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DAMS, RADIATORS AND THE SHARD: THE LEGACY OF ENGLISH GARDENING

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I'm very grateful to Gresham College and to Allen Lane for allowing me to launch my new book *An Economic History of the English Garden* with this lecture. This will be the fourth lecture on the topic of the economic history of the English garden that I've given at Gresham. The College supported my research on this topic, with funds provided by the European Science Foundation, when I was Provost and since, and it is most appropriate that the result of my labours over more than 10 years is launched at the College. It is an institution which I was proud to lead and for which I have great affection and respect.

In my previous lectures I have discussed the overall growth of English gardening since 1660, the making and running of the great gardens of the 17th and 18th centuries and the entrepreneurs who designed and built gardens or ran the nurseries which supplied them.

My interest in the whole topic stems, many years back, from a simple question which I asked as I wandered round a beautiful garden. The question was: it's lovely, but how much did it cost? I found that none of the thousands of books on garden history, none of the guidebooks of the National Trust or English Heritage, none of the books of my own discipline - economic history - answered, or even asked, that question. So, I set out to answer it for myself.

The result is, in essence, a history of the garden industry in England since 1660. I think I can claim that it is a new kind of garden history. My simple question has led me in many directions, some of which I covered in earlier lectures. It has been hugely enjoyable.

Tonight, I'm going to discuss the technology of gardening and its effect on our lives. One might call it "What Gardening has done for us" except that I'm not going to talk about the most important answer, the pleasure that gardens bring to our lives. That pleasure is shared by millions. 50% of the British population describe themselves as gardeners and it is by far the largest leisure pursuit other than watching television, reading or using our computers. As an outside pursuit it dwarfs any form of sport.

When one mentions the technology of gardening, everyone thinks immediately of the lawnmower. Actually, it was Savery's engine - the first working steam engine - that was the first modern machine to be used in English gardens, less than 25 years after its invention. Historians of the steam engine have failed to notice this fact. Wooden waterwheels had been used in gardens, probably for millennia, but this metallic forerunner of the industrial revolution was a new departure. The engine was designed to pump water from mines. But in the flat lands of southern England, pumps were required to power the fountains which everyone wanted in their gardens and Thomas Savery saw an opportunity, as did his successor Thomas Newcomen. Savery's engines had a short life, owing to a tendency to explode, but by the middle of the seventeenth century, Newcomen's engines were widely used in gardens.

Savery's engine is an example of borrowing a technology designed originally for a different purpose. The lawnmower, on the other hand, is an example of borrowing an idea; Edwin Budding saw a cylindrical machine for

cutting the nap off woollen cloth and wondered if the idea could be applied to grass. Ultimately, it put an end to the backbreaking task of scything the lawns of our stately homes - here at Hartwell House in Buckinghamshire.

As with Savery's engine, Budding's idea took decades to be perfected. A stationary machine, cutting wool in a factory, had to become mobile. There was a tension between making a machine that was sturdy enough to do the job but also light enough to be manoeuvred around a lawn. The initial solution was a horse - wearing covers over its hooves to protect the grass - pulling with a man guiding and pushing. The machines were also expensive; early models cost the modern equivalent of £8,000 or more, not including the horse.

Pumping engines and mowing machines were technologies, borrowed from other activities, that assisted the gardeners of England. But I actually want to discuss three technologies that emerged from gardens to have much wider ramifications for our lives. They are concerned with water, with fire and with light.

Despite decades of research, economists often find it difficult to explain the processes of invention - when the germ of an idea emerges - and innovation - when that germ is turned into reality. Explaining invention can be like trying to explain the music of Mozart or the writing of Jane Austen. Innovation is sometimes easier; often, at least, one can chart its course through a complex interaction of supply and demand. It is always possible to argue that a new technology would have occurred anyway or that it might have come about by a different route, but at least one can follow what actually occurred. That's what I'm going to do.

Water

When Charles II took up his throne in May 1660, he had much on his mind. He needed to re-establish the monarchy, reassure an anxious Church of England, appoint ministers, placate the many people seeking jobs at court and pursue the regicides who had killed his father. But he had another priority, gardening. By Christmas 1660 he had set unemployed soldiers to work to build a rectangular lake - which he called a canal - in St James's Park. It was 850 yards long by 42 yards wide. Evelyn and Pepys record how the King, and his queen Catherine of Braganza walked in the park that winter to watch the "sliders" - skaters - on the lake, as well as to see the waterfowl. The pelicans introduced by Charles are still a feature of the lake - now altered into a sinuous form - but vultures and golden eagles, let alone cassowaries and ostriches, no longer feature.

