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Leonardo to the INTERNET

Technology and Culture from the Renaissance to the Present

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CHAPTER 4

1840 – 1914

Instruments of Empire

British technology, propelled forward by the industrial revolution, reached something of a plateau by the mid-nineteenth century. The display of Britain's mechanical marvels at London's Crystal Palace exposition in 1851 stirred the imagination, but now British industry faced a host of rising competitors in Europe and North America. (And as chapter 5 describes it was Germany and the United States that would spearhead a "second" industrial revolution in the decades to come.) At midcentury in Britain, and soon across much of the industrialized world, a new technological era took shape as colonial powers attended to the unparalleled problems of far-flung overseas empires. To a striking extent, inventors, engineers, traders, financiers, and government officials turned their attentions from blast furnaces and textile factories at home to steamships, telegraphs, and railway lines in the colonies. These technologies, supported and guided by empire, made possible the dramatic expansion of Western political power and economic influence around the globe.

Britain was of course no newcomer to empire. In 1763, after the Seven Years' War, Britain had gained most of France's holdings in India and North America. In the next decade, however, American colonists rejected new taxes to pay for the heavy costs of this war and initiated their rebellion, which, in the view of one Englishman, would have failed if only Britain had possessed effective communications technology.[1] British rule in India was the next dilemma. The East India Company, a creature of Britain's mercantilist past, ran afoul of Britain's rising industrialists. Owing greatly to their relentless antimercantile lobbying, Parliament in 1813 stripped the East India Company of its monopoly of the lucrative Indian trade and, by rechartering the company in 1833, ended its control over private British traders within India and terminated its sole remaining commercial monopoly, that of trade with China. New players crowded in. The Peninsular & Oriental Steam Navigation Company, the legendary "P&O," gained a valuable mail contract between England and Egypt in 1840, with an onward connection to India. The rise of "free trade" in the 1840s, also promoted by British industrialists keen to secure raw materials for their factories and cheap food for their factory workers, led to a wild scramble in the Far East. At least

FIG. 4.1. INDIAN MUTINY OF 1857–1858

"Attack of the Mutineers on the Redan Battery at Lucknow, July 30th 1857." British accounts inevitably stressed the "atrocities" committed by the rebel Indian soldiers, but in his *Memories of the Mutiny* (London, 1894, pp. 273–80), Col. F. C. Maude detailed his own part in desecrating the bodies of executed Indian prisoners at Bussarat Gunj.

Illustration from Charles Ball, *The History of the Indian Mutiny* (London: London Printing and Publishing, 1858–59), vol. 2, facing p. 9.

sixty British trading firms in China clamored for military assistance to uphold "free trade" there. The British government intervened, and this led to the first opium war (1840–42).

New technologies were critical to both the penetration phase of empire, in which the British deployed steam-powered gunboats and malaria-suppressing quinine to establish settlements inland beyond the coastal trading zones, and in the subsequent consolidation phase that stressed the maintenance and control of imperial outposts through a complex of public works.[2] Effective military technologies such as steam-powered gunboats, breechloading rifles, and later the fearsome rapid-firing machine guns helped the British extend their control over the Indian subcontinent and quell repeated uprisings. Even before the Indian Mutiny of 1857–58, which was a hard-fought battle against insurgent Indian troops who ranged across much of the northern and central regions of India and whose defeat cost the staggering sum of £40 million, there were major military campaigns nearly every decade (fig. 4.1). These included three Mahrattan wars (1775 to 1817), two Mysore wars in the 1780s and 1790s, the Gurkha war of 1814–15 in Nepal, two Anglo-Burmese

wars in the 1820s and 1852, and the first of two opium wars in China. In the 1840s alone the British conducted a three-year military occupation to subdue and secure Afghanistan, which failed in 1842, a swift campaign crushing the Sinds in what is now Pakistan the following year, and the bloody Sikh wars over the Punjab in 1845 and 1848.

The tremendous cost of these military campaigns as well as the ongoing expenses for transporting, lodging, provisioning, and pensioning imperial officials simply ate up the profits of empire. We noted in chapter 3 that the East India Company put on the imperial payroll 1,200 workers in London alone. On balance, these collateral expenses of British empire completely absorbed the sizable profits of imperial trade. Imperialism in India did not generate wealth. Rather it shifted wealth from taxpayers in India and Britain to prominent traders, investors, military officers, and imperial officials, who became its principal beneficiaries.[3] This point is important to emphasize because critics have long taken for granted that the imperatives of capitalism required imperialism (for acquiring cheap raw materials and disposing of surplus factory-made goods) and that the machinery of imperialism made money. Equally important, the wealth-*consuming* nature of imperial technologies sets off the imperial era from the earlier wealth-generating ones of commerce and industry. Imperial officials, and the visionary technology promoters they funded, spared no expense in developing instruments of empire that promised to achieve rapid and comfortable transportation, quick and secure communication, and above all sufficient and effective military power.

STEAM AND OPIUM

Steam entered India innocently enough in 1817 when an 8-horsepower steam engine was brought to Calcutta in a short-lived attempt to dredge the Hooghly River. This plan was revived in 1822 when the East India Company bought the engine and again used it to clear a channel up the Hooghly to speed the passage of sailing vessels to Calcutta proper, some 50 miles inland from the ocean. At the time, Calcutta was the chief British port in India and the principal seat of its political power. The second city, Bombay, on India's western coast, was actually closer as the crow flies to London, but favorable winds made it quicker to sail to Calcutta via the African cape. The initial experiments with steam engines around Calcutta were, from a commercial point of view, rather disappointing. The steamship *Diana* worked on the Hooghly for a year as a passage boat while the more substantial *Enterprise*, a 140-foot wooden vessel with two 60-horsepower engines, a joint project of Maudslay & Field, the great

London engineers, and Gordon & Company, was the first steam vessel to reach India under its own power, having steamed around the African cape in early 1825. The trip took a discouraging 113 days. The huge amount of fuel required by early steamers made them commercially viable only where abundant supplies of fuel were readily at hand, such as along the Mississippi River, or where their use secured some special advantage that covered their astronomical operating costs.[4]

An early indication of the significance of steamers in imperial India came in the first Anglo-Burmese war (1824–26). At first the war went badly for the British, who hoped to claim valuable tea-growing lands recently annexed by Burma. Britain's hope for a quick victory literally bogged down—in the narrow twisted channels of the lower Irrawaddy River. Britain's majestic sailing vessels were no match for the Burmese *prau*, a speedy wooden craft of around 90 feet in length propelled by up to seventy oarsmen and armed with heavy guns fixed to its bow. The British lost three-quarters of their force, mostly to disease, in the swamps of the Irrawaddy. The tide turned abruptly, however, when the British ordered up three steam vessels whose shallow draft and rapid maneuverability altered the balance of power. The *Enterprise* rapidly brought in reinforcements from Calcutta, while the *Pluto* and *Diana* directly towed British sailing ships into militarily advantageous positions. Another steam vessel that saw action later in the war was the *Irrawaddy*, arguably the first steam gunboat, with its complement of ten 9-pound guns and one swivel-mounted 12-pound gun. The defining image of this war was of the *Diana*, known to the Burmese as "fire devil," tirelessly running down the *prau*s and their exhausted oarsmen. The king of Burma surrendered when the British force, assisted by the *Diana*, reached 400 miles upstream and threatened his capital.

