

“COMMERCE DES LUMIÈRES”: THE INTERNATIONAL TRADE IN TECHNOLOGY, 1763-1815

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It is well known fact that the peace treaty signed in Paris in 1763 which brought to a conclusion the Seven Years' War inaugurated the great age of the Grand Tour. For the next three decades Europeans were able to indulge in land and sea travel largely unhindered. The ramifications of the colonial struggle in North America may have diminished the flow of continental travellers crossing the Channel for a time between 1778 and 1781, but this episode seems only momentarily to have caused cultural exchange within Europe's intelligentsia to falter. Less well known is the fact that the final quarter of the eighteenth century also witnessed a remarkable growth in the practice of industrial tourism. Irina and Dmitri Gouzevitch¹ have drawn attention to this phenomenon, as have I in my own published work². Travel specifically in order to make contact with entrepreneurs and to view industrial premises was a practice driven by a number of considerations. This paper will concentrate mainly on what we can learn about the motivations of travellers, whether admitted openly or concealed.

I

We need to begin with the broader picture, however. The practice of continental travel –whatever its objective– provides evidence that an important cognitive shift was taking place during these decades. Edward Gibbon (1737-1794) recommended that those embarking on a foreign journey should equip

¹ See GOUZEVITCH, Irina; GOUZEVITCH, Dmitri (2007) “El *Grand tour* de los ingenieros y la aventura internacional de la máquina de vapor de Watt: un ensayo de comparación entre España y Rusia”. In: LAFUENTE, Antonio; CARDOSO DE MATOS, Ana; SARAIVA, Tiago (eds.) *Maquinismo ibérico*, Madrid, Doce Calles, 147-190.

² JONES, Peter M. (2008) “Industrial Enlightenment in Practice: Visitors to the Soho Manufactory, 1765-1820”, *Midland History*, vol. 33, Spring, 70-98.

themselves with the following: “a correct and exquisite eye”; “fine feeling of the mind” and “dexterity of the pencil”³. But for travellers whose sight-seeing was inspired by rather more than a desire for improvement, self-discovery or curiosity, his advice came to be understood differently. In the later decades of the eighteenth century the encyclopaedic approach to knowledge accumulation was giving ground to an altogether more analytical and interpretive style of data collection. The industrial traveller exemplified this trend. Furthermore, if he (they were nearly all men) was uncertain of how to go about the task of assimilating useful knowledge there were, by the 1780s, a number of technological guide books available which offered training for the eye. In this connection the plea for “dexterity of the pencil” would be acted on in ways that Gibbon could scarcely have imagined.

It would be a help if we could quantify the community of travelling *savants* who were united in the common aim of harnessing natural philosophy –science– to the useful arts. Joel Mokyr⁴ supposes that they must only have numbered a few thousand at the most in the second half of the Eighteenth century; that is to say during the pioneer phase of what he and others have dubbed “industrial” Enlightenment. But this is to take a narrow view of the knowledge economy. We need to add to this itinerant intelligentsia a large swathe of Europe’s prospering commercial classes. These individuals often dabbled in science for the “politeness” it conferred, yet they understood intimately the relationship between experimentally derived knowledge and industrial application. Europe’s entrepreneurs, I would argue, travelled no less extensively and purposefully than *ancien-régime* aristocrats, *savants*, *Gelehrten* or *cognoscenti*.

These actors in the unfolding drama of Industrial Enlightenment, together with the plethora of inventive craftsmen who brought their activities to fruition, were most numerous in Hanoverian England. How can we be sure? Because numerous intelligent and independent-minded visitors to the British Isles would testify to the fact. Ever since the 1760s such travellers had been recording the remarkable cultural porosity of English urban society, its permissiveness, the extraordinary skill levels of its craft workers, the high status awarded to Newtonian experimental philosophy, the easy availability of capital for industrial ventures, and the astonishing affluence of England’s

³ GIBBON, Edward (1814) *Memoirs of the Life and Writings of Edward Gibbon*, London, J. Murray (*The Miscellaneous Works of Edward Gibbon Esq.*, vol. 3).

⁴ MOKYR, Joel (2002) *The Gifts of Athena: Historical Origins of the Knowledge Economy*, Princeton (N. J.), Princeton University Press, 66.

swelling ranks of consumers. By the 1780s this testimony had become a veritable chorus. One need only think of Alessandro Volta⁵ who arrived in Britain from an obscure corner of northern Italy and marvelled at what he beheld: a society brimming with confidence and seemingly poised for industrial lift-off. This was in 1782, moreover, when the Continent's competitor economies were showing every sign of having been ravaged as a result of intervention in the American War.