For at least the next 150 years - arguably much longer - water was an essential feature of English gardening. Charles II soon also created the Long Water at Hampton Court while his successors constructed similar water features at Kensington Palace, but the real growth of lake-building took place in the gardens of the aristocracy, as they emulated their Kings and Queens. By the end of the 17th century, canals of different sizes had been dug all over the country. Soon, they were embellished with garden buildings, as with the beautiful Thomas Archer pavilion at Wrest Park in Bedfordshire: it was designed to create a reflection, of the main aims of waterworks at the time. Water meadows were sometimes flooded for the same reason.

In the north of England, Chatsworth soon had its canal, in which the great Emperor Fountain was to be placed in the 1840s, although there was a fountain there as early as 1675. The canal complemented the other great water feature at Chatsworth: the cascade, built by the French engineer Grillet for the 1st Duke of Devonshire. It was and is fed by pipes from a nine-acre reservoir in the hills high above the house and garden. But the apogee of early 18th century water engineering was further north, at Studley Royal in Yorkshire where John Aislabie, the Chancellor of the Exchequer disgraced for his part in the great financial scandal of the South Sea bubble, created what is still the greatest water garden in England. It was complemented when, later in the eighteenth century, his son acquired the ruins of Fountains Abbey higher up the valley.

I could go on in this way, showing you beautiful pictures of English gardens, but you may already be asking: what has all this got to do with technology?

The answer is that these waterworks and many others round the country were feats of civil engineering which developed skills and techniques which then transformed our countryside and enabled our economy to grow. They

were complex creations, but their most important features sprang from the technologies of dam building and of puddling, which together made the canals and lakes watertight.

It's important to realise that there are few, if any, natural lakes in England south of the Lake District of Cumbria. The lakes which adorn the south and midlands are artificial, man-made, although most of those who admire them think of them as natural features of the landscape. They are not. Nor are the reservoirs which followed them, using the techniques which had been tried and tested in gardens, in the nineteenth and twentieth centuries. Finally, in the twentieth century, came lakes and waterparks filling old gravel pits.

The canals and lakes of the earlier period were formed, essentially, in one of two ways. The first way, used in St James's Park and Hampton Court, was to dig it out by hand - probably partly by linking together earlier artificially created fishponds - and to supply the water by pipes from a convenient water source. At Hampton Court, a river was diverted to do this. The second method was to dam a stream and wait for the water to fill the area above the dam. In both cases, the water had to be persuaded to flow through the lake, to avoid it becoming stagnant. All this work used huge quantities of labour. Making the long water at Hampton Court would have meant digging up and carting away about half a million barrow loads of soil.

Building a dam, without any mechanical aids, was equally arduous. The construction method used by Brown at Petworth was replicated by him and others elsewhere for at least a century. Soil was piled up into a bank and, on the water side, reinforced by clay, sand and stone. The design used at Petworth incorporated an oak door which could be raised or lowered from above to reduce the water level or, if necessary, to drain the lake. Dams of this kind, developed for gardens, became ubiquitous. The method was used later, for example, to construct the reservoirs which topped up water levels in canals, like that at Whaley Bridge which nearly collapsed recently.

The garden dams were not meant to be obvious and they are often difficult to find. Brown's dam at Blenheim stretches for several hundred metres at the southern end of the lake, with a path running along the top of it. The outlet from the lake, at the western end of the dam, has been turned into an entirely artificial foaming cascade. Both dam and cascade hold back an immense weight of water. Lakes and dams such as these are to be found around the whole of England, in shapes and sizes fitting the topography of their landscapes. Few lakes are as large as the 150 acres of Blenheim, but some dams were much longer; at Coombe Abbey in Warwickshire, the dam stretched for half a mile.

Many lakes were designed by Brown to imitate a slow-flowing and winding river. Others had more complex shapes, such as the three lakes at Wotton in Buckinghamshire, one of the least known of Brown's landscapes. Here two bodies of water - actually on different levels - are connected by an artificial canal, with the engineering carefully concealed under bridges and boat houses. Meanwhile, one's attention is drawn to the temples and other eye-catchers which adorn its banks. Like most others, the lake at Wotton is very shallow, only 3-4 feet but it was deep enough to be used for mock naval battles - the cannonballs still turn up - and for fish, with 2000 brace of carp being netted from it in a year.

The artifice of these lakes, which many now think are natural features of the landscape, also depended on making them watertight, where they are not on impermeable soils. Lakes which leak, as even some of Brown's did, aren't much use. The technology of leak-proofing was and is called "puddling". It is still used to restore canal beds today. Puddled clay linings are produced by beating clay with large hammers and then laying it, layer by layer and interspersed with lime and stones, to form an impermeable base and sides for the canal. The layers had to be able to repel rodents as well as hold water. Sometimes, oxen were used to trample down the clay; at Lake Pichola, in Rajasthan, in the 14th century, they used elephants.

