sources of information, though of course they overlap to some extent. There is also a useful series of his letters to Alströmer.[3]

In the course of his travels around the country, Kalmeter visited most of the important industrial locations, and met many interesting and important people. While on his way south from Edinburgh in 1719 during his first visit to the country, he made a detour through the Derwent valley to see the famous works of the Hollow Sword-Blade Company, and of the Crowleys. Of the former, he wrote in his journal:—

"At Shotley Bridge some merchants in London have established a foundry which they after handed over to the craftsmen themselves, who are twelve in number, mostly Germans, who each have their own workshops, and pay yearly to the owners in rent for the factory 44 dozen swords, each dozen reckoned at 18 shillings. These craftsmen send their work mainly to London and pool their earnings, sharing it out in proportion to their work. For steel, each craftsman reckons for a dozen swords, 4s. 4d., but grinders who have there two stones, 4s. 8d., not including coal and other things. Formerly these craftsmen could produce a great quantity. Though one can make at least three dozen a week, nevertheless they make now no more than 350–60 dozen in a year."[4] Lower down the river, at Swalwell, he found the "considerable and costly works constructed by John Crowley's father some ten to twelve years earlier."[5] The corresponding section of his Reports to the Bergskollegium gives similar information in greater detail.[6]

In London Kalmeter studied the technique of silk weaving at Spitalfields, visited the Mint, the notorious William Wood's ironworks at Southwark, and Sir Hans Sloane's famous botanical collection. His correspondence with Alströmer dates from this stay in London in 1723 and 1724, and this has the advantage of being written in English. In one letter he notified Alströmer that he had sent back to Sweden an account of an alum works.[7] He regretted not being able to join Alströmer in Holland as he could not "leave England before I have seen and got an account of what remains for me to observe, I mean the Tinn works, and those about Bristol." He mentioned that "I had lately a letter from Assessor Bergenstierne, who tells me that the Court of Mines was well enough pleased with my last letter and account." There is mention of another new invention: "I here a man has invented a thing to preserve people from being drowned, keeping them that never could swim upon the water, that they can swim, sit, eat, shoot and do everything on the water."[8] His next letter tells more: "In my last I had the honour to tell you something about the swimming engine, and I have since been present at the tryall publickly made of it. A man armed with it may sit and do anything upon the water being in no danger of sinking. It is performed by means of four cylindrical bodies, two on the breast and two behind, and made of thin iron plates, which are to answer to a man's weight more and above the column of the water, and which weight ordinarily is of about 18 lb., so that this engine by its composition, and, as I suppose, the compression of the air, is to make good or keep up that overweight. The price of it is a guinea."[9]

[1] Henrik Kalmeter, *Dagbok öwer en . . . 1718–26 företagen resa till Tyskland, Holland, Frankrike och England*, Kungliga Bibliotek, MS. M.249.
[2] Henrik Kalmeter, *Relationer om de engelska bergverken*, 1720–25. MS. in Riksarkivet.
[3] Uppsala University, MS. G.130. These letters are in the English language.
[4] H. Kalmeter, *Dagbok*, fo. 329, 31 August 1719.
[5] *Ibid.*, fos. 334–335.
[6] H. Kalmeter, *Relation*, fos. 11–14.
[7] Kalmeter to Alströmer, 24 September 1723, Uppsala University Library MS. G.130.
[8] *Ibid.*
[9] *Ibid.*, 12 October 1723.