With the benefit of hindsight we can see that the 1780s were years in which the most perceptive continental Europeans first grasped that something truly momentous was happening across the Channel. This decade will therefore serve as the main pivot of our paper. Yet it is important to emphasise that the industrial developments espied during the 1780s were not based on a one-way flow of *lumières* and expertise. The eighteenth-century knowledge economy was not uni-directional. Britain certainly played a significant role in exporting know-how embedded in men, machines and tools, but she also imported this valuable commodity as economic historians have in recent years acknowledged⁶. Rather than emphasise the build up of an ineluctable technological *lead* during the closing years of the eighteenth century, we would do better to emphasise the relative fluidity of Britain's social climate, and institutional structures which enabled her entrepreneurs both to access knowledge and to profit from it in a supremely cost-effective manner.

However, a caveat must be entered at this juncture. If the "commerce des lumières" –in this context the international trade in technology– was relatively free-flowing still at the start of the 1780s, this situation no longer obtained by 1802 or, *a fortiori*, by 1815. At any rate, this is the conclusion to which I am drawn following an extensive investigation of the voluminous Archives of Soho⁷. In the 1780s technology transfer was still being conducted within

⁵ See PANCALDI, Giuliano (2003) *Volta: Science and Culture in the Age of Enlightenment*, Princeton (N. J.) and Oxford, Princeton University Press, 160-164.

⁶ See particularly McLEOD, Christine (2004) "The European Origins of British Technological Predominance". In PRADOS DE LA ESCOSURA, L. (ed.) *Exceptionalism and Industrialisation: Britain and its European Rivals, 1688-1815*, Cambridge, Cambridge University Press, 111-126.

⁷ The Archives of Soho are made up of the business papers of the Boulton & Watt steam engine partnership, 1775-1800, and its successor companies; the private papers of Matthew Boulton, proprietor of the Soho Manufactory; and the private papers of James Watt, steam pioneer and partner of Boulton, and his family. The Archives of Soho are located in Birmingham Central Library, Birmingham, West Midlands, United Kingdom. This paper is based chiefly on the business and personal letters of Matthew Boulton and James Watt for the period 1765-1820, that is to say around 20,000 items of correspondence.

the ample parameters of the civility code of the Enlightenment, although the notion that knowledge of all descriptions should be communicated freely was beginning to wear a little thin as we shall see. By 1802, however, this had largely ceased to be the case –notwithstanding attempts by Europe’s *savants* during the peace interval to reinstate the cultural practices of the Enlightenment. The balance of trade also shifted in this period. Whereas Matthew Boulton (1728-1809), James Watt (1736-1819) and their collaborators in the Lunar Society visibly and gratefully exchanged knowledge with continental *savants* and entrepreneurs in the 1780s, Britain was becoming a net exporter of know-how by 1802; even more so by 1815. Or if I can put it in the terms in which this paper is framed, many more Europeans were coming to inspect industrial sites in Birmingham, Coalbrookdale and the Midlands generally during the Peace of Amiens (1801-03), than British entrepreneurs were setting off for the Continent on a similar mission. Once the peace treaties of 1814-15 had been signed, the one-way flow of traffic would become even more pronounced.

The explanation of this divergence lies embedded in the turmoils of the pan-European revolution of 1789, allied to the mercantilist policy which Napoleon Bonaparte pursued on a grand scale from 1804. Many researchers have drawn attention to the role of political revolution in re-routing, if not retarding, European industrialisation –most recently Jeff Horn⁸ writing about France. But this view risks overlooking important changes that were taking place in the 1780s: the retreat of the universal knowledge project of the Enlightenment; the acceleration of economic competition between nations; and the new aggressiveness of governments in their unrelenting pursuit of useful knowledge. In possession of several leading-edge technologies, the Boulton & Watt partnership at Soho near Birmingham found itself in the forefront of these developments. It would bear the brunt of both free-lance and state-sponsored industrial espionage, not to mention attempts at worker enticement. The Archives of Soho can be said to open a window on this seminal decade, therefore, and in the process they enable us to catch a glimpse of the mechanisms of the transition from Industrial Enlightenment to Industrial Revolution.

⁸ HORN, Jeff (2006) *The Path Not Taken: French Industrialization in the Age of Revolution, 1750-1830*, Cambridge (Mass.) and London, The MIT Press.