Following this imposing performance in Burma, steamboat ventures proliferated in the next decade. The East India Company deployed steamers to tow sailing vessels between Calcutta and the ocean and dispatched the pioneering steamer up the Hooghly and onward to the Ganges River. Accurately mapping the Ganges had been a necessary first step in transforming the vague territorial boundaries assumed by the company into a well-defined colonial state. To this end one could say that the first imperial technology deployed on the Ganges was James Rennell's detailed *Map of Hindoostan* (1782). Rennell also published the equally valuable *Bengal Atlas* (1779).[5] Regular steam service on the Ganges between Calcutta and upstream Allahabad began in 1834; the journey took between twenty and twenty-four days depending on the season. The river journey bore a high price. A cabin on a steamer between Calcutta and Allahabad cost 400 rupees, or £30, about half the cost of the

entire journey from London to India and completely beyond the means of ordinary Indians. Freight rates from £6 to £20 per ton effectively limited cargoes to precious goods like silk and opium, in addition to the personal belongings of traveling officials and the necessary imperial supplies such as guns, medicines, stationery, official documents, and tax receipts. In the strange accounting of imperialism, however, even these whopping fares may have been a bargain for the East India Company, since in the latter 1820s it was paying a half-million rupees annually for hiring boats just to ferry European troops up and down the Ganges. Quicker river journeys also trimmed the generous traveling allowances paid to military officers. The economics of river transport were not only administrative ones. General Sir Charles Napier, who led the military campaign in the 1830s to open up for steam navigation the Indus River, India's second most important inland artery, pointed out direct commercial consequences. He wrote, "India should suck English manufacturers up her great rivers, and pour down these rivers her own varied products."[6]

Steam also promised to tighten up the imperial tie with London. Before the 1830s a letter traveled by way of a sailing vessel from London around the African cape and could take five to six months to arrive in India. And because no ship captain would venture into the Indian Ocean's seasonal monsoons, a reply might not arrive back in London for a full two years. Given these lengthy delays, India was not really in London's control. British residents in Madras urged, "Nothing will tend so materially to develop the resources of India . . . and to secure to the Crown . . . the integrity of its empire over India, as the rapid and continued intercourse between the two countries by means of steam." Merchants and colonial administrators in Bombay were eager to secure similar benefits. In the new age of steam Bombay's proximity to the Red Sea was a distinct advantage. From there the Mediterranean could be reached by a desert crossing between Suez and Cairo and then down the Nile River to the port at Alexandria. Efforts of the Bombay steam lobby resulted in the 1829 launch of the *Hugh Lindsay*, powered by twin 80-horsepower engines, which carried its first load of passengers and mail from Bombay to Suez in twenty-one days. Even adding the onward link to London, the *Hugh Lindsay* halved the transit time for mail. So valuable was the Red Sea route that the British became by far the largest users of the French-funded, Egyptian-built Suez Canal, opened in 1869. In 1875 Britain purchased the Egyptian ruler's entire share in the canal company for £4 million and in 1882 invaded Egypt to maintain control over this vital imperial lifeline. The 102-mile-long canal cast a long shadow in the region. British troops remained in Egypt over seven decades until after the Suez Crisis in 1954.

Already by 1840 steamboats in several ways had shown substantial capacity for knitting together the wayward strands of the British Empire. In the opium war of 1840–42 they proved their value in projecting raw imperial power. The opium wars, in the early 1840s and again in the late 1850s, were triggered by China's desperate attempts to restrain "free trade" in opium. Opium was grown on the East India Company's lands in Bengal, auctioned in Calcutta, and then shipped by private traders to China. The large-scale trade in opium closed a yawning trade gap with the Celestial Empire, for whose tea Britain's citizens had developed an insatiable thirst. British exports of factory-made cotton to India completed the trade triangle. Opium, like all narcotics, is highly addictive. (One of the most chilling scenes in the Sherlock Holmes series is a visit to one of London's numerous opium dens, in "The Man with the Twisted Lip," where "through the gloom one could dimly catch a glimpse of bodies lying in strange fantastic poses . . . there glimmered little red circles of light, now bright, now faint, as the burning poison waxed or waned in the bowls of the metal pipes.") The opium war began when China took determined steps to ban importation of the destructive substance, and the British government, acting on the demand of Britain's sixty trading firms with business in China, insisted on maintaining "free trade" in opium and dispatched a fleet of warships to China.

Steamers played a decisive role in the opium war. The British fleet was able to do little more than harass coastal towns until the steamer *Nemesis* arrived in China in November 1840, after a grueling eight-month voyage around the African cape. The *Nemesis*, at 184 feet in length, was not merely the largest iron vessel of the time. It was, more to the point, built as a gunboat with twin 60-horsepower engines, shallow 5-foot draft, two swiveling 32-pound guns fore and aft, along with fifteen smaller cannon. The *Nemesis* was central in the 1841 campaign that seized the major city of Canton. *Nemesis* sank or captured numerous Chinese war "junks" half its size, took possession of a 1,000-ton American-built trading ship recently purchased by the Chinese, towed out of the way deadly oil-and-gunpowder "fire rafts," and attacked fortifications along the river passage up to Canton. The *Nemesis*, wrote its captain, "does the whole of the advanced work for the Expedition and what with towing transports, frigates, large junks, and carrying cargoes of provisions, troops and sailors, and repeatedly coming into contact with sunken junks—rocks, sand banks, and fishing stakes in these unknown waters, which we are obliged to navigate by night as well as by day, she must be the strongest of the strong to stand it."[7]

In 1842 the *Nemesis*, now leading a fleet comprising ten steamers, including its sister ship *Phlegethon*, eight sailing warships, and fifty smaller vessels, carried the

campaign up the Yangtze River. At one battle, *Nemesis* positioned an eighteen-gun warship, whose guns dispersed the Chinese fleet, including three human-powered paddle wheelers. The steamers promptly overtook them. The steamers also hauled the sailing vessels far up the river, over sandbars and mud, to take control of Chinkiang (today's Zhenjiang) at the junction of the Yangtze River and the Grand Canal. The Grand Canal was China's own imperial lifeline, linking the capital, Beijing, in the north to the rice-growing districts in the south. The Chinese had little choice but to accept British terms. In 1869, in the aftermath of a second opium war, the Chinese Foreign Office pleaded with the British government to curtail the deadly trade:

> The Chinese merchant supplies your country with his goodly tea and silk, conferring thereby a benefit upon her; but the English merchant empoisons China with pestilent opium. Such conduct is unrighteous. Who can justify it? What wonder if officials and people say that England is willfully working out China's ruin, and has no real friendly feeling for her? The wealth and generosity of England are spoken by all; she is anxious to prevent and anticipate all injury to her commercial interests. How is it, then, she can hesitate to remove an acknowledged evil? Indeed, it cannot be that England still holds to this evil business, earning the hatred of the officials and people of China, and making herself a reproach among the nations, because she would lose a little revenue were she to forfeit the cultivation of the poppy.[8]

Unfortunately for the Chinese people more than "a little revenue" was at play. Opium was a financial mainstay of the British Empire, accounting for one-seventh of the total revenues of British India. Repeated attempts by humanitarian reformers to eliminate the opium trade ran square into the sorry fact that British India was hooked on opium. While opium addiction was a severe problem in some districts of India, the imperial system depended on the flow of opium money. Annual net opium revenues—the export taxes on Malwa opium grown in western India added to the operating profits from growing opium in Bengal in the east, manufacturing it in government factories at Patna and Ghazipur, and exporting the product to China—were just over £3.5 million in 1907–8, with another £981,000 being added in the excise tax on opium consumption in India.[9] In 1907 Britain officially agreed over a ten-year period to wind down the odious enterprise. This was difficult. In April 1917 the Shanghai Opium Combine, a group of private British traders, was left holding around 420,000 pounds of opium and with no official legal market; a

corrupt vice president of China purchased the lot for $20 million, purportedly for "medical purposes." Five years later, humanitarian reformers in Peking organized an international anti-opium association to enforce existing international laws and crack down on "vast quantities of morphia . . . manufactured in, and transported across, the United States" to evade existing laws and agreements. Finally, after much additional pain and suffering, in the 1950s the People's Republic of China suppressed opium with brutal force.[10]

TELEGRAPHS AND PUBLIC WORKS

In the industrializing countries of Western Europe and North America, telegraph systems grew up alongside railroads. Telegraph lines literally followed railway lines, since telegraph companies frequently erected their poles in railroad right-of-ways. Telegraphs in these countries not only directed railroad traffic, a critical safety task because all railways had two-way traffic but most had only a single track; telegraphs also became the information pipelines between commercial centers, carrying all manner of market-moving news. In India, by contrast, the driving force behind the telegraph network was not commerce or industry but empire. As one Englishman phrased it, "the unity of feeling and of action which constitutes imperialism would scarcely have been possible without the telegraph."[11]

Telegraph lines were so important for imperialism in India that they were built in advance of railway lines (fig. 4.2). The driving figure in this endeavor was the Marquis of Dalhousie. As governor-general over India from 1848 to 1856, Dalhousie presided over an energetic campaign to bring Western ideas and Western technology to India. Dalhousie's territorial annexations in these years increased by almost half the size of British India and added substantially to the administrative complexity of governing it. The new possessions included the Punjab in the far northwest, the province of Pegu in Burma, and five native states including Satara, Sambalpur, Nagpur, Jhansi, and Oudh. The addition of Nagpur was especially welcomed by Lancashire cotton industrialists eager to secure alternative sources of raw cotton (to lessen their dependence on the American South as the Civil War loomed); colonial troops deployed to Nagpur helped fortify the continent-spanning road between Bombay and Calcutta. To help consolidate these far-flung holdings Dalhousie launched or completed a number of technological ventures, including the Grand Trunk Road and the Ganges Canal, in addition to the railroad and wide-ranging Public Works Department discussed later. His first priority was the telegraph.

Dalhousie shaped India's telegraph network to fulfill the administrative and

FIG. 4.2. ERECTING THE INDIAN TELEGRAPH

The telegraph network across India as well as between India and Europe depended on native Indian labor to erect, operate, and maintain the lines.

Frederic John Goldsmid, *Telegraph and Travel* (London: Macmillan, 1874), frontispiece.

military imperatives of empire. The first experimental line was built in two phases and ran from Calcutta to the mouth of the Hooghly River at Kedgeree. Events immediately proved its significance. News of the outbreak of the second Anglo-Burmese war arrived by ship at Kedgeree on 14 February 1852 and was telegraphed at once to Dalhousie at Calcutta. "If additional proof of its political value were required," Dalhousie wrote in the midst of war two months later, "it would be found in recent events when the existence of an electric telegraph would have gained for us days when even hours were precious instead of being dependent for the conveyance of a material portion of our orders upon the poor pace of a dak foot-runner."[12] In December Dalhousie delineated his nationwide plan. His top priority was "a telegraph line connecting Calcutta, Benaras, Allahabad, Agra, Amballa, Lahore and Peshawar" to link up all locations "in which the occurrence of political events was at all likely." After the line to Peshawar, at the Afghan border in the far west, came a line to Bombay, through which a line to London might be completed. Of lesser importance was a line to Madras, considered politically reliable. Moreover, to connect Calcutta with Madras Dalhousie planned not a direct telegraph line south down the eastern coastline but a much longer, indirect connection via Bombay. From Bombay

to Madras this line down the western coast passed through the military outposts at Poona, Bellary, Bangalore, and Arcot. The India Office in London quickly approved funds for the entire 3,150-mile network outlined in Dalhousie's plan.

Construction on the telegraph network began in November 1853, after a team of sixty installers was trained under the supervision of William O'Shaughnessy. O'Shaughnessy, a self-taught electrical expert and formerly deputy assay master of the Calcutta Mint, pushed the lines forward with breakneck speed. At first his installers placed a "flying line" of 5/16-inch iron rod on uninsulated bamboo poles for immediate military use, later transferring it to insulated poles of stone, ironwood, or teak. Within five months the first trunk line, running the 800 miles from Calcutta to Agra, was opened; and by the end of 1854 the entire national backbone was complete, with links to Peshawar, Bombay, and Madras. Two years later, all the major military stations in India were interconnected by telegraph. Dalhousie, who aimed to mobilize 150,000 troops in one hour with the telegraph, had become acutely worried about increasing signs of military and civil discontent around him by the time he left India in 1856. ("Those who have travelled on an Indian line, or loitered at a Hindoo railway station, have seen the most persuasive missionary at work that ever preached in the East," wrote his biographer. "Thirty miles an hour is fatal to the slow deities of paganism."[13]) The wrenching cultural changes brought by his rapid-fire Westernization touched off a major nationwide rebellion.

The outbreak of the Indian Mutiny, on 10 May 1857, began a nerve-wracking "week of telegraphs." Earlier that spring native Indian troops near Calcutta had in several instances been openly disobedient, refusing to load cartridges in the new Enfield rifle. Loading the rifle required soldiers to bite open cartridges that they believed to be coated with beef or pork fat, substances deeply offensive to Hindus and Muslims. (The Woolwich factory in England had indeed used beef fat, while the Dum-Dum factory in India had apparently not.) On 10 May native troops in Meerut, close to Delhi in the north central part of the country, seized control of that station, after eighty-five native members of a cavalry troop stationed there had been court-marshaled, publicly stripped of their uniforms, and imprisoned for refusing the suspect Enfield cartridges. The rebels marched on Delhi, took control of the city, and proclaimed a new Mogul emperor of India. By destroying the surrounding telegraph lines, the rebels cut off communication with the Punjab to the north but not before a telegraph message had gone out on the morning of 12 May warning the British officers in the Punjab that certain native troops planned a rebellion there the following evening. Officers at Punjab quickly disarmed the native regiments

before they got word of the uprising, which had been sent by foot runner. "Under Providence, the electric telegraph saved us," affirmed one British official. Calcutta heard by telegraph of the fall of Delhi on 14 May and immediately dispatched messages requesting reinforcements for Delhi and Agra and inquiring about numerous potential trouble spots. "All is quiet here but affairs are critical," Calcutta heard on 16 May from Lucknow station. "Get every European you can from China, Ceylon, and elsewhere; also all the Goorkas from the hills; time is everything."[14]

Swift use of the telegraph saved not merely the British in Punjab but arguably the rest of British India as well. The telegraph made possible massive troop movements aimed at the most serious sites of rebellion against British rule. British and loyal native troops returning from Persia were directed to trouble spots in Calcutta, Delhi, and the Punjab; loyal native troops from Madras moved to reinforce Calcutta; while British troops in Ceylon, Burma, and Singapore were called in as well. Officials in Calcutta coordinated steamers and sailing vessels and in short order resolved numerous logistical difficulties, all by telegraph. In June and July the Mutiny spread across the northern and central provinces of India. But by then the deployment of numerous regiments loyal to the British prevented the Indian rebels from gaining ground. The promptness of the British responses astonished them. In the field campaigns that followed, the most famous use of telegraphs was in the Cawnpore–Lucknow "flying line" that aided the British troops in their assaults on the beleaguered Lucknow in November 1857 and March 1858. Isolated acts of rebellion continued until the capture of an important rebel leader in April 1859, and memories of atrocities poisoned relations between rulers and ruled for decades. One rebel on his way to execution pointed out the telegraph wire overhead as "the accursed string that strangles me."[15]

News of the Mutiny took forty days to arrive in London, traveling by steamers, camels, and European telegraphs. Consequently, imperial officials there were helpless bystanders as the conflict unfolded, was fought, and eventually ended. Insistent calls for action in the wake of this exasperating situation led to the inevitable government subsidies, but the first attempts to lay undersea telegraph cables or to use landlines across the Middle East proved expensive, slow, and unreliable. Messages relayed by non-English-speaking telegraph clerks might arrive a month after being sent and be totally unreadable. Not until 1870 was there a reliable telegraph connection between London and India (see fig. 4.3). The first line to open, a double landline running across Europe to Tehran, where it connected with a cable to Karachi via the Persian Gulf, was built by the German firm of Siemens and Halske, a leader in the second industrial revolution (see chapter 5). A second telegraph, also opened

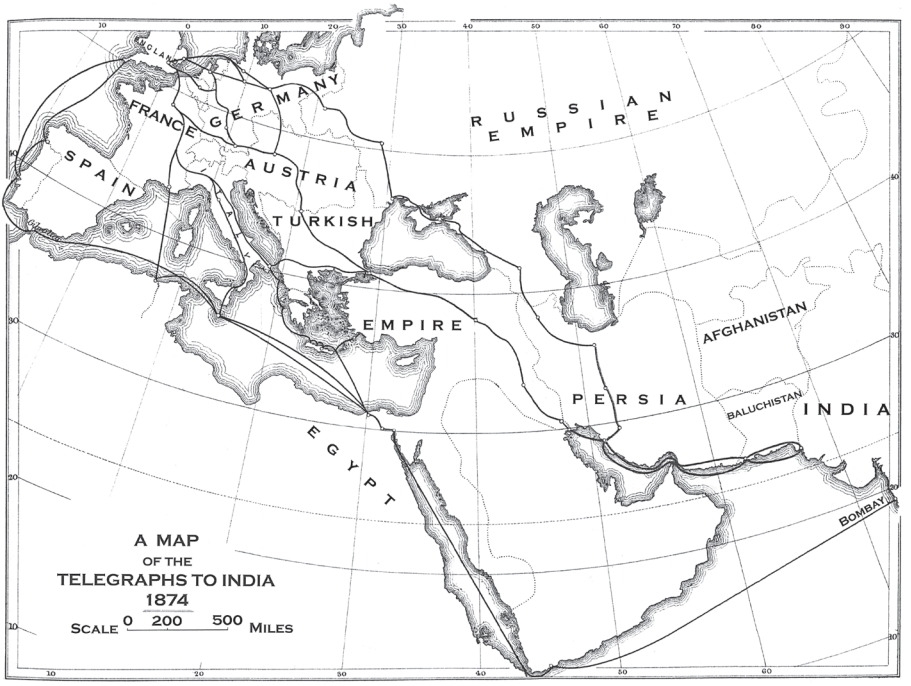

FIG. 4.3. TELEGRAPH LINES BETWEEN INDIA AND EUROPE, 1874

A high-technology imperial lifeline connecting Britain with India was established in 1870. Two overland telegraph lines ran from London, through Europe and the Middle Eastern countries, while a third, all-underwater line went through the Mediterranean Sea, the Suez Canal (opened in 1869), the Red Sea, and on to the Indian Ocean. The telegraph cut the time needed to send a message between London and India from months to hours.

