THE SHOCK OF THE OLD

Technology and Global History Since 1900

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I stood on a hill and I saw the Old approaching, but it came as the New.
It hobbled up on new crutches which no one had ever seen before and stank of new smells of decay which no one had ever smelt before.

Bertolt Brecht (1939), from 'Parade of the Old New', in *Bertolt Brecht: Poems 1913–1956*, John Willett and Ralph Manheim (eds) (London: Methuen, 1987), p. 323

Introduction

Much of what is written on the history of technology is for boys of all ages. This book is a history for grown-ups of all genders. We have lived with technology for a long time, and collectively we know a lot about it. From economists to ecologists, from antiquarians to historians, people have had different views about the material world around us and how it has changed. Yet too often the agenda for discussing the past, present and future of technology is set by the promoters of new technologies.

When we are told about technology from on high we are made to think about novelty and the future. For many decades now the term 'technology' has been closely linked with *invention* (the creation of a new idea) and *innovation* (the first use of a new idea). Talk about technology centres on research and development, patents and the early stages of use, for which the term *diffusion* is used. The timelines of technological history, and they abound, are based on dates of invention and innovation. The most significant twentieth-century technologies are often reduced to the following: flight (1903), nuclear power (1945), contraception (1955), and the internet (1965). We are told that change is taking place at an ever-accelerating pace, and that the new is increasingly powerful. The world, the gurus insist, is entering a new historical epoch as a result of technology. In the new economy, in new times, in our post-industrial and post-modern condition, knowledge of the present and past is supposedly ever less relevant. Inventors, even in these post-modern times, are 'ahead of their time', while societies suffer from the grip of the past, resulting in a supposed slowness to adapt to new technology.

There are new things under the sun, and the world is indeed changing radically, but this way of thinking is not among them. Although the emphasis on the future itself suggests originality, this kind of

futurology has been with us a long time. In the nineteenth century the idea that inventors were ahead of their time and that science and technology were advancing faster than the ability of human society to cope was a commonplace. By the early twentieth century this notion was made academically respectable with the label 'the cultural lag'. In the 1950s and even later, one could claim without embarrassment that scientists 'had the future in their bones'. By the end of the twentieth century, futurism had long been *passé*. The technological future was as it had been for a long time. Intellectuals claimed there was a new kind of future, one prefigured by 'post-modern' architecture. Yet this new kind of future was to be brought about by an old-style technological or industrial revolution which would change everything.

In the case of technology reheated futurism has held its appeal long after it was declared obsolete. The technological future marched on as before. Consider the case of the first successful flight of NASA's X-43A space aeroplane on 27 March 2004. Although it lasted all of ten seconds, it made the news the world over. 'From Kitty Hawk to the X-43A has been a century's steady advance', wrote one newspaper; from 'seven miles an hour to Mach Seven is a striking indication of how far powered flight has travelled in a hundred years'.[1] Soon we would be enjoying, yet again, almost instant travel to Australia from London.

Just below the surface was another history, which blew great holes in this old-fashioned story. Every few weeks between 1959 and 1968 B-52 aircraft took off from Edwards Air Force Base in California, with one of three X-15s under their wings. Once high up the X-15s fired their rocket engines and were actively flown by twelve 'research pilots', clad in silver pressurised space suits, reaching speeds of Mach 6.7 and touching the edge of space. These hard-drinking engineer-pilots, mostly combat veterans (among them Neil Armstrong, the first man to set foot on the moon), looked down on mere 'spam in the can' astronauts, as Tom Wolfe observed in *The Right Stuff*. While the astronauts became famous, the elite X-15 pilots were left to lament, as one did, that in the early 1990s he was still 'one of the fastest airplane pilots in the world. I am too old for that. Someone younger should have that honor.'[2] Past

and present were connected even more directly. The B-52, which took the X-43A and its booster rocket up, was one of the same B-52s used on the X-15 programmes and was now the oldest flying B-52 in the world.[3] It was built in the 1950s. Not only that, but the key technology of the X-43A was the scramjet, a supersonic version of the ramjet. A technique decades old, it was used in a 1950s-designed British anti-aircraft missile, the Bloodhound, which was itself in service into the 1990s. In short, the story might well have been '1950s aeroplane launches unmanned ramjet plane which flies a little faster than 1960s Right Stuff pilots'.

By thinking about the history of technology-in-use a radically different picture of technology, and indeed of invention and innovation, becomes possible.[4] A whole invisible world of technologies appears. It leads to a rethinking of our notion of technological time, mapped as it is on innovation-based timelines. Even more importantly it alters our picture of which have been the most important technologies. It yields a global history, whereas an innovation-centred one, for all its claims to universality, is based on a very few places. It will give us a history which does not fit the usual schemes of modernity, one which refutes some important assumptions of innovation-centric accounts.

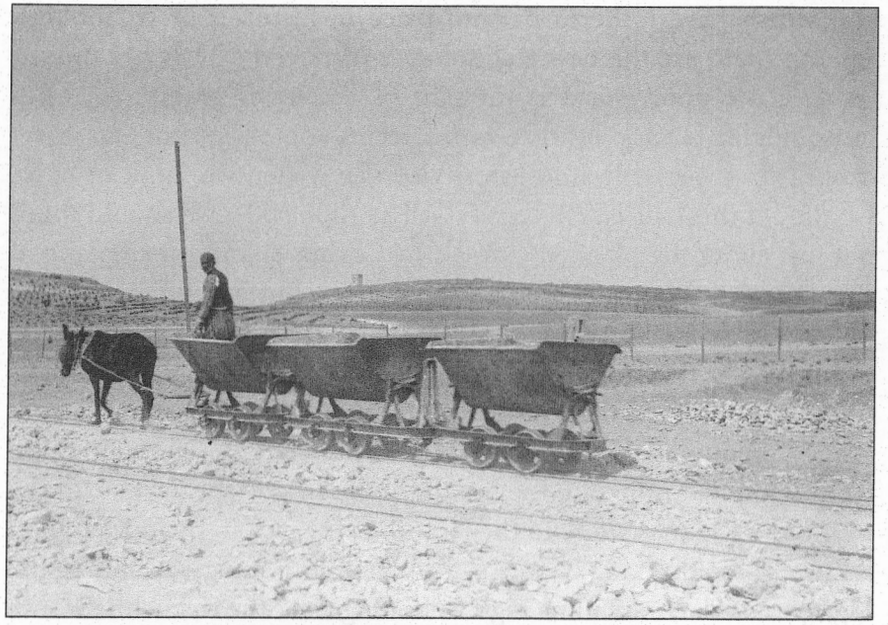
The new history will be surprisingly different. For example, steam power, held to be characteristic of the industrial revolution, was not only absolutely but relatively more important in 1900 than in 1800. Even in Britain, the lead country of the industrial revolution, it continued to grow in absolute importance after that. Britain consumed much more coal in the 1950s than in the 1850s. The world consumed more coal in 2000 than in 1950 or 1900. It has more motor cars, aeroplanes, wooden furniture and cotton textiles than ever before. The tonnage of world shipping continues to increase. We still have buses, trains, radio, television and the cinema, and consume ever-increasing quantities of paper, cement and steel. The production of books continues to increase. Even the key novel technology of the late twentieth century,

the electronic computer, has been around for many decades. The post-modern world has forty-year-old nuclear power stations as well as fifty-year old bombers. It has more than a dash of technological retro about it too: it has new ocean-going passenger ships, organic food and classical music played on 'authentic' instruments. Aging, and even dead, rock stars of the 1960s still generate large sales, and children are brought up with Disney films seen by their grandparents when they were children.

Use-centred history is not simply a matter of moving technological time forward. As Bruno Latour has aptly noted, modern time, where this behaved as moderns believed, has never existed. Time was always jumbled up, in the pre-modern era, the post-modern era and the modern era. We worked with old and new things, with hammers and electric drills.[5] In use-centred history technologies do not only appear, they also disappear and reappear, and mix and match across the centuries. Since the late 1960s many more bicycles were produced globally each year than cars.[6] The guillotine made a gruesome return in the 1940s. Cable TV declined in the 1950s to reappear in the 1980s. The supposedly obsolete battleship saw more action in the Second World War than in the First. Furthermore, the twentieth century has seen cases of technological regression.