II

Personal contact seems to have been the key to technology transfer. Unlike continental Europe, Britain was slow to encode knowledge in the form of a readily accessible technical literature, perhaps because the line of demarcation between natural knowledge generators and hands-on practitioners was far less sharply drawn on this side of the Channel than elsewhere. Only once, to my knowledge, did Boulton & Watt agree to compile a complete set of technical specifications relating to their high performance steam technology. This was in 1786, for the benefit of the French government, after Controller-General Calonne had hired them to act as consulting engineers for the refurbishment of the Machine de Marly. As for models of their machines they would refuse all requests, whether those requests came from government agencies, learned societies or individual *savants*.

If personal contact was generally considered to facilitate the process of technology transfer, who should provide the point of contact? Ignace de Wendel (1746-1795), the Hayange ironmaster, believed firmly that travellers in search of useful knowledge should make contact “with the leading men of the industry”⁹; that is to say the manufacturers and their foremen. Unsurprisingly, therefore, he sought collaboration with the Wilkinson brothers in the late 1770s, called on Boulton & Watt in Soho in 1784, and again in 1792. But Swedish and German travellers often preferred to seek direct access to technological processes via knowledgeable artisans¹⁰. Targeting artisans offered a short-cut. It implied that the niceties of Enlightenment civility could be dispensed with in favour of explicit bribery and other forms of inducement.

Personal contact on site, whilst helpful in building webs of reciprocity and obligation, only occasionally resulted in efficacious technology transfer on its own, though. The Venetian architect Giannantonio Selva (1751-1819) might

⁹ BELHOSTE, Jean-François; WORONOFF, Denis (2005) “The French Iron and Steel Industry during the Industrial Revolution”. In: EVANS, C. and RYDEN, G. (eds) *The Industrial Revolution in Iron: the Impact of British Coal Technology in Nineteenth-Century Europe*, Aldershot, Ashgate, 77; also JAMES, Harold (2006) *Family Capitalism: Wendels, Haniels, Falcks and the Continental European Model*, Cambridge (Mass.), Harvard University Press, 44-60.

¹⁰ In this connection, see the travel journal of ANGERSTEIN, Reinhold Rucker (2001) *R. R. Angerstein's Illustrated Travel Diary, 1753-1755: Industry in England and Wales from a Swedish Perspective*, transl. by BERG, T. and BERG, P., London, Science Museum, 38, 16. Also CHAMBERS, Neil (2007) (ed.) *Scientific Correspondence of Sir Joseph Banks 1765-1820*, London, Pickering & Chatto, vol. 3, letter 612, Sir Charles Blagden to Sir Joseph Banks, London, 23 October 1785.

very well report to his home government James Watt's latest experiments with rotative motion following a visit to Soho in 1781, but this intelligence scarcely enabled the Arsenal of Venice to take advantage of the technology¹¹. After several abortive attempts to carry away knowledge acquired in this fashion in Birmingham and Coalbrookdale, the Prussian government seems to have decided by the mid-1780s that it would make more sense (and prove more cost-effective) to persuade British industrial pioneers to make the arduous journey to Silesia instead. To this end the Welsh ironmaster, Samuel Homfray (?-1822), was induced to travel to Tarnowitz in 1786 and supervise the erection of the steam engine that had been ordered from his Pennydarren Works at Merthyr Tydfil. A couple of years later William Wilkinson (1738-1808) who was already a familiar face in France, travelled to Friedrichsgrube in Silesia where he succeeded in introducing the technology required to smelt lead ore using coke.

Behind these initiatives lay Friedrich August Alexander Eversmann (1759-1837), the Prussian Commissioner for Affairs of War, Taxation, Mining and Factories whose superiors were Baron Heinrich Friedrich von Stein (1757-1831), and the Mines Minister Freiherr Friedrich Anton von Heynitz (1725-1802). Eversmann would conclude that Homfray's visit, in particular, had paid handsome dividends to the Prussian state: "some ideas were made active in Silesia, old ones improved, some implemented in part, insofar as the differing location of German industry as compared to that of England permits"¹². Prussia did not abandon the policy of on the spot data collection as we shall see, but this twin-pronged approach has nevertheless prompted some researchers to question the value of journeys of investigation (not to say espionage), which all European states seem actively to have encouraged in the 1780s. Commenting on the Prussian iron industry, Ralf Blanken for instance insists that "before 1800 no concrete case of transfer of technology can be put down solely to foreign travel"¹³.

