1

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Asia and the Industrial Revolution, 1990

Here a modern historian of technology demonstrates how Indian and East Asian manufacturing techniques were assimilated by Europeans, particularly by the English successors of the Mughal Empire, providing a boost to the industrial revolution in Britain. In what ways was Indian technology considered superior prior to the industrial revolution? How did European products gain greater markets than those of India?

THINKING HISTORICALLY

Notice how the author distinguishes between capitalism and the industrial revolution. Was India more industrially advanced than capitalistic? Did the British conquest of India benefit more from capitalism, industry, or something else?

Deindustrialization

During the eighteenth century, India participated in the European industrial revolution through the influence of its textile trade, and through the investments in shipping made by Indian bankers and merchants. Developments in textiles and shipbuilding constituted a significant industrial movement, but it would be wrong to suggest that India was on the verge of its own industrial revolution. There was no steam engine in India, no coal mines, and few machines. . . . [E]xpanding industries were mostly in coastal areas. Much of the interior was in economic decline, with irrigation works damaged and neglected as a result of the breakup of the Mughal Empire and the disruption of war. Though political weakness in the empire had been evident since 1707, and a Persian army heavily defeated Mughal forces at Delhi in 1739, it was the British who most fully took advantage of the collapse of the empire. Between 1757 and 1803, they took control of most of India except the Northwest. The result was that the East India Company now administered major sectors of the economy, and quickly reduced the role of the big Indian bankers by changes in taxes and methods of collecting them.

Meanwhile, India's markets in Europe were being eroded by competition from machine-spun yarns and printed calicoes made in Lancashire, and high customs duties were directed against Indian imports into

Source: Arnold Pacey, *Technology in World Civilization* (Cambridge: MIT Press, 1990), 128–35.

Britain. Restrictions were also placed on the use of Indian-built ships on voyages to England. From 1812, there were extra duties on any imports they delivered, and that must be one factor in the decline in shipbuilding. A few Indian ships continued to make the voyage to Britain, however, and there was one in Liverpool Docks in 1839 when Herman Melville arrived from America. It was the *Irrawaddy* from Bombay and Melville commented: "Forty years ago, these merchantmen were nearly the biggest in the world; and they still exceed the generality." They were "wholly built by the native shipwrights of India, who . . . surpassed the European artisans." . . .

Attitudes to India changed markedly after the subcontinent had fallen into British hands. Before this, travellers found much to admire in technologies ranging from agriculture to metallurgy. After 1803, however, the arrogance of conquest was reinforced by the rapid development of British industry. This meant that Indian techniques which a few years earlier seemed remarkable could now be equalled at much lower cost by British factories. India was then made to appear rather primitive, and the idea grew that its proper role was to provide raw materials for western industry, including raw cotton and indigo dye, and to function as a market for British goods. This policy was reflected in 1813 by a relaxation of the East India Company's monopoly of trade so that other British companies could now bring in manufactured goods freely for sale in India. Thus the textile industry, iron production, and shipbuilding were all eroded by cheap imports from Britain, and by handicaps placed on Indian merchants.

By 1830, the situation had become so bad that even some of the British in India began to protest. One exclaimed, "We have destroyed the manufactures of India," pleading that there should be some protection for silk weaving, "the last of the expiring manufactures of India." Another observer was alarmed by a "commercial revolution" which produced "so much present suffering to numerous classes in India."

The question that remains is the speculative one of what might have happened if a strong Mughal government had survived. Fernand Braudel argues that although there was no lack of "capitalism" in India, the economy was not moving in the direction of home-grown industrialization. The historian of technology inevitably notes the lack of development of machines, even though there had been some increase in the use of water-wheels during the eighteenth century both in the iron industry and at gunpowder mills. However, it is impossible not to be struck by the achievements of the shipbuilding industry, which produced skilled carpenters and a model of large-scale organizations. It also trained up draughtsmen and people with mechanical interests. It is striking that one of the Wadia shipbuilders installed gas lighting in his home in 1834 and built a small foundry in which he made parts for steam engines. Given an independent and more prosperous India, it is difficult not to believe that a response to British industrialization might well have taken the form of a spread of skill and innovation from the shipyards into other industries.

As it was, such developments were delayed until the 1850s and later, when the first mechanized cotton mill opened. It is significant that some of the entrepreneurs who backed the development of this industry were from the same Parsī families as had built ships in Bombay and invested in overseas trade in the eighteenth century.

Guns and Rails: Asia, Britain, and America

Britain's "conquest" of India cannot be attributed to superior armaments. Indian armies were also well equipped. More significant was the prior breakdown of Mughal government and the collaboration of many Indians. Some victories were also the result of good discipline and bold strategy, especially when Arthur Wellesley, the future Duke of Wellington, was in command. Wellesley's contribution also illustrates the distinctive western approach to the organizational aspect of technology. Indian armies might have had good armament, but because their guns were made in a great variety of different sizes, precise weapons drill was impossible and the supply of shot to the battlefield was unnecessarily complicated. By contrast, Wellesley's forces standardized on just three sizes of field gun, and the commander himself paid close attention to the design of gun carriages and to the bullocks which hauled them, so that his artillery could move as fast as his infantry, and without delays due to wheel breakages.