A use-based history will do much more than disturb our tidy timelines of progress. What we take to be the most significant technologies will change. Our accounts of significance have been peculiarly innovation-centric, and tied to particular accounts of modernity where particular new technologies were held to be central. In the new picture, twentieth-century technology is not just a matter of electricity, mass production, aerospace, nuclear power, the internet and the contraceptive pill. It will involve the rickshaw, the condom, the horse, the sewing machine, the spinning wheel, the Haber-Bosch process, the hydrogenation of coal, cemented-carbide tools, bicycles, corrugated iron, cement, asbestos, DDT, the chain saw and the refrigerator. The horse made a greater contribution to Nazi conquest than the V2.

A central feature of use-based history, and a new history of



1. A mule hauling equipment on a track in the building of the Berlin–Baghdad railway near Aleppo between 1900 and 1910. Mules, and railways, were vitally important technologies of the twentieth century in both rich and poor countries.

invention, is that alternatives exist for nearly all technologies: there are multiple military technologies, means of generating electricity, powering a motor car, storing and manipulating information, cutting metal or roofing a building. Too often histories are written as if no alternative could or did exist.

One particularly important feature of use-based history of technology is that it can be genuinely global. It includes all places that use technology, not just the small number of places where invention and innovation is concentrated. In the innovation-centric account, most places have no history of technology. In use-centred accounts, nearly everywhere does. It gives us a history of technology engaged with all the world's population, which is mostly poor, non-white and half female. A use-perspective points to the significance of novel technological worlds which have emerged in the twentieth century

and which have hitherto had no place in histories of technology. Among them are the new technologies of poverty. They are missed because the poor world is thought of as having traditional local technologies, a *lack* of rich-world technologies, and/or has been subject to imperial technological violence. When we think of cities we should think of *bidonvilles* as well as Alphaville; we should think not just about the planned cities of Le Corbusier, but the unplanned shanty towns, built not by great contractors, but by millions of self-builders over many years. These are worlds of what I call 'creole' technologies, technologies transplanted from their place of origin finding uses on a greater scale elsewhere.

A consequence of the new approach is that we shift attention from the new to the old, the big to the small, the spectacular to the mundane, the masculine to the feminine, the rich to the poor. But at its core is a rethinking of the history of all technology, including the big, spectacular, masculine high technologies of the rich white world. For all the critiques, we do not in fact have a coherent productionist, masculine, materialist account of technology and history in the twentieth century. We have big questions, and big issues to address, which are surprisingly open.

A use-centred account also refutes some well-established conclusions of innovation-centric history. For example, it undermines the assumption that national innovation determines national success; the most innovative nations of the twentieth century have not been the fastest growing. Perhaps the most surprising criticism that arises from the use perspective is that innovation-centric history gives us an inadequate account of invention and innovation. Innovation-centric history focuses on the early history of some technologies which became important later. The history of invention and innovation needs to focus on all inventions and innovations at a particular time, independently of their later success or failure. It needs to look too to invention and innovation in all technologies, not just those favoured by being well known and assumed to be the most significant. Traditional innovation-centric histories have space for Bill Gates,

2. The United States became one of the richest agricultural nations in the world partly by creating highly mechanised, but animal-powered, agriculture. Here a farmer drives a team of twenty mules pulling a combine harvester through the wheat fields of Walla Walla County, Washington in 1941. By this time the tractor had been displacing horses and mules in some areas for twenty-five years.

but a history of invention and innovation would also include Ingvar Kamprad, who made his money from mass-producing and selling wooden furniture. He founded IKEA and is, some think, richer than Gates. More importantly, our histories need to have a place for the majority of failed inventions and innovations. Most inventions are never used; many innovations fail.

The innovation-centric view also misleads us as to the nature of scientists and engineers. It presents them, as they present themselves, as creators, designers, researchers. Yet the majority have always been mainly concerned with the operation and maintenance of things and processes; with the uses of things, not their invention or development.

Given the importance of innovation-centric futurism in discussing technology, history can be an especially powerful tool for rethinking technology. History reveals that technological futurism is largely unchanging over time. Present visions of the future display a startling, unselfconscious lack of originality. Take the extraordinary litany of technologies which promised peace to the world. Communications technologies, from railways and steamships, to radio and the aeroplane, and now the internet, seemed to make the world smaller and bring people together, ensuring a perpetual peace. Technologies of destruction, such as the great ironclad battleships, Nobel's explosives, the bomber aircraft and the atomic bomb were so powerful that they too would force the world to make peace. New technologies of many sorts would emancipate the downtrodden. The old class system would wither under the meritocracy demanded by new technology; racial minorities would gain new opportunities – as chauffeurs in the motor age, pilots in the air age, and computer experts in the information age. Women were to be liberated by new domestic technologies, from the vacuum cleaner to the washing machine. The differences between nations would evaporate as technology overcame borders. Political systems too would converge as technology, inevitably, became the same everywhere. The socialist and capitalist worlds would become one.

In order to be at all convincing these arguments had to deny their own history, and they did so to a remarkable extent. The obliteration of even recent history has been continuous and systematic. For example, in the middle of 1945 the bomber ceased to be a peace-creating technology; the atomic bomb took its place. When we think of information technology we forget about postal systems, the telegraph, the telephone, radio and television. When we celebrate on-line shopping, the mail-order catalogue goes missing. Genetic engineering, and its positive and negative impacts, is discussed as if there had never been any other means of changing animals or plants, let alone other means of increasing food supply. A history of how things were done in the past, and of the way past futurology has worked, will undermine most contemporary claims to novelty.

We need to be aware that this futurology of the past has affected our history. From it we get our focus on invention and innovation, and on the technologies which we take to be the most important. From this literature, the work of low- and middle-ranking intellectuals and propagandists, ranging from, say, the books of H. G. Wells to the press releases of NASA's PR officials, we get a whole series of clichéd claims about technology and history. We should take them, not as well-grounded contributions to our understanding, for they rarely are that, but as the basis of questions. What have been the most significant technologies of the twentieth century? Has the world become a global village? Has culture lagged behind technology? Has technology had revolutionary or conservative social and political effects? Has new technology been responsible for the dramatic increase in economic output in the last hundred years? Has technology transformed war? Has the rate of technical change been ever increasing? These are some of the questions this book will try to answer, but they cannot be answered within the innovation-centric frame in which they are usually asked.

These questions become much easier to answer if we stop thinking about 'technology', but instead think of 'things'. Thinking about the use of things, rather than of technology, connects us directly with the world we know rather than the strange world in which 'technology' lives. We speak of 'our' technology, meaning the technology of an age or a whole society. By contrast 'things' fit into no such totality, and do not evoke what is often taken as an independent historical force. We discuss the world of things as grown-ups, but technology as children. For example, we all know that while the use of things is widely distributed through societies, ultimate control of things and their use has been highly concentrated, within societies and between societies. Ownership, and other forms of authority, on the one hand, and use on the other, have been radically separated. Most people in the world live in houses that do not belong to them, work in workplaces belonging to others, with tools that belong to others, and indeed many of the things they apparently own are often tied to credit agreements.

Within societies, states and/or small groups have had disproportionate control; some societies have much more stuff than others. In many places of the world much is owned by foreigners. Things belong to particular people in ways which technology does not.

2

Time

An Imperial Airways aeroplane flies over a camel caravan in the 1920s; a donkey cart carries the remains of a motor car through Bombay. This juxtaposition of what is taken to be old and new has long been a common photographic genre. The first represented technological optimism, the second a much more ambivalent attitude. These seeming clashes of technological time arise from a particular understanding of old and new. We see technologies such as the camel, the donkey cart, the wooden plough or the hand-loom as technologies of previous historical eras. Yet they, just like the aeroplane and the motor car, were made, maintained and used throughout the last century; they existed in the same, interconnected world. What better example of this is there than that shown in some startling photographs which appeared at the end of the twentieth century: poor Indians and Bangladeshis were dismantling giant ocean-going ships, not in some state-of-the-art dry-dock, but with minimal equipment on the beaches of the Bay of Bengal and the Arabian Sea.

