Swiss Visitors to the Soho Manufactory, Birmingham, c. 1765-1820
and the Business of Technology Transfer

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The sponsors of the workshop draw attention to the important role which the circulation of scientific knowledge and the dissemination of new technologies have played in defining pathways of social and economic development since the eighteenth century. However, the international dimension of the story of growth has received less emphasis than it deserves in Swiss historiography. This, despite the fact that Switzerland did not begin to cross the threshold of self-sustaining innovation in the technological domain until some point in the second half of the nineteenth century. In this respect the country resembled other small European states such as Denmark-Norway as depicted by Dan Christensen.1 Its route to modernity necessarily passed by way of the big knowledge and ‘know how’-generating economies of Britain and France.

We may question whether Switzerland began from as modest a base as the kingdom of Denmark-Norway, for the Republic of Geneva was already in the eighteenth century a significant site of natural knowledge production and dissemination in Europe. We may question, too, a model which posits that technology transfer was essentially a unidirectional phenomenon before c. 1880; in other words a largely invisible export from Britain to the rest of Europe. Such a model owes much to the vision of ‘the first industrial nation’2 cherished by economic historians of the 1970s which, with the benefit of hindsight, has burdened the debate about economic development with a simplistic

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2 The proposition was formalised in Peter Mathias’s book The First Industrial Nation: the Economic History of Britain, 1700-1914 (London: Methuen, 1969).
linearity. It is a model which owes more to logical deduction than to evidence gathered in the archives, as researchers now increasingly acknowledge. Just because Britain emerged as the first industrial nation, must it therefore follow that she alone would define the path to be taken and supply the technology which enabled other nations to take it?

These are big issues which my paper will not resolve. However, I hope this communication will help to rescue from relative historiographical neglect the critical role played by technological knowledge transfer between Britain and Switzerland in the final quarter of the eighteenth and in the opening decades of the nineteenth centuries. The research on which it is based derives from a larger pan-European enquiry which I have been conducting over a number of years and which was published recently in monograph form. The principal source enabling me to open a window on the international trade in technology and to identify the vectors along which this trade tended to flow is the Archives of Soho. A very considerable body of documentation, it comprises the family papers of the steam engineer James Watt, the family papers of his research and development backer and partner Matthew Boulton, the business papers of the partnership they established and those of several subsequent partnerships to which the two families attached their names between 1775 and 1894. These papers are all located in the Archives and Heritage department of Birmingham Central Library in the United Kingdom. In the course of preparing this paper I have principally used, not the business archives but the letter correspondence between the partners and the thousands of visitors from Britain and overseas who applied for permission to tour Matthew Boulton’s showcase manufactory at Soho on the outskirts of Birmingham. This information has been supplemented with a quantity of travel literature, both published and unpublished.

Although Swiss visitors to Soho were not particularly numerous (see figures 1 and 2), they are nearly all identifiable and relatively straightforward to place in context. We are fortunate, moreover, to possess the travel diaries or note books of a number of extremely able Swiss publicists, savants and technologists, among which those of Marc-Auguste Pictet (1752-1825) of Geneva, Johann-Georg Bodmer (1786-1864) and Hans-Caspar Escher (1775-1859) of Zurich, and Johann Conrad Fischer (1773-1854) of Schaffhausen constitute documents of exceptional quality. We can extract relevant information from the published correspondence of nodes figures of the European Enlightenment in its Swiss dimension such Leonhard Euler (1707-1783), Albrecht von Haller (1708-1777) and Jean-Henri-Samuel Formey (1711-1797) as well. Historians of science and technology often neglect the correspondence networks of the eighteenth-century Republic of Letters on the supposition that participant members of these réseaux only ever discussed elevated themes drawn from philosophy, pedagogy and religion, else socio-political issues of contemporary interest. On the contrary, the correspondence of the philosophes can provide much of interest to the researcher interested in the topic of technology transfer. By the same token, entrepreneurs such as Matthew Boulton (1728-1809) scarcely confined their correspondence to matters of business as a perusal of the

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Archives of Soho rapidly serves to demonstrate. This should not come as a surprise to us. The second half of the eighteenth century was an age in which cultivation of the sciences was fast becoming the cultural hallmark of the gentleman, and nowhere more so, perhaps, than in Hanoverian Britain. Moreover, by the 1780s, the emphasis was shifting decisively in the direction of experimental science with useful applications. This empirical outlook particularly aided communication between British and Swiss natural philosophers, as David Bickerton\(^5\) has pointed out. It would serve as one of the factors that helped to ensure the unimpeded movement of technological knowledge from the one country to the other.

Despite the extraordinary riches\(^6\) of the Archives of Soho, we shall never know exactly how many visitors passed through the gates of the Soho Manufactory when it opened in earnest for business in 1766. The letter files and visitor books maintained by Boulton’s clerks enable us to identify around 1500 of these individuals and to ascertain with reasonable accuracy their date of arrival and departure. However, it is likely that the true number, when unnamed and unannounced visitors are added, was triple or even quadruple. After all, the manufactory remained accessible to visitors for the best part of four decades (until 1802 or thereabouts). In fact, Matthew Boulton continued to show visitors around his mechanised coining premises which were located only a few yards from the factory proper even after this date. Prior to the arrival on the scene of James Watt in 1775 and the construction of heavy engineering yards, the Soho complex afforded sight of nearly one hundred workshops in which metal casting, cutting, shaping, piercing or polishing was taking place. Matthew Boulton (1728-1809) was principally a ‘toy\(^7\)’ manufacturer, but visitors could also observe the rolling and plating of copper, the casting and forging of silver, the engraving and annealing of steel dies, enamelling, painting on glass and the production of replica fine art by a colour process known as ‘mechanical painting’. Most of the machines used in the manufactory before the appearance of Watt and the introduction of steam power to supplement and then replace hydraulic energy would have been familiar to technologically savvy travellers, of course. But the organisation of manufacturing processes on the principle of the ‘division of labour’ would have appeared to visitors as something of a revelation. Adam Smith acknowledged as much when in 1768 he toured Soho and other industrial sites in Birmingham including the celebrated pin manufactory described in Wealth of Nations (1776).

As one of the few manufacturers in Birmingham to trade directly with London houses and even with merchants on the continent of Europe, Boulton’s first contacts with the Swiss were confined to commercial transactions. In the early days much of his London business was handled by Jean-Louis Baumgartner, a partner in the firm Baumgartner & Hoofstetter, who were import – export merchants. Baumgartner arrived

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\(^7\) Buttons and buckles were his stock in trade, but in the eighteenth century the term ‘toys’ also embraced watch chains, key rings, snuff boxes, tweezers, pen knives, etc.
in England from Geneva in 1757, possibly as a political exile. As we shall see, the turbulent politics of the Calvinist city-state would become an important vector for technology transfer in the second half of the century. At any event Baumgartner set up in Birmingham initially, before becoming a British subject by naturalisation and moving his operation to London. Another Birmingham – Geneva connection was forged when Baumgartner’s nephew, Jean-Louis Moilliet (1770-1845), also migrated to Birmingham and in 1789 established an export trading house with the support of Matthew Boulton. Moilliet in his turn would marry into the family of James Keir, the Tipton industrial chemist who was the first to devise and commercialise a fully synthetic process for making caustic soda.

We know of at least thirty-seven travellers from the Switzerland who came to inspect Boulton’s Soho Manufactory. This is not an inconsiderable number when we bear in mind the population of the Swiss cantons and the absence of a ‘push’ factor from a centralised bureaucratic monarchy as in the case of Sweden-Finland (34 visitors), or Brandenberg-Prussia (30 visitors). Both the Swedish and the Prussian governments targeted Soho over several decades in the shape of a constant stream of travellers who were also able technologists. Although the occasional Swiss visitor arrived on an official commission, too, the majority were free-lance; that is to say they were travelling entrepreneurs, skilled craftsmen or peripatetic savants in pursuit of natural knowledge. Entrepreneurs (Jean-Pierre Ador of Geneva, Christian Fueter of Berne, Johann-Sebastian Claiss of Winterthur, Argand, Fischer, Bodmer etc.) often came to Soho with business propositions or else to recruit specialised metal-workers in a neighbourhood noted for its high-skill economy. Swiss precision craftsmen (watchmakers, instrument makers, engravers, modellers etc.), by contrast, were in heavy demand in the industrial centres of Britain in the late eighteenth century. When Matthew Boulton launched his mint venture in 1787, he issued a call for engravers and die-sinkers that echoed all over Europe from Stockholm to Naples. The talented, but unreliable Swiss engraver Jean-Pierre Droz (1746-1823) was induced to come to Soho by way of France, and was remunerated handsomely in return for bringing with him his high-tech lathe and other items of equipment which Boulton had seen demonstrated at the Hôtel de la Monnaie in Paris. Yet he would later grumble that Droz’s sojourn at Soho served chiefly to transfer knowledge of coining by steam power to France rather than vice versa. Natural philosophers formed the largest contingent of Swiss visitors, however. As we shall see, their presence attests both to the vitality of science culture in eighteenth-century Geneva and to the emergence of Soho in the final quarter of the eighteenth century to a position of prominence as a node point in the knowledge circuits of the Republic of Letters.