During the 1740's, European wars kept Swedish visitors away from this country, but shortly after the signing of the Peace of Aix-la-Chapelle in 1748, two distinguished Swedish experts visited this country, and their travel-diaries are among the most valuable of all. They were Samuel Schröderstierna, who toured Europe between 1748 and 1751, and Reinhold R. Angerstein, who was in England between 1753 and 1755. Schröderstierna, who was born in 1720, joined the staff of the *Bergskollegium* at the age of 18, remaining with the Board for 33 years. From 1753 until his retirement in 1771, he was Director responsible for the development of high-grade iron manufacture in Sweden. In this last capacity he supervised both technical and economic aspects of the industry, taking a particular interest in the organisation of labour in the industry. When he came to England, therefore, Schröderstierna was principally concerned with the state of the English iron industry. He was shrewdly aware of the importance for the Swedish iron industry of the efforts being made in England at this time to overcome the dependence on imports of Swedish iron, and evidently spent much time collecting information on the subject. His journal,[1] for example, includes complete transcriptions, in English, of the reports of the English Parliamentary Committees on the state of the iron industry of 1736 and 1737.[2] His observations on the state of the English iron industry are drawn together in a substantial report of 3,000 words,[3] in which he surveyed briefly the recent history of the industry in England and examined the nature of the American and Russian iron which were competing with Sweden in the English market. He concluded that Sweden had more to fear from America than from Russia. "The worst that can happen so far as Sweden is concerned," he wrote, "is that the English government should at some time resolve to give the American colonists freedom to erect forges and to export bar iron. The Swedes have undoubtedly more to fear from American iron production than from Russian, for, in the first place, the latter iron is not of such high quality as the Swedish, and secondly, it is doubtful whether Russian production could be increased much in view of the long distances involved."[4] Schröderstierna's prognostications, in the event, turned out to be wrong, for British imports of American iron never grew to very large proportions in the eighteenth century, while imports of Russian iron grew steadily until, by the 1780's, they exceeded those of Swedish iron.

The main body of Schröderstierna's journal, however, is of more general interest. This account of his travels is substantial and detailed. Unfortunately this is not one of the journals surveyed in any detail by Rydberg, but if the section in which Schröderstierna describes some of the works he visited in the north-east in May 1749, which I have examined, is typical of other sections, then his journal is clearly a source of the utmost value. In the north-east, needless to say, he devoted a whole day to a tour of the several Crowley works outside Newcastle, and his account of this visit covers seven pages of his journal.[5] Of particular interest is his description of the cast-iron cylindrical bellows used at Swalwell for blowing hearths. The problem of producing a continuous air blast at all seasons of the year was one of the more pressing of the lesser technical problems of the iron industry, and it will be recalled that Triewald had experimented a dozen years earlier with an interesting type of bellows that would operate with a much reduced supply of water. Both the Crowleys and Isaac Wilkinson had experimented with cylindrical bellows in the middle years of the eighteenth century, and Schröderstierna's journal gives the earliest known account of those at Swalwell. "At one hearth," he wrote, "two leather bellows are used, and at the other, in their

[1] Samuel Schröderstierna, *Dagbok rörande Handel, Näringar och Manufakturer . . . under verkställde Resor, åren* 1748–51, Kungliga Biblioteket, MS. X.303.
[2] *Dagbok*, fos. 498 ff. The official reports are in *Commons' Journal*, XXII, pp. 850–855, and XXIII, pp. 109–117.
[3] See M. W. Flinn, "Samuel Schröderstierna's 'Notes on the English iron industry' (1749)," translated from the Swedish with notes, *Edgar Allen News*, Aug. 1954.
[4] *Dagbok*, fo. 493.
[5] *Dagbok*, fos. 314–320.

place, two cast cylinders, of two ells in height and one ell diameter with valves at the bottom (as with wooden bellows) with pipes which go from the base to the hearth. Inside the cylinders are iron pistons packed round with leather, which are driven up and down by the same movement, and in this way produce the same effect as two wind bellows."[1]

The Crowleys claimed, with some justification, to produce the finest anchors in the country in the eighteenth century, and Schröderstierna found the manufacture of anchors of particular interest. "Anchors are forged by hand from Swedish bar iron with great sledge-hammers. The bars of iron are heated, and the anchors built up by welding piece to piece, at the cost of a great deal of labour. The anchors are moved in and out of the forges by swivelling cranes [there is a small drawing here showing a device like a steelyard]. The hearths are large and wide, and each has two great leather bellows which must be worked by foot-power if water-power is not available. The bars of iron to be built into the anchors are heated at an adjacent hearth. You could watch eight men at a time forging an anchor here. In addition to these, there were three or four other smiths who kept the smithy working pretty fast. They make small as well as large anchors for warships. The price for middle-sized anchors is £28 per ton, and for the largest ones £30 to £33 per ton. At a very conservative estimate, the anchor smiths here consume more than one hundred tons of iron a year."[2]