While donkey carts and hand-looms belong in folkloric museums, aeroplanes and motor cars belong in science and technology museums. Very occasionally they are combined. The Science Museum in Bangkok, which opened in 2000, brought together the usual displays of science and technology with those more characteristic of a folk museum: it had a section on 'traditional technology', including carving, pottery, metallurgy, wickerwork and textiles. These were not technologies

to be left behind, but were displayed to help preserve and *revive* traditional handicraft skills. In the rich world, science museums and folk museums are usually separate, and each has a different sense of time. Science and technology museums want, and do, tell a story of novelties, firsts and of the future.

The London Science Museum has a showcase gallery, grandly entitled 'The Making of the Modern World'. This has a timeline inscribed on its floor, but it is an innovation timeline. Thus steam power appears only in the eighteenth- and nineteenth-century parts of the display. Yet, on entering the main hall of the museum the visitor had, until recently, to pass by a triple-expansion reciprocating marine steam engine. Most adult visitors confidently dated this machine to the mid nineteenth century, for it looked like something from 'the industrial revolution'. Yet the labels told a different story: the engine was built in 1928 for a British fishing boat. Converted to a pleasure yacht the boat and engine were in use for decades, long enough indeed to become of historical interest: a museum piece, as the expression goes. In fact, the museum is full of twentieth-century steam engines; they are just not part of the story it sets out to tell its mostly young visitors. Such machines are more likely to be highlighted in folkloric industrial museums, or in those devoted to old forms of transport or warfare. 'Useful things disappear more completely than meaningful and pleasurable things,' noted a brilliant analyst, who recalled how we keep old paintings, jewels and suchlike, but not tools.[1] They disappear as soon as they no longer have practical use. Yet many things we think of as old remained in practical use for longer than our future-oriented accounts of technological history allow. Our industrial, scientific and technological museums testify to the long life of many machines, and yet, at the same time, many deny the significance of this point for our thinking about technology.

Many of the most important technologies of the twentieth century were invented and innovated long before 1900. Some, but not all, declined during the twentieth century. Their importance should not be underestimated, for even as technologies disappear they remain significant. It is not until they are nearly completely gone that they

6. A new technology in the early twentieth century. Rickshaws on Benten-Dori Street, Yokohama, Japan, on a feast day in 1906. The rickshaw spread to the rest of South and South East Asia from Japan in the twentieth century. Its use was still increasing in certain places late that century, and it is still in use in the twenty-first.

become as insignificant as when they first appeared. Indeed the history of twentieth-century technology usefully starts with technology usually seen as old, perhaps even obsolete, merely persisting anachronistically, like camel caravans and donkey carts, or better still horsepower.

Times are changing

Traditionally technological timelines date technology by invention or innovation. Timelines imply that *time* is a key variable, that it is the march of time which shapes history. That is the assumption behind graphing so much economic data against time. Yet things do not spread like a contagious disease, with a few people getting new technologies early, followed by increasing numbers learning from those who have them, until the rate of adoption falls as most people have them. The international spread of ownership of things shows that the diffusion of things works differently – the rate of take-up has varied enormously between countries, irrespective of how long the technology took to arrive in the first place.

New technologies appeared in every corner of the world very soon after innovation. Cars appeared in Barcelona by 1898. The famous firms of Hispano-Suiza and Elizalde were formed in the city in 1904 and 1911, respectively. By 1912 the Dutch East Indies (now Indonesia) had 1,194 automobiles.[2] The Argentine city of Salta, in the foothills of the Andes, had more than 200 motor cars by 1915. The first aeroplane flight in Barcelona was in 1910, and the first locally produced aircraft to fly was built in 1916. The first plane to fly in Japan did so in 1910 and in 1914 Japanese forces used aircraft against German forces in China. Aeroplanes were used in war in North Africa and the Balkans, before the Great War. Colombia's first airline started operations in 1919.

Television provides another rich example of rapid initial adoption around the world. Before 1939 only Britain and Germany had TV; the rich countries established or re-established broadcasting in the late 1940s and early 1950s, as did Argentina (1952) and Japan (1953).[3] Much of Africa was not far behind. Morocco, Algeria and Nigeria got television in the 1950s; in the early 1960s it arrived in many more African nations, Korea, Singapore, Malaysia, China, India, Pakistan, Indonesia, and most of the Middle East.[4]

The time it took for a new technology to reach a particular part of the world tells us little about the rate at which its use was to be taken up, and thus its impact, in different countries. This was not a matter of

time but of money. Crudely speaking the uptake of new technologies was determined by income. In the United States there was a profusion of consumer goods such as cars and washing machines in the 1920s at levels which were some thirty years in advance of even the richest *European* countries. Europeans were poorer than Americans; once they became as rich as the Americans had been they bought them in similar quantities. And that process is repeating itself: as other countries become richer they too see more and more of their people buying these standard goods which have been around for a long time. Many countries have not reached the levels of income per head or motorisation or electrification that the United States achieved in the 1920s. Although much of Africa first got television in the 1950s and 1960s there were only around twenty-five TV sets per 1,000 population in the 1980s, well below the level of countries now richer who first got television at the same time or later.

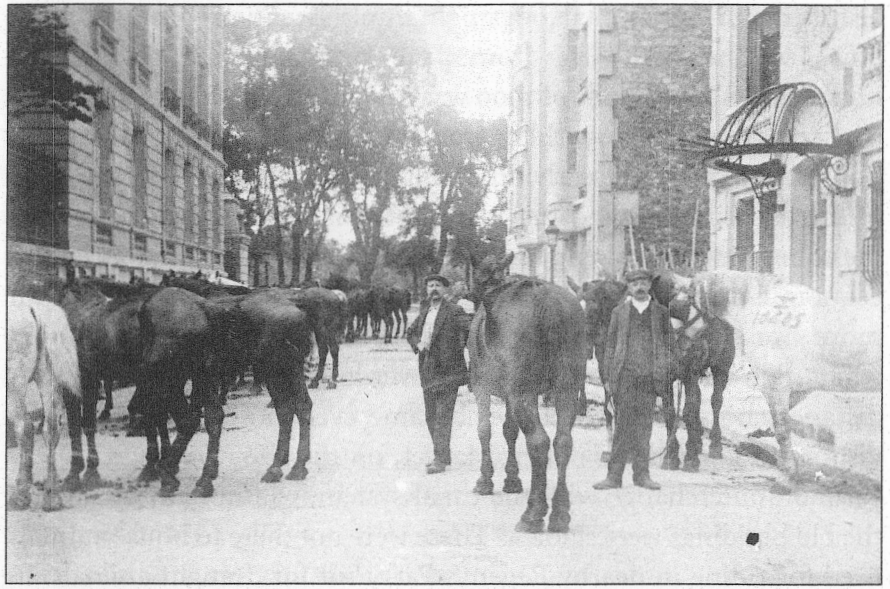
Yet while technological replication over time, driven by economic development, is a crucially important element in the history of the twentieth century, it can mislead us. The replication over time is far from exact. Thus at the end of the twentieth century places such as Colombia, Morocco, Mexico, Thailand, China and Brazil had roughly the same level of income per head as the richest countries of the world and the great imperial powers had in 1913. Clearly they had different technologies for transportation, communication, health care and so on. Part of the reason was that new technologies became available; technological time is a factor. But, equally, 'old' technologies came into use in ways which were not prefigured in the past. As poor countries became richer they expanded the use of technologies that form no part of the usual schemes of modernisation.