¹¹ See ZORZANELLO, Giulio (1984) "Il diplomatico veneziano Simon Cavelli e le sua legazione in Inghilterra (1778-1782)", *Ateneo Veneto*, vol. 22, 226-248; *idem* (1984) "L'inedita corrispondenza del diplomatico veneziano Simon Cavelli con Matthew Boulton (1779-1786)", *Archivio Veneto*, vol. 122, 35-64; also DE LA RUFFINIÈRE, Pierre (1982) "Giannantonio Selva in England", *Architectural History*, vol. 25, 22, 25.

¹² KNAU, H. L. (unpublished paper 2007) "The Importance of Steel and Osemund in the Südergebirge", Cardiff.

¹³ BLANKEN, Ralf (2005) "The Diffusion of Coke Smelting and Puddling in Germany, 1796-1860". In: EVANS and RYDEN, *The Industrial Revolution in Iron*, 55.

I would not be so categorical. Nonetheless it is undoubtedly the case that in matters of technology transfer much depended on the qualities of the individual observer; that is to say on his credentials, his cast of mind, his reason for visiting and his technical competence. There was a world of difference between the superficial observer who turned up at the Soho Manufactory, or the Albion Mills in London with a request to view the engines driving the hammers or the mill stones, and the technologically literate investigator who was eminently qualified to make sense of what he was shown. As Irina and Dimitri Gouzevitch¹⁴ have pointed out, the remarkable Russian mechanic Lev Fedorovich Sabakin (1746-1813) was able, very quickly, to transfer reasonably accurate intelligence of James Watt's double-acting improvement to his steam engine as a result of visits to Birmingham and to Blackfriars, London (site of the Albion Mills) by 1786. Agustín de Betancourt y Molina (1758-1824), as we know, performed the same feat on behalf of the Spanish government in 1788, just a couple of years later. Yet Thomas Jefferson (1743-1826) whose pretensions to scientific competence now seem rather overblown, also applied to visit the steam-powered corn mills at Blackfriars at about the same time as Sabakin. Having returned to France, he reported to a correspondent: "when I was in London, Boulton made a secret of his mill. Therefore I was permitted to see it only superficially. I saw no waterwheels, and therefore supposed none". However, he then recounted how he had also inspected a steam-driven corn mill in Nîmes, southern France: "they shewed it to me in all it's [*sic*] parts. I saw that their steam raised water, and that it turned a wheel. I expressed my doubts of the necessity of the inter-agency of water, and that the London mill was without it. But they supposed me mistaken; perhaps I was so"¹⁵.

It will be apparent from the foregoing that technological "grand tourism" was approaching a crescendo in the 1780s. We know the names of 183 individuals who were shown around the Soho Manufactory during this decade, of whom around 142 were foreigners. In fact the flow of visitors, whether native or foreign, would reach a peak in 1792. With the extension of the continental war between revolutionary France and the German states to much of the rest of Europe the following year, the number of cross-Channel visitors

¹⁴ GOUZEVITCH; GOUZEVITCH (2007), 154-163.

¹⁵ T. Jefferson to C. Thomson, Paris, 20 September 1787, reproduced in BOYD, P. J. (ed.) (1955) *The Papers of Thomas Jefferson*, vol. XII: 7 August 1787 to 31 March 1788, Princeton (N. J.), Princeton University Press, 30.

making their way to Birmingham dropped by nearly two-thirds¹⁶. Some idea of the purposeful way in which continental governments and their agencies were now setting about the business of useful knowledge collection can be gleaned from the table below. It identifies those who appear to have been the major players in the business of transferring technology around Europe.

Date of visit to Soho	Visitor
March 1782	Reden, Friedrich-Wilhelm, Graf von Périer, Jacques-Constantin
1782	Magalhães, João-Jacinto de
June? 1783	Cronstedt, Axel-Fredrik, Count
July 1783	Genet, Edmond-Charles-Edouard
1784	Swediaur, Franz-Xaver
1784	Wendel, Ignace de Givry, Aimable-Marie de
November 1784	Andreani, Paolo, Count Faujas de Saint-Fond, Barthelémy
1785	Lesage, Pierre-Charles Prony, Gaspard de Perronet, Jean-Rodolphe Cachin, Joseph
October 1785	Réveillon, Jean-Baptiste Montgolfier, Joseph-Michel de Argand, Aimé
1786	Sabakin, Lev Fedorovich
June 1786	Virly, Charles-André-Hector, Grossart de
April 1787	Stein, Heinrich-Friedrich-Carl, Baron vom
June 1787	Coulomb, Charles-Augustin Tenon, Jacques-René
June 1787	Pictet, Marc-Auguste
December 1787	Göttling, Johann-Friedrich-August
May 1788	Lamétherie, Jean-Claude de Angiolini, Luigi

¹⁶ See JONES (2008), 80.

August-September 1788	Ljungberg, Jøns Matthias
September 1788	Mensa y March, Pascual Landriani, Marsiglio, Chevalier
November-December 1788	Betancourt, Agustín, Chevalier de
August 1789	Liender, Jan-Daniël Huichelbos van
October 1789	Torres, Fernando Casado de

III

Many of the names listed above are more familiar to us as travelling natural philosophers. Here we have the measure of what was happening by the 1780s. The categories of “grand tourist”, “*savant*”, “entrepreneur” and “technological intelligence gatherer” (in modern parlance industrial spy) were collapsing. Of course, these categories had never been water-tight. Indeed, their existence and use probably reveals more about the epistemological priorities of different bodies of specialist researcher than about realities that could be observed on the ground, or in the workshop. In 1786 the *chargé d'affaires* Daniel Hailes would report from the Paris Embassy to the British Foreign Secretary, Lord Carmarthen: “there is scarcely a Frenchman of any note who travels to England that does not endeavour on his return to ingratiate himself with the minister by some account of the state of our country”¹⁷.

This influx of highly competent visitors from the Continent perplexed Boulton & Watt, and they were not alone in their reactions. Josiah Wedgwood, the north Staffordshire potter, reported from Etruria a new aggressiveness among his visitors as they cajoled and bribed their way into parts of his factory complex that they were not supposed to enter. Even John Wilkinson, the Bradley ironmaster, was alarmed. However, the solution that lay to hand –the closure of industrial premises to tourists– was not adopted at Soho until the turn of the century. The dilemma facing these early pioneers can be stated simply, for they were evidently products of Joel Mokyr’s Industrial Enlightenment rather than of the early nineteenth-century Industrial Revolution so dear to economic historians. As conspicuous figures

¹⁷ BROWNING, Oscar (ed.) (1909) *Despatches from Paris, 1784-1790*, London, vol. 1, 135.

in the project to fashion a domestic variant of Enlightenment culture, their reflexes operated in favour of the free and open communication of knowledge. As hosts, indeed, they accepted unhesitatingly the obligation to supply the wants of any traveller presumed to be a social equal. Yet at the same time they were entrepreneurs and manufacturers in temporary and insecure possession of leading-edge technologies. This raised the question of the status of what we would call nowadays “sensitive” knowledge; a question to which the civility code elaborated during the High Enlightenment decades could provide no satisfactory answer.

Dealing with international *savants* was familiar territory for Matthew Boulton. This much is clear. So was dealing with thieves and “pirates” (those seeking to infringe Watt’s engine patents). But what was he to make of gentleman “spies” who cloaked themselves in the garb of natural philosophers? This dilemma became acute in the 1780s for reasons that should by now be obvious. Faced with an onslaught of worthy gentlemen who were prepared to resort to unworthy behaviour, the partners had to contrive a new semantic category. They called them “philosophical & mechanical robbers”¹⁸ or “philosophical pirates”¹⁹.

