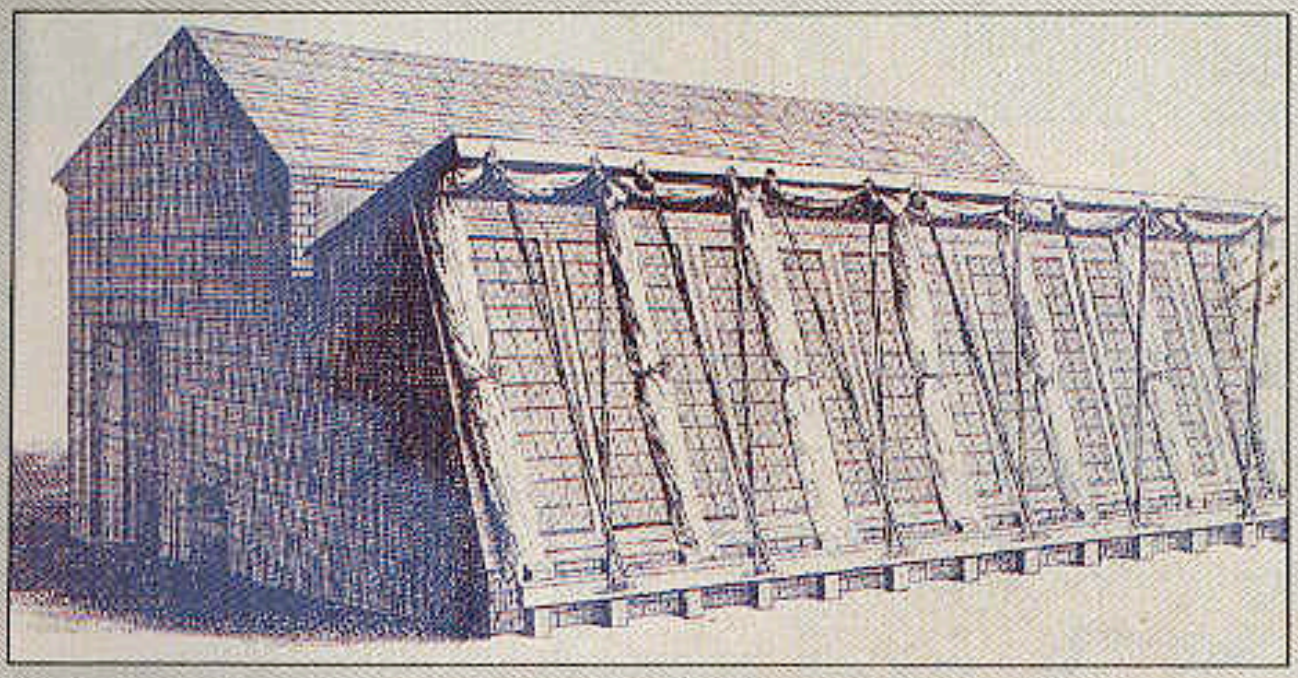
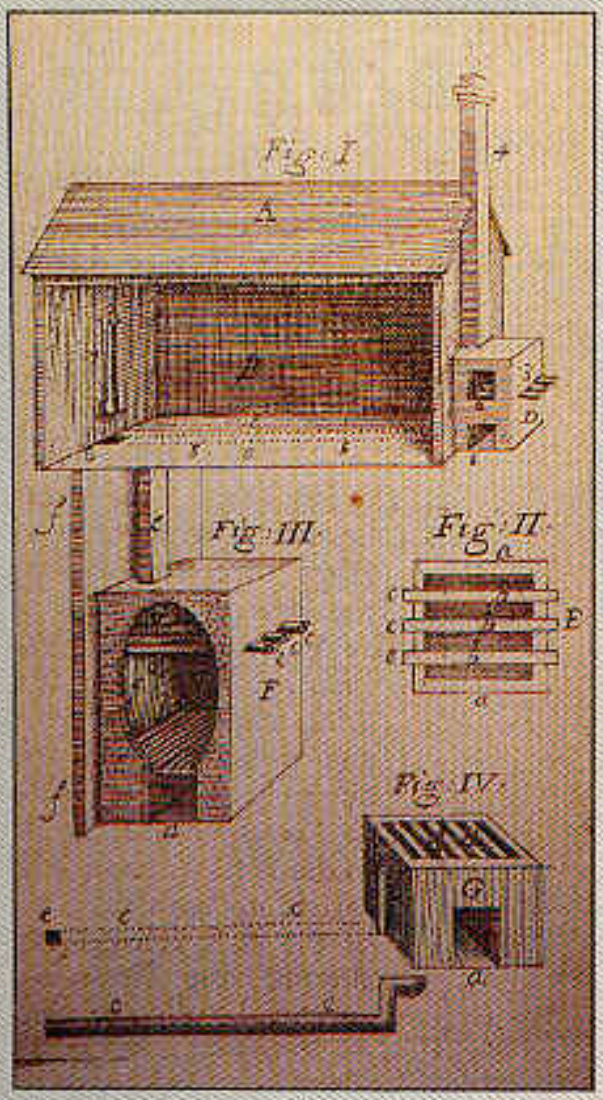
Orangeries and lemons