Horses, mules and oxen

The use of the horse for human purposes was invented thousands of years ago. The breeding, rearing, training and maintaining of horses was expert work that created beasts which did not exist in the wild. If we were to date the age of horsepower by its maximum use, it would

be much more recent than one might think. Twentieth-century horsepower was not a left-over from a pre-mechanical era; the gigantic horse-drawn metropolis of 1900 was new. In Britain, the most industrialised nation in the world in 1900, the use of horses for transportation peaked not in the early nineteenth century but in the early years of the twentieth. How could it be that horse transport expanded at the same time as trains pulled by 'iron horses'? The answer is that economic development and urbanisation went hand in hand with more horse-buses, horse-trams and horse-carriages. In addition, while train and ship carried goods over long distances, over shorter distances horse-drawn vehicles became ever more necessary. Thus visitors to London's Camden Market, on the site of a huge railway yard and interchange with the canal system, will note that many of the old buildings were stables.[5] These were not there to house animals used for riding in nearby Regent's Park, but for draught animals. In 1924 the largest and most progressive British railway company, the London, Midland and Scottish, had as many horses as it had locomotives – 10,000. By contrast it had just over 1,000 motor vehicles. In 1930 the London and North Eastern Railway railway had 7,000 steam locomotives and 5,000 horses, and only about 800 motor vehicles.[6] There is no doubt though, that by 1914 in the great rich cities of the world, horse transport was giving way to the motor-powered buses, lorries and cars, and electric-powered trams.

In agriculture, the horsepower peak was to come later. For example, in Finland the horse population peaked in the 1950s because they were used in logging. The United States provides the most graphic example. Agricultural horsepower peaked in 1915 with more than 21 million on American farms, up from 11 million in 1880, a level to which it had returned by the mid-1930s.[7] The US case is particularly interesting because at the beginning of the twentieth century it had highly mechanised agriculture, but this was horse-powered agriculture. We are apt to underestimate the implications of relying on horsepower in the countryside. At the peak of agricultural horse use in Britain and the USA, about one-third of agricultural land was devoted to the



7. The horse was vital to all belligerents in the Great War. Here horses destined for the war are taken from Paris. In the Second World War they were crucial to the German army, which marched into the Soviet Union with many more horses than Napoleon did in his invasion of the Russian Empire in 1812.

horses' upkeep: they were large consumers of grass, hay and grain.[8] Mechanised agriculture helped the US to become the richest large nation in the world, and one that by the 1910s was by far and away the largest producer of motor vehicles.

In one area of twentieth-century life, the use of horses for transport was particularly remarkable. The Great War and the Second World War are seen as industrial wars, as feats of engineering and science and organisation. And so they were. Because of this both involved huge numbers of horses, which, like men, were conscripted. Every belligerent depended on them, as well as on mules and other beasts of burden. Before the Great War, the small British army had 25,000 horses but by the middle of 1917 the great new mass British armies had 591,000 horses, 213,000 mules, 47,000 camels and 11,000 oxen. In late 1917 there were 368,000 British horses and 82,000 British mules on the Western

Front alone, hugely outnumbering British motor vehicles. This was not a question of a deluded commitment to cavalry. Only one-third of the British horses on the Western Front were for riding (and only some of these were in cavalry units) – the great majority transported the vast quantities of materiel required in modern war, particularly from the railheads to the front. The use of the animals was not an exceptional emergency measure to make use of Britain's existing horses. Horses were desperately needed, and Britain bought 429,000 of them and 275,000 mules from the US, and imported vast quantities of fodder too. Britain's ability to exploit world horse markets was crucial to its military power.[9] In any case the British were not unique. The vast American armies pouring into Europe in 1918 equipped each of their very large infantry divisions with 2,000 draught horses, another 2,000 riding horses and no fewer than 2,700 mules: one horse or mule for every four men.

An even starker example of the continuing importance of the horse is provided by the Second World War. The German army, so often portrayed as centred on armoured formations, had even more horses in the Second World War than the British army had in the Great War. The horse was the 'basic means of transport in the Germany Army'. German rearmament in the 1930s involved mass purchase of horses such that by 1939 the army had 590,000, leaving 3 million others in the rest of the country. Each infantry division needed around 5,000 horses to move itself. For the invasion of the Soviet Union in 1941, 625,000 horses were assembled. As the war progressed the German horse army got ever larger as the Wehrmacht pillaged the agricultural horses of the nations it conquered. At the beginning of 1945 it had 1.2 million horses; the total loss of horses in the war is estimated at 1.5 million.[10] Could it be that the Great War and the Second World War saw more horses in battle than any previous war? Could it be that the draught-horse-to-soldier ratio also increased, despite the use of other forms of transport?[11] Certainly the Wehrmacht embarked on its march to Moscow with many times more horses than Napoleon's *Grand Armée*. Indeed, it took longer to get there.

There is no doubt that the global horse and mule population dropped from the early decades of the twentieth century. Horses disappeared from rich cities and from the fields of wealthy countries. Yet in some parts of the world not only did animal traction remain important, but it became *more* important as animals replaced human power. In one dramatic case, animal power replaced tractors. Cuban agriculture was transformed from the early 1960s with Soviet and East European agricultural machinery and supplies, resulting in a downgrading of animal traction. But the collapse of the Soviet bloc in 1989 led the Cuban government to develop an animal traction programme. The agricultural horse population recovered, but the main focus was on oxen. They were bred and trained in large numbers, and the technical infrastructure needed to use them was built up. The recovery in the number of oxen was spectacular. They had fallen from 500,000 in 1960 to 163,000 in 1990 but increased to 380,000 in the late 1990s. They replaced 40,000 tractors.[12]

The decline of the 'mule' spinning machine

The twentieth century has seen the decline in use of many industrial machines. A good example is the cotton-spinning machine that dominated the most important cotton industry existing in 1900 – the 'mule' spinning machine of the British cotton industry. The 'mule', invented in the early nineteenth century, was so-called because it was a hybrid of two different types of spinning machines – it used the stretching motion of the spinning 'jenny' and the roller action of the 'water-frame'. Each twentieth-century mule had around 1,500 spindles, and each pair of mules was operated by the male spinner and his two assistants, called the 'big piecer' and the 'little piecer'.

The spinning mule was at the centre of what was a globalised industry. Cotton was processed thousands of miles from where it was grown and was exported from a few industrial centres to the whole world. The hub of the industry was free-trading Britain, and particularly Cottonopolis itself, the city of Manchester. The peak year of the British cotton industry was 1913 when it was not only the

largest, but also the most efficient cotton industry in the world.[13] In the interwar years, as trade de-globalised and Japan emerged as a major competitor, Manchester's exports slumped. In 1931, the worst year of the depression, output was half what it had been in 1913. It was not to recover very much, and from the early 1950s a long steady decline continued, though this declining industry remained important. In the 1930s it had around 30 per cent of world textiles exports, and 15 per cent in the early 1950s. Cotton goods accounted for 25 per cent of all British exports in the 1920s, and still made up 5 per cent in the early 1950s.

The machinery in use in the cotton-spinning industry into the late 1950s was overwhelmingly mule spinning machines, all of which were old. Around 80 per cent of the mules in use in 1930 had been installed before 1910. Hardly any mules were added after 1920, and none after 1930, so that by 1950 a great majority of the mules were well over forty years old, the estimated life of the machines in 1930. In other countries an alternative spinning technology, the ring-spindle spinning machines, had taken over but the peculiarly high proportion of mules in the British industry was not due to resistance to rings. It followed from the fact that after the early 1920s there was little investment in new machines at all. So low was investment that at the rate of re-equipment obtaining in 1948 it would have taken fifty years to replace all the mules with new rings, and another fifty years to replace the old rings.[14] In the mid-1950s too, investment was at a rate at which it would take decades to replace just the existing ring-spindles.[15]

The history of the industry after 1913 was thus one of a shrinking number of increasingly old machines. Many mules were lost simply because they became so old that they were not worth keeping, but many machines were taken out of use when still workable, because there was no market for their product. Some argued that these old machines took work from the new ones which might otherwise be installed. As a result the government went to the lengths of setting up something called the Spindles Board, which bought and scrapped spindles from those firms willing to sell. This is one example of a

worldwide phenomenon which shocked progressive opinion in the 1930s – the destruction of machines when people needed work and the world needed clothing. Between 1936 and 1939 the Board scrapped 6.2 million spindles, which compares with 15 million scrapped independently between 1930 and 1939. In the different economic circumstances after the war further scrapping schemes were promoted. The greatest came following the 1959 Cotton Industry Act, which led to the breaking up within a year of nearly 10 million mule spindles, which were by then fifty, sixty and seventy years old. Some lived on and found themselves in folklore museums, or in museums of science and technology.