Figure 1: Swiss Visitors to the Soho Manufactory, c. 1765-1820

Achard, Jacques 1747-1828
Ador, Jean-Pierre 1724-1784
Achard, Jacques 1747-1828
Fueter, Christian 1752-1844
Gautier, Etienne
What vectors of knowledge transfer can we identify as a result of this initial juxtaposition of Britain and Switzerland? There are a number of links which invite investigation: epistolary exchanges between savants; ‘grand tourism’; entrepreneurship and trade; artisan migration; and politics. These headings will be familiar enough to
historians of science and technology. There was nothing characteristically Swiss about the correspondence networks of the Enlightenment, for instance. Nor were the business relationships between Soho and Swiss-born entrepreneurs fundamentally different in character from those between Soho and French or Dutch entrepreneurs and projectors. On the other hand Switzerland did occupy a somewhat unusual position in the pan-European circuits of ‘grand tourism’, particularly with the development of glacier tourism at the turn of the eighteenth century. As for politics, Geneva was commonly regarded as a cockpit of political revolution in the years before 1789; that is to say before France began to make the running in this area. Civil strife is not an obvious vector for technology transfer, but we will see that it produced considerable frictional movement of men and ideas.

Whilst it may be helpful to separate the above categories for analytical purposes, though, it should be remembered that technology transfer rarely takes place in such a neat and schematic fashion. On the evidence of the Archives of Soho, links forged in the epistolary ‘cyberspace’ of the Republic of Letters often led to person-to-person contacts which led in turn to enduring commercial relationships. Equally, Swiss refugees who found themselves in involuntary exile in London, Edinburgh or Birmingham often became conduits for the diffusion of British experimental science and its derivatives in the form of technologically useful knowledge.

Correspondence Networks
In the eighteenth-century a great deal of pure scientific knowledge circulated by means of the letter. In the interval between the end of the Seven Years War and the outbreak of the wars of the Revolution and Napoleon (1763 - 1792), the velocity of knowledge transfer by this method reached levels never before seen in Europe. The great mercantile and capital cities were now all linked by efficient postal services. For instance it took only five days, generally speaking, for a letter from Birmingham to reach Paris, whether a business letter or a letter transmitting the latest scientific news. Only in the most formal sense can this epistolary contact be described as private correspondence, for the savants of the Enlightenment were men strongly committed to public knowledge dissemination, and a loosely configured infrastructure\(^8\) of societies and academies had grown up to manage the process of diffusion. Thus, if a letter from the naturalised French chemist Claude-Louis Berthollet (1748-1822) describing the bleaching properties of oxymuriatic acid (chlorine gas) reached James Watt in 1787, we can be reasonably sure, indeed certain, that both the process and the theory behind the process would have been examined in depth by the Académie Royale des Sciences in Paris and would have been tabled for after-dinner discussion and experiment at a meeting of the Lunar Society in Birmingham.

It is true, however, that scientific knowledge travelled more easily than technological ‘know how’. In part this was a problem of inscription for only at the very end of the century is it possible to detect the presence of a specifically technological literature as opposed to an undifferentiated science literature disseminated in periodical form. Indeed, Swiss publicists and amateur experimentalists such as the Pictet brothers played an important role in fostering this transition. But the term ‘technology’ which we

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\(^8\) See D. S. Lux and H. J. Cook, ‘Closed Circuits or Open Networks? Communicating at a Distance during the Scientific Revolution’, *History of Science*, 36(1998), 179-211.
now take for granted was a loan word with German cameralist origins which appeared in the English language only towards the end of the century.

The encoding of knowledge to make it more portable and therefore transmissible was not the main problem, though. It is apparent from the Archives of Soho that industrialists and engineers such as Boulton and Watt drew a rough and ready distinction between discoveries in natural philosophy (to use their term) which were, or should be, made ‘public’, and knowledge with commercial potential which should be ‘protected’ by means of patents and privilèges. Thus the laboratory work involved in the decomposition of water, which took place in large part in Birmingham during the early 1780s, became a truly collaborative venture involving Henry Cavendish (1731-1810) in London and Antoine-Laurent Lavoisier (1743-1794) in Paris, not to mention other members of the Royal Society and the Académie Royale des Sciences. However, when Berthollet advised Watt of the extraordinary properties of oxymuriatic acid, the latter’s initial reaction was to suppose that this was privileged information which he was not at liberty to disclose to third parties. We can thank this tension within the bosom of the Enlightenment knowledge project for the elaboration of some of the alternative mechanisms of technology transfer.

