Victorian and Edwardian Glasshouses: History and Conservation

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Prior to the mid nineteenth century a 'glasshouse' was an object of awe to the majority of the population. The combination of the window tax and the glass tax (levied by weight) made even the smallest conservatory remarkable and put glasshouses far beyond the reach of the average squire. The construction of large glasshouses designed by the likes of Joseph Paxton (1803–65) were strictly for the social élite, and their commissioning was a powerful expression of wealth and status. The word 'glasshouse' evokes the grand kitchen gardens of major estates, but in the Victorian period efforts were soon made to satisfy increasing demand from the rising middle classes. Manufacturers produced plain, functional, self-assembly glasshouses for this emerging market. Surviving glasshouses and their surrounding gardens represent a unique legacy of Victorian and Edwardian society. Significant in terms of their architecture and design, they are also expressions of social and industrial progress during those periods.

Developments

The rapid emergence of glasshouses was due to a combination of factors. Social changes brought about by new wealth generated from the industrial revolution and Britain's expanding empire enabled an increasing number of people to pay for such luxuries. The demand for glasshouses also increased in response to the fashion for cultivating exotic plants, and the need to extend the growing season for more ordinary food for home consumption.

Meanwhile, the repeal of the glass tax in 1845 and of the window tax in 1851 dramatically reduced the cost of glasshouses, as did manufacturing innovations of the industrial revolution. The principal technical advances that were incorporated into the manufacture of glasshouses included:

- innovations in the machine tool industry
- the mass production of paints
- mechanisation of brick manufacture
- greatly increased production of wrought and cast iron
- growth of the railway network, enabling the efficient distribution of goods
- improved shipping, reducing the cost of imported timber.

Design

Earlier bespoke designs, which used larger and heavier components and so admitted less sunlight, were rapidly displaced by standard products of much lighter construction. Victorian glasshouse manufacturers aimed to produce durable structures that would give maximum infiltration of sunlight with a minimum of shadowing, good ventilation and heating, and minimal maintenance. With the exception of heating technology, the general design principles were set by the mid-1800s and changed very little thereafter.

Most glasshouses used frames that incorporated both wood and metal, with only a small proportion being entirely cast or wrought iron due to the high initial cost and the requirements of a more intensive maintenance schedule. Exclusively iron-framed glasshouses tended to be used for curvilinear work because this is difficult to produce in wood. Metal houses were also difficult to seal, making them cold and difficult to fumigate.

An original Foster & Pearson clear-span cold frame at the Lost Gardens of Heligan. Photo: Jonathan Taylor, Cathedral Communications

As cast and wrought iron became more readily available, they were combined with wood to produce rigid, lightweight constructions. For example, the use of cast iron truss brackets and wrought iron ties enabled far shallower sections of timber to be employed which reduced shadowing and painting requirements. Surprisingly, small sections of timber proved to be more durable than larger sections in humid conditions as the deeper sections retained more moisture, making them prone to decay.

A new example of a Foster & Pearson clear-span cold frame with beaver tail glass. The lever at the end operates the ridge ventilator

Extensive product ranges soon developed, some for very specific purposes and others for a variety of uses. Houses for the cultivation and display of exotic and ornamental plants varied significantly from those built for the more functional production of food. Products included conservatories, display houses, palm houses, vineries, ferneries, orangeries, cut flower houses, peach houses, hot houses and cold frames. Winter gardens, essentially large conservatories which allowed residents and visitors to exercise in bad weather, became very popular in larger establishments, often being attached directly to the main house, other glasshouses tended to be further away. Glasshouses of all types have survived along with ancillary buildings including potting sheds, tool sheds, cutting rooms, mushroom houses, fruit and other storage facilities.

Siting and aspect

Glasshouses can be divided into two simple categories, large and small. The larger permanent group included greenhouses, conservatories and hot houses, which were generally constructed to one of the following patterns:

- lean-to: the cheapest design, with the structure built against a high wall and fitted with full-length front and ridge ventilation
- three-quarter span: requiring a lower back wall than a lean-to and therefore less brickwork, this design has the advantage of enabling longer periods of sunlight penetration
- clear span house: a free-standing building with full length ventilation along both sides and the ridge.

Small designs included forcing pits, hot and cold garden frames (many of which were movable), and glazed shelters (fixed to the wall with brackets and projecting above trained fruit trees).

Ranges of glasshouses were often sited far from the main house and encircled by kitchen garden walls. These high walls were frequently used to support lean-to and three-quarter span houses as well as providing walls for glazed shelters.

The aspect of glasshouses is of paramount importance and they generally followed these principles:

- span houses should have their ridges running north-south
- lean-to and three-quarter span houses should face south
- ferneries and other houses for shade-tolerant plants should face north.

The inclination of the roof is also important. Roof slopes varied from 30-45 degrees depending on the time of year at which the most sunlight was required, with the angle increasing where the requirement was for greater light penetration earlier and later in the year. At these times the sun's rays will strike more squarely on a steeper pitch as it is closer to the horizon.