Our technological museums, with their emphasis on first design, tend to miss out on the extraordinary life stories of the objects they have. But the old stuff still in use now has its own nostalgic journals. There are many specialist publications on old trains, cars and ships still in operation. There are magazines such as *Propliner,* which deals with working old propeller-driven aircraft. That we are nostalgic for twentieth-century technologies, as well as nineteenth-century ones, points to the importance of the disappearance of things which represented the future. The ironer, a machine to iron clothes, diffused to 10 per cent of Canadian households, but rather than being the beginning of a new wave of household automation, promptly disappeared, much as the British tea-making machines would.[16] The airship, a technological wonder of the early decades of the century, went out of use quickly from the 1930s. The miracle insecticide DDT was to disappear faster than the mosquitoes and other insects it was used to kill. Concorde looks like being the first and the last supersonic airliner. Manned hypersonic aeroplanes disappeared in the 1960s. At the end of the twentieth century, nuclear power, once the technology of the future, was set to be phased out in many countries. And in medicine too, many treatments invented in the twentieth century were discontinued, lobotomy and ECT being prominent examples, though the last is still occasionally used.

Not Alphaville but *bidonville*: technology and the poor megacity

The story of the poor world (a term preferable to the euphemistic 'developing world', and the now irrelevant 'Third World') and technology is usually told as one of transfer, resistance, incompetence, lack of maintenance and enforced dependence on rich-world technology. Imperialism, colonialism and dependence were the key concepts, and the *transfer* of technology from rich to poor, the main process. The crucial measures in play were the stock of rich-world technology in the poor world and its innovative capacity. There is a second line of thought, in which the poor world betrayed its true nature by adopting, even partially, 'western' technology.[17] Dating to at least the interwar years, this view held that modern technology destroyed these local, ancient, alternative and more authentic cultures. More recently 'western' technology has been thought of as spearheading a violent assault on poor societies. Both accounts fail to take into consideration the distinctiveness of the new poor world as it emerged in the twentieth century. In particular, they fail to see the poor world as a distinctive *technological* world, one that was particularly fast-growing, and dependent on local and what are usefully called 'creole' technologies, many of which we think of as 'old'. That distinctive world can be voyeuristically consumed, as in the writings of the architect Rem Koolhaas and his associates, but it also needs to be understood not as the future, but as a distinctive world with its own technology of poverty.[18]

World population trebled in the twentieth century, but Europe's population increased by only about 50 per cent. The significant growth has been in the poor world – Asia, Latin America and Africa. One of the greatest changes was in the *cities* of the poor world, which grew at extraordinary rates. By the end of the century (in stark contrast to the beginning) most of the largest cities of the world were poor places: where once Paris, London and New York led in scale and opulence, the largest cities of 2000 were places few would seek to emulate: São Paolo, Jakarta, Karachi, Mumbai (Bombay), Dhaka, Lagos and Mexico

City. This was a new kind of urbanisation, and a spectacularly fast one, which did not replicate the earlier experience of Berlin or Manchester. These were not cities of horses, or of trains, or spinning mules, or great electrical or chemical industries. Furthermore, large parts of them were built without architects, engineers or building contractors, and without conforming to building regulations. These parts of these cities were not made for cars or trains, let alone the information superhighway.

Central to this new urbanisation was the growth of the slum, or shanty town, though we must be wary of these terms because they describe many different types of housing. For example, the *favelas* of Rio de Janeiro are connected to electricity and water, while the *asentamientos* (settlements) of Guatemala City are dark at night. At first sight, the term slum might refer, as it generally did in the rich world and in many parts of the poor world, to decayed old parts of cities where the poorest lived. But in the later twentieth century in particular a new kind of slum, a newly built – one might say purpose-built – one, arose. The optimistic term *pueblos jóvenes*, or young towns, used to describe the slums of Lima says something important about them even though many are decades old.

We need to be particularly wary of definitions of slums in terms of the *lack* of facilities characteristic of rich cities, such as permanent structures, particular forms of sanitation or electricity. We need to ask not what technology the shanty town lacks, but what it has. For poor cities had particular and often novel systems of building, of sanitation, or supply of water, of food and all the other necessities of life, which were not traditional but new. They proved capable of sustaining a new kind of rapidly expanding urban existence on an enormous scale, even if usually a miserable one. One modern technology of the slum was the Kenyan 'flying toilet'. A plastic bag, that ubiquitous product of the post-Second World War chemical industry, was used not only to defecate into, but to dispose of what was once quaintly called 'night soil': the bag was tied, taken outside, swung around, and hurled away as far as possible from one's patch.[19]

The modern materials from which many slums are built are sometimes inscribed in their very names. The early temporary slums of North Africa were known as *bidonvilles*, for the buildings were made from opened-up and flattened-out oil drums (*bidons*). The term is now generic in French. The Arabic term for *bidonville* in Morocco is *mudun safi*, 'metal towns'. The Durban slum dwellings are called *imijondolos* in Zulu, possibly derived from the use of wood from crates that had carried John Deere tractors in through the port in the 1970s.[20]

One material stands out in the development of the poor world, rural and urban, and that is corrugated iron or galvanised iron used for making 'tin roofs'. In the nineteenth century, it spread around the world to areas of British army operation as transportable housing. It also became a key material for building roofs and walls of white settler communities in Australia, New Zealand and the Americas, where it is now of interest as a vernacular architecture. It was hugely important in the twentieth century as a truly global technology. Its cheapness, lightness, ease of use and long life made it a ubiquitous material in the poor world in a way it never had been in the rich world. A visitor to West Africa in the Second World War noted of 'Ibadan, then the largest town in black Africa … [it] had grown in less than a century from a local market into a city with nearly 100,000 inhabitants – though alas, as so often in Africa, the houses were mostly roofed with galvanized iron.'[21] Today Ibadan is at one end of a shanty-town corridor of 70 million people.[22] Its roofs, to judge from aerial photographs, are still of rusted corrugated iron.

Corrugated iron was not just an urban technology; it was used to replace thatch roofs on traditional rural buildings as well. In Rwanda corrugated iron was first used by the Belgian colonisers for their public buildings. By the end of the twentieth century a lighter type was the standard roofing material of even the poorest homes. Farmers' houses built of adobe had corrugated iron roofs, and were called *terres-tôles* (earth-sheets). As the only part of the house villagers cannot make, the iron roof became a prized possession; it was looted from Tutsis'

homes in the genocide of 1994. As the tables turned, Hutu refugees trudged to the Congo bearing sheets on their backs, others buried them in their fields.[23]

As in other technologies, there has been innovation in corrugated iron, in both shapes and materials. It has become lighter and stronger, available in many more grades and types. New shapes of corrugations have been used, and new coating introduced. Yet the long-established sinusoidal corrugations still dominate the cheapest grades.