Frederic John Goldsmid, *Telegraph and Travel* (London: Macmillan, 1874), facing p. 325.

in 1870, went wholly by undersea cables from England to Bombay via the Atlantic, Mediterranean, and Red Sea. By 1873 telegraph messages between England and India took three hours. The British went on to lay undersea telegraph cables literally around the world, culminating with its famous "all red" route—named for the color of imperial possessions in the official maps—completed in 1902.[16]

By the time of the 1857 Mutiny, British rule in India had become dependent on telegraphs, steamships, roads, and irrigation works; soon to come was an expanded campaign of railway building prompted by the Mutiny itself. Yet, as hinted in the training of those sixty telegraph assistants, the British also became dependent on a technical cadre of native assistants to construct, operate, and maintain the instruments of empire. Budgetary constraints made it impossible to pay the high cost of

importing British technicians for these numerous lower-level positions. The colonial government in India had little choice but to begin large-scale educational programs to train native technicians. These pressures became acute in the decade following the Mutiny because the colonial government embarked on a large and expensive program of roads, canals, and railroads designed to reinforce its rule. The East India Company was dissolved in the wake of the Mutiny, and the British government assumed direct rule through top-level officials in London and Calcutta.

During these same years, Lancashire industrialists were frantic to secure alternative supplies of cotton imperiled by the American Civil War. Their well-organized lobbying in this instance prevailed on the home government in London, which directed the colonial government in India to open up India's interior cotton-growing regions to nearby ports. A wide-ranging public works campaign might have led to balanced economic development, but the effect of British policy was to discourage the development of Indian industry. The prevailing view was neatly summarized by Thomas Bazley, president of the Manchester Chamber of Commerce and member of Parliament for Manchester: "The great interest of India was to be agricultural rather than manufacturing and mechanical."[17]

One can discern a decidedly nonmechanical slant in the structure of the Public Works Department (PWD) itself, the technical education it presided over, and not least the public works projects that it helped construct. The PWD, founded in 1854 to coordinate Dalhousie's numerous transportation and infrastructure projects, dominated state-sponsored technology in India. (Quite separately, wealthy Indian traders from Bombay revived the cotton textile industry that had flourished in the eighteenth century around that city, leading the Lancashire cotton lobby to redouble its effort in the 1870s to secure "free trade" in cotton.) Most immediately the PWD set the agenda for technology in India through large construction efforts that included roads, canals, and irrigation projects, often—explicitly—with a view toward increasing exports of cotton or wheat.[18]

The character of the PWD's projects was no accident. The department reported to the British colonial officials in Calcutta, who could sometimes engage in creative interpretation of directives from the London-based secretary of state for India. But the policy was set in London, and there the officials responsible for India policy were receptive to domestic pressure groups such as the Lancashire textile industrialists. The secretary of state's office brimmed with letters, petitions, and all manner of insistent appeals from the Manchester Chamber of Commerce. In 1863, fearful of "the insurrection of cotton people," Charles Wood, secretary of state for India from 1859

to 1866, directed his colonial colleague in India to build "cotton roads" at great haste. "I cannot write too strongly on this point," he said. "The sensible cotton people say they acquit us of any serious neglect . . . but that we must make roads."

The first of two large ventures taking shape in this political climate was a road-and-harbor project to link an inland region southeast of Bombay (Dharwar) to a new harbor site at Karwar, about 100 miles distant. Dharwar was of particular interest to the Manchester Cotton Company, a recently formed joint-stock company that aimed to ship new sources of raw Indian cotton to Lancashire, because the region grew the desirable long-staple cotton previously obtained from the American South. In October 1862 the British governor of Bombay, apprehensive that the complex project was being pushed so rapidly that proper engineering and cost estimates had not been made, nevertheless endorsed it: "The money value to India is very great, but its value to England cannot be told in money, and every thousand bales which we can get down to the sea coast before the season closes in June 1863 may not only save a score of weavers from starvation or crime but may play an important part in ensuring peace and prosperity to the manufacturing districts of more than one country in Europe."[19]

Even larger than the Dharwar–Karwar project, which cost a total of £225,000, was a grandiose plan to turn the 400-mile Godavari River into a major transportation artery linking the central Deccan plain with the eastern coast. The plan would send to the coast the cotton from Nagpur and Berar in central India, and this time the Cotton Supply Association was the principal Lancashire supporter. Work on this rock-studded, cholera-ridden river proved a vast money sink, however. By 1865, when the Lancashire lobby quietly gave up its campaign for Indian cotton and returned to peacetime American supplies, the Godavari scheme had cost £286,000 with little result. In July 1868 the first 200-mile stretch was opened, for limited traffic, and by the time the ill-conceived project was canceled in 1872 it had cost the grand sum of £750,000. Such terrific expenditures guaranteed that imperialism soaked up investments rather than generated profits. As it turned out, the Lancashire lobby threw its support behind the Great Indian Peninsula Railway that connected cotton-rich Nagpur with the western port of Bombay.

The PWD's leading role also stamped an imperial seal on technical education in India. The four principal engineering schools in India, founded between 1847 and 1866 at Roorkee, Calcutta, Madras, and Poona, had a heavy emphasis on civil engineering. The PWD was not only the source of many faculty at the engineering schools and of the examiners who approved their graduates but also far and away the leading employer of engineers in India. Indian courses were "unduly encumbered

with subjects that are of little educational value for engineers, but which are possibly calculated to add to the immediate utility of the student in routine matters when he first goes on apprenticeship to the PWD," observed a witness before the Public Works Reorganization Committee in 1917. Another witness stated, "mechanical engineering has been greatly neglected."

The development of a well-rounded system of technical education in India was further hampered by the elite Royal Indian Engineering College, located, conveniently enough, twenty miles west of London at a country estate in Surrey called Cooper's Hill. It was founded in 1870 explicitly to prepare young, well-educated British gentlemen for supervisory engineering posts in India. Successful applicants had to pass a rigorous examination in mathematics and physical science; Latin, Greek, French, and German; the works of Shakespeare, Johnson, Scott, and Byron; and English history from 1688 to 1756. The college was permitted to enroll two "natives of India" each year "if there is room." Its founding president evidently was a worried soul, writing in a grim novella, "And what was there left to us to live for? Stripped of our colonies . . . India lost forever." At the PWD in 1886, natives of India accounted for just 86 of 1,015 engineers, although they filled many of the lower ("upper subordinate" and "lower subordinate") grades. Indian prospects for technical education improved somewhat with the closing of the flagrantly discriminatory Cooper's Hill in 1903 and the founding of the native-directed Bengal Technical Institute (1906) and Indian Institute of Science (1911). By the 1930s Indian students could gain degrees in electrical, mechanical, and metallurgical engineering in India.[20]

RAILWAY IMPERIALISM

Railroads in countries throughout Western Europe and North America were powerful agents of economic, political, and social change. Their immense capital requirements led to fundamental changes in the business structures of all those countries and in the financial markets that increasingly spanned them. Building and operating the railroads consumed large amounts of coal, iron, and steel, leading to rapid growth in heavy industries. Their ability to move goods cheaply led to the creation of national markets, while their ability to move troops rapidly strengthened the nation-states that possessed them (fig. 4.4). In the 1860s superior railway systems shaped military victories by railroad-rich Prussia over Austria and the northern US states over the southern Confederacy.