Construction

The increasing use of iron simplified glasshouse design, because cheap but attractive multi-functional components, which were often surface mounted, were employed. A fine example was the muntin (glazing bar) produced by Messenger & Co. Limited, which combined a muntin with additional functions including a projection to receive hinges for the front ventilators, together with mountings for their operating mechanisms, support for the eaves plate and rafter, a shoe to receive a roof tensioning rod and carriers for vine strainers. Wherever possible, simple designs were employed, such as cup hinges for ventilators which were virtually maintenance free and reasonably resistant to corrosion.

A sound foundation was essential, especially where stable high walls were required for lean-to houses. Walls built from brick or stone were reduced to a single skin to permit sills of reasonably shallow depth to be placed on them and be weathered on both sides.

In some structures underground boiler rooms had to be incorporated because the heating systems were not pumped and relied solely on thermo-cycling (the natural rise of warmer water leaving the boiler and the fall of the cooling water in the return pipe), with drainage/heating channels below floor level and chimneys above. Decorative cast iron gratings or wooden slats covered these channels. Galvanised steel or lined brick tanks were used to harvest rainwater. Housing the tanks inside the glasshouse had the advantage of maintaining the stored water at ambient temperature.

Straight grained Scandinavian Red Deal (a softwood) was the most commonly used timber because of its inherent stability and durability and its tendency to receive paint more readily than most hardwoods. However, the increasing availability of Burmese Teak in the mid-1880s meant this could be used in the finest work or where additional durability was required, for example, in the tropical conditions found in orchid and other hot houses.

Ventilation arrangements progressed from the inconvenient opening of individual ventilators, which frequently disturbed plants, to remotely operated mechanisms activating full length side and roof ventilators. Front ventilators were generally top-hung, whereas roof ventilators included top-hung arrangements, sliding sashes running on rollers (either manually or remotely operated by chains) and, in the case of Foster and Pearson's patent design, a full length lifting ridge ventilator which afforded weathering when open.

Glazing

Glazing was generally carried out using 21oz (per sq ft) glass in the roofs and 15oz glass for vertical work (with average thicknesses of approximately 2.8mm and 2mm respectively). 'Wet glazing', introduced from Holland in the 1770s, using linseed putty was the norm but some manufacturers preferred 'dry glazing'. Here the glass was retained either by the incorporation of metal clips, channels and caps, or in some instances folded lead T-sections. These lead strips had the advantage of being available in very long continuous lengths. The advantage of the dry system was that panes could be replaced more easily. Various attempts were made to help shed water more readily and joint the panes satisfactorily, with experiments ranging from simply butting the panes together to cutting the glass into hexagons to help throw water away rapidly both internally and externally. The most common and attractive practice for glazing roofs was to use beaver-tailed panes laid with minimal lap. Cut with curved rather than straight upper and lower edges,

A new Foster & Pearson three-quarter span glasshouse with attached boiler house

beaver-tailed panes encourage the water to flow away from the wooden glazing bars towards the centre of the pane and increase the rate at which rainwater is shed.

Heating

From the early eighteenth century decomposing dung or bark was used to produce background warmth in hot frames and pit houses. The sunken houses were surrounded by pits to receive the dung which was periodically renewed. Heating using stoves or other means of burning solid fuels dates back to the seventeenth century. During the Victorian era, boiler technology advanced from simple stoves at the start of the century to very sophisticated segmental cast iron boilers using pressurised systems by the end of the century. Coke was preferred instead of coal as it was cleaner burning and therefore produced fewer smuts on the glasswork. Edwardian systems relied on thermo-cycling; pumped systems were not used in glasshouses until later in the twentieth century.

Cast iron staging with a grating below covering the cast iron hot water heating

Experimental heating systems using oil lamps and gas were also produced but these were comparatively rare and used in smaller glasshouses. The use of stoves within glasshouses proved unpopular mainly because the fumes were detrimental to the plants and the distribution of heat was very uneven.

Common problems in maintaining historic glasshouses

Timber decay

As with any timber construction, and particularly in the warm and damp conditions encountered in glasshouses, the threat of decay was always present. This tended to result from neglect rather than poor design, manufacturers having made every effort to minimise the number of exposed joints and to introduce internal and external weatherings wherever possible. Biological decay in timber takes several forms with wet and dry rot and beetle attack being the most common.

Wet and dry rot are both caused by forms of fungi. Their spores germinate on damp timber and grow into fine threads of mycelium which spread through the timber causing it to decay. Usually the first visible sign of decay is surface crazing of the timber. The mushroom body of a fungi, the sporophore, only appears in the most advanced stages of decay.

Above ground heating pipes and remote operating mechanism for front ventilators in a vinery

Dry rot (*Serpula lacrymans*) requires moisture contents in excess of 28 per cent, but once established the fungi can remain active at moisture contents of more than 20 per cent and it can remain dormant at still lower levels. More problematically, dry rot can transport moisture from the source, enabling it to colonise dry timber further afield, often travelling between the masonry plinth and the timber above. This makes eradication very difficult in a glasshouse and the removal of affected timbers may be required. However, the application of fungicides such as ethylene glycol (common anti-freeze) is an effective preventative as well as killing the fungus.