Schröderstierna's account of the Crowley works shows him to be familiar with the particular processes and techniques used in the iron manufacturing districts of Sheffield, Birmingham and Staffordshire. After a day well spent at the Crowley works, where he secured information concerning works organisation and wages as well as technical processes, he visited the coal mines and staiths of a Mr. Silvertop, a little higher up the Tyne than Swalwell.

In the same year that Schröderstierna came to England, another interesting and better-known traveller also paused in this country on his way to America. Pehr Kalm spent six months in 1748 in the Home Counties, and his account of his experiences has the distinction of being the only journal of the many Swedish travellers to England in the eighteenth century to be translated and published in English.[3] But although Kalm has been described as a "man of keen observation, of refined taste, and of high scientific training,"[4] his interest lay primarily in agriculture, and his journal therefore, in the main, falls outside the scope of this paper.

Probably the most valuable of all the Swedish technical travel-diaries of the eighteenth century is that of Reinhold Angerstein, who visited England during the years 1753 to 1755 in the course of travels round Europe over a period of seven years which took him to Russia, Hungary, Italy, Spain and Portugal. Of Angerstein, Rydberg writes: "[His] notes are a gold mine when it comes to exact information about the most diversified things in England of the time. He noted prices and wages and conditions regarding commerce and industry in all the places he visited, small as well as large, and the size of the labour force at various workshops. . . . He was not unacquainted with the method of spying to find out things not given him voluntarily."[5] Angerstein's great travel-journal,[6] covering some 900 pages, has the advantage of comparative clarity, and is well illustrated by simple but informative drawings.

Angerstein was an official of the *Jernkontor*, or the "Iron Bureau." This important institution, for which there was no parallel in eighteenth-century England, had been founded in 1747 in order

[1] *Dagbok*, fo. 316.
[2] *Dagbok*, fo. 315.
[3] *Kalm's Account of his visit to England on his way to America in* 1748, trans. Joseph Lucas, London, 1892. A popular version of Kalm's account of his stay with William Ellis at Little Gaddesden has recently been produced by Vicars Bell, in *To Meet Mr. Ellis*, 1955.
[4] Rydberg, p. 243, n. 5.
[5] Rydberg, p. 415.
[6] R. R. Angerstein, *Resa genom England* 1753–55, MS. journal in Jernkontoret, Stockholm.

to give State encouragement and direction to the iron industry. The directors of the *Jernkontor* pressed continually for the improvement of techniques in the metallurgical industries, recognising that only by maintaining superiority in quality could the Swedish industry retain its hegemony. Much of the inspiration as well as the initiation of the technological expeditions of Swedish metallurgists in the eighteenth century came from the *Jernkontor*.[1] In 1753, Angerstein was appointed Director of Steelworks, the first holder of this office,[2] and it seems that his first act was to come to England, which by this time led the world in the varied techniques of steel production.[3]

Angerstein arrived in England in September 1753, and made straight for London, where he rapidly made the acquaintance of many members of the numerous Swedish colony. In March of the following year, he set out on a short tour of the Midlands. His first stop was at Birmingham to visit a steel furnace, where he was glad to note that only first-class Swedish Oregrund iron was used, "Russian iron having been tried, but it does not make such good steel."[4] In Birmingham he also visited button and brass works, rolling and grinding mills, and many other works. At Wolverhampton, he visited and described rolling mills and other ironworks. He then returned to London.

