Scaling London's early XIXth century docks, bridges and manufactories : Charles Dupin's writings and technological exchange

*Donner la mesure des docks, ponts et manufactures de Londres au début du
XIX^e siècle :
les écrits de Charles Dupin et les échanges techniques*

Alex Werner

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Scaling London's early XIXth century docks, bridges and manufactories: Charles Dupin's writings and technological exchange

Alex Werner
Museum of London

Charles Dupin during his tours of Britain between 1816 and 1819 spent time examining the naval dockyards along the river Thames and Medway, as well as London's port facilities, commercial buildings, bridges and manufactories.¹ He described for French readers many of the major technological and engineering advances that had occurred in London over the last thirty years as well as the very latest developments. Vast areas of the city had been transformed and major construction projects were underway. The lengthy period of war had made travel between France and Britain very difficult and had clearly disrupted technical exchange. Throughout Europe and the wider world, there was a pent up demand to view, experience and learn about British technological and industrial advances. Dupin was just one of many French and other foreign visitors who came to Britain at this period.² His writings attempted to convey especially the scale of London's infrastructure. He was not alone in being astounded by the extent of the capital and by the multitude of people gathered together in just one place. Karl Friedrich Schinkel noted in 1826 in a letter to his wife how:

"Everything here is enormous. The city is, it seems, never-ending; if you want to visit three places you need a whole day; even within the town distances are reckoned in miles when you go by carriage".³

London was measured against the work of the ancient Egyptians or Romans. Ancient Rome, seemingly, was the only city in history to compare with London. Dupin told how a visit to the London Dock Company's wine vaults at Wapping was like a descent into the catacombs at Rome or Naples such was their extent.⁴ He described Waterloo Bridge as worthy of 'Sésostris and the Ceasars' and 'the courses of the piers and the arches are composed of very large blocks' which gave 'the appearance of the most imposing buildings of the Romans'.⁵ Continuing the Egyptian theme, Dupin, the French equivalent of England's G.F. Bidder, 'the calculating boy', worked out how long it would take to build the pyramids if all of Britain's steam engines were put to work together to accomplish the task.⁶ Visitors found it difficult to comprehend how London's docks and bridges came to be built in such a short time and how such enormous sums of private capital had been raised while the country was still at war. The scale of London's new structures was best conveyed through illustrations. Dock engineering drawings that detail the new technological features fail to communicate the magnitude of the capital's

1 For a study of Charles Dupin's British excursions see Margaret Bradley and Fernand Perrin, "Charles Dupin's study visits to the British Isles", 1816-1824, *Technology and Culture*, Vol. 32, No. 1, 1991, p. 47-68.

2 For French visitors, see Michel Cotte, *De l'espionnage industriel à la veille technologique*, Belfort-Montbéliard, Presses Universitaires de Franche-Comté, 2005, p. 29, 121-149 and for a more general survey see Giorgio Riello and Patrick K. O'Brien "Reconstructing the industrial revolution: analyses, perceptions and conceptions of Britain's precocious transition to Europe's first industrial society", *LSE Working Papers in Economic History*, 84, 2004.

3 Karl Friedrich Schinkel, 'The English Journey'. *Journal of a visit to France and Britain in 1826*, David Bindman and Gottfried Riemann ed., New Haven, Yale University Press, 1993, p. 112.

4 Charles Dupin, *The Commercial Power of Great Britain*, London, Charles Knight, 1825, Vol. II, p. 40.

5 *ibid.*, Vol. I, p. 360.

6 *Mechanic's magazine*, 1827, VI, p. 212. Dupin worked out that it would have taken just 18 hours.

Scaling London's early XIXth century docks, bridges and manufactories

fig. 1 - Panorama of London, around 1807 ((c) Museum of london)

fig. 2 - A view of the London Docks, 1808 by William Daniell ((c) Museum of london)

port facilities. To understand visitors' reactions of awe and wonder one has to turn to William Daniell's large aquatint prints that take a bird's eye view of the docks. These images were influenced by the panorama craze of the 1790s and early 1800s in London.⁷ The so-called 'Rhinebeck panorama of London' of around 1807 (fig. 1) is an example of these type of high level wide angle urban perspectives. John Soane in his influential lectures on architecture at the Royal Academy in 1814 used bird's-eye illustrations drawn and coloured by his assistant James Underwood for his talk on lighthouses, docks and canals. The one of the West India Docks showed the extent of this dramatic new port facility, the world's largest at the time. In Daniell's series of aquatints, the gargantuan nature of these new docks becomes clear. (fig. 2) Men are reduced to the size of ants and even the ships are dwarfed by

the immense dock basins, the long quaysides and the substantial warehouses. Dupin's descriptive strategy for conveying the docks's scale for French readers was to overlay them on part of central Paris;

"Concevons que les hôtels de la rue de Rivoli, du ministère de la Marine et de l'ancien garde-meuble, ne forment qu'un seul magasin et que la moitié du palais de nos rois soit ajoutée comme appendice à cet entrepôt. Creusons un premier bassin, depuis le pavillon du Marsan jusqu'aux Champs-Élysées, depuis la rue de la Rivoli (dont nous faisons un quai spacieux) jusqu'à la grande Allée des Tuileries..."⁸.

This was just the West India Docks (1802) on the Isle of Dogs, the first of the capital's new commercial docks for the handling of cargo. Its size astonished him and

⁷ For a historical study of panoramas see Ralph Hyde, *Panoramania*, London, Trefoil Publications, 1988.

⁸ Charles Dupin, *Force commerciale de la Grande-Bretagne*, Paris, Bachelier, 1824, Tome II, p. 39.

others who visited them – 44 hectares in extent with 100,000 square metres of warehousing. The London Docks (1805) at Wapping and the East India Docks (1806) at Blackwall were only slightly smaller in scale.

The management of such enormous undertakings became another essential detail of Dupin's study. He emphasized French backwardness in effectively running such huge operations that were dependent on an army of labourers. But it was also the way that such operations were promoted and funded that interested him. For the West India Docks, he discovered that it was the work of a private company:

"Voilà les vastes travaux qu'une association de particuliers a pu faire, par une simple souscription; et vingt-sept mois n'ont pas même été nécessaires pour accomplir ces prodiges".⁹

Having learnt of the history of this company, how it had been built rapidly with a resolution and firm direction, Dupin believed that he had uncovered one of the secrets of British commercial success and power:

"Tous ces travaux, s'exécutent avec une régularité, une activité, une intelligence très-dignes de remarques; et sur lesquelles j'insiste à dessein, parce que nous avons beaucoup à faire pour égaler les Anglais, dans ce genre de manipulation, si essentiel à l'économie ainsi qu'à la célérité des opérations commerciales".¹⁰

When it came to specific features Dupin focused in especially on aspects of engineering and technology which were different to normal French practice. For example he was interested in the design of the lock-gates at London's docks which were 'curvilinear' and made up of 'two vertical cylinders, the convexity of which forms an arch to resist the water'. Typically, French lock gates were rectilinear in shape. Dupin, a skilled geometrician and mathematician, worked out that the British gate pattern was advantageous in regards to 'economy and solidity'.¹¹ He encouraged the design's introduction in France. He honed in on any use of steam or hydraulic power. For instance, he was particularly fascinated in dock dredging machines worked by steam engines. He looked for the explanation of why new machinery, techniques and modes of construction had been introduced. Timber dock walls had been replaced by brick and rubble in London's commercial docks and hewn stone, marble and granite in the

royal naval dockyards. The reason for this change he discovered was the result of commercial considerations. The cheaper wooden dock walls required frequent rebuilding and repair thus making stone and brick walls more cost effective when the facilities were in heavy use. A further consideration was that the disruption to the dock's operation was infrequent as repairs were rarely required. Thus a larger capital outlay directed towards an infrastructure made of durable materials was shown in the long term to be a sound business strategy.