A second crucial cheap material was asbestos-cement, especially corrugated asbestos-cement. Asbestos-cement was patented in 1901 by an Austro-Hungarian, Ludwig Hatschek, an asbestos producer. He called his invention 'Eternit', and the material and the name have both been long lasting. Production started by a Swiss company of the same name in 1903, which became a major multinational with branches all over the world. Eternit still means asbestos-cement in many places; in others it was called 'Uralite' or 'Uralita'. Although this is not always clear, by far the main use of asbestos – a fibrous mineral – has been for the manufacture of asbestos-cement (also known as fibro-cement), mainly used to produce corrugated roofing, sheets for building work, and water and sewage pipes. It has been a key material in modern urbanisation. At the beginning of the century it was primarily utilised in North America; after the Second World War its use boomed there, and particularly in Europe, but growth took off in Asia, South America and Africa in the 1960s and 1970s.[24] Unfortunately asbestos was found to be a serious carcinogen, and its use was progressively banned in the US, Europe and elsewhere. As a result, world production fell from the mid-1970s. But at the end of the century production was still at the levels of the 1950s. Even in the 1990s in South Africa, 24 per cent of new subsidised housing had asbestos-cement roofing.[25]

The Martinican/French writer Patrick Chamoiseau, in his book *Texaco*, the great novel of the shanty town, reflected a new understanding of the poor city that was emerging in the 1960s and 1970s. In *Texaco* the history of Martinique is divided into the age of the *ajoupas* (shelters) and longhouses, the age of straw, the age of crate wood, the age of asbestos (fibro-cement) and the age of concrete, reflecting the key materials of the shanty towns.[26] In the age of asbestos, asbestos-cement sheet was used for walls; the roofs were of corrugated iron. Thereafter the people bought the occasional bag of cement to make their world more stable and secure. One of the characters in the book is a new model urbanist who began to understand this new kind of city. Indeed, 'self-help housing' and '*auto construcción*' became terms of art in urban planning, recognising that houses were being built in vast numbers, well outside the standard networks of modernity.

Corrugated iron, asbestos-cement and cement were not invented in the poor world, they were first exported to it, and then locally produced. The growth of the poor world went along with a massive increase in use of these 'old' technologies from the rich world, and yet also, importantly, it was a story of the spread of distinctive technologies often adapted from 'old' technologies. One can usefully describe them as 'creole' technologies. 'Creole' is a complex term with a long history and many variant meanings. It most commonly means local derivatives of something originally from elsewhere (typically the white and black populations of the Americas). The term also carries the sense of earthy, local, genuine, vulgar, popular, in contrast to the sophistication of the metropolitan. Creole means derived, but different from, the originating case. It sometimes carries the sense of hybrid between the incomer and the existing, though this is not the common form.[27]

Creole technology

One important aspect of creole technology is that the basic imported technology acquired a new lease of life in the poor world. There were many cases of late adoption and long use in the poor world of rich-country technologies. A small example would be that carrier pigeons were introduced to the police services in Orissa (India) in 1946 and were phased out only in the 1990s. The Indian motor-vehicle industry provides some better-known examples. From the mid-1950s the 1955-

model Royal Enfield Bullet motorcycle was manufactured in India. Production of the same model continues to this day at the rate of 10,000 a year in the original Madras factory, and with methods which still involve little assembly-line work. Hindustan Motors in Uttarpara, West Bengal, still make the Ambassador, based on a mid-1950s Morris Oxford Series II motor car. Production started in 1957 and to date 800,000 have been produced. The history of the Volkswagen Beetle is a particularly notable case given the scale of its production. By the early 1970s it had overtaken the Model T Ford as the car most widely produced in the world (15 million), and it would continue to be manufactured, reaching a total of 21 million. The end of production came in Mexico in 2003, where it had been made since 1954. Brazilian production stopped in 1986, restarted in 1993 and finally came to an end in 1996, long after production finished in Germany.

Communist China had its own distinctive attitude to old technologies of production. It pursued a 'walking on two legs' policy of industrialisation that has been called 'technological dualism'. The first leg was large-scale, urban, factory production, using models brought from the Soviet Union. This was a huge effort of transfer of technical skills, models, designs and factories. China long remained a producer of Soviet technology: till the end of the 1980s it was making Soviet trucks and steam locomotives from the 1950s. Steam-train buffs flocked to the sidings and marshalling yards of China, for only in the mid-1980s did diesel and electric locomotive production overtake that of steam locomotives.

The second leg was locally run, small-scale industry, reliant on local raw materials and supplying local needs, usually in the agricultural sector. These industries were based on centrally-supplied designs of technologies, usually themselves based on 'old' technologies that had gone out of use elsewhere in the world. From the late 1950s 'backyard iron and steel' production, together with small-scale cement kilns, fertiliser plants, agricultural machinery workshops, food-processing works, power generation and mining boomed under the Great Leap Forward. Fertiliser production was a rare example of a novel technology, for local plants made a fertiliser used nowhere else in the world – ammonium bicarbonate.

The Chinese people paid an enormous price for what was by any measure the profoundly unsuccessful Great Leap Forward. Millions of lives were lost to famine, and there was also a cruel waste of technological and natural resources in a desperately poor country. With the collapse of the Great Leap many local enterprises closed. But many did not, and survived till the next great expansion phase for these industries, the Cultural Revolution. By 1971 60 per cent of fertiliser production came from small plants; 50 per cent of cement; 16 per cent of hydro-generating capacity; overall around 10 per cent of Chinese factory output.[28]

Transport

The idea that the technologies of the poor world simply lag behind those of the rich world in time is not generally applicable, as the case of the fabric of the poor megacity illustrates. Transport provides a second example, since the poor megacities had different transport patterns from those of the great rich cities of 1900, or even of 1930. These rich cities did not have the bicycle or motorcycle densities of the megacities of late twentieth-century Asia. Indeed bicycle and motor-bicycle production boomed in the world, particularly in the poor world, from the 1970s. For the first time in many decades bicycle production surged ahead of motor-car production. In recent years around 100 million bicycles were produced every year and only about 40 million cars. In 1950 there were around 10 million of each, and they remained about equal to 1970. The great change was the expansion in Chinese production to 40–50 million bicycles from a few million in the early 1970s.[29] In addition Taiwan and India between them were, at the end of the century, making more bicycles than were produced in the world in 1950. Bicycle-derived technologies of the poor megacity provide an instance of a creole technology.

In 2003 it was reported that the city of Calcutta was still trying to get rid of the hand-pulled rickshaw, long gone from most of the

rest of Asia. These rickshaws were deemed old-fashioned even by the standards of hand-rickshaws: Calcutta's had spoked wheels, but not ones derived from bicycle technology; they were made of wood and were rimmed with solid rubber rather than pneumatic tyres. Surely these were survivals from the distant past?

In fact the hand-pulled rickshaw, far from being an ancient invention, was apparently devised in Japan in the 1870s, though similar things had been in use in Europe on a small scale. The rickshaw replaced the palanquin/sedan chair. Use boomed from the very late nineteenth century, first in Japan, where numbers peaked around 1900 and quickly spread in Asia. In Singapore the total was highest in the early 1920s, while Calcutta saw hand-rickshaw growth in the 1920s and 1930s. In most places the hand-rickshaw went out of use after the Second World War, condemned as a barbarous machine humiliating the poor pullers.

The cycle-rickshaw (sometime called a trishaw) was, as an invention, almost as old as the rickshaw; yet as a thing-in-use it peaked even more recently.[30] Developed in the 1880s, it found hardly any use until around 1929 in Singapore, where by 1935 cycle-rickshaws outnumbered hand-pulled rickshaws. They appeared in Calcutta around 1930, Dhaka about 1938, and Jakarta around 1936. By 1950 they were present in every country in south and east Asia. Japan had never had many. There were variations in design across countries but relatively little within countries. The most common was that with the passenger sitting behind the driver (India, Bangladesh, China, the Macao '*triciclo*'). But the version with the passengers forward of the driver was also common, for example the Indonesian '*becak*', the Vietnamese 'cyclo' and the Malaysian 'trishaw'. Others had the passenger to the side, as in the Philippines 'sidecar', the Burmese '*sai kaa*' and the Singapore 'trishaw'.[31]

Far from disappearing after the Second World War, the cycle rickshaw continued to expand rapidly in the 1960s and 1970s. It was estimated in the late 1980s that there were 4 million in the world, and that the number was still increasing overall though in some countries there were decreases. Dhaka was the capital of the cycle-rickshaw with some 300,000 at the end of the twentieth century. A subsequent creole technology, unknown in the rich cities of the world, is the scooter-based taxi. From the 1950s these 'auto-rickshaws' appeared in India, and similar designs have spread all over Asia (for example, the Thai '*tuk-tuk*' and the Bangladeshi 'baby-taxi').