Shortly after he set out on a second journey, this time to the West. Pausing to examine the manufacture of woollen cloth at Salisbury, and stone-quarrying at Portland, he made a longer stay at Exeter, where he found Swedish iron being used again for nail-making. He visited many places as far west as Land's End, before turning back to Bristol. Here he investigated ironfounding, glass-making, soap- and salt-boiling, lime-burning and steel-making. Crossing the Bristol Channel, he visited the Hanbury tinplate works at Pontypool before investigating the Forest of Dean iron industry. At Worcester he studied the porcelain industry, and at Kidderminster carpet-making. Visiting Birmingham for the second time, he looked at more iron and steel works, as well as coal mines, before returning to London.

On his third and last journey into the provinces, Angerstein chose to visit the North of England. He passed through Nottingham, Sheffield, Leeds and Darlington on his way to Newcastle. Like Kalmeter and Schröderstierna before him, Angerstein made an extensive and detailed study of the industry of Tyneside, concentrating, needless to say, on the Crowley works. Angerstein's description of the latter is detailed and accurate. It occupies 27 pages of his journal,[5] and is by far the best account of these famous works until Arthur Young and other Englishmen described them towards the end of the century. Naturally, in view of his position in the *Jernkontor*, it was the manufacture of steel at Swalwell that interested Angerstein most, and his journal includes an excellent account of the shear steel process. He observed also in detail all the different processes being carried on at each of the four separate Crowley factories, noting the material used, and its cost, the wages of labour and the prices of the finished articles. He estimated that the Crowley works consumed a total of 2,300 tons of bar-iron every year, and as nearly 2,000 tons of this was imported, the Crowley firm must have been consuming about 10 per cent. of the total English import of bar-iron at this time. In the Derwent valley, he also visited the Bertram steelworks, and has left an interesting description of the famous works of the Hollow Sword-Blade Company.

He returned south, down the west coast, visiting Wood's ironworks at Whitehaven, before making a more careful study of the ironworks of Shropshire and the Welsh border. He noted at Bersham furnace that it "gets its ore partly from Cumberland and partly from some coal mines in Flintshire." Though it is known that Bersham was one of the earliest furnaces to smelt iron with

[1] See E. F. Heckscher, *An Economic History of Sweden*, trans. G. Ohlin, Cambridge, Mass., 1954, p. 180.
[2] C. Sahlin, *Svenskt Stål*, p. 190.
[3] See M. W. Flinn and A. Birch, "The steel industry before 1856 with special reference to the development of the Yorkshire steel industry," *Yorkshire Bulletin of Economic and Social Research*, VI, 1954, pp. 163–177.
[4] *Resa genom England*, II, fo. 5.
[5] *Resa genom England*, II, fos. 203–230.

coke in the 1720's, Angerstein noted that in 1754 the fuel used was charcoal. He gives some interesting costings of bar-iron production at Pont-y-Blew and Abenbury forges. There is a long description of the Coalbrookdale district, where he made some interesting observations on the lining of furnaces. With regard to the hearths of the furnaces at Coalbrookdale, he wrote, "[They] are made of ordinary dry sand usually up to three or four inches, but a sand which is more fireproof and hardened and which is packed firmly down. This sand is renewed every day. The furnace is charged twelve times during each 24 hours with nine tubs each of 5½ quarters deep and three quarters diameter containing in all 45 bushels of ore. Two bushels of unburnt lime are added, but at the beginning and end of the blast, they put in much less ore. When the furnace is in full operation they cannot smelt more than twelve or thirteen tons of pig-iron per week, whereas with charcoal they can get eighteen to nineteen tons a week."[1] Angerstein visited the Birmingham area for a third time on his way back to London.

I have described Angerstein's visit to this country and his journal in more detail because it is probably the most valuable of all the Swedish sources, both from the point of view of accuracy and fullness of detail, and also in view of its comprehensiveness. There can be few industrial sites of importance or processes employed, particularly in the metallurgical industries, not described by Angerstein.

Before concluding with an account of the last of the major journals of the eighteenth century, I would like to mention one or two of the less important ones, some of which are valuable on account of the particular interests of the authors.