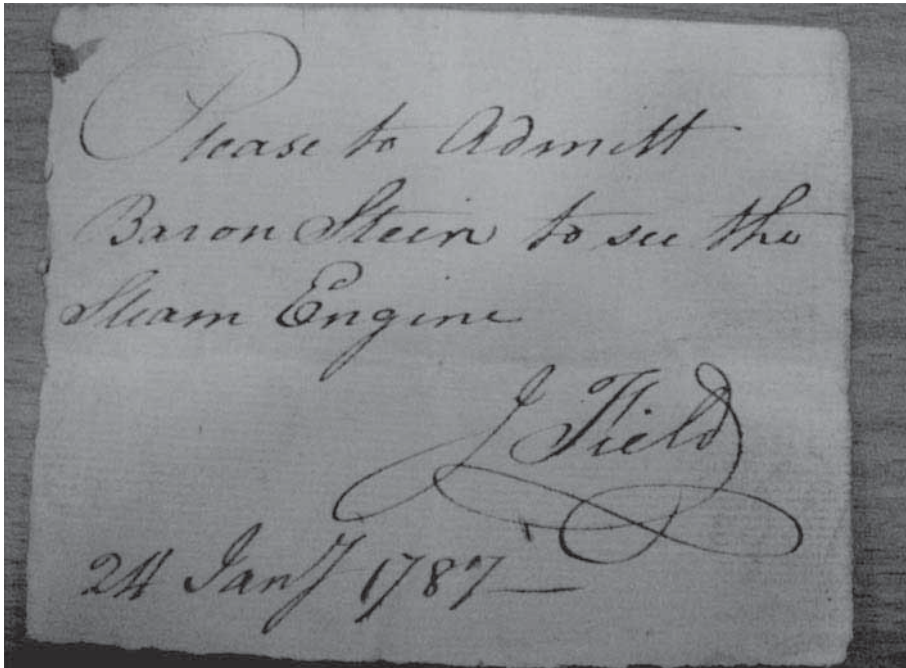
IV

Agustín de Betancourt was not quite the first to earn this appellation, for the firm had already had a number of encounters with intelligence gatherers passing themselves off as disinterested philosophers in 1785, 1786 and 1787. In fact, he may have suffered as a consequence of the questionable behaviour of those who had come before him. The snooping activities of the Prussian Baron Heinrich Friedrich vom Stein had caused particular alarm among Midlands manufacturers during the winter and spring of 1787, the more so as he had attempted initially to visit industrial premises in Britain under a false name. Before agreeing to receive him at Soho, Matthew Boulton wrote him a letter which included a polite warning: “if I can promote your views as a Natural Philosopher, as a Mineralogist or as a Gentleman, I shall be happy.

¹⁸ Birmingham Central Library (hereafter BCL) MS 3782/12/57: M. Boulton to M. R. Boulton, 26 October 1789.

¹⁹ BCL Timmins Collection: J. Watt jnr to Messrs Firmin de Tastet, Soho, 3 September 1794.

But as a Mechanick & as an Engineer you must pardon me if I throw obstructions in your way"²⁰.



A ticket granting permission to view the steam-powered corn mills at Blackfriars, London (Birmingham Central Library MS 3782/12/108/48).

This is the context in which we should view the visit of Charles-Augustin Coulomb (1736-1806) and his party to the Albion Mills in June 1787. John Harris²¹ provides the best introduction to what happened, although his account introduces a slight confusion in supposing that the draughtsman named Marquis whom Coulomb and Tenon brought along with them was in fact a French titled visitor. Whilst the bulk of the party accompanied Boulton on a tour of inspection of the granaries, it appears that Coulomb and the draughtsman disappeared into the bowels of the building and only rejoined

²⁰ See TANN, Jennifer (ed.) (1981) *The Selected Papers of Boulton & Watt*. Vol. 1: *The Engine Partnership*, Cambridge (Mass.), The MIT Press, 163.

²¹ HARRIS, John R. (1998) *Industrial Espionage and Technology Transfer: Britain and France in the Eighteenth Century*, Aldershot, Ashgate, 316-317.

the group after a long interval. Boulton was soon informed by one of his employees that the two men had been spotted “in a dark hole” next to the engine’s rotative gear where they were busily sketching –with considerable “dexterity of pencil” no doubt. The sketch was immediately concealed when they were approached. In a forced show of good manners, Boulton managed to contain himself but he gave full vent to his irritation in a letter to his partner Watt: “I had great difficulty to suppress my indignation, but I thought it would then do no good to show it.” Coulomb and party were preparing to set out for Soho, and he urged his partner on no account to admit these “thieves” to the innermost recesses of the Manufactory. He added pointedly: “they might have obtained more Knowledge if they had behaved like philosophers and gentlemen”²².

As John Harris has noted, Charles-Augustin Coulomb was already conversant with Watt’s prototype steam engine. One suspects, therefore, that he had got wind of the improvements which the Scottish engineer had been introducing steadily since 1783. The first of the double-acting rotative engines at Albion Mills had started work in March 1786. However, it would seem that the aborted technical drawing made by Marquis was not of sufficient quality for the purposes of technology transfer. This is scarcely surprising. We know from other sources that the production of useable technical drawings –in adverse conditions– was an extremely precarious and laborious process. In 1791 it took the young Bavarian mechanic and spy, Georg von Reichenbach (1772-1826)²³, a residence of six weeks to reconstruct on paper the specifications of the Soho “lap” engine.