The cycle-rickshaw was an urban, not a rural, machine. It followed, rather than preceded, seemingly newer transport techniques. Rickshaws needed the metalled roads which were built for cars and buses and lorries. Yet in the great expanding cities of Asia they were seen as demeaning technologies of poverty and as technologies of the past that needed to be got rid of. The city governments of Asia, whether colonial or post-colonial, wanted to control them, restricting licences, and indeed in places banning them outright. Yet if governments had success in getting rid of machines such as the spinning mule in the middle of the century, they failed miserably in the case of the rickshaw, for numbers, as we have seen, continued to rise. They have now appeared in places they had never been before, including central London, where they operate regularly from the Soho entertainment district.

Remodelling the boat

Water transport provides some good examples of creole technologies, particularly in the sense of hybrids. In Bangkok the great river which runs through that megacity is home to a remarkable breed of craft. Long, thin, wooden boats have been converted to a species of powerboat by the addition of a large car engine mounted on gimbals which powers a propeller on the end of a long shaft. The operator controls the boat by moving the whole engine and associated propeller. A brilliant invention, these 'long-tailed boats' first appeared in Bangkok, but have since spread through Thailand, not just for the tourist trade, but as a standard means of powering a boat. The tails are made in Bangkok and cost $100; engines can be bought for around $600, compared with a motorbike at $500. They are also present on the Mekong, in Cambodia and Vietnam, and some say on the Amazon in Peru.

8. Collecting hay in the Carpathian foothills in the Ukraine on the eve of the twenty-first century. Although it might seem to be a relic from the past, the wheels of the cart seem to be from a car, and there is an electricity or telephone connection. Furthermore, Ukrainian agriculture was forcibly modernised decades ago.

Another case of a creole technology is the rejuvenated 'country-boat' of Bangladesh, a country where millions depended on water transport. These boats, hand built by itinerant and miserably poor boat carpenters (*mistri*), increasingly lost out to land transport. It was in the north-west of Bangladesh that they were transformed in the early 1980s. New wells, powered by petrol pumps, were installed there, but these were idle most of the year. An anonymous engineer used one of these engines to drive a boat; by the late 1980s many were used in the wet season and on market days in the dry season. Increasingly engines were permanently fitted, but irrigation-pump engines remained the most popular since they were subsidised. In the 1980s iron sheet started to be used to make boats, and for bigger boats, recycled steel plates from the shipbreakers on the coast.[32]

The cycle-rickshaws, the motorised country-boats, the long-tailed

boats, as well as the buildings of the shanty towns, combine the products of large-scale industry – the car engine, the bicycle, cement, asbestos-cement – and the local and small scale. These were derivative, adapted technologies. But they were more than that – for they were local adaptations that gave new life to older, more traditional forms. This hybridity was common. In many parts of the world donkey carts were made using motor-car axles and especially wheels. Wooden fishing boats of the most primitive sort were made much more efficient by synthetic fishing nets; larger wooden boats of craft construction were fitted with engines, with radar and with sonar, as a visit to any number of the world's small fishing ports will confirm.

Retro and reappearance

In the rich world there have also been many reintroductions of 'old' technology. Cable TV was a disappearing technology in the 1950s and 1960s, yet returned with a vengeance in the 1980s, as a seemingly new form promising ever more TV channels. Indeed cables in general returned, though often in the form of fibre-optic cables which carried many times more traffic than copper ones. The use of condoms expanded massively through the twentieth-century, then declined with the introduction of the Pill and other new contraceptives, but growth resumed following the appearance of AIDS. Acupuncture, known in Europe from the seventeenth century, had a boom in the early nineteenth, from which it slowly declined in Europe till it re-emerged in the 1970s. The passenger liner gave way to the airliner in the late 1950s and early 1960s, yet many were converted to cruise ships in the 1960s and 1970s, developing an industry which at the end of the twentieth century carried more passengers than ever before. Cruise ships take over 8 million passengers on holiday; the greatest passenger port in the world is now Miami. The biggest liners ever built were no longer the interwar behemoths such as the *Normandie* or the *Queen Elizabeth*, but a new generation dating from the last years of the twentieth century. One company has built the largest sailing ship ever made, based on the *Preussen* of 1902, for the luxury cruise market.

The *Royal Clipper*, delivered in 2000, was built at the former Lenin Shipyard in Gdansk and the Dutch Merwede yard. The Harland and Wolff shipyard in Belfast gets regular enquiries about rebuilding the ill-fated *Titanic* as a cruise liner. Airships are used for televising major events, and for taking tourists over great cities.

The Ambassador and the Bullet were sold back into the rich world from whence they came decades earlier. Old treadle sewing machines made for the poorest markets are also sold as replicas in the rich world.[33] Luxury mechanical watches, such as those of Patek Philippe, are still made. Before 1988, when it converted to making diesel locomotives, the Datong Locomotive Works in China, exported steam locomotives to the USA for use on tourist lines.[34] Among gun aficionados in the USA an industry grew up making working replicas of nineteenth-century rifles. Antique cameras and replicas of classics, notably Leicas, sell to a discerning clientele, and vinyl records have a distinct niche market.

One of the most important novelties in food production and consumption has involved, according to Tim Mondavi of the California wine-maker Mondavi, 'moving forward to the past'. Mondavi introduced oak fermentation barrels and other 'old' technology to their high-tech winery and vineyards.[35] The production of 'organic' foods has a special relationship with the past. Part of the claim of the organic movement is that organic production is less damaging to the environment and more conducive to animal and human health. Central to the practice is the abandonment of the use of synthetic fertilisers, pesticides and fungicides. Yet organic certification rules allow for the use of many of the materials which were standard in late nineteenth-century agriculture, such as mined and crushed phosphate rock as fertiliser. Guano use is permitted under certain circumstances, as are nineteenth-century copper-based fungicides such as Bordeaux and Burgundy mixtures, though allowed quantities are being restricted.

Sailing cruise ships and other manifestations of retro take place in a world which is radically different from the one in which sailing

ships dominated sea transport and where synthetic fertilisers were not available. Corrugated iron roofs and the bicycle were the products of modern industries, of a world whose productive capacity was transformed in the twentieth century. Yet in that remarkable story too, the seemingly old was much more important than we sometimes care to recognise.

Conclusion

We have long been told that we live with an 'ever-increasing rate of change', yet there is good evidence that it is not always increasing. Measuring change is extremely difficult, but let us start with economic growth in the rich countries as a crude measure. While there was rapid growth before the Great War, there was slower growth overall between 1913 and 1950. There was spectacular growth in the long boom, followed by less strong growth since. In other words, growth rates were lower in the interwar years than before 1914, and average rates of economic growth after 1973 were considerably lower than in the period 1950–1973. In the 1970s there was a 'productivity slowdown' and since then the rich world has continued to grow, but not at historically unprecedented rates.

Since the 1980s one could be forgiven for believing that high growth rates had returned, not least because of the constant evocations of the notion of 'ever increasing change', and all the talk of fundamental transitions to new economies and new times. But in the USA, Japan, the EU and Britain, growth rates were lower in the 1990s than in the 1980s, lower in the 1980s than in the 1970s and lower in the 1970s than in the 1960s.[1] In the USA it appears that productivity growth increased in the late 1990s, but there is still a dispute as to whether this was general, or concentrated in the computer-manufacturing sector. Growth is not the same as change but there is no evidence that structural change in the rich countries was any faster in recent decades than in the long boom. Once again, our future-oriented rhetoric has underestimated the past, and overestimated the power of the present.

Not all parts of the world grew at these same rhythms. For example the USSR grew very fast in the 1930s, while the rest of the world did not.

Especially since the 1970s many economies in the Far East have grown very fast, but from a low base. The increasing scale of the Chinese economy in particular has meant that its growth has been enough to alter the global statistics materially. For example, global steel production is growing at long boom rates again thanks to China.