One of the most important of these minor characters is Bengt Quist Andersson, who visited this country in 1766 and 1767. Several Swedish travellers had visited Huntsman's workshop in Sheffield in the hope of discovering the secret of the crucible steel process, but for a long time without success. Huntsman had not patented his process, but appears to have relied on the smallness of his staff to keep the secret. The Swedes were naturally very anxious to acquire the newest and best techniques of steel production, for these all depended in the main on Swedish iron, and there seemed no reason why Sweden should not also acquire the monopoly of the manufacture of steel as well as that of the production of the only kind of iron from which the steel could be made. Yet it seems surprising that the secret which had been discovered by the Walkers of Rotherham as early as 1749 was not known to the Swedes until Andersson made the discovery in 1766. His travel-diary[2] is of particular value for the historian of the iron and steel industry. He made the usual pilgrimage to Coalbrookdale, and showed, both here and at Whitehaven, keen interest in the experiments being made to produce bar-iron from pig-iron, using raw coal as the fuel. Success in this, which ultimately came, of course, in 1783 and 1784, would have served a death-blow to the Swedish industry, for Sweden's advantage lay in her ability to produce bar-iron far more cheaply than the English manufacturer. On his return to Sweden, Andersson set up the first cast-steel works outside England, near Stockholm.

Erik Geisler, who visited England in 1772, was primarily an engineer. His journal is freely illustrated with his own drawings.[3] When he visited the renowned Crowley works, what interested him was not the processes or materials employed, but the blowing machinery. Geisler travelled widely in England, visiting the Cornish mines, as well as going to Scotland. On his way back from the North he visited the home of Smeaton near Leeds. Unfortunately, Smeaton was away in London, but his wife demonstrated a model of the Eddystone lighthouse.

I have left to the last one of the most interesting of all the Swedish visitors to England—Johan Ludvig Robsahm, who came to this country in 1761. Robsahm was one of two brothers, descended

[1] *Resa genom England*, II, fo. 391.
[2] B. Q. Andersson, *Anmärkningar samlade på resan i England åren* 1766 *och* 1767. MS. in Jernkontoret, Stockholm.
[3] Erik Geisler, *Reseanteckningar*, 1772, MS. M.243, Kungliga Bibliotek, Stockholm.

from a Scottish emigrant of the seventeenth century named Robson,[1] who owned jointly a steel furnace at Vissboda in Sweden. They were also partners in other steelworks, and Johan was a "notary" of the *Bergskollegium* (Board of Mines). Like many other steelmakers in Sweden at this time, the Robsahms were very anxious to establish the manufacture of crucible steel by the Huntsman method. In the early days of his operations, Huntsman, unable at first to convince the rather conservative Sheffield craftsmen of the quality of his new product, found a readier market for it abroad. Thus the quality of crucible steel was well known in Europe in the 1750's and 1760's. So the brothers Robsahm drew lots to decide which of them should journey to England to acquire the secrets of crucible steel manufacture. The lot fell on the elder brother, Johan, and in 1761 he came to England. From the historian's point of view, this was a happy chance, for Johan wrote an ample travel-diary describing his journey through England in search of technological information.[2] Needless to say, his main aim was to visit Sheffield, where he hoped to find out Huntsman's secret by hook or by crook. Huntsman's little backyard workshop in Sheffield was much visited by foreigners at this time. In addition to Robsahm, in 1761, Gabriel Jars came in 1765, followed by Bengt Andersson, as already related, in 1766. However, though Robsahm landed at Hull, he made first, not for Sheffield, but north for Newcastle, where his first visit was to the Crowley works. This probably indicates the importance held by the Crowley firm in the steel industry of the day. Robsahm was shown round various other industrial sites in the Newcastle area by a steel-maker called Hodgson. Although Robsahm mentioned steel-making at both the Crowley and Hodgson's works, there is no indication in his journal that he learned anything in Newcastle about crucible steel.[3]

Leaving Newcastle, Robsahm travelled south via Whitehaven and Liverpool before crossing over to Sheffield. There he made a determined onslaught on Huntsman. He noted in his journal that he was told in advance that there was no hope of getting the vital information out of Huntsman. Huntsman was very civil to him, showing him over his whole establishment, but he refused categorically to tell him anything about the making of the crucibles, "even if we offered him £50," for in this art lay most of the secret of the cast steel process. Robsahm noted carefully all details of the furnace with the measurements of the crucibles, and was surprised to learn that the staff of the workshop comprised only three people in addition to Huntsman himself, and that the annual output amounted to a mere eight tons of steel. Robsahm invited Huntsman out to a meal, and hung around the place for several days, but quite in vain. All the more surprising that Andersson was successful five years later.