A lean-to conservatory with top-hung roof ventilator

Wet rot, although not as destructive as dry rot, is caused by several different forms of fungi. Generally its spread is not as rapid as dry rot, and it requires higher moisture content level (50 per cent and above) as well as consistently damp conditions. It is therefore easier to eradicate.

Beetle infestations, such as common furniture beetle or 'woodworm', cause damage when the larvae bore through timber as they feed on it. Fungal decay often promotes beetle infestation because it changes wood into a more digestible form. Insecticide treatments are readily available, but ensuring the environment is low in moisture and humidity and that the conditions are light, well ventilated and clean will prevent infestation.

Corrosion

When exposed to air and water, cast iron, wrought iron and steel corrode in an electrochemical process. The result is a layer of hydrated iron oxide known as rust. Unlike aluminium and lead, which form a passive oxide layer protecting the metal from further corrosion, rust is porous, admitting both water and air, so the metal continues to corrode beneath the surface. Cast and wrought iron tend to resist corrosion far better than mild steel due to impurities in the metal and the formation of a protective surface skin in the casting or forging process. Nevertheless, all iron relies on the integrity of its paint layer to prevent corrosion, particularly when used externally, and wrought iron is more vulnerable than cast iron. It is vital to maintain protective coverings, particularly on wrought iron.

Maintenance

Maintaining good drainage and weathering is essential. Care should be taken to ensure that brickwork, copings and lead flashings are kept in good order, and that gutters and drainage pipes are running freely. Glass should be kept clean and, as with timber, free from lichen and mould. Putty work should be regularly inspected. Replacement glazing should be laid on putty but not face puttied, with the panes secured by galvanised or stainless steel sprigs (flat metal spikes) as pins tend to split the delicate glazing bars. Beaver-tailed panes can be hand cut using a hardboard template. When fitted, their overlap should be no more than half an inch.

Ironwork

In the interior of a glasshouse cast iron needs relatively little maintenance, it being more susceptible to physical damage than corrosion, as it becomes more crystalline and therefore brittle with age. However, it is susceptible to frost damage from trapped water, particularly in rainwater pipes, and rust-jacking (where rust expands between components), both of which can cause fractures. Broken castings can be re-welded by skilled craftsmen but, as it can fracture when heated, mechanical repairs such as pinning and stitching are often preferred. Alternatively, new components may be cast using existing ones as patterns if only one or two replacements are needed. The co-efficient of shrinkage in iron is only 1 in 96, so the original pattern would have been only fractionally larger than the finished component, and copies made in this way generally suffice. Brittle castings can have their structure modified to make them less brittle through regulated heating (normalising).

Wrought iron is more susceptible to corrosion, particularly in glazing bars and in those areas that are difficult to paint. The fibrous structure makes it extremely difficult to weld, and although mechanical reinforcements may be possible in some instances, a high degree of replacement is often unavoidable.

Paint and rust may be removed from cast iron by the selective and careful use of grit blasting, although there are risks attached to the process, not least of which is damage to the protective skin formed in the casting or forging process. If this method is to be used it is important to select a grit suitable for cast iron as some types contain chemicals that impregnate the porous iron and promote corrosion. It is important to warm cast iron before blasting to drive out residual moisture. Hot zinc spraying followed by etch priming to allow the paint to key, gives a very durable base for decorating.

Wrought iron should not be grit blasted because this removes the protective layer of mill scale formed during its manufacture. Paint may be removed where necessary using chemicals such as dichloromethane (methylene chloride). Rust is best removed by careful heating until it can be removed by brushing.

Simple seize-proof hinges for a top-hung opening light

Abandoned glasshouses in Devon, showing fine cast iron spandrel brackets.

Photo: Jonathan Taylor, Cathedral Communications

Joinery

Timber should be kept clean and well protected. It is best to take the paintwork right back to the timber if using modern paints because they do not always adhere to old paint types, however well prepared they may be. Be careful to use adequate protection when removing lead based paints. Micro-porous paints are not suitable for use within glasshouses. While moisture can be drawn into the timber in the normal way, glasshouses heat up very quickly in the morning sunlight and the moisture cannot be expelled through the paint quickly enough, resulting in blistering. Linseed oil paints offer satisfactory alternatives to modern systems. Modern hand applied paints are capable of giving a service life in excess of ten years.

New timber decays much more rapidly than old timber because the Victorians could use ancient, slow-grown timber, usually from virgin forest in the Baltic. This timber contained a far smaller percentage of sapwood (white wood) and tighter growth rings. Modern plantations are sited in the most favourable conditions and are thinned to maximise growth, allowing the trees to be felled earlier. The timber therefore has wider growth rings and a greater proportion of sapwood, making it much more susceptible to decay. Douglas fir is the best substitute for the original red deal, and iroko is an excellent substitute for teak. Timber should always be ordered in the longest lengths available because it will be found that these timbers are generally taken from straighter, older trees. If splicing timbers together, always try to obtain a good fit, use an appropriate glue and stainless steel or brass screws. Joints should always be pre-painted prior to assembly.

Recommended reading

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All photographs by Robert Jameson unless otherwise stated.

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