The achievement of Agustín de Betancourt in the autumn of 1788 appears all the more significant, therefore. With the Stein and Coulomb affairs still rankling, Boulton and his partner Watt were scarcely going to welcome with open arms his presence in Birmingham. In fact we know that Boulton greeted him affably, as he did nearly all his visitors, but took care to allow sight only of the hand-tool operations taking place within his Manufactory. Unsurprisingly, Betancourt discovered that Boulton & Watt’s Albion Mills venture was carefully policed as well. Yet, on somehow securing admission, he was still able to deduce the “double effect” of the mill engine, and to verify

²² *Ibid.*, 317; also BCL MS 3147/3/11: Boulton to J. Watt snr, London, 25 June 1787.

²³ See Deutsches Museum, Munich Handschriften. Des DM. 8277; HS 6168: Tagebuch von Georg von Reichenbach, The episode is recounted in KLEMM, Friedrich (1959) *A History of Western Technology*, London, George Allen and Unwin Ltd, 259-261.

his hypothesis on returning to Paris. The story is too well known to be related here, even if several versions of it appear to exist²⁴.

Once the news of this successful piracy operation reached Birmingham, however, Boulton's resentment knew no bounds; as a matter of fact it increased over time as he began to make connections –both real and imagined– between Betancourt and others who had presumed to make lucrative use of ill-gotten knowledge. The Spaniard may have returned to Birmingham in order to confer with Jean-Pierre Droz (1746-1823), a Swiss craftsman and *médailleur* turned *monnayeur* whom Boulton hired at vast expense in an effort to monopolise his skill in constructing dye replicating machines. This visit would have to have been in 1789 or 1790, for Boulton and Droz parted on very bad terms early in 1791. Betancourt next came to England in November 1793 on a commission from the Spanish government and remained in the country for nearly three years as far as we can tell. His brief included the acquisition of steam engines for Spain's Caribbean sugar plantations among other activities. However, he avoided writing to Boulton, and instead made contact with James Watt senior. But memories were long in Soho, and when Watt junior, acting on behalf of his father, made enquiries through a third party about the credentials of the Chevalier de Betancourt, he referred to him in the following fashion in a postscript to the letter: "we formerly saw him here [i.e. at Soho] & have some reason to complain of his proceeding as a philosophical pirate"²⁵.

When the peace window of Amiens opened in 1801-2, Betancourt's shadow appeared once more in Soho. Matthew Boulton would complain that he had received from France a deputation of technically-savvy individuals who appeared bent on filching his minting technology. One of them was reported as being a Corsican [*sic*] who had previously served as Betancourt's secretary. In all probability this was a man named Bartolomé Sureda²⁶ who had married into the Bréguet family of watchmakers, for Antoine-Louis Bréguet (1776-1858) numbered among the party. I obtain this information from a

²⁴ When recording his recollection of the episode a decade later, James Watt asserted that Betancourt was "shown" the engine at the Albion Mills and informed that steam was applied to both the ascent and the descent of the piston. "How far the particular mechanism was explained to him I do not now remember; but he had the modesty to ask to have the engine stopt, on which 50 or 100 men were attendant, that he might see the inside of it which was refused. But the outside he was at liberty to examine & the principle of action was explained to him." See TANN, J. (ed.) (1981) *The Selected Papers of Boulton & Watt*. Vol. 1: *The Engine Partnership*, 60-61.

²⁵ See note 18.

²⁶ Most likely Bartolomé Sureda y Miserol (1769-1851) who married Thérèse-Louise Bréguet.

subsequent letter which Boulton wrote in 1804 to Sir Joseph Banks, president of the Royal Society, in which he unflinchingly labelled Betancourt as “by profession a Thief”²⁷. The receipt in Britain of the *Rapport fait à la Classe des Sciences Mathématiques et Physiques de l’Institut National* (Paris, an XI) on the supposed coining inventions of Jean-Pierre Droz was the occasion for this further display of invective. The Report, which was signed by Gaspard de Prony amongst others, mis-attributed to Jacques-Constantin Périer and Betancourt the credit for the improvements introduced to the steam engine. As for the shadowy Sureda, Boulton reported –wearily– that he had attempted to stray off limits when escorted around the rebuilt Soho Mint.