Dupin noted especially the novel use of iron roofs and columns in the construction of dock warehouses and transit sheds. Generally, he failed to place such new features in a wider context. However, this is no different to many other commentators who describe the finished work rather the lengthy process of trial and error that led to their realization. Such new technologies were developed in London often with disastrous consequences. Even Henry Maudslay and his manufactory, eulogised by Dupin and many other visitors, had set backs. The description in *The Times* of the collapse of his factory's iron roof reveals a different sort of narrative where disaster and death existed alongside progress and technological achievement.¹² Alexander Galloway, another skilled London engineer and manufacturer, also experimented with an iron roof that collapsed at his factory.¹³ John Rennie made similar experiments with iron roofs at the West India Dock with major financial loss and practical failure, though only his successful later warehouse and shed designs were described and analysed by Dupin.¹⁴ Perhaps, the most calamitous loss of new technology in London in the late 18th century was the burning down of the Albion mills, close to Blackfriars Bridge. (fig. 3) With their two impressive Boulton & Watt steam engines, installed and perfected by their resident engineer John Rennie, this corn mill was of unparalleled size and threatened the livelihoods of many millers in the London region. A fire swept through the building on 2nd March

12 *The Times*, 25 May 1826, p. 3. Three of Maudslay's employees were reported to have been killed and many others seriously injured when the wall supporting the iron roof of his steam engine manufactory collapsed.

13 Samuel Smiles, *Industrial Biography: iron workers and toolmakers*, London, John Murray, 1863, pp. 241-242. Peter Keir, an engineer employed by the government, on arrival at Galloway's works observed the construction of its iron roof. He was so fearful of it falling that he would only speak to Galloway outside. The following day, Keir learned of its collapse and the death of a number Galloway's workmen.

14 C. Dupin (1825), *op. cit.*, pp. 53-60. See also the Survey of London volumes, Stephen Porter ed., *Poplar, Blackwall and the Isle of Dogs*, London, Athlone Press, 1994, Vol. XLIII, pp. 293-305 and illustrations in Vol. XLIV, Fig. 48d and 49a.

9 *ibid.*, Tome II, p. 39.

10 *ibid.*, Tome II, p. 44.

11 Charles Dupin, *Two excursions to the ports of England, Scotland, and Ireland*, in 1816, 1817, and 1818, London, Sir Richard Philips and Co., 1819, p. 3.

fig. 3 - Fire at the Albion Mills, print of 1808 but showing the fire of 1791 ((c) Museum of london)

1791. Some thought that it was the work of arsonists while other such as Rennie believed that the fire had started due to a lack of grease on the gearing wheels. The blackened and ruinous building stood empty for a decade and was thought to have been one of the inspirations for the poet William Blake's 'dark satanic mills'.¹⁵ Likewise, those experimenting with the development of steam boats on the Thames met with many disasters and disappointments. The introduction of new technologies was fraught with difficulties and engineers and inventors were often bankrupted.

If Dupin's narrative of the metropolis and Britain is set against the descriptions and experience of visitors from different parts of the world including Europe, the United States and the British Empire, it will be seen that there are shared perspectives though some elements are shaped by specific national traits.¹⁶ The anonymous

translator of Dupin's *Two excursions to the Ports of England, Scotland and Ireland* (1819) points out in his introduction the commonly held opinion that the French excel in 'theoretical knowledge' while the English display 'great powers of invention' and 'superior practical knowledge of the useful arts'. Further, it was claimed that 'Englishmen' had 'outstripped the French' largely because they were 'unfettered by the prejudices which exalted theoretical speculations too often engender'.¹⁷ The debate over 'theory' and 'practice' was seen as central to those seeking an explanation for British superiority in the field of the mechanical arts. Dupin's works were very influential not only in France but also in Britain. His main works on British commerce, military facilities, ports and naval dockyards were translated almost immediately into English. They were well reviewed and became standard texts. His emphasis on technical education was significant as well as his promotion of the British model of privately funded commercial undertakings. A British reviewer of his work in 1825 claimed that his enthusiasm suggested 'a

15 See Peter Linebaugh, Marcus Buford Rediker and Marcus Rediker, *The many-headed Hydra. The hidden history of the revolutionary Atlantic*, London, Verso, 2000, p. 250.