Significantly, the one major criticism regularly made of Indian artillery concerned the poor design of gun carriages. Many, particularly before 1760, were little better than four-wheeled trolleys. But the guns themselves were often of excellent design and workmanship. Whilst some were imported and others were made with the assistance of foreign craftworkers, there was many a brass cannon and mortar of Indian design, as well as heavy muskets for camel-mounted troops. Captured field guns were often taken over for use by the British, and after capturing ninety guns in one crucial battle, Wellesley wrote that seventy were "the finest brass ordnance I have ever seen." They were probably made in northern India, perhaps at the great Mughal arsenal at Agra.

Whilst Indians had been making guns from brass since the sixteenth century, Europeans could at first only produce this alloy in relatively small quantities because they had no technique for smelting zinc. By the eighteenth century, however, brass was being produced in large quantities in Europe, and brass cannon were being cast at Woolwich Arsenal in London. Several European countries were importing metallic zinc from China for this purpose. However, from 1743 there was a smelter at Bristol in England producing zinc, using coke[1] as fuel, and zinc smelters were also developed in Germany. At the end of the century, Britain's imports of zinc from the Far East were only about forty tons per year. Nevertheless, a British party which visited China in 1797 took particular note of zinc smelting methods. These were similar to the process used in India, which involved vaporizing the metal and then condensing it. There is a suspicion that the Bristol smelting works of 1743 was based on Indian practice, although the possibility of independent invention cannot be excluded.

A much clearer example of the transfer of technology from India occurred when British armies on the subcontinent encountered rockets, a type of weapon of which they had no previous experience. The basic technology had come from the Ottoman Turks or from Syria before 1500, although the Chinese had invented rockets even earlier. In the 1790s, some Indian armies included very large infantry units equipped with rockets. French mercenaries in Mysore had learned to make them, and the British Ordnance Office was enquiring for somebody with expertise on the subject. In response, William Congreve, whose father was head of the laboratory at Woolwich Arsenal, undertook to design a rocket on Indian lines. After a successful demonstration, about two hundred of his rockets were used by the British in an attack on Boulogne in 1806. Fired from over a kilometre away, they set fire to the town. After this success, rockets were adopted quite widely by European armies, though some commanders, notably the Duke of Wellington, frowned on such imprecise weapons, and they tended to drop out of use later in the century. What happened next, however, was typical of the whole British relationship with India. William Congreve set up a factory to manufacture the weapons in 1817, and part of its output was exported to India to equip rocket troops operating there under British command.

Yet another aspect of Asian technology in which eighteenth-century Europeans were interested was the design of farm implements. Reports on seed drills and ploughs were sent to the British Board of Agriculture from India in 1795. A century earlier the Dutch had found much of interest in ploughs and winnowing machines of a Chinese type which they saw in Java. Then a Swedish party visiting Guangzhou (Canton) took a winnowing machine back home with them. Indeed, several of these machines were imported into different parts of Europe, and similar devices for cleaning threshed grain were soon being made there. The

[1] Fuel from soft coal. [Ed.]

inventor of one of them, Jonas Norberg, admitted that he got "the initial idea" from three machines "brought here from China," but had to create a new type because the Chinese machines "do not suit our kinds of grain." Similarly, the Dutch saw that the Chinese plough did not suit their type of soil, but it stimulated them to produce new designs with curved metal mould-boards in contrast to the less efficient flat wooden boards used in Europe hitherto.

In most of these cases, and especially with zinc smelting, rockets, and winnowing machines, we have clear evidence of Europeans studying Asian technology in detail. With rockets and winnowers, though perhaps not with zinc, there was an element of imitation in the European inventions which followed. In other instances, however, the more usual course of technological dialogue between Europe and Asia was that European innovation was challenged by the quality or scale of Asian output, but took a different direction, as we have seen in many aspects of the textile industry. Sometimes, the dialogue was even more limited, and served mainly to give confidence in a technique that was already known. Such was the case with occasional references to China in the writings of engineers designing suspension bridges in Britain. The Chinese had a reputation for bridge construction, and before 1700 Peter the Great had asked for bridge-builders to be sent from China to work in Russia. Later, several books published in Europe described a variety of Chinese bridges, notably a long-span suspension bridge made with iron chains.

Among those who developed the suspension bridge in the West were James Finley in America, beginning in 1801, and Samuel Brown and Thomas Telford in Britain. About 1814, Brown devised a flat, wrought-iron chain link which Telford later used to form the main structural chains in his suspension bridges. But beyond borrowing this specific technique, what Telford needed was evidence that the suspension principle was applicable to the problem he was then tackling. Finley's two longest bridges had spanned seventy-four and ninety-three metres, over the Merrimac and Schuylkill Rivers in the eastern United States. Telford was aiming to span almost twice the larger distance with his 176-metre Menai Bridge. Experiments at a Shropshire ironworks gave confidence in the strength of the chains. But Telford may have looked for reassurance even further afield. One of his notebooks contains the reminder, "Examine Chinese bridges." It is clear from the wording which follows that he had seen a recent booklet advocating a "bridge of chains," partly based on a Chinese example, to cross the Firth of Forth in Scotland.