However, Robsahm's journey was not entirely in vain, for he visited a great many other places of interest, and wrote full accounts of them in his journal. In addition to the Crowley and other works near Newcastle, Robsahm visited Coalbrookdale and several metallurgical centres around Wolverhampton and Birmingham. While in Birmingham, Robsahm received a letter from Johan Kinninmundt, the Secretary of the *Jernkontor*, asking him to find out all he could about the latest English methods of constructing steam engines. Robsahm was able to secure a skilled mechanic from Wednesbury, who, for £50, was willing to go to Sweden to build an engine.

Outside the fields of iron, steel and engineering, Robsahm also took a keen interest in glass-making. He studied processes in this industry both at Bristol and Newcastle, and recorded a good description of the making of crown glass at a Newcastle glasshouse. "We went back to the town [of Newcastle]," he wrote, "and visited a glasshouse, where they make crown glass or the best kind of window glass, and although for several years they have not permitted any foreigner to look over the glassworks, on my companion's assurances that I did not intend any dishonesty, I was allowed

[1] G. Bodman, *Daedalus*, 1948, pp. 80–81.
[2] J. L. Robsahm's *Dagbok över en resa i England*, 1761, Kungliga Bibliotek MS. M.260.
[3] *Robsahm's dagbok*, fos. 24–25, 29–30.

in. I saw the whole establishment, and found that the preparation of crown glass required the use of three kinds of furnaces, in one of which the raw material is smelted and kept fluid, in another (the aperture of which had to be very large) the glass was prepared, and the third in which the glass is laid to cool. The preparation of the glass is easier to understand after one has seen it, than it is to describe it. It is blown out first by a worker into a great globe, which globe is attached to an iron rod held by another workman right opposite. The first one breaks his blow-tube away, making a hole in the globe of about three inches diameter. The second workman then takes the globe to the other furnace which is made like a baker's oven with a great circular opening of about two ells diameter, in which he twists the globe with a deft movement of the hands, keeping it there until the heat has caused it to open out and it is transformed from a globe into a circular cake. As soon as the glass has become this shape they must take it from the fire or flame to solidify. After this they take it to the cooling furnace, which is similarly constructed to the previous one, and in which there are no flames but only a red heat. Twelve such discs are sold at the glass furnace for £1 18s. 9d. The sand which is used here is mostly obtained from Lynn in Norfolk, and it is the only kind in the whole country suitable for crown glass and which is also used by the glass furnaces in London and Bristol. The potash used here comes from Dantzig. All the crown glass-makers in England must pay £50 to the Crown for each week of working, even if they only work for four days a week, which accounts for the dearness of this kind of glass. However, when it is exported, they are allowed a very considerable reduction of this fee to the crown in order to encourage exports, and to compete with others."[1]

When Robsahm finally returned to Sweden, he submitted a report on English methods of steel-making to Sven Rinman, who had succeeded Angerstein as Director of Steel-making at the *Jernkontor* in 1760.[2]

The flow of Swedish visitors to England diminished towards the turn of the new century, though one of the better-known Swedish technicians to visit and describe English industry—Erik Svedenstierna—came as late as 1802–03. His travel-diary was published in 1804.[3] By this time the technical situation was much altered from the earlier decades of the eighteenth century, when Sweden's interest in English technology was that of an equal concerned either to keep one step ahead, or at least not to lag too far behind. By the last quarter of the century England's leadership in technical matters had been unquestionably asserted. But that leadership was now firmly based on coal, and Sweden's lack of that vital raw material meant that her interest in technical progress in iron, glass or engineering industries was purely academic. It is not surprising, therefore, to find that Swedish interest in English technology declined as the English coal-based industries advanced. But so long as the field of technical progress was narrow enough to remain within the scope of her own resources, Sweden might profit from observation of English developments; for this reason the diarists reviewed in this paper recorded the emergence, rather than the triumph, of English technical superiority in the eighteenth century.

Discussion

The President (Mr. L. E. Harris) said that Mr. Flinn was to be congratulated on the way he had learned Swedish for the sake of reading those diaries and preparing that Paper, but he would like to know whether in fact those diaries did provide any information about technological processes in this country of which we either had no other information, or less than was given in the diaries? To quote an example: it was stated in the Paper that the diary of Schröderstierna contained complete

[1] *Dagbok*, fos. 27–29.
[2] Sahlin, *Svenskt Stål*, pp. 90, 202–203; Rydberg, pp. 189–193.
[3] Erik T. Svedenstierna, *Resa igenom en del af England och Skottland åren* 1802 *och* 1803, Stockholm, 1804.

transcriptions in English, of the reports of the English Parliamentary Committees on the state of the iron industry in 1736 and 1737. Those reports on the English iron industry, were, of course, published in the *House of Commons Journal.*

He would also like to know if Mr. Flinn could tell him anything about a Swede called Cletscher, who came to England to study the iron industry in this country in 1696, the same year in which Peter the Great of Russia came to England for the same purpose. He was mentioned in a Paper given by Dr. H. W. Dickinson before the International Congress of the History of Science held in Amsterdam in 1950.

Mr. P. JUMP said that, after reading the extracts from the diaries, one could not but be struck by the great scope of the knowledge which they covered. Under one of the titles reference was made to "spying," which was not a very pleasant word. Those people came over here to get what information they could, but many of our people also went over to Sweden to learn what they could. There was, of course, the well-known case of Fiddler Foley, who went over to Sweden from Staffordshire to learn the art of slitting metal. To do it he had to make two or three visits and was only able to get into the works by playing his fiddle around the fires when the men were resting at their meal times. By getting into the works in that way he eventually got hold of the knowledge he wanted and established slitting mills in this country.

He had been privileged to get Per Hillstrom's book; he was a great painter of the Gustaf III period and in many of his paintings he reproduced the smelting of iron, the forging of chain and the making of anchors, which particularly interested him. At the time he was working practically only one British painter was painting fire pictures of industrial processes in this country. They followed very much the British technique of manufacture.

The diaries were of value. The important thing in any industry was not the principle but the "know-how," and the diaries did give a guide in that direction.

Dr. H. R. SCHUBERT said he had three points to raise. First, Mr. Flinn had referred to three famous travellers of outstanding importance, coming to this country in the first quarter of the eighteenth century. He would like to add a fourth—Emanuel Swedenborg. He wrote an excellent report and very detailed, not only on England but on other countries also. When he first referred to the English ironworks at that time he distinctly mentioned as his source of information Kalmeter. It would be interesting to know how far the information Swedenborg obtained came from Kalmeter. Swedenborg arrived in England between 1710 and 1712 as a young man of some 20 years; Kalmeter came later. They both worked for the Board of Mines. He obtained a lot of information in this country, directly, and also indirectly through Kalmeter.

It had been stated that the secret of Huntsman's invention of cast steel was discovered in 1766 and that his success was dependent on the use of a special flux. The last report mentioned in the Paper was in 1804 and he would like to know if in the first account or in the later ones there was any mention of what Huntsman's secret was.

Mr. REX WAILES pointed out that the Society had twice visited the Huntsman works and therefore it was very interesting to have a reference to the solution of the secret. Would the author be so kind as to make a reference note to it in his Paper?

He remembered that the only unique operation which Huntsmans said they did in their works was that they trod the material of the crucibles. That eliminated pebbles that might be in the mixture and secured a better result.