But in the imperial arenas, the dynamics of empire subtly but perceptibly altered railways and the changes they brought. Where imperial officials were essential in

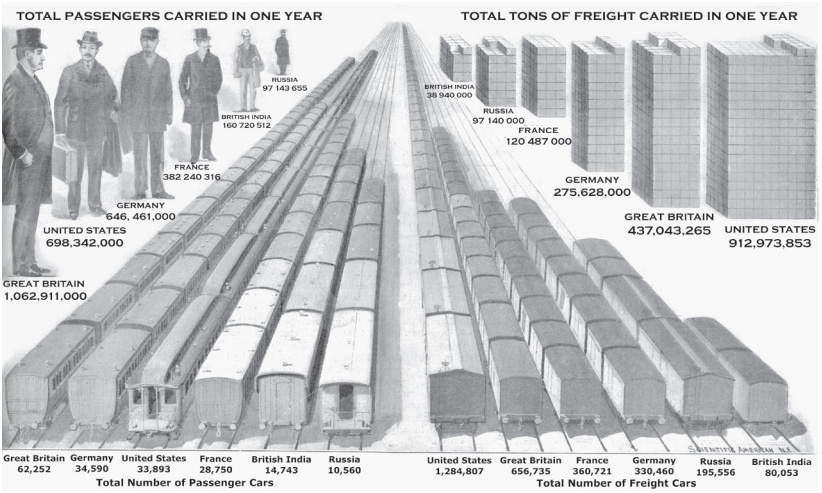

FIG. 4.4. WORLD LEADERS IN RAILWAYS, 1899

By the turn of the century, the Indian railway was the fifth largest in the world in passenger travel and sixth largest in freight.

"Railways of the World Compared," *Scientific American* (23 December 1899): 401. Courtesy of Illinois Institute of Technology Special Collections.

arranging financing, their military and administrative priorities shaped the timing, pace, and routes of colonial railroads. Colonial railroads also reflected the economic priorities of bankers in London and other financial centers who floated huge loans for their construction; nearly always these bankers preferred open "free trade" markets to closed high-tariff ones, strong central colonial governments to divided regional ones, and easily collected import-and-export taxes. For all these reasons, railway imperialism typically led toward political centralization, economic concentration, and extractive development. This is not to say that railway imperialists always got what they wanted. For both the colonies and the metropoles, railroads were above all a way of conducting "politics by other means" often involving contests between local and global imperatives and powers. A survey of railway imperialism in India, North America, and South Africa rounds out this chapter.

In India the political and military utilities of a wide-ranging railroad network were painfully obvious to the railroad promoters, since their thunder had been stolen by the prior construction of the telegraph network. Yet even as commands for troop movement could be sent down an iron wire at nearly the speed of light, the troops themselves required a less ethereal mode of transport. Railways constituted

political power in such a sprawling and politically unsteady place as colonial India. "It is not," wrote one railway economist in 1845, "with any hope of inspiring the company of British merchants trading to India with an expensive sympathy for the social and moral advancement of their millions of native subjects that we urge the formation of a well-considered means of railway communication,—but as a necessary means of giving strength, efficiency, and compactness to their political rule in those territories."[21]

Imperial priorities informed the two British engineers who planned the pioneering lines, Rowland M. Stephenson and John Chapman. Stephenson came from a family long associated with Indian commercial and political affairs, with no evident relation to the railroad pioneer George Stephenson. After becoming a civil engineer in the 1830s, Stephenson promoted various Indian steam ventures to investors in London. Having seen the success of the Peninsular & Oriental's steamship venture (he briefly served as secretary for one of its rivals and later for the P&O itself), Stephenson journeyed to Calcutta. Writing in the *Englishman* of Calcutta in 1844, Stephenson proposed a 5,000-mile network consisting of six major lines. "The first consideration is as a military measure for the better security with less outlay of the entire territory," he wrote of his plan. "The second is a commercial point of view, in which the chief object is to provide the means of conveyance to the nearest shipping ports of the rich and varied productions of the country, and to transmit back manufactured goods of Great Britain, salt, etc., in exchange." Developing native Indian industry, which his plan would simultaneously deprive of homegrown raw materials and overwhelm with British manufactured goods, was assuredly not among his goals. In 1845 Stephenson joined the newly formed East Indian Railway Company as managing director. Stephenson's plan was given official sanction by Dalhousie's 1853 "Minute" on railroads, which set railroad policy for decades. John Chapman was the chief technical figure of the Great Indian Peninsula Railway, or GIP, formed also in 1845. Its projected line, originating at the port of Bombay, climbed steeply up the Western Ghats to the central Deccan plateau, a prime cotton-growing area as noted above. Three years later, Chapman observed that the Lancashire merchants thought of the GIP as "nothing more than an extension of their own line from Manchester to Liverpool."[22]

The first generation of Indian railways took form under a peculiar and still-controversial imperial arrangement. Under a precedent-setting 1849 contract with the East India Company (EIC, the statelike entity responsible for governing India until 1858), the pioneering East Indian Railway and the Great Indian Peninsula Railway

turned over to the EIC their entire paid-in capital. As the railroads planned routes that met the EIC's criteria, including specific routings, single- or twin-tracking, and various engineering standards, the EIC disbursed the "allowed" expenditures to the respective railroad. The EIC leased generous swaths of land to the railroads without cost for ninety-nine years. At any time through the ninety-eighth year, the railroads could turn over their companies to the state and demand full compensation; in the ninety-ninth year, just possibly too late, the state could claim the right to take over the roads without compensation.

The controversial point was the guaranteed return to investors. The EIC, which held the railroads' capital in Calcutta, promised interest payments to investors of 5 percent. Operating profits up to 5 percent went to the EIC to offset its guarantee payments, while any profits above 5 percent were split equally between the EIC and the railroad or, if the operating revenues had completely covered the EIC's 5 percent payments, with no backlog from previous years, the profits above 5 percent went entirely to the railroad company. The guaranteed interest payments rested ultimately on the EIC's ability to collect money from Indian taxpayers. The rub was that through 1870 the roads consistently made average annual profits of only around 3 percent while the EIC-backed investors collecting 5 percent were overwhelmingly British. (In 1868 less than 1 percent of shareholders were Indians, 397 out of 50,000—understandably enough, since shares traded only in London.) The scheme thus transferred money from Indian taxpayers to British investors. The finance minister of India, William Massie (1863–69), saw the problem clearly: "All the money came from the English capitalist, and so long as he was guaranteed 5 per cent on the revenues of India, it was immaterial to him whether the funds that he lent were thrown into the Hooghly or converted into bricks and mortar."[23]

In fact, however, since nearly all of the locomotives, most of the rails, and even some of the coal were imported from Britain, fully two-fifths of the money raised in Britain was spent in Britain. The Indian railroads' high expenses were the result not so much of flagrant corruption as of the subtle but again perceptible way in which the dynamics of empire shaped their form. Imperial considerations most obviously structured the financing and routing of the Indian railways. A vision of empire also inspired the vast, overbuilt railway terminals, such as Bombay's Victoria Station. One can furthermore see empire inscribed in the railroads' technical details, including their track gauges, bridge construction, and locomotive designs.

In 1846 the British Parliament passed the Act for Regulating the Gauge of Railways, setting what would become the standard gauge in Europe and North

FIG. 4.5. GOKTEIK VIADUCT IN UPPER BURMA

The railway track is 825 feet above the level of the Chungzoune River, which flows through a tunnel beneath the bridge.

Frederick Talbot, *The Railway Conquest of the World* (London, Heinemann, 1911), following p. 256. Courtesy of Illinois Institute of Technology Special Collections.

America: 4 feet 8½ inches (or 1.435 meters). Nevertheless, the EIC's Court of Directors set the gauge of India's railroads at 5 feet 5 inches (or 1.676 meters) and furthermore decided in 1847 that all tunnels, bridges, and excavations must be made wide enough for double tracking. The mandate for a wide gauge and double tracking inflated construction costs: all bridge superstructures had to be extra wide, while all curves had to be extra spacious. The Great Indian Peninsula Railway's double-track construction up the Western Ghats, a steep mountain range rising to the cotton-rich central Deccan plain, required an ungainly arrangement of reversing stations, in addition to numerous tunnels, viaducts, and bridges to gain the needed elevation. Some of the vast sums spent on bridges can be fairly traced to India's wide, deep, and at times fast-flowing rivers and their fearsome monsoon flooding (figs. 4.5 and 4.6). Adding

FIG. 4.6. BRIDGING THE GANGES RIVER AT ALLAHABAD

In building the Curzon Bridge to cross the mighty Ganges River at Allahabad in northern India, native laborers moved 50 million cubic feet of earth to narrow the river from its high-water clay riverbanks (3 miles) to the width of its low-water channel (about 1¼ miles). The railway bridge's span at 3,000 feet was opened in 1905.