16 G. Riello and P. K. O'Brien, *op. cit.*

17 C. Dupin (1819), *op. cit.*, pp. iv-v.

little of what, in France, has been called 'Anglomanie'.¹⁸ His name would have been known to many literate workshop and factory foremen and journeymen in Britain who read popular monthly publications such as the *Mechanic's Magazine* or consulted Nicholson's *The Operative mechanic* (1829) a standard workshop manual, which had an illustrated appendix on British industrial and technological achievement adapted from Dupin's writings. No British author had attempted to describe and detail the country's achievement in this field in such a clear and comprehensive way. A critic reviewing the translation of Dupin's *The Commercial Power of Great Britain* (1825) wrote that

"He has also rendered us no small service, by teaching us to know ourselves. Whether to our own disgrace or not we do not ask; but it true that, from no work in this country could the information here presented to us have been derived".¹⁹

It could be claimed that his writings, such was their circulation, contributed greatly to technical exchange within Britain itself.

To most visitors to the capital, London's docks and dockyards were essentially hidden features surrounded by high walls. Those of a commercial, mercantile, engineering or architectural standing (and with the right letters of introduction such as Dupin) were admitted to the undertakings but most had to make do with descriptions and illustrations found in guidebooks and the sparse technical literature. Two of the docks could be viewed from afar at the top of Greenwich Park. In contrast, London's new bridges were visible to all. They were distinctive, prominent features, symbols of the city's modernity. Dupin's description of John Rennie's stone Blackfriars Bridge and iron Southwark Bridge reveal questions about national and civic identity, the revolution in the use of new materials, the use of geometry and mechanics in creating a perfect constructed form, and in general terms, the role of the engineer and his place in shaping technological progress.²⁰

Waterloo Bridge or Strand Bridge was praised by Dupin. He wrote how 'the structure of the bridge ... is managed with great skill, the result of profound

experience'.²¹ One element of the bridge was criticized – its lack of harmony with the nearby buildings, Somerset House in particular – 'the effect which results from this is contrary to good taste'.²² This was clearly something that would not have been possible in France, showing how architectural order and harmony were controlled there to a much greater extent. Here, Dupin may have been calling into question Rennie's aesthetic and architectural skills, though he found no fault with his geometry and engineering. Rennie himself admitted that the detailing and shape of the parapet caused him more problems than the bridge's structural engineering. Despite this, Dupin eulogized that in some future time (prophetically conceiving of a 'destructive climate' that will have devoured most surviving buildings) the bridge will remain and stand as a symbol for the greatness of London. Its dignified mass will reveal that 'Here stood a rich, industrious and powerful city'.²³ What was even more surprising to Dupin and his French readers was the fact that the bridge had only taken six years to construct and had been conceived of and paid for by a company of merchants. Southwark Bridge interested Dupin particularly because of its use of cast-iron. John Rennie's design allowed for the maximum width of the waterway by employing just three flat segmental arches. These were vast spans for the period, the world's largest cast-iron structure then built (fig. 4).

Only a few London manufactories and workshops beckoned for the specialist traveller. Other parts of Britain seemed to offer a more direct experience of the industrial revolution such as the cotton mills of Manchester. However, there were specialist French workers coming to London to learn in practical terms about the introduction of machinery into the production process. J. B. C. Odier, the renowned Parisian goldsmith sent his son to work at Garrard's in Panton Street, Haymarket to learn about how machinery could be used to aid the production of silverware.²⁴ He would have been interested in die-stamping, soldering and the use of steam engines to drive machinery in the larger London workshops. Steam engines had become quite common in London manufactories and workshops by the 1820s. Dupin praises what he calls the 'extremely ingenious machines' that were made by Henry Maudslay.²⁵ His lowly birth was remarked on - how 'he had raised himself' 'from the

18 *Westminster Review*, 1825, p. 369, also G. Vapereau, *Dictionnaire universel des contemporains*, Paris, L. Hachette, 1858, p. 591.

19 *Westminster Review*, 1825, pp. 337-338.