Two of the foremost figures in the reséaux channelling information between Britain and Switzerland in the second half of the eighteenth and the early nineteenth centuries were Jean-André Deluc (1727-1817) and Marc-Auguste Pictet (1752-1825). Merchant by vocation, natural philosopher and author by inclination, Deluc hailed from an ‘ingenious’ craft background (his father had been a watchmaker). He arrived in London from Geneva in 1773 and obtained the post of Reader to Queen Charlotte, a post that entailed residence at Court of George III and provided opportunities for considerable patronage. He carried out experiments with Joseph Priestley (1733-1804) and James Watt (1736-1819) in the early 1780s and would make significant contributions in the fields of geology and atmospheric physics, despite becoming embroiled in a priority controversy with Joseph Black (1728-1799) over the question of ‘latent heat’. In the context of this paper, however, it is his role as a point of contact for a whole generation of Swiss travellers to Britain and as a two-way conduit for knowledge and ‘know how’ exchange which is the most important. It was Deluc for instance who provided Aimé Argand (1750-1803) with a letter of introduction to the firm of Boulton & Watt when the Swiss inventor arrived in London in search of backers and manufacturers for his tubular wick oil lamp (lampe à double courant d’air) in 1784, and when Jean-Charles Trembley (1764-1846), son of Abraham, the Genevan naturalist, called on Watt in the summer of 1789.

It is perhaps not surprising to find that men of a similar background and outlook tended to have known one another from an early age. The socially fluid environment which enabled entrepreneurs, natural philosophers and skilled artisans to mix on terms of familiarity if not quite equality in London, Birmingham or Glasgow could be found in Geneva also. London’s Society of Arts, which had been founded in 1754 to promote enterprise, innovation and technological knowledge transfer, spawned several similar initiatives, the most successful of which appears to have been the Société pour l’Encouragement des Arts of Geneva. The product of a collaboration between the most illustrious of the Republic’s savants, the botanist Horace-Bénédict de Saussure (1740-1799), and the clockmaker Louis Faizan in 1776, it established a bridge between the
patriciate and a petite bourgeoisie of talented artisans. Aimé Argand and Marc-Auguste Pictet who had been friends since childhood both came under Saussure’s influence at the Académie. All three, in turn, would receive James Watt’s eldest son when he came to complete his education in Geneva in 1784.

Like Saussure before him, Marc-Auguste Pictet would make a number of trips to Britain. In 1775-6 he toured the sites of London in the company of his fellow Genevan the astronomer Alexandre Aubert (1730-1805), a well integrated member of the capital’s expatriate community. He was in England again in 1787 and secured access to Matthew Boulton and the Soho Manufactory on production of a letter of recommendation signed by Abraham Guyot (? - 1794) of Neufchâtel. Guyot was another peripatetic Swiss who combined the role of travelling natural philosophy tutor with that of colporteur technologique. The suspension of hostilities in Europe made it possible for Pictet to make further extensive tours of the British Isles in 1801-02 and these were extensively reported in the Bibliothèque britannique. Finally, we know that he visited the elderly James Watt senior in Birmingham in 1819, the year of the latter’s death.

Having suffered losses as a result of the outbreak of the revolution in France, Marc-Auguste Pictet made a virtue out of necessity and turned his energies in the direction of journalism. For three decades he was the most energetic and effective populariser of scientific and technological knowledge between Switzerland and Britain, a role which was formalised with the launch of the Bibliothèque britannique. This widely read periodical appeared seven times a year between 1796 and 1815, with Marc-Auguste editing the sciences and arts section and his younger brother Charles covering literature and agriculture. In practice the brothers filled the journal with hefty chunks of material translated from English in which the emphasis was directly focused on the concrete applications of scientific knowledge. During the period of the Continental System (1806-14) when even the letter post had largely broken down as a vector for information exchange between Britain and the Continent, the Bibliothèque britannique remained one of the few accessible sources of information in continental Europe. Even so, the reception of its issues on the far side of the Channel could be intermittent: ‘we all regret in England that your excellent journal does not arrive regularly’, wrote Sir Humphry Davy to Pictet on 27 December 1813, ‘I had not seen any number for 12 months till I arrived in Paris.

Pictet’s extensive correspondence, it should be said, was very much of a piece with his journal: a miscellaneous bringing together of the scientific, the pedagogic and the industrial ranging from reports of weather phenomena to reports of an English invention called the ‘water closet’.

Tourism and Commercial Exchange
As can be seen already, the movements of men are scarcely to be separated from the movement of ideas within the Republic of Letters. If we set aside for a moment the occupationally-driven migration of skilled artisans, it is likely that a self-replenishing cohort of some 45,000 English tourists could be found on the continent of Europe in the years immediately prior to the French Revolution. This at least, is the estimate provided by the historian Edward Gibbon. Yet as other contemporaries would acknowledge, the

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10 Bickerton and Sigrist, Marc-Auguste Pictet, 1752-1825: Correspondance, iii, p.166.
Grand Tour was losing its lustre by the 1780s; or rather it was metamorphosing like the Enlightenment itself into something more focused and utilitarian. The popularity of industrial sites such as Matthew Boulton’s Soho Manufactory bears witness to this transition. The ‘classic’ Grand Tour was being undercut by a discrete cultural practice which we may label the ‘technological’ Grand Tour.