Frederick Talbot, *The Railway Conquest of the World* (London: Heinemann, 1911), following p. 254. Courtesy of Illinois Institute of Technology Special Collections. See *Scientific American* (26 September 1908): 204–206 at https://ia801607.us.archive.org/1/items/scientific-american-1908–09-26/scientific-american-v99-n13–1908-09–26.pdf.

to the costs, however, was the British engineers' preference for expensive designs: no rough-and-ready timber trestles like those American railroad engineers were building. Instead, Indian bridges mostly conformed to British designs, built of wrought-iron trusses over masonry piers. Numbered bridge parts sent from Britain were riveted together into spans by Indian craftsmen and the spans placed by elephant-powered hoists. In 1862 the second largest bridge in the world was opened across the Sone River near Delhi, and it cost the astounding sum of £430,000.

British-constructed Indian locomotives were also built for the ages and were correspondingly expensive. The most common class of locomotive in India, the Scindia, was built on a rigid frame with six sets of driving wheels (known as a 0-6-0 configuration) and featured copper fireboxes, copper or brass boiler tubes, forged valves, and inside cylinders with cranked axles. These were the Rolls-Royces of locomotives. By contrast, North American locomotives of this era had steel fireboxes and boiler tubes, cast-iron valves, and external cylinders, as well as leading "bogie" wheels that improved steering on sharp turns (4-4-0 or 2-8-0 configuration). Although India's

railroad shops constructed approximately 700 locomotives before independence in 1947, the vast majority (80%) were built in Britain, supplemented by imports from America and Germany. During these years Indian railroads bought fully one-fifth of the British locomotive industry's total output.[24]

Railway construction under the first guarantee system picked up pace after the Mutiny of 1857–58, when there were just 200 miles of rail line. In 1870 the Indian colonial government, reeling under the budget-breaking costs of the 5,000 miles of privately constructed but publicly financed railroads, embarked on a phase of state-built railroads featuring a narrow (meter-wide) gauge. The Indian colonial government built 2,200 miles of these roads at half the cost per mile of the guaranteed railroads. But in 1879 the secretary of state for India mandated that the Indian government only build railroads to the strategically sensitive northern (Afghan) frontier. Private companies, under a new guarantee scheme negotiated with the government in 1874, took up the sharp boom of railroad building across the rest of the country. At the turn of the century India had nearly 25,000 miles of railroad track. India's railway mileage surpassed Britain's in 1895, France's in 1900, and Germany's in 1920, by which point only the United States, Soviet Union, and Canada had more mileage. Unfortunately for the Indian treasury, the roads built under the second guarantee scheme were also money pits (only the East Indian Railway's trunk line from Calcutta to Delhi consistently made money). Guarantee payments to the railroads between 1850 and 1900 totaled a whopping £50 million.[25] By the 1920s, Indian railroads, by then run-down for lack of investment, became a prime target of Indian nationalists agitating for the end of British rule.

Compared with India, railway imperialism in North America was a more complicated venture, not least because two imperial powers, Britain and the United States, had various claims on the continent. Railway building in the eastern half of the United States reflected commercial and industrial impulses. Merchants and traders in Baltimore and Philadelphia, for example, backed two huge railroad-building schemes to capture a share of the agricultural bounty that was flowing east via the Erie Canal to New York City. By 1860 a network of railroads from the Atlantic Ocean to the Mississippi River had created an industrial heartland that extended to Chicago. The United States, with 30,000 miles, had more than three times the railroad track of second-place Britain and nearly five times the mileage of third-place Germany.

Construction of the transcontinental railroads from the Mississippi to the Pacific Ocean during the next four decades (1860s–1900) boosted the country's railroad trackage to 260,000 miles. The defining governmental action—the Pacific

Railroad Act of 1862—granted huge blocks of land to the transcontinental railroads for building their lines and for developing traffic for their lines by selling land to settlers. All but one of the transcontinental lines—including the Union Pacific, Central Pacific, Northern Pacific, Kansas Pacific, Southern Pacific, and Atchison, Topeka & Santa Fe railroads—were beneficiaries of these land grants. The Illinois Central had pioneered the federal land grant, receiving 2.6 million acres in 1850 for its rail line south to New Orleans.

The strange economics of empire also came into play in North America. The US government faced a heavy financial burden in mobilizing and provisioning sufficient army units to safeguard settlers and railroad construction crews from the Native Americans who were determined not to give up their buffalo hunting grounds without a fight. In 1867 the *Omaha Weekly Herald* claimed that it cost the "large sum" of $500,000 for each Indian killed in the recurrent prairie battles. The same year General William T. Sherman stated: "The more we can kill this year, the less will have to be killed in the next war, for the more I see of these Indians the more convinced I am that they all have to be killed or maintained as a species of paupers." Railway promoters pointed out that the increased military mobility brought by the railroad, cutting the needed number of military units, would dramatically reduce the high cost of projecting power across these many sparsely settled miles. In this respect, the railroads in British India and the American West have more than a casual similarity. "The construction of the road virtually solved the Indian problem," stated one American railroad official two years prior to the infamous massacre of 300 Lakota Sioux at Wounded Knee, South Dakota, in 1890.[26]

Citizens of British North America reacted with some alarm to these territorial developments. At the time, Canada was not a unified nation but a set of independent provinces. Yet not even the fear of being annexed to the United States, as was nearly half of Mexico in the 1840s, united them. Merchants and traders along the St. Lawrence–Great Lakes canal system, a huge project of the 1840s, looked naturally to the shipping ports of the south; some even favored joining the United States. A railroad boom in the 1850s resulted in 2,000 miles of disconnected lines whose operating deficits emptied colonial Canadian treasuries and whose north-south orientation drained off Canadian products to the south. Would-be railway imperialists still lacked the necessary east-west lines that might bring economic and political cohesion to the provinces. Worse, during the Civil War the United States started a trade war with the Canadian provinces and made threats, deemed serious by many Canadians, to invade their western lands. Equally worrisome, US economic domi-

nation might formally detach British Columbia from the British Empire and, on the other side of the continent, informally control the maritime provinces.

A generous program of imperial railway subsidies was the glue that fixed the slippery provinces into place. In the 1860s a series of labyrinthine negotiations between Canadian colonial officials, British imperial officials, and London financiers arrived at this formula: London financiers would support large railway loans if the provinces were politically united; the independent provinces would agree to confederation if the Colonial Office sweetened the deal with government guarantees for railway construction (valuable not least for the patronage jobs). So, the Colonial Office in London duly arranged government guarantees for the railway loans. Thus was the Dominion of Canada created in 1867 as a federation of Canada West and Canada East with the maritime provinces of New Brunswick and Nova Scotia. Railroads figured explicitly. The maritime provinces made their assent to the confederation agreement conditional on the building of an intercolonial railroad in addition to the Halifax–Quebec railroad, already planned. Furthermore, expansion-minded citizens of Canada West received promises of amiably settling the Hudson Bay Company's preemptive claim on western lands. By 1874 the *British* government had made guaranteed loans and grants totaling £8 million for the intercolonial lines and transcontinental Canadian Pacific Railway. Of the Canadian Pacific the first premier of the Canadian confederation commented, "Until that road is built to British Columbia and the Pacific, this Dominion is a mere geographical expression, and not one great Dominion; until bound by the iron link, as we have bound Nova Scotia and New Brunswick with the Intercolonial Railway, we are not a Dominion in Fact."[27]