Brian Roberts brushes aside the musty cobwebs of the CIBSE heritage files to reveal the history of glasshouses and the methods used to heat them.



Above: A stove or forcing house for fruit and vegetables (from Diderot and d'Alembert's *Dictionnaire Encyclopedie* of 1760). Hot-air flues, fed from a furnace in a rear shed, kept a temperature around 20°C inside. Windows were angled to catch maximum winter sun and could be covered at night by canvas curtains.



Above: John Evelyn's greenhouse heating scheme from the 1691 edition of his book. From figure 1, the whole greenhouse and furnace in perspective, the furnace air-pipes, the whole stove (or furnace), and the ash hearth. The object labelled 7 is a thermometer.

Today's heating engineers owe a large debt to the early gardeners and their attempts, by artificial warming, to protect tropical plants from European winters.

When citrus trees and other delicate plants from the East reached the centre of the Roman Empire, primitive arrangements were made to protect them in winter. Roman gardeners employed the principle of forcing growth by making hot-beds, either pits in the ground or raised beds with a surrounding low brick wall, filled with manure.

Other heating techniques included pouring hot water into trenches around rose roots, covering plants with bell jars, lighting fires between vines on frosty nights and covering hot-beds with thin sheets of mica (a transparent form of rock used by Romans in windows).

Many of the formal gardens of the Italian and French nobility during the 15th and 16th centuries relied heavily on theatrically arranged rows of movable citrus plants for their decorative effect, notably orange trees in pots. It was often found easier to move plants into an orangerie during winter, rather than to cover them with protective wood or canvas screens.

In England, the most famous orange garden of the Elizabethan age was in the grounds of Sir Francis Carew's house at Beddington in Surrey. The trees were

planted in the ground and a wooden shelter, most likely with windows, was erected around them each winter. Heating was provided by two iron stoves, possibly from Holland since the word stove has a Dutch origin.

The accounts of 1609 record that 55 shillings was paid for a stove, more than the 40 shillings advertised price in *Rates of Merchandise* of 1618. In 1652, the new tenant, the Earl of Warwick, "paid £7 for repairs to the old stoves in the orange house". He also paid £7.10s each for the two new iron stoves but a note in the accounts reads, "New stoves sett up by my ld. (lord) but of little use".

The removable shed principle was also popular elsewhere. Olivier de Serre gave a detailed description of how to build a protective house in the first edition of *Le Theatre d'Agriculture* of 1600. He stated that it should have large windows and be heated by pans of charcoal or dry wood; he gave his name to the French word for greenhouse – serre.

In 1684, John Watts, the keeper of the Chelsea Physic Gardens, experimented with different methods of heating and used a Dutch design which "conveys warmth through the whole house by tunnels". Sir Christopher Wren added a greenhouse to Hampton Court in about 1690. The writer and traveller Celia Fiennes noted stove houses "so artificially contrived that all foreign plants are there preserved in gradual heats, suitable to the climes of the respective countries whereof they are natives".

William Cavendish, 1st Duke of Devonshire, had a greenhouse at Arlington House (later Buckingham Palace) and in 1698 had one built at Chatsworth, a name later to be associated with its most famous gardener, Joseph Paxton, and the greatest of all glasshouses – the Crystal Palace. Around 1710, Vanbrugh built a greenhouse as part of Blenheim Palace.