V

By this date the Mint alone was officially accessible to visitors. Nevertheless, Boulton kept his new vacuum presses deliberately concealed from view²⁸. Both the original Manufactory and the Soho Foundry whose construction had begun in 1796, were by now closed to nearly all comers whatever their social station. It remains hard to explain why Agustín de Betancourt, among all the “philosophical pirates” who succeeded in penetrating Boulton & Watt’s industrial premises in the 1780s, left such an enduringly negative impression. Baron Heinrich Friedrich vom Stein had made no pretence to philosopher status. His behaviour was found wanting on other grounds. But *académiciens* such as Coulomb were *savants* of the highest order. Their escapades at the Albion Mills, Soho and elsewhere pointed up the flaws in the Enlightenment’s free-flow knowledge project. Not long after Betancourt had hastened back to France with his precious cargo of knowledge, Midlands manufacturers were scandalised to learn that Jøns Matthias Ljungberg²⁹ (1748-1812), one-time

²⁷ BCL MS 3782/12/56: Copy letter of M. Boulton to Sir Joseph Banks, Soho, 23 January 1804. By this date Boulton’s memory of his dealings with Betancourt some fifteen years earlier was becoming rather hazy for he implies in this letter that the Spanish engineer was allowed to see the double-acting engine *in situ*, that is to say in Soho, which is not consistent with the statements made by Betancourt and others at the time. See also note 18.

²⁸ Even Sir Charles Blagden was not made privy to the technology involved. In a letter of 28 February 1804 to Sir Joseph Banks, he recounted how he saw eight presses each working at ninety-two strokes a minute, “the effect is very striking, as they appear to be all moving of themselves: but nothing of the construction can be known by this kind of view; and I believe that the precise manner of communicating the motion is kept strictly secret.” See CHAMBERS, N. (2007) *Scientific Correspondence of Sir Joseph Banks*, vol. 5, letter 1766.

professor of mathematics and astronomy at the University of Kiel, had been stopped at the Customs House as he tried to export to Denmark models, machine tools and numerous well-executed drawings of machinery inspected at Soho and other industrial sites in England and Scotland. Perhaps Agustín de Betancourt's sin was that he had succeeded magnificently where others had failed. That, together with the fact that his collaborators (the Périers, Jean-Pierre Droz, the Bréguets, etc) were no friends of Boulton & Watt.

This paper has concentrated on the role of entrepreneurs during the Industrial Enlightenment. It is rooted in the Archives of Soho, Birmingham, which remain an under-utilised resource for historians of science and technology, not to mention business historians and students of material culture. The Boulton & Watt archive is of interest for its own sake, of course. However, only recently have scholars come to realise the capacity of the archive to shed light on one of the great transitions along the road to modernity. My paper has narrowed the focus to the 1780s –on the ground that these were the years in which the actors themselves first showed signs of grasping the *structural* character of the social and economic changes that were now taking place in favoured regions of Europe such as Birmingham and the West Midlands.

However, the extraordinarily amphibian entrepreneurs and philosophers who emerge from the correspondence files of the Archives of Soho were not the only individuals involved in the international technology trade. The important transfer role performed by inventive craftsmen and mechanics should not be left out of the account. Indeed, the re-evaluation of the role of the entrepreneur and the *savant* that has taken place is now being applied to the artisan as well³⁰. But hard though it may be to construct a rounded picture of the activities of entrepreneurs in the second half of the eighteenth century, it is even harder to subject the technical culture of skilled workmen to systematic scrutiny, and to track their movements around the Continent. Here again, the Archives of Soho await the researcher, for material from which to construct a connected history of Boulton & Watt's peripatetic engine erectors exists in abundance. In the meantime we can only speculate. What became

²⁹ For Ljungberg, see BERGQUIST, Olle (1994) "Jøns Matthias Ljungberg. Matematiker, astronom, tekniker och industriman", *Personhistorisk tidskrift*, vol. 90, Häfte 1, 1-32; Häfte 3-4, 65-74.

³⁰ See HILAIRE-PEREZ, Liliane (2007) "Technology as a Public Culture in the Eighteenth Century: the Artisans' Legacy", *History of Science*, vol. 45, 135-53; HILAIRE-PEREZ, Liliane (2008), "Steel and toy trades between England and France: the Huntsmans' correspondence with the Blakeys (Sheffield-Paris, 1765-1769)", *Historical Metallurgy*, vol. 42, n° 2, 127-147.

of Betancourt's pupils? Is Bartolomé Sureda to be numbered among them, as seems likely? What of the draughtsman Marquis, or the young mechanic Reichenbach? If the Archives of Soho can be taken as a reliable guide, the inventive craftsmen of Georgian England often metamorphosed into successful engineers and entrepreneurs in their own right³¹. But the picture elsewhere in Europe –given the present state of our knowledge– remains unclear.

³¹ In this connection see also SKEMPTON, A. W. (1996) *Civil Engineers and Engineering in Britain, 1600-1830*, Aldershot, Variorum, 23-43.