20 For a discussion of John Rennie's new London Bridge see Dana Arnold, "London Bridge and its symbolic identity in the Regency Metropolis: the dialectic of civic and national pride", in Dana Arnold ed., *The metropolis and its image: constructing identities for London c. 1750-1950*, Oxford, Blackwell, 1999, pp. 79-100.

21 C. Dupin (1825), *op. cit.*, p. 358.

22 *Ibid.*, p. 356.

23 *Ibid.*, p. 360.

24 John Culme, *Nineteenth century silver*, London, Hamlyn, 1977, p. 23.

25 Charles Dupin, *View of the history and actual state of the military force of Great Britain*, London, John Murray, 1822, pp. 296-297.

fig. 4 - Southwark Bridge as seen from Bank-side, 1819 ((c) Museum of London)

condition of a simple artisan to that of the creator and proprietor of one of the finest mechanical establishments in Great Britain'. One steam engine design in particular was singled out for special attention - Maudslay's table engine. Dupin was impressed in the construction of such engines noting their 'precision', 'smoothness and regularity of their movements' and in design terms how they took up 'very little space'. Such engines were eagerly bought by London workshop and manufactory owners as they were ideal for use in the confined urban environment.

Having considered Dupin's visits and texts in terms of Anglo-French technical exchange, it is worth widening the frame and scale to a global context. A number of Indian engineers visited Britain to study marine engineering and learn about new inventions. Their perspective and contribution to technological exchange and transfer has received little study.²⁶ In 1839, the Parsi Bombay engineer

Ardaseer Cursetjee set off on an overland journey to Britain via Egypt. Wherever he stopped along the way he saw exported British machinery in use, much of it made in London. At Boolak, the northern harbour of Cairo, he toured an iron foundry where a small high-pressure steam engine made by Galloway was in operation and at a copper works a large steam engine also by the same maker of twenty four horse power which drove three pairs of rollers and four furnaces. At Alexandria, he visited a dockyard and found a 'beautiful' Holtzapffel lathe designed for making toothed wheels lying idle because the workmen did not understand how to use it.²⁷ Cursetjee's aim in London was to work in a Thames shipbuilding yard when steamboats and marine engines were constructed so that on his return to India he would be able

"to impart to my countrymen the benefit of my researches in a branch of science, which has greater influence upon the interests of mankind than all the discoveries of the many centuries past; for such

²⁶ See Michael Herbert Fisher *Counterflows to Colonialism: Indian travellers and settlers in Britain 1600-1857*, Delhi, Permanent Black, 2004, pp. 339-351 and Rajesh Kochhar, "Ardaseer Cursetjee (1808-1877), the first Indian fellow of the Royal Society of London", *Notes and Records of the Royal Society*, 47(1), 1993, pp. 33-47.

²⁷ *The Empire writes back*, Part 2, Black and Asian visitors to Britain, 1734-1942, Adam Matthews Publications. Reel 12 Ardaseer Cursetjee, *The diary of an overland journey from Bombay to England*, London, Henington and Galabin, 1840, pp. 14, 20.

must be considered the various adaptations of steam power to the wants, the conveniences, and luxuries of civilized life".

He toured many of the places that European and American engineers visited in London – Holtzapffel's workshop, Maudslay's manufactory, the Adelaide Gallery and the Polytechnic Institution in Regent Street. The latter two public exhibition spaces delighted his cousins Jehangeer Nowrojee and Hirjeebhoy Merwanjee, also naval architects who were visiting England at the same period. They explained that:

"To us then brought up in India for scientific pursuits, and longing ardently to acquire practical information, connected with modern improvements, more particularly with naval architecture, steam engines, steam boats, and steam navigation, these two Galleries of practical science seemed to us to embrace all that we had come over to England to make ourselves acquainted with".²⁸

Cursetjee was placed at Seaward's marine engine manufactory at Millwall and over time gained the trust of his employer working in the drawing office and pattern shop. He attended meetings regularly at the Institution of Civil Engineers. He noted in his diary;