Dr Richard Bradley published a book in 1718 called *The Gentleman and Gardener's Calendar* with advice on greenhouse design. This included building the greenhouse in an outward-facing circle to catch every available ray of sunshine, providing an insulated roof storage area, and installing floor to ceiling removable windows with insulated shutters. He advised against heating with underfloor flues because the mortar between the bricks often cracked in the heat, filling the conservatory with smoke.

At Cannons, in Hertfordshire, Bradley collaborated with the Italian architect Galilei to provide what he hoped was a better solution than pans of heated charcoal. His idea was that at either end of the greenhouse there should be a small room with a fireplace in the greenhouse wall and the chimney should have a number of bends in it, so as to provide a heated wall.

Unfortunately his arrangement provided an insufficient area of heating surface, but his ideas were later taken up and improved upon.

During the 18th century, pineapple mania struck the country. In Yorkshire, in 1758, William Constable built a greenhouse with two stove houses for pineapples on either side. The greenhouse, which had a total length of 63 m, was heated by "fire walls", using horizontal chimney flues progressing gradually up the wall.

Philip Miller, another keeper at the Chelsea Physic Garden, designed a stone-built greenhouse with minimal heating while on either side were stove houses kept at a higher temperature; one a "dry stove" for aloes and cacti, the other for plants needing both heat and humidity. *Miller's Dictionary* of 1752 featured stove houses with glass roofs and two furnaces per stove, one serving an underfloor flue, the other serving a fire wall.

Countless theories on the best way to design, glaze and heat glasshouses appeared in the columns of the *Gardener's Magazine* where "heat was as controversial as roof angles".

Steam heating was an English innovation, first proposed by a Captain William Cook in 1745, though not then put into practice. James Watt used it to heat his writing room in 1784; Boulton to warm his living room and bath in 1789.

Its invention has also been credited to a Mr Wakefield of Liverpool in 1788, but it was John Hoyle of Halifax who took out a patent for steam heating in 1791, followed by Green for a steam-to-air calorifier in 1793.

The steam heating of glasshouses appears to have been widely adopted for the first 30 years or so of the 19th century, during which time its use spread to Germany. However, it was not universally popular for "a steam boiler was expensive to buy, temperamental, liable to explode (while) the furnace had to be stoked frequently day and night".

This may be why Mr M'Diarmid, a Scottish gentleman, put forward the notion that glasshouses should be heated by the breath of cattle, a method which he stated was common in Russia.

The accounts of Queen Henrietta Maria's Wimbledon manor house in 1649 record regular deliveries of charcoal, suggesting heating by open trays, rather than furnaces.

Louis XIV, the Sun King, was passionately fond of orange trees. At Versailles the second vast orangerie of 1685 was built without any form of heating system; but with a roof 2 m deep, only one outside wall, and double-glazed windows, it was thermally very efficient, making heating unnecessary.

However, technology was advancing. Glass was getting cheaper, thinner and finer. It was still blown and spun of a disc until cold, but the discs now reached 1500 mm in diameter. Since panes were cut between the edge of the circle and the thick eye in the middle their size was restricted to about 450 mm.