Railway imperialism in Mexico affords a glimpse of what might have happened to Canada absent the countervailing power of imperial Britain. The Mexican railroad system took shape under the long rule of the autocratic Porfirio Díaz (1876–1911). As early as the 1870s the Southern Pacific and Santa Fe railroads, then building extensive lines in the southwestern United States, began planning routes south into Mexico. Mexico at the time consisted of fourteen provinces whose disorganized finances left no hope of gaining external financing from London or other international money centers. With few options in sight, and a hope that railroads might bring "order and progress" to Mexico, Díaz gave concessions to the US railroads to build five lines totaling 2,500 miles of track. Something like free-trade imperialism followed. In 1881 the US secretary of state informed the Mexican government that it would need to get rid of the "local complicated . . . tariff regulations which obtain between the different Mexican States themselves" and sign a reciprocal free-trade

agreement with the United States. Díaz prevailed upon the Mexican Congress to ratify the free-trade pact, as the US Senate had done, but the agreement did not go into effect owing to a quirk of US domestic politics. US railroad and mining promoters flooded south all the same. Mexico, as one railroad promoter effused in 1884, was "one magnificent but undeveloped mine—our India in commercial importance."[28]

Trade between Mexico and the United States increased sevenfold from 1880 to 1910. Total US investment in Mexico soared to over $1 billion, an amount greater than all its other foreign investment combined and indeed greater than Mexico's own internal investment. Fully 62 percent of US investment was in railroads; 24 percent was in mines.[29] By 1911 US firms owned or controlled most of the 15,000 miles of railroad lines; three-quarters of mining and smelting concerns processing silver, zinc, lead, and copper; and more than half of oil lands, ranches, and plantations. Four great trunk lines shipped Mexican products north to the border. But the extractive mining boom brought wrenching social and political changes. The blatant US domination of railroads inflamed the sensibilities of Mexican nationalists. The Díaz government nationalized two-thirds of the country's railroads in 1910, but the aging dictator was overthrown the next year. The legacy of railway imperialism in Mexico was not the "order and progress" that Díaz had aimed for but a confusing period of civil strife (1911–17) and a transportation system designed for an extractive economy.

In South Africa railroads at first had some of the centralizing and integrating effects that we have noted in India, Canada, the United States, and Mexico, but railway imperialism there ran headlong into a countervailing force, "railway republicanism." The result was not railroad-made confederation along Canadian lines, as many in Britain hoped, but a political fracturing of the region that ignited the second Anglo-Boer War (1899–1902). Southern Africa even before the railway age was divided into four distinct political units: two acknowledged colonies of Britain (the Cape Colony, at the southern-most tip of the continent, and Natal, up the eastern coast) and two Boer republics (the inland Orange Free State, and the landlocked Transvaal republic) over which Britain from the mid-1880s claimed suzerainty. Britain understood this subcolonial status as a step to full integration into the British Empire, whereas the fiercely independent Boers, descendants of seventeenth-century Dutch settlers who had trekked inland earlier in the nineteenth century to escape British rule, saw it as one step from complete independence.

Imperial concerns mounted with the waves of British citizens brought to the region by the discovery of diamonds (1867) at Kimberley in eastern Orange Free State (fig. 4.7) and gold (1886) in the central Transvaal. One of the British newcomers

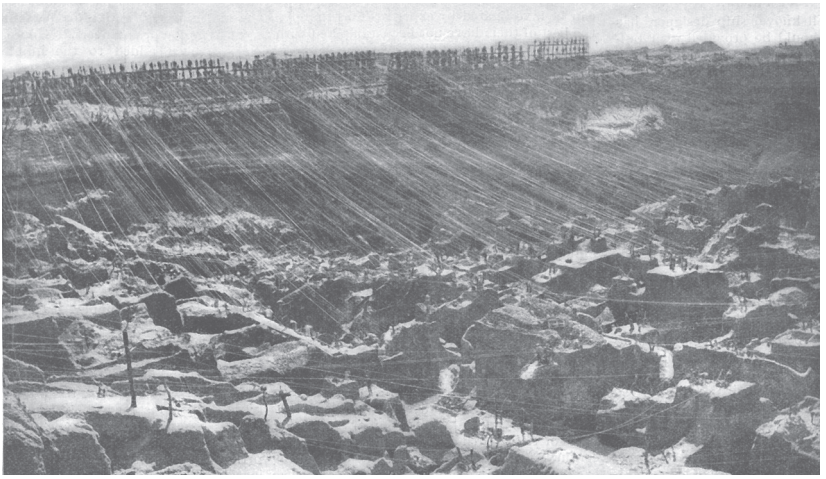

FIG. 4.7. KIMBERLEY DIAMOND MINE, SOUTH AFRICA, CA. 1880

Southern Africa's premier diamond mine, with its 31-square-foot claims, was covered by hundreds of wire ropes connecting each claim to the unexcavated "reef" visible in the background. "Each claim was to all intents and purposes a separate mine."

Scientific American (27 January 1900): 56. Courtesy of Illinois Institute of Technology Special Collections.

was Cecil Rhodes who made his fortune in the Kimberley fields in the 1870s, formed the De Beers Mining Company in the 1880s (a successor of which set worldwide raw diamond prices throughout the twentieth century), and secured a wide-ranging royal charter for his British South Africa Company in 1889. The story goes that Rhodes, his hands on a map of Africa, had gestured: "This is my dream, all English."[30] Rhodes, along with other centralizing imperialists, hoped to form southern Africa's diverse linguistic and ethnic groups into a single, unified colony dependent on Britain. Rhodes used the promise of building railroads with his chartered company to secure the political backing of the Cape Colony's Afrikaner majority. As the Cape's prime minister from 1890 to 1896 he led the railway-building campaign north across the Orange Free State and into the Transvaal, not least by arranging financing in London. In getting his rails into the Transvaal Rhodes hoped to preempt that republic's plans to revive a defunct railway to the Portuguese port city of Lorenço Marques (now Mobutu, Mozambique). The early railway campaigns brought a degree of cooperation, through cross-traffic railroad agreements and a customs union, between the Cape Colony and Orange Free State, on the one hand, and the Natal Colony and Transvaal on the other.

Ironically, railroads thwarted the imperial dream in South Africa. Rhodes found his match in the "railway republican" Paul Kruger, president of the Transvaal, and political leader of the region's Afrikaner Boers. Nature had dealt Kruger's Transvaal the supreme trump card: the massive Witwatersrand gold reef near Johannesburg, discovered in 1891 and about which would pivot much of the region's turbulent twentieth-century history. Mining the Rand's deep gold veins required heavy machinery and led to large-scale industrial development around Johannesburg. Accordingly, three of the region's four railroads had their terminals there.

Although Rhodes had hoped that his Cape Colony railroad's extension to the Transvaal would give him leverage over the inland republic's leader, quite the opposite happened. Kruger contested the imperialist's plan and gained the upper hand by appealing directly to London financiers himself. With a £3 million loan from the Rothschilds in 1892, Kruger completed the Transvaal's independent rail link to the port at Lorenço Marques.[31] From then on, Kruger could bestow as he saw fit the Rand's lucrative traffic among three railroads (his own, Natal's, and the Cape's). The tremendous fixed investment of these railroads, along with the light traffic elsewhere, gave whoever controlled the Rand traffic tremendous clout. Having failed to achieve anything like political union by railway imperialism, Rhodes tried it the old-fashioned way—militarily. In the Drifts Crisis of 1895, sparked by a dispute over railway freight charges around Johannesburg, the Cape Colony called for British military intervention against the Transvaal. With this crisis barely settled, Rhodes launched the Jameson Raid, an ill-conceived military invasion aimed at overthrowing Kruger.