The invention of puddling is usually attributed by canal historians and civil engineers to James Brindley in the mid-18th century, but in fact it was used in gardens at least a century before - in India four centuries before. It may in fact be, in Europe, a Roman technique, but it was brought to perfection in the canals - rectangular ponds - of the gardens of English and French aristocrats and then transferred to the building of transport canals.

This technique was used to waterproof the 150 acres of the Blenheim lake, using 100 workmen for three years. It cost the 4th Duke of Marlborough about £35 million in modern values. In the process, it drowned part of the Vanbrugh bridge in front of the Palace. In case anyone thinks this cost is exaggerated, the Blenheim estate is about to drain only a part of the lake, to remove the silt, an operation which will cost 6 million.

The lakes of England, and the reservoirs which followed them by imitating the methods of 18th century garden builders, together transformed our landscape. They were imitated again in innumerable public parks. It is extraordinary, by the way, that these huge civil engineering works have been ignored by historians of technology and of engineering.

Lakes are the first of my three legacies of English gardening. The second began in a much less dramatic and less visible fashion.

Fire

An early greenhouse is illustrated in a book by the writer and gardener John Evelyn, published in 1691. Greenhouses came into use in Northern Europe during the seventeenth century as houses in which to keep the greens - the citrus trees and other tender plants beloved by the Renaissance gardeners of Italy - during northern winters. Some were initially rudimentary temporary structures, but they soon became larger and permanent. Evelyn's greenhouse is the earliest example of my second gardening innovation which has changed our lives - central heating. Hot air from the outside fireplace circulates through a pipe under the building.

Greenhouses rapidly became more elaborate, as at Kensington Palace, and the term orangery began to be used for them. But even such structures could not keep the greens warm enough to survive the winter. Heating was needed. At first, charcoal braziers were used, but these had a problem: their fumes poisoned both the plants and, in some cases, the gardeners. This was why John Evelyn and others devised greenhouses with indirect heating sources, the boilers outside the greenhouses feeding hot air through pipe systems into the houses.

This was not really a new technology, since the Roman hypocausts had worked in the same way, but it was the first use of it for about fifteen hundred years. Central heating was used in our gardens at least a century before it was installed in some industrial buildings and - with only a few exceptions - two or even three centuries before its widespread use in the domestic house. There was central heating outside as well as inside. Many of the large walled kitchen gardens incorporate a wall, often running along the middle of the garden and known, appropriately, as a hot wall. It incorporates boilers and flues, heating the wall and the fruit trees planted along it.

Although hot air and, later, steam systems were used in greenhouses during the eighteenth century, a massive development of heating technologies followed in the greenhouses of the nineteenth century, using piped hot water in iron pipes. This technique was pioneered in greenhouses. Many hothouse builders such as Mackenzie and Moncur advertised complete heating systems. The accounts of Henry Hope of Birmingham, later to become Crittall-Hope, show a gradual transition from the garden to the house, from heating plants to heating people. By the end of the 19th century, they were marketing systems for domestic houses as well as greenhouses. Why did it take so long?

One reason, I suppose, is that plants can't either put on or take off their clothes; nor can they move closer to or further from a coal fire. But it is also probably for the reason given by Deborah, late Dowager Duchess of Devonshire, when she was asked why the greenhouses at Chatsworth were heated two centuries before central heating was installed in the great house. One had to realise, she said, that plants were much more important than people.

Light and air

The greenhouses of English gardens were also the source of my third legacy of English gardening, the buildings of light and air, suspended on a delicate tracery of metal, which are now such a feature of our towns and cities.

The Dutch were constructing greenhouses from the late 17th century and one was built at Hampton Court to take Queen Mary's botanical collection, brought from Holland after 1688. She was the first but not the last Queen to be an expert botanist. These early greenhouses had a problem. They were suitable for keeping greens alive during the winter, but not for nurturing plants. It was not realised for some time that plants needed light and air, as well as warmth; as soon as gardeners began to grow, in English conditions, the new and exciting plants that began to flow in from North America and other parts of the world, they realised that it was necessary to build larger and permanent constructions, which would provide more light and windows which could be opened and closed. Ventilation was as important as heating.

To the men of taste who were paying for the gardens, permanent buildings had to look good. We should always remember that the greenhouses were as much a part of luxury consumption and show as rolling grassland or sinuous lakes. So, the next generation of greenhouses were built - like the Orangery at Kensington Palace or the later Conservatory at Warwick Castle, according to the tenets of classical architecture.

There was a side-benefit. Greenhouses could be constructed - but called conservatories or orangeries - for the use of people as well as plants. From the middle of the eighteenth century to the end of the nineteenth - and arguably again today - no garden was complete without its conservatory and a very large industry was created to make them. And conservatories were well-adapted for amorous encounters, as many Victorian novels attest.