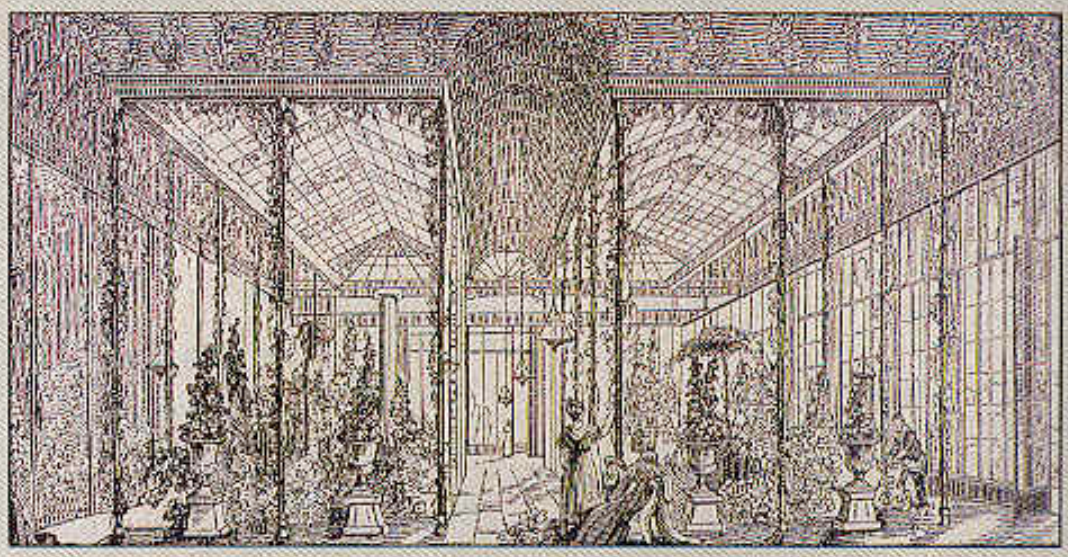
Its use in protecting plants was recognised and the benefits of the "greenhouse

effect" could be exploited. 17th century gardeners realised that winter and early spring sun must be captured so that only south-facing windows were of much value. Since plants were moved outdoors in summer a glass roof was not required.

Later, as even more exotic plants arrived the heat of a northern summer proved insufficient. Thus started the design of glasshouses as we recognise them today, with walls and roofs of glass, and using the experiences gained from Anet, Wimbledon and Versailles; but the new glasshouse design called for an improvement in heating methods.

Use was still made of free-standing iron stoves and these were capable of maintaining the 20°C temperatures required by tropical plants in winter. In fact the word "stove" gave its name in England to the building which housed the tropical plants. The iron heating stoves were not without their problems since the noxious fumes polluted the air and poisoned the plants. Burning charcoal was less damaging but the required temperature could not be maintained.

John Evelyn, the diarist, invented a new method of heating which he described in his book Kalendarium Hortense, published in 1664. He wrote, "Evelyn's stove was outside the house, and the heat was transferred inside by air passing through very hot pipes; cold air from the floor area was drawn through a ground pipe to fan the flames of the furnace. Natural convection would therefore ensure a continual supply of fresh warm air."



Above: The conservatory at The Grange in Hampshire. Designed by Cockerell in 1824 and much praised in *The Greenhouse, Hot House and Stove* magazine in 1838.

Evelyn's design called for a porch with a door, to minimise infiltration, and for an internal thermometer. He also had a theory that walls should be lined with cork. The Oxford English Dictionary credits him with inventing the word "conservatory".

The first successful use of hot water as a medium for conveying heat was noted by Tomlinson in his *Rudimentary Treatise on Warming and Ventilation* of 1850. Tomlinson recorded Sir Martin Triewald's application for a greenhouse heating system in 1716. Its original use has also been ascribed to Evelyn in 1675, but in

Water was heated in a boiler, located either underground or in a rear shed, and circulated round the greenhouse or conservatory through cast-iron pipes. It apparently provided a more even, controllable heat than steam or flues, and did not need to be stoked so regularly. Usually the pipes were routed above the floor along the sides and front of the building, but they could also be sunk into the floor where the flue had been, and covered by an iron grille.

Hot water heating was the breakthrough that enabled the enormous mid-19th century glasshouses to be built and properly warmed, such as the Great Conservatory at Chatsworth (1841) and the Palm House at Kew (1848).

At Chatsworth it was said that seven miles of four-inch pipes, fired by eight boilers hidden underground, were needed to heat this "massive edifice". Coal was brought to the boilers on an underground railway, and the chimney flues taken underground to a chimney stack some distance away. Alas, the Great Conservatory was deliberately blown up in 1920, but Kew's Palm House survives and has recently been completely restored.

Acknowledgements

The history of glasshouses is extensively covered in "Glasshouses" by May Woods & Arete Warren, Aurum Press (1988) and "The Glass House" by John Hix, MIT Press (1974).

Brian Roberts FCIBSE MASHRAE MIP RP MASPE is technical director of Colt HH Airpower and chairman of the CIBSE Heritage Group.