By the time the phenomenon of overseas travel resumed again in the late summer of 1801 (the Preliminaries of Peace), this new development had become even more pronounced. Leisured travellers with no particular objective other than sight-seeing still traversed the Channel, in both directions, but the emphasis was now increasingly laid upon the investigative. Whilst English tourists whose apprehensions of nature were in a state of pre-Romantic flux flocked to Switzerland in order to contemplate the glaciers\(^{11}\), the flows in the other direction seems to have been altogether more hard-headed. Nearly half of the passports issued in Paris by the British ambassador for travel to London were requested by entrepreneurs, manufacturers, tradesmen and craftsmen.\(^{12}\)

Swiss technologists and businessmen did not wait upon the uneasy Peace of Amiens (1802-03) in order to come to Soho, of course. In fact the partners concluded quite early on that some of their overseas visitors were using business as a cover for technological knowledge collection. It was difficult, after all, to deny access to a particular technology if the applicant appeared to be a customer who was proposing to buy it (an improved steam engine, for example). Aimé Argand incurred this suspicion until the partners were able to satisfy themselves that he was both a first-rate practical scientist and an entrepreneur.

Christian Fueter is another case in point. A member of the city council of Berne, he arrived at the gates of Soho in 1791 with a request that he be permitted to visit the works. Fueter, too, had a business transaction on his mind. As Director of the Berne Mint he was engaged on a Europe-wide tour of inspection of facilities for the striking of coin. Matthew Boulton needed no encouragement to try and interest him in his new steam-powered coining press, but the coining needs of a Swiss canton scarcely justified the introduction of rapid-strike machines and flow production. Boulton therefore changed tack and offered to sell Fueter bullion scraps which were a waste product of the Soho’s Sheffield Plate manufacturing operation.

When Johann-Conrad Fischer crossed the Channel for the first time in 1794, it was the quest for metallurgical knowledge that prompted his progress northwards to the West Midlands. Within a decade he would become Director of Mines for the canton of Schaffhausen. Apart from the extraordinary quantities of cast iron employed as a constructional material, what chiefly attracted his attention, however, were the exceptionally high skill levels on display in English manufactories. Like others before him he drew the conclusion that it was not so much hardware (i.e. machines) that were the key to successful technology transfer, as human resources.

Artisan Migration

\(^{11}\) ‘[les anglais] vont aux glaciers at the rate de 50 par jour’, M.-A. Pictet to A. Marcet, 30 June 1802 in Bickerton and Sigrist, Marc-Auguste Pictet, 1752-1825: Correspondance, iii, p.356.

\(^{12}\) See R. Morieux, ‘“An Inundation from our Shores”: Travelling across the Channel around the Peace of Amiens’, http://www.politics.ox.ac.uk/philp/text/Papers/Morieux_Paper.pdf.
We know that considerable numbers of skilled workmen moved around Europe transferring skills as they went during the second half of the eighteenth century and the early decades of the nineteenth century. Some estimates put the figure as high as 200,000. What we do not know much about, however, are their identities and their occupational itineraries or parcours. As a result the story of knowledge transfer in the late eighteenth and early nineteenth centuries has an in-built bias in favour of entrepreneurs and technologists; in other words in favour of those whose names appear in the historical record. We can document, for example, the movements of a William Wilkinson or a William Cockerill, or in the Swiss case those of a Johann-Georg Bodmer or a Johann-Conrad Fischer, but the artisans and craftsmen who also moved from employer to employer in what was fast developing into a market economy for skill go by default. The fact that the government of Great Britain sought to prevent the expatriation of artisans and the export of many types of machine tools until the second quarter of the nineteenth century nonetheless testifies to the potency of artisanal technology transfer. When the legal ban on the emigration of British artisans was lifted in 1825, the toolmaker Henry Maudslay (1771-1831) observed that skilled workmen ‘have gone in flocks’ to Europe.

In the case of Matthew Boulton we do know a little about the migration of the Soho Manufactory’s engine erectors. These men were despatched to supervise the installation of the static steam engines purchased by customers, and they occupied an intermediate niche between the craft-based artisan and the technician. A few would even become engineers in their own right. Several spent long periods on the Continent, erecting engines for French, Dutch and Spanish entrepreneurs, and also one on a commission from the King of Naples and Sicily at Capua near Naples. As living embodiments of a skill that was but poorly encoded before the 1820s, they were frequently poached by rival employers.

I have come across no instances of engine erectors working in the Swiss cantons in the period covered by this paper, however. In the late 1780s Aimé Argand acting on behalf of the Société pour l’Encouragement des Arts contacted James Watt with a view to purchasing an auxiliary steam engine to back up a pumping station on the Rhône. Aware of technological developments in London (the Albion Mills) and in Paris (on the Ile des Cygnes), he stipulated that the engine should also be capable of turning two mill stones. No doubt the enquiry was prompted by the flour shortage which Geneva had faced during the frosts of 1788-89. Yet it does not seem that the political will existed in the Republic for works of utilité at this time. In any case, Watt doubted whether Switzerland possessed the infrastructure to domesticate successfully his invention. When Marc-Auguste Pictet asked Jean-André Deluc to sound out the Birmingham engineer on the subject of steam technology, he was rather dismissive. In the light of their discussion, Deluc reported, ‘il en est résulté que tout ce qu’il [Watt] vous communiquerait ne saurait

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16 Marine engines for the paddle steamers plying the Swiss lakes were commissioned from Boulton, Watt & Co. in 1825. The vessels in question were the Léman (Geneva) and the Union (Lake Neuchatel).
vous servir à rien. La théorie à cet égard ne sert pas plus à la pratique qu’un ouvrage d’horlogerie ne servirait à faire des montres à Otahiti. Après la description la plus exacte et la plus circonstanciée, il faudrait avoir des fourneaux de fonte, et les raffineries qu’on a dans ce pays-ci, tous les divers ateliers et le nombre des machines que l’expérience a accumulés à Soho, et tous les ouvriers que Messrs Watt & Boulton ont éduqués.  

This seems a rather severe judgement, even when applied to the new steam power technology. After all, by the 1800s, Prussia was well on the way to establishing in Silesia a heavy engineering capability that had been developed more or less from scratch. Nonetheless, it is important to keep in view the broader picture of artisanal transfer operating at more mundane levels. Matthew Boulton’s quest for gold and silversmiths, gilders and engravers has already been mentioned, and he routinely employed recruiting agents such as Johann- Sebastian Claiss (1742-1809) to funnel talented craftsmen towards his manufactory. By the same token, he frequently found himself the target of enticement activities by fellow industrialists. A case in point is the visit to Soho of the two Swiss entrepreneurs Ador and Préponnier in 1766. Having been entrusted with the extension of the Pforzheim jewellery factory established by Margrave Karl Friedrich von Baden, they came to Birmingham in search of the expertise involved in the manufacture of steel ‘toys’. In effect, they planned to establish a replica of the Soho Manufactory in Baden-Württemberg and they seem to have succeeded in recruiting a highly competent English workforce for this purpose. So much so, indeed, that four years later the directors of the firm wrote to Boulton to propose a business merger on the ground that their English-trained workforce could now turn out goods that were every bit as competitive as those manufactured in Soho. In fact, they informed Boulton that they would be glad to send back home their English operatives on the ground that their skills in the cutting and polishing of metals had now been successfully transferred. It is true that foreign entrepreneurs often viewed migrant British artisans with some distaste, regarding their presence as a necessary evil. They were often considered to be ‘mauvais sujets’ whom it was better to dispense with once a more docile (and less costly) native labour force had been trained on the job.

Politics
As Jacques Trembley has remarked, eighteenth-century Geneva was a veritable ‘laboratory of revolutions.’ Prior to the obliteration of the Republic in 1798, there had been repeated episodes of crisis and internal revolt against its political system (in 1734, 1762-65 and 1782), although the ancien régime would not be dislodged finally until a
French army with revolutionary credentials invaded in 1792. Each of these civil commotions produced a complement of political refugees, and it is apparent that exile and even incarceration as a prisoner of war could serve as a vector for the transfer of technology. Boulton & Watt received a stream of wandering Swiss natural philosophers who had either quit or been forced to leave their homeland. Usually, they were in search of employment and they sought to make themselves useful by conveying information from one science and technology node to another. Thus Dr Silvestre, a Genevan whose identity remains obscure, settled in Edinburgh in the early 1780s and was absorbed into the coterie of savants grouped around the chemist Dr Joseph Black. In 1785 Black provided him with a letter of introduction to the West Midlands industrialists. He visited Watt in Birmingham who seems to have been active in exploring possibilities for employment in Broseley – as a physician to the local landowners and iron founders. By the summer of 1785, however, the political situation must have been easing in Geneva for Silvestre decided to head for home instead.