Another important feature of change in the last three decades is that there has been a decline of economies, as well as growth. In some places the last years of the twentieth century saw retrogression. The income per head of the 700 million sub-Saharan Africans fell from $700 per head in 1980 to the even more miserable $500 at the end of the century; to make matters worse for the majority, 45 per cent of this output was produced in South Africa so the real fall elsewhere was even worse.[2] Malaria has become more common, and new diseases such a HIV/AIDS have swept through the continent as no other. Yet this is not a reversion to an old world, for this is a continent with cars and new kinds of shanty towns, a rapidly urbanising world without what is taken to be modern industry.

From 1989 there was a remarkably rapid collapse in the economies of the Soviet Union and its former satellites, of 20, 30 and 40 per cent, far outstripping the capitalist recession of the early 1980s. Although this dramatic fall in output cannot be characterised generally as a technological retrogression such a phenomenon was evident in some places. Now independent Moldova, formerly part of the USSR, lost 60 per cent of its output. Machines virtually phased out as the economy had developed since the Second World War, things such as 'spinning wheels, weaving looms, butter churns, wooden grape presses and stone bread ovens – are now back in use', it was reported in 2001. The 'only way to survive is to be totally self-sufficient,' claimed the curator of the ethnological museum in Belsama, 'and that means turning the clock back.'[3] Cuba, as we have seen, expanded the number of its oxen as it lost its supply of tractors.

In some industries, such as shipbreaking, there has been a move towards a new kind of low-tech future. By the 1980s Taiwan had become by far the largest shipbreaker, demolishing more than a third

27. The Brazilian aircraft carrier Minas Gerais, *broken up with a novel lack of modern technology on Alang Beach, Gujarat, India, in 2004. Alang Beach became the single largest centre of the shipbreaking industry, and a startling example of the new technological retrogression. The ship, originally HMS* Vengeance, *launched in 1945, was built at a time when shipbreaking was more capital intensive.*

of the world's ships. By the early 1990s it was out of this industry, now dominated by India, Pakistan and Bangladesh, which between them had more than 80 per cent of the world market by 1995.[4] Taiwan used specialised dock facilities, but the new shipbreaking was on beaches, with the most minimal equipment, carried out by thousands of barefoot workers. The reason shipbreaking was done in these places was that scrap steel was in demand locally. But it is used in a markedly different way from other places and times: it is re-rolled, re-worked, rather than used to make fresh steel.

What seems at first technological retrogression was perhaps not unknown in earlier years of the century. No one had ever attempted to build such a large canal with what were then such primitive means as were used on the White Sea canal or in the erection of the great steel

works of Magnitogorsk. Collective farming itself involved technological retrogression, for all the emphasis on the tractor. However, not for many centuries has a global industry retrogressed like shipbreaking has.

This book has argued for the importance of the seemingly old. It is also a plea for a novel way of looking at the history of the technological world, one which will change our minds about what that world has been like. And implicit in it is a plea for novel ways of thinking about the technological present.

We should be aware, for example, that most change is taking place by the transfer of techniques from place to place. The scope for such change is enormous given the level of inequalities that exist with respect to technology. Even among rich countries there are very important differences in, for example, carbon intensity. If the USA were to reduce its energy-use levels to those of Japan, the impact on total energy use would be very significant. But for poor countries, as well as for rich ones, such a message is often unwelcome. For *imitating* is seen as a much less worthy activity than innovating. To imitate, to replicate, is to deny one's creativity, to impose upon oneself what was designed for others by others. '*Que inventen ellos*' ('Let *them* invent') is seen not as sensible policy advice, but a recipe for national humiliation. To have technology or science is, it is often deeply felt, to create something new. The answer to such concerns that is implicit in this book is that all countries, firms, individuals, with rare and unusual exceptions, have relied on others to invent, and have imitated more than they have invented.

Arguments about imitating policies and practices for innovation might seem to fall in the same category. That is to say, that it might seem like a good thing that they should be the same or similar around the world. Indeed there is a remarkable lack of originality in innovation policies globally, and many explicit calls for copying those

perceived as the most successful models. Yet while copying existing technology is very sensible, imitating innovation policies may be a mistake. For if all nations, areas and firms are agreed about what the research should be, by definition it will no longer be innovative; and it might not be a good thing that all nations pursue the same policies for research, because they are likely to come up with similar inventions only a few of which will be used even if technologically successful. 'If I knew the future of jazz I'd be there already,' said one wise musician.

Calling for innovation is, paradoxically, a common way of avoiding change when change is not wanted. The argument that future science and technology will deal with global warming is an instance. It is implicitly arguing that in today's world only what we have is possible. Yet we have the technological capacity to do things very differently: we are not technologically determined.

Getting away, as this book has, from the conflation of use and invention/innovation will in itself have a major impact on our thinking about novelty generation. The twentieth century was awash with inventions and innovations, so that most had to fail. Recognising this will have a liberating effect. We need no longer worry about being resistant to innovation, or being behind the times, when we chose not to take up an invention. Living in an inventive age requires us to reject the majority that are on offer. We are free to oppose technologies we do not like, however much interested pundits and governments tell us it is essential to accept, say, GM crops. There are alternative technologies, alternative paths of invention. The history of invention is not the history of a necessary future to which we must adapt or die, but rather of failed futures, and of futures firmly fixed in the past.

We should feel free to research, develop, innovate, even in areas which are considered out of date by those stuck in passé futuristic ways of thinking. Most inventions will continue to fail, the future will remain uncertain. Indeed the key problem in research policy should be ensuring that there are many more good ideas, and thus many more failed ideas. Stopping projects at the right time is the key to a successful invention and innovation policy, but doing this means being critical

of the hype that surrounds, and often justifies and promotes funding for invention.

Although we can stop projects, it is often said that we cannot un-invent technologies, usually meaning that we cannot get rid of them. The idea is itself an example of the conflation of invention and technology. For most inventions are effectively un-invented, in being forgotten and often lost. A few things are going out of use as the world economy grows – among them are asbestos, declining since the 1970s, and refrigerants like CFC gases. And one of the new tasks faced by scientists and engineers is actively making old technologies disappear, some of which, like nuclear power stations, are extremely difficult to dispose of.

Thinking about the technological past can give us insights into 'the question of technology' – what is it, where does it come from, what does it do? But this book has attempted to do much more than take historical examples to address this perennially interesting question. It has been concerned primarily with asking questions not about technology, but about technology in history – asking questions about the place of technology within wider historical processes. This important distinction is not obvious, but it is central to a proper historical understanding of technology. It will help wean us off the idea that invention, 'technological change' and the 'shaping of technology' need to be the central questions for the history of technology. Instead the history of technology can be much more; and it can help us rethink history.

If we are interested in the historical relations between technology and society we need a new account not only of the technology we have used but also of the society we have lived in. For existing histories of twentieth-century technology were embedded in particular assumptions about world history, while world histories had embedded in them particular assumptions about the nature of technological change and its impact – each was already defined, usually implicitly, in relation to the other. Hence the history of the society into which this new account is placed is very different from the one usually found: for example, it takes as central the expansion of a new kind of poor world, a world

which has been almost continuously at war, and in which millions have been killed and tortured. This necessitates an account of the global technological landscape that is very different from those found implicitly and explicitly in existing global histories and histories of technology – and an account that might help revise our views about world history.

It is a measure of the importance of technology to the twentieth century, and to our understanding of it, that to rethink the history of technology is necessarily to rethink the history of the world. For example, we should no longer assume that there was ineluctable globalisation thanks to new technology; on the contrary the world went through a process of de-globalisation in which technologies of self-sufficiency and empire had a powerful role. Culture has not lagged behind technology, rather the reverse; the idea that culture has lagged behind technology is itself very old and has existed under many different technological regimes. Technology has not generally been a revolutionary force; it has been responsible for keeping things the same as much as changing them. The place of technology in the undoubted increase in productivity in the twentieth century remains mysterious; but we are not entering a weightless, dematerialised information world. War changed in the twentieth century, but not according to the rhythms of conventional technological timelines.

History is changed when we put into it the technology that counts: not only the famous spectacular technologies but the low and ubiquitous ones. The historical study of things in use, and the uses of things, matters.