"This is a most delightful and intellectual association, which has already contributed very beneficially to the progress of science and the arts of Great Britain, and which I hope to see imitated in my native country, as the best means of concentrating the scientific resources of India, and of cherishing kindly feeling among men of talent, more especially of advancing the important science of civil engineering".²⁹

He toured Britain taking in all the new technology and manufacturing processes. He viewed the dockyard at Portsmouth including Brunel's block-making machinery, and numerous manufactories in Liverpool and Glasgow. All this knowledge he took back to India. Cursetjee's skill and expertise was admired by English engineers. He was elected to the Institution of Civil Engineers and appointed as the Chief Engineer and Inspector of Machinery at the East India Company's Bombay steam manufactory and foundry. He is believed to have been the first Indian to manage such an undertaking comprising of a large staff of British and Indian workmen. The technological exchange between London and India was very beneficial

to the East India Company's trading operations. It cemented British power in the region and brought new skills to local production centres. The transfer of skills to Indians who worked closely with the British was deemed acceptable. Maintenance of the engines and machinery of steamboats was crucial for securing and developing trade routes. Ultimately, this led to the construction of steamboats in India, a process paralleled a century earlier in the construction of teak ships for the British.³⁰

In 1840, the *Mechanic's Magazine* carried a short feature about Cursetjee's career.³¹ It concluded with a slightly alarmist discussion of British technical exchange. The argument was that while Indians and the inhabitants of other British colonies had received 'no helping hand' other nations had been received 'into this country with open arms':

"Our dockyards have swarmed with them – our manufacturers have been persuaded to receive them – ... scarcely a man-of-war went to sea without some half dozen Russians on board ... The French, too, have always had a free access to all our dockyards, to examine and learn all the improvements of the age ... Egyptians also still swarm in our Government dockyards ...".

It was argued that this liberality to 'sworn enemies' should end and more encouragement be given to Indians. A disturbing picture of a global war was presented where the French, Egyptians and Russians would 'form a league against us' and to counter this threat 'an army and a fleet' would be raised in 'our Indian possessions inferior to none in the world.'

Dupin found the same kind of openness and friendship, as Cursetjee had met with, amongst London's engineers. Thomas Telford and John Rennie became friends and correspondents. He appraised their work as well as that of manufacturers such as Henry Maudslay. Dupin writings can be set alongside the views and opinions of London engineers in regards to technical exchange and transfer when they gave evidence to the government *Select Committee on artizans and machinery* (1824).³² They discussed the consequences of the law that prohibited the export of certain machinery and tools. They revealed

30 See Andrew Lambert, "Strategy, policy and shipbuilding: the Bombay Dockyard, the Indian Navy and Imperial Security in the Eastern Seas", 1784-1869, in H. V. Bowen, Margarette Lincoln and Nigel Rigby ed., *The worlds of the East India Company*, Woodbridge, Boydell Press, 2006, pp. 137-151.

31 *Mechanic's magazine*, 1840, 12 September, No. 892, pp. 285-286.

32 *Six Reports from the Select Committee on artizans and machinery – 23 February – 21 May 1824* [facsimile edition], London, Frank Cass, 1968.

28 Jehangeer Nowrojee and Hirjeebhoy Merwanjee, *Journal of a residence of two and half years in Great Britain*, London, W. H. Allen, 1841, p. 120.

29 A. Cursetjee, *op. cit.*, pp. 41-42.

that there were excellent channels of communication between London and Paris, both of a commercial as well as a technical nature. Most of the engineers seemed to have paid visits to the continent. John Martineau noted his 'numerous connections' and 'constant communication ... with that city'. Questioning revealed how 'English artizans' had been lured to France to work at Chaillot and Charenton, the former works specialised in the 'manufacture of machinery' and the latter had recently 'erected rolling mills for making iron bars'.³³ Reading between the lines, it would appear that some English manufacturers circumvented the law through shipping machinery in parts, making it very difficult for customs officers to identify what was being exported. Workmen followed later, completing the skilled assembly of the machine at the client's manufactory.

It was reported that Mr Manby at the Charenton works had 'established iron steamboats on almost every river in France'; the machinery to run them had been entirely exported from England.³⁴ Other Englishmen such as Steele and Edwards were employed to help run the works at Chaillot. Martineau had been informed that there were about 500 Englishmen working there. Care has to be taken with such evidence as the London engineers may have been trying to alter government policy to allow the free export of tools and machinery. They expressed the opinion that the financial and economic profitability of such overseas machine and tool making manufactories would be undermined if British technology was freely available for export at current prices. The communities of English workmen at iron foundries and engine manufactories near Paris were noted by many visitors. In the early XIXth century the code-written diaries of Anne Lister, known for their explicit accounts of lesbian affairs, there is a reference to British workers in Paris. She meets three English workmen at the new Bourse who were employed in 'the installation of the steam apparatus to heat the building'. Probably as a result of a conversation with them she was able to record in her diary that:

"5 hundred English workmen employed (workmen, women & children) living at Charenton where the iron foundry is, under Mr Manby. All employed by the kg. have from 5 to 10 francs a day. Have a church & clergyman – 'very fine preacher' – at Charenton. Quite an English village".³⁵

She gave them some money for drink. As an educated and enlightened Englishwoman, during her time in Paris, she visited the *Conservatoire des Arts et Métiers* where she viewed the trade models made at the suggestion of Mme Genlis 'for the instruction of the children of the Duke of Orleans'. She was denied access to the 'chambres particulières' by a man in king's livery as they had no letter permitting them entry. She and her companion were told that such items on display were 'not interesting to ladies – full of mathematical instruments and chronometers etc.' Schinkel also visited the *Conservatoire des Arts et Métiers* and then was taken on immediately to Manby's works at Charenton.³⁶ Obviously, the ironworks with its furnaces, hammers, rollers and steam-engines made an impressive sight.

The progress of French manufacturers, possibly owing something to Dupin's writings and actions, was revealed by Alexander Galloway, the radical London engineer and owner of a machine manufactory employing eighty men. He knew Dupin, describing him as 'a most able man' someone who possessed 'great mechanical knowledge'.³⁷ Galloway had visited France in 1818 and then returned again in 1823 to view the public exposition in the Louvre. He was astonished at the progress of French manufactures, particularly in 'bar and sheet iron, sheet steel, copper of every class, together with brass'.³⁸ Although the export of British machinery and tools was restricted, specifications, descriptions and drawings of many new machines were freely available such as those published by the Society for the Encouragement of Arts and Sciences. Galloway said that this allowed

"foreigners all the advantage of our own knowledge, and ... the means of fabricating all we know, with as much readiness as any native of this country can possess; and in many instances, patent machines are known sooner in France than they are in this country".³⁹

He also explained that Dupin had asked him to supply him with drawings.⁴⁰ What would Dupin have done with them? No doubt he would have circulated them to French engineers and manufacturers and deposited them in relevant archives where they could be easily consulted. Thus, the French were kept up-to-date with the latest British technological inventions and improvements.

Admission to some manufactories was denied to foreigners. Galloway explained that Dupin was unlikely to have been admitted to Boulton & Watt's manufactory as

33 *First report from the Select Committee on artizans and machinery*, p. 6.

34 *Ibid.*, p. 8.

35 *No Priest but love, excerpts from the diaries of Anne Lister, 1824-26*, edited by Helena Whitbread, Otley, Smith Settle, 1992, pp. 195, 197-198.

36 K. F. Schinkel, *op. cit.*, p. 49.

37 *First report from the Select Committee on artizans and machinery*, p. 19.

38 *Ibid.*, p. 16.

39 *Ibid.*, p. 19.

40 *Ibid.*, p. 20.

"they have displayed an uncommon degree of mystery; and have always *shut* their works against any competent judge in England, and therefore foreigners have been no worse treated than anybody else".⁴¹

This brings up the question of why Dupin made no detailed reference to the works of Bryan Donkin. He viewed a continuous paper-making machine in operation near Newcastle, noting it to be the invention of Didot. This was arguably the most remarkable technological transfer from France to Britain at the beginning of the XIXth century, along with the Jacquard loom. Dupin mentioned it just in passing. The continuous paper-making machine, well known to historians of the paper industry, has probably not been given sufficient standing in general histories of the industrial revolution.⁴² The story of how the invention was brought to England and perfected reveals much about technical exchange between the two countries.