By this time Britain may well have wished to wash its hands of the region's bitter disputes, but there remained the matter of protecting its investors' £28 million in colonial railway debts. In the face of Kruger's open hostility toward its citizens, Britain launched the Second Boer War (1899–1902), during which its army crushed the independence-minded Boer republics. The same Transvaal railway that carried gold out to the ocean also carried the British army in to the Rand and carried Kruger away to exile. The region's railroad problem was a high priority for the British high commissioner charged with rebuilding the region after the war: "On the manner and spirit in which the peoples and Parliaments of South Africa handle this railway question depends the eventual answer to the larger question, whether South Africa is to contain one great and united people . . . or a congeries of separate and constantly quarreling little states," he wrote in 1905.[32] In his 1907 blueprint for federating the South African colonies, fully two-thirds of his 90,000-word text dealt with railroad issues. Railway union, he saw, was imperative, since independent provincial rail-

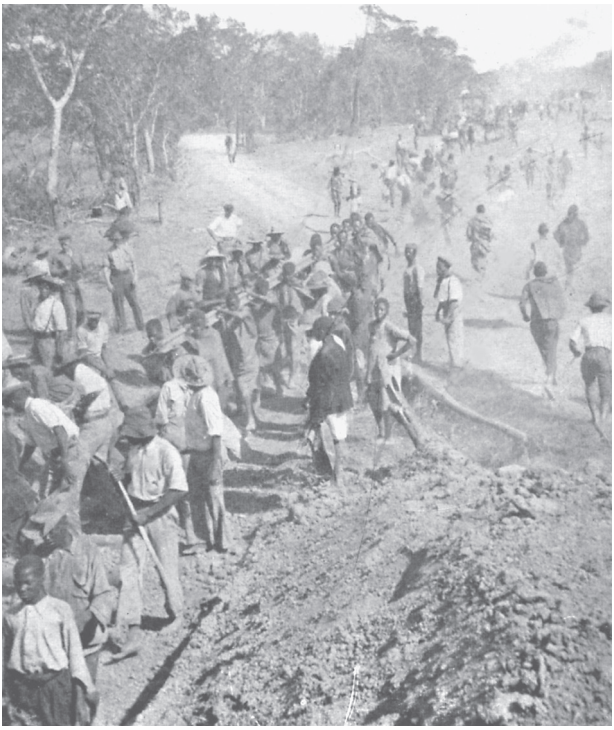

FIG. 4.8. BUILDING THE CAPE TOWN TO CAIRO RAILWAY

Native laborers at work on Cecil Rhodes' grand imperial dream, a railroad that would connect the southern tip of Africa with a Mediterranean port. Here, workers set a continental record, laying 5¾ miles of track in ten hours.

Frederick Talbot, *The Railway Conquest of the World* (London: Heinemann, 1911), following p. 144. Courtesy of Illinois Institute of Technology Special Collections.

roads would continually be instruments for sectional strife. The South Africa Act of 1909 created the region-wide South African Railways and Harbours Administration and helped unify the shaky Republic of South Africa, formed the next year. In 1914 the center of a unified railway administration was fittingly enough relocated to Johannesburg, the seat of railway power.

Although his political career ended with the failed Jameson Raid, Rhodes in his remaining years turned his considerable promotional abilities toward that most grandiose of all imperial schemes, the Cape Town to Cairo Railway, which aimed to stitch together a patchwork of mining and settlement ventures northward through Africa (fig. 4.8). Rhodes' British South Africa Company had no realistic chance of laying rails all the way to Egypt, not least because the scheme ran square into the

determination of the Belgian Congo to control the rich Katanga copper belt in central Africa and of German Southeast Africa to dominate the territory from there east to the Indian Ocean. Rhodes' scheme did hasten the European settlement of the landlocked Rhodesias. The railroads just completed through Southern Rhodesia (now Zimbabwe) prevented mass starvation when *rinderpest* decimated the region's draft animals in the late 1890s, while in 1911 Northern Rhodesia (now Zambia) was created through and circumscribed by its mining and railroad activities (fig. 4.9). Perhaps the farthest-reaching achievement of the Cape-to-Cairo scheme was in durably linking the midcontinent copper belt with South Africa well into the postcolonial decades.[33]

The legacies of imperialism remain fraught with controversy in our own postcolonial time. Indeed the arguments have sharpened with the debate on globalization, since many of its critics denounce globalization as little more than an updated imperialism (discussed in chapter 8). Few today have sympathy for the "civilizing mission" of the imperialist era, with the assumption that selling opium or stringing telegraphs or building railroads would bring the unalloyed benefits of Western civilization to the native populations of Asia, Africa, or South America. From our present-day sensibilities we see only too clearly the gunboats, rifle cartridges, and machine guns that these ventures entailed. The title of Jared Diamond's prize-winning *Guns, Germs, and Steel* (1997) gives a three-word explanation for the rise of Western global power through technology.

Imperialism in the nineteenth century left a long shadow over the globe. We have seen how key transport nodes like the Suez Canal (as well as the Panama Canal completed in 1914) fell captive to imperial powers. The fraught history of Hong Kong can be traced to the first opium war in the 1840s after which Britain annexed this compact but valuable port and then, years later, signed a ninety-nine-year lease with China; in the interim, China itself went through political upheavals so that today Hong Kong is at the center of battles over the "authoritarian internet" (see chapter 10). In the early twentieth century, Great Britain and the United States carved up the Middle East's immense but untapped oil reserves, tying that region of the world to geopolitical instabilities and systemic risk (see chapter 9).

Both before and since the anticolonial independence movements of the late 1940s through 1960s, nationalists in Asia, Latin America, and Africa condemned the schemes that brought imperialist-dominated "development" to their countries. "It is difficult to measure the harm that Manchester has done to us. It is due to Manchester [and cotton machinery] that Indian handicraft has all but disappeared,"

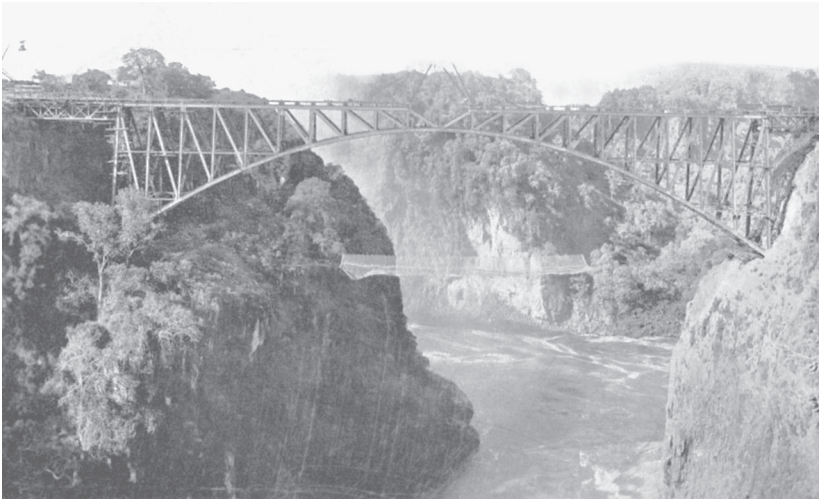

FIG. 4.9. SPANNING THE ZAMBESI RIVER AT VICTORIA FALLS

The 500-foot span over the Zambesi River just below the stunning Victoria Falls. Trains passed across the gorge 420 feet above low water. The net beneath the bridge was "to catch falling tools and workmen."

Frederick Talbot, *The Railway Conquest of the World* (London, 1911), following p. 144. Courtesy of Illinois Institute of Technology Special Collections.

wrote Mohandas Gandhi.[34] During the long decades of the Cold War (1947–89), the superpowers imposed a marked preference for capital-intensive, centralized, extractive industry that tied their clients' economies and politics to the superpowers. Even today one can discern a shadow of the imperialist era in railroad maps of North America (look carefully at Canada, the western United States, and Mexico), in the prestige structure of technical education, and in the policy preferences of the mainline development agencies in the United States and Europe.

Even for the dominant countries, imperialism was a venture with mixed economic results. In the aggregate Britain as a country did not profit by imperialism. While many of its traders and entrepreneurs, as well as the technological visionaries who tapped the imperial impulse, made their individual fortunes, the profits of the imperial economy were simply not large enough to pay for the heavy expenses of sending imperial military forces overseas, maintaining the imperial bureaucracy, and funding the high-priced imperial technologies. We now have insight into why imperialism did not make money. Profit was simply not the point of imperial technologies: the expensive steam vessels, the goldbricked locomotives, the double-tracked wide-gauge railways, the far-flung telegraph and cable networks.

In this respect, we can see that imperialism was not merely a continuation of the eras of commerce or industry; rather, to a significant extent, imperialism competed with and in some circumstances displaced commerce and industry as the primary focus of technologists. By creating a captive overseas market for British steamships, machine tools, locomotives, steel, and cotton textiles, imperialism insulated British industrialists in these sectors from upstart rivals and, in the long run, may even have hastened their decline in worldwide competitiveness.[35] Is it only a coincidence that Britain, a leader in the eras of industry and imperialism, was distinctly a follower behind Germany and the United States in the subsequent science-and-systems era? At the least, we must allow that the imperialist era had a distinct vision for social and economic development, dominated by the Western countries, and distinctive goals for technologies.