Mr. J. FOSTER PETREE pointed out that there was an Angerstein Wharf on the Thames, which might be connected with the family of the Angerstein mentioned in the paper. There were so few commentators on technological subjects in the eighteenth century that diaries like those, even though they did nothing but repeat what was known already, were valuable confirmation, and he

regarded them in that light. It was, unfortunately, a curious thing that many people who might question a statement in yesterday's newspaper would accept that same fact without question if it had been printed 150 years ago. A group of confirmatory writers was valuable in itself.

What made William Wood "notorious"? Was he on the borderline between fame and notoriety?

On the occasion of the visit of the Society to Hunstman's works in Sheffield he had been shown some booklets describing the Huntsman plant, and had managed to get one, which was now in the library of the Institution of Mechanical Engineers.

There might be useful information in the Admiralty Library on anchors and the materials they were made from, and possibly the process by which they were made. There might be more in the National Maritime Museum.

Mr. K. R. GILBERT said that there was a diary by John George Bodmer of a journey in England in 1816–17. Extracts from it had been published by Helen and Paul Schoch-Bodmer in the *Vierteljahrschrift der Naturforschenden Gesellschaft* in Zurich, 1936, pp. 1–26.

Mr. FOSTER PETREE observed that in a Paper by the late David Brownlie (Member) it was claimed that Bodmer was the inventor of the chain-grate stoker. The Paper was printed in Vol. VI of the *Transactions*.

To this Mr. WAILES added that his grandfather had made a press, designed by either Bodmer or a son, if he had one, in the late 'fifties, to press tea into bricks, which was sent out to China for that specific purpose. The tea was taken from China by camel to Russia.

He did not know whether Mr. Flinn had searched through the Huntsman records and found the references, during the Napoleonic wars, which told of their selling cast steel to the French. It went out via Hamburg and was paid for in good French brandy.

Mr. FLINN, in reply, said that the value of the diaries as a source of historical technological information was really a question for experts who knew the state of knowledge at the time. His own particular study was the iron industry and on that he could say definitely that the diaries were of value. The President was quite right when he said Schröderstierna had merely transcribed a series of *House of Commons Journals*, but he had not known that when he ordered Photostats of the report. He was firmly of opinion that those Swedish diaries did contain a great deal of extreme value to technological history in the eighteenth century. Where he had been able to compare in one or two cases he had found useful descriptions of processes only touched on in our records.

With regard to Cletscher, he had not come across him previously. He was, however, mentioned by Rydberg, pp. 149–50. He visited England in 1696, and made an extensive tour, concerning himself principally with ironworks. His manuscript journal was in the Riksarkiv.

Mr. Flinn remarked that he had already been charged with not having made any mention of Swedenborg in his Paper. He readily admitted that Swedenborg was a man of importance, but he did not write a journal diary. The diaries he had selected were chosen principally because their writers had visited the Crowley works. When Kalmeter came to this country in 1719 he was a very young man, yet his account of the Crowley works and the Bertram steelworks was very good indeed; there was, however, no reference to Swedenborg or any suggestion that he was acquainted with him.

In reply to a question on Angerstein by Mr. Wailes, Mr. Flinn said it was such an uncommon name in this country and in Sweden that he felt there must be some connection, but as far as he knew the Angerstein who came to this country in 1753 went back to Sweden, though a son of his might have come back. He knew of no connection with the well-known John Julius Angerstein of the nineteenth century, who did so much for the National Gallery and the National Portrait Gallery.

Mr. Flinn said that as far as prices were concerned one did not need to go further than Beveridge's *Prices and Wages in England* for prices and such details. He had also used the Sergison Papers

in the National Maritime Museum and the Admiralty Papers in the Public Records Office in his search.

He said, in reply to a question by Mr. Petree, that he understood that a translation of Johann Conrad Fischer's travel-diary of the nineteenth century was now being prepared. It had already been published in German. (Johann Conrad Fischer, *Tagebücher, 1773-1854*. Schaffhausen, 1951.)