Sometimes, the result was overwhelming, as in this sadly soon demolished Gothic example at Carlton House. This amazing building is shown entirely devoid of plants. Indeed, a plant would have had to be very hardy to grow without much light and with the smoke pollution which hung over London. But there was a more fundamental technical problem which afflicted all the 18th century greenhouses. They had very small panes of glass. This was not, as is sometimes thought, because of the window tax, which was not levied on garden buildings, nor of the glass tax - since glass was not more expensive than brick - but sprang from technical problems in making larger glass sheets and in supporting them on glazing bars, particularly since at least some windows needed to be able to open to get air to the plants.

The first answer came, early in the 19th century, from the garden designer and writer - really a gardening polymath - John Claudius Loudon. He devised a method of supporting glass panes on curved wrought-iron glazing bars and another method, known as ridge-and-furrow glazing, which allowed maximum light to pass through them. An early example of his designs, the Camellia House at Loddiges' nursery in Hackney, still used small panes, but was one of the first examples of the glass and iron - later steel - construction, which has become such a ubiquitous feature of our towns and cities.

Another important feature of Loudon's design, showing it to be at the forefront of technological progress, was that the glazing bars were interchangeable. This seems obvious to us, but the first manufacture and use of interchangeable parts had been only ten or so years before, in the Portsmouth Dockyard during the Napoleonic Wars. So gardens were in at the beginning of modern mass production.

Other examples soon followed. The Anthaeum in Hove was intended to be an early 19th century version of the Eden Project. I say "intended" because, although the architect had designed it with a central iron pillar supporting the entire structure, the builders decided to dispense with that essential element and the building collapsed completely as soon as its scaffolding was removed. An offer to rebuild it for over £8 million was refused. But the Anthaeum shows how much glass and metal construction had already achieved.

Other enormous, but slightly less ambitious, uses of glass - though sometimes with wood instead of iron - followed. The Great Stove at Chatsworth, built by Joseph Paxton for the 6th Duke of Devonshire, was then the largest greenhouse ever built. It was equipped with a tunnel, which one can still walk through, for the tons of coal which were needed to heat it in Derbyshire winters. The Stove was large enough for Queen Victoria to drive through it in her carriage. More conventional greenhouses, for plants rather than people, continued to be built, as at the magnificent Royal Kitchen Garden at Frogmore near Windsor. The whole garden cost £33 million to

construct, with the greenhouses contributing quite a lot of that. By the 1840s, Chance Brothers had developed a method of making larger glass panes, making possible even larger structures.

The apogee in England of the new construction methods was, of course, Paxton's Crystal Palace for the 1851 Exhibition, based not on the Giant Stove but on one of his other earlier greenhouses at Chatsworth. Much of it was made, in its first incarnation in Hyde Park, from wood rather than metal, but it was still based on mass production of interchangeable parts - which is why it could be built so quickly, an incredible five months. Although England was acknowledged as the leader in greenhouse and conservatory design and construction, other European countries were not far behind, as Le Grand Palais in Paris showed at the end of the century.

The principles established in gardens and greenhouses were soon applied to other types of building. The world's first steel framed and glass curtain walled building, with the steel concealed by stone, by Peter Ellis, was built in 1864 but, by the end of the century - and particularly in the United States - much larger buildings became possible. The full development of these construction methods came in skyscrapers, as shown in the Guaranty Building in Buffalo of 1894-5 and many more thereafter. They were made possible by another new technology - though one not developed in gardens - the lift. The culmination of metal and glass construction, now back in the country in which it all began, can be seen in the Shard and so many other buildings around us here in the City of London.

Tracing the course of a new technology from its invention to its adoption as a commonplace is never easy. Much depends on serendipity, of the kind which led Edwin Budding to adopt an idea from cloth production in inventing the lawnmower. Much depends also on what is often a long series of very small modifications to original designs, modifications made by skilled workmen and women rather than by the grand inventors who get all the publicity. As the example of the lawnmower shows, even a good idea can take decades before the engineering problems it poses can be overcome.

Conclusion

As I've said, it is always possible to argue that a new technology would have occurred anyway or, at least, that it came about by a different route. But the fact remains that it was the technology of dam-building in the service of the lakes of the aristocrats of the Stuart and Hanoverian period which was pressed into use in our canals and our reservoirs. These became fundamental to our way of life, while also changing the entire shape of the English landscape. It was the greenhouses of Stuart England which began the development of central heating which has also altered our lives. And it was those greenhouses which ultimately gave us the skyscrapers which now - love them or loathe them - have transformed our cities.

All of these legacies owe their origin and development to talented individuals but, above all, to the growth of that neglected British industry, the garden industry. But to find out more about that, you will have to read my book.

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