The most high-profile Genevan expatriate was of course Jean-André Deluc. Although it is not entirely clear whether political antagonisms or business failures were the main reason for his relocation in 1773, he stayed in Britain for most of the rest of his life and yet would follow events in his homeland with passion and not a little anguish. By the late 1790s we find him combining the role of natural philosopher and intelligence gatherer for the British government, a combination which also applied in the case of Marc-Auguste Pictet if we may judge from a recent article on William Wickham, Britain’s anti-French spymaster.22

Another Swiss patriot who fled Geneva following the conservative riposte to the revolution of 1782 was Jacques-Antoine Du Roveray (1747-1814). In November 1785 James Watt complained to his partner that the ‘scoundrel’ Du Roveray had been seen ‘snooping’ around the Soho Manufactory. However, this less than flattering description would not deter Boulton from using Du Roveray as a business intermediary several years later when he was trying to secure a contract to sell copper to the Paris Mint. Despite Watt labelling him a scoundrel, he was clearly a man of parts. We know that both the French and the British governments made use of his talents as a diplomatic go-between. After returning to Geneva in 1789, he would reappear in London in March 1792 on a commission from the French to sound out Britain’s stance in the event of a continental war. Yet by 1793 he seems to have been acting as a Swiss advisor to the British government. The Terror in France and the political turmoil in Geneva must have taken its toll, though, for by 1798 he was back in London. On his third marriage and living in straitened circumstances, he wrote to Matthew Boulton in that year with an offer to travel to Paris and report on the French cut-steel ‘toy’ trade.

The common denominator in the politics of technology transfer was France as will be apparent; a France which since the appointment of Charles-Alexandre de Calonne as Contrôleur-général in 1783 had been putting considerable resources behind its commercial and industrial policies. When Aimé Argand came to London and subsequently Birmingham early in 1784, it was because the necessary manufacturing skills, together with the high quality flint glass needed for his lamp, could not easily be found in Paris. But after a less than fruitful business relationship with Matthew Boulton, a

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22 See M. Durey, ‘William Wickham, the Christ Church Connection and the Rise and Fall of the Security Services in Britain, 1793-1801,’ The English Historical Review, 492(2006), 731 and note 81.
French government subsidy persuaded him to build a manufacturing plant of his own at Versoix in the Pays de Gex, just on the French side of the border with Geneva. Yet he would confide to Boulton that the choice of location was intended principally to ensure easy access to components smuggled overland from Britain, which was not at all what the Contrôleur-général had intended when arranging for start-up capital to be provided: ‘my secret reason I did not tell him [i.e. Calonne] as you think, which is that I may get there [i.e. Versoix] through Ostende all the lamps & parts of the lamps which will be more convenient to be made in England, especially the plated [lamps].’

Clearly the complicated politics of border control could also play a role in technology transfer, as indeed could war. We know, for instance, that at the height of the Terror in France the Comité de Salut Public routinely interrogated British prisoners of war in the hope of obtaining information about machine tool design and steel-making technologies. Bonaparte would continue this aggressively mercantilist approach to knowledge and know-how. English entrepreneurs and artisans who chose to cross the Channel during the Peace of Amiens were welcomed with open arms. Ambassador Anthony Merry reported to the Foreign Secretary Baron Hawkesbury in August 1802 that ‘the Officers of the French Government at Calais, Boulogne, Dieppe and the other ports make no difficulty to allow any person calling himself a manufacturer to land and proceed to the interior of France.’

Yet it should not be forgotten that Britain also adopted a defensive stance at this time; a time when the arguments for freedom of trade and industry were only just beginning to make an impact in government. Upon the outbreak of war against revolutionary France in 1793, an Alien Act was introduced to enable supervision of the movements of foreigners. Those who were suspected of being industrial spies were often forced to remain within a narrow radius of the Channel ports. However, when the sea lanes re-opened in the autumn and winter of 1801, the focus switched to surveillance of out-going artisans and manufacturers. In February 1802 a secret circular from the Alien Office urged Customs officers at Dover, Gravesend and Harwich not to deliver passports for France or Holland to anyone suspected of ‘conveying away machines employed in manufacturing certain staple commodities of this country’. The wartime siege economies which developed on either side of the Channel following the collapse of the Peace of Amiens were not intrinsically inimical to innovation, though, even if they impeded technical transfer. Denied access to the sugar cane production of the Carribean plantations, France’s beet industry made extraordinarily rapid technological advances between 1806 and 1814. Similarly, Hans-Caspar Escher’s firm Escher, Wyss & Cie were able to make a success of mechanised spinning in Neumühle for as long as Napoleon’s Continental System prevented Lancashire mill owners from flooding European markets with their products.

Conclusion
In the light of his study of the introduction of steam power to Sweden, Svante Lindqvist remarks that ‘scientific discoveries are quickly published in detail for the satisfaction and prestige of priority. In technology on the other hand, innovations are kept secret for as

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23 Birmingham Central Library MS 3782/12/30 A. Argand to M. Boulton, Paris, 4 August 1785.
long as possible for reasons of commercial or military competition.26 Evidence drawn from the Archives of Soho seems to bear out this dictum. Yet what must strike anyone who pauses to research eighteenth and early nineteenth-century technology transfer in greater depth is how unsuccessful were the attempts to prevent the migration of ‘know how’ from one national context to another. Perhaps this helps to explain why governments largely abandoned their efforts to prevent competitor states from gaining access to endogenous ‘know how’ from the 1820s. However, it is at least as likely that key political decision-takers had come to the conclusion that ‘improvement’ passed by way of emulation; in other words that invention and innovation were more likely to be nurtured in an environment in which knowledge and ‘know how’ were permitted to flow freely, albeit competitively, in whatever direction they were needed.

In the case of Switzerland, the development of an endogenous technical capacity seems to have started relatively late, notwithstanding the pioneer role played by technicians and entrepreneurs such as Bodmer, Claiss, Escher and Fischer. The latter’s prowess as a metallurgist had been remarked on in Soho on the occasion of his second visit in 1814, and he would go on to break the British monopoly of crucible cast steel production. As for his travelling companion, Hans-Caspar Escher, the early attempt to introduce mechanised spinning may only have proved a temporary success, but it would give birth to the Swiss Confederation’s biggest machine building company. From modest beginnings Escher, Wyss & Cie became a company with 400 employees by 1835, the year in which it launched its first iron steam ship. Nineteen more would be launched over the following decade. Even Johann- Sebastian Claiss, whose career is much less well documented, would use ‘know how’ gleaned during his travels in France and England to found an important chemical works catering for the needs of the textile manufacturers and calico printers of the newly independent town of Winterthur.

My paper has concentrated on the actors in the process of technological knowledge transfer between Britain and Switzerland. In view of the inadequacy of the historiography in this area, even a listing of the names of some of the individuals involved (see figure 1) represents a significant step forward. However, to take this step it has proved necessary to have recourse to primary sources, and to link these sources to other bodies of documentation such as travel accounts which rarely seem to engage the attentions of historians of science or technology. There can be no doubt that this approach is fruitful, or that it could be taken further – particularly by researchers working in situ and therefore with access to the bibliographical holdings of Swiss universities.

On the other hand, my paper has had little to say about the sociology of technology transfer; in other words the role of cultural variables. I do not discount this factor, quite the contrary. Indeed, there remains much to be found out in this domain: how, for instance, a gentleman savant such as Marc-Auguste Pictet with a fundamentally empirical cast of mind responded to the more deductive and theoretical approach to the sciences that inclusion within the French ‘Grande Nation’ after 1798 necessarily required. In carrying out this research I am struck, too, by the extraordinary capacity of the Genevan savants to absorb and disseminate both natural and applied knowledge, yet also by the evidence that the really productive technological and industrial advances appear to have taken root elsewhere in Switzerland in the early decades of the nineteenth century.

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26 S. Lindqvist, Technology on Trial: the Introduction of Steam Power Technology into Sweden, 1715-1736 (Uppsala, 1984), p. 116[?]
But this is simply to restate one of the questions raised by the organisers of the colloquium.

Another of the themes which my paper has highlighted is the extent of the exchange, including multi-lateral trade in technology, which was taking place in the second half of the eighteenth century. Even though Boulton & Watt never actually exported a static steam engine to Switzerland during this period, they received in Soho a veritable procession of customers from Europe, and they made no bones about sending machine components out of the country even in times of war (the engines and pipe-work despatched to the Périer brothers in Paris during the American War of Independence provide a case in point). Yet I would be the first to acknowledge that this was a fragile commerce, and one which suffered both from too much and too little legislative interference. Unable to control smuggling, European governments tended to respond with the blunt instruments of trade embargoes instead. British machine manufacturers meanwhile tried – usually in vain – to ensure that their patents were recognised abroad. Sometimes they discovered that even the securing of remittances could pose a problem, particularly in countries such as Russia and Spain where the rules of commercial law were not always respected.

Although I am scarcely qualified to comment, it does appear that Swiss industrialisation, in its initial phase, was significantly aided by technology transfer. This is no more than what one might expect after all, and in this paper I have tried to identify some of the channels or vectors which facilitated the process. An actor-driven approach does have the virtue of allowing the researcher to track quite specifically the movements of technological knowledge, even if it is much less effective in explaining how (or indeed whether), the knowledge thus transferred was subsequently taken up in a practical way. It is this next, ‘environmental’ stage creating the conditions for the growth of an endogenous capacity for self-sustaining innovation which researchers find so hard to explicate. This said, however, I would be hesitant about pushing the distinction between ‘initiator’ and ‘follower’ economies too far. Technology transfer is rarely a one-way street: Switzerland lay at the hub of Europe in the eighteenth and early nineteenth centuries and knowledge circulated.

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