It was Louis Robert, an inventor working as a book-keeper in Leger Didot's papermaking works at Essonnes who devised the machine and made a small working model of it between 1796 and 1798. Robert obtained a 'brevet d'invention' in 1799 for a term of 15 years and was awarded 8 000 francs for his ingenuity. Didot acquired Robert's patent for 25 000 francs payable in instalments. However, he failed to keep up with his payments and Robert recovered possession of the patent in June 1801. However, before this recovery, Didot had approached his brother-in-law, John Gamble, who was working for the British Commissioner in Paris negotiating the exchange of prisoners of war in France, to see whether he would return to England and take out patents there for the paper making machine. Gamble did this and took out a patent in April 1801. To help with the promotion of the invention, the original working model was brought to London and Didot travelled there also in 1802 during the short peace. Henry and Sealy Fourdrinier, of Huguenot descent who ran a successful wholesale stationery business, agreed to invest in the invention. John Hall, an iron manufacturer at Dartford was approached to make the machine. He passed the work on to his gifted assistant Bryan Donkin who left to set up a manufactory in Bermondsey to start the production of the machine. The works were bankrolled by the Fourdriniers to the tune of £ 31,667, with over a third being directly related to the experiments, improvements and alterations to the paper-making machine. In total, the Fourdriniers were to invest over £ 60,000 and the inability to extend the period of the

patent led to their bankruptcy. The scale of capital needed to invest in such technology was clearly lacking in France at this time. Only in Britain was investment available for such ambitious projects. As has been shown, in terms of bridges and docks, capital investment was raised in London for many commercial undertakings. With the paper-making machine another essential element was required - the ingenuity and invention of one of London's most skilled engineers.

Dupin did not visit Bryan Donkin's London manufactory where the paper making machines were made. Admittance was denied to foreigners here anyway, like at Boulton & Watt, though finished machinery could be viewed. What Donkin wanted to protect were the machines that made the machinery. A few engineers did manage to gain admittance to the works and were astonished at its perfection. Donkin was one of the first manufacturers to standardise parts, making wheels and cogs, rollers and cylinders to such accuracy that spare parts could be shipped out anywhere in the world with great expedition, knowing that they would definitely fit the machine.⁴³ Donkin's achievement in perfecting the papermaking machine was acknowledged by Andrew Ure as was his remarkable manufactory. He said that he had

"never witnessed a more admirable assortment of exquisite and expensive tools, each adapted to perform its part with dispatch and mathematical exactness, though I have seen probably the best machine factories of this country and the Continent".⁴⁴

It was reported that 'after nearly three years of intense application, he produced a self-acting machine for making an endless web of paper'. Furthermore, Donkin continued to make improvements. By the 1830s, the machine was in use all over Europe including France. The 'unfailing regularity, precision, promptitude, and productiveness' earned Donkin in Ure's words a 'place along with Watt, Wedgwood, and Arkwright in the temple of technical fame'. British engineers, such as Donkin, involved with adapting and perfecting French inventions were not investigated by Dupin. All he did was to lament how 'the most ingenious mechanics thus carry to a foreign country the treasure of their industry'.⁴⁵

43 Eugene S. Ferguson ed., *Early engineering reminiscences (1815-40) of George Escot Sellers*, Washington D. C., Smithsonian Institution, 1965, pp. 116-127, and 130.

44 Andrew Ure, *A dictionary of arts, manufactures, and mines*, London, Longman Brown Green and Longmans, 1853, p. 336.

45 C. Dupin (1819), *op. cit.*, pp. 36-37.

41 *Ibid.*, p. 20.

42 A good general introduction can be found in D. C. Coleman, *The British paper industry 1495-1860*, Oxford, Clarendon Press, 1958.