Conservation of Decorative Leadwork

SPAB Technical Advice Note

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This Technical Advice Note describes principles and practices used in the conservation of decorative architectural leadwork.

Ornate leadwork is an overlooked aspect of building conservation. Although historic designs demonstrate the skill and artistry of early plumbers, metalworking techniques such as piercing and wrought work are no longer readily associated with the craft. It is also forgotten that leadwork was often brightly tinned, gilded or painted.

This lack of awareness is compounded by the construction industry's neglect of the plumbing techniques essential to decorative leadwork, which is different from modern lead sheet work and requires a wider range of skills.

Much original leadwork has already been lost, and poor repairs threaten Britain's surviving stock of historic decorative lead items, so every effort must be made to save what remains.

Cover image: Seventeenth-century decorative rainwater head at Hatfield House, Hertfordshire.
Photo: Peter T J Rumley

1 Introduction

The chief characteristics of lead are its weight, colour, durability and malleability. These properties, and the ease with which the metal can be manipulated, cast, decorated and jointed, make it suitable for a wide variety of architectural uses.

Lead's resistance to water makes it ideal for weatherings and conveying rainwater: the runoff from lead-covered roofs can be carried via lead gutters and downpipes into cisterns and pipework made of the same material (see figures 1 and 2).

Figure 1: Decorative rainwater head of 1635 at St John's College, Oxford. Photo: Peter T J Rumley

Figure 2: Early 19th-century print (anon) showing plumbers undertaking sheet leadwork. Note the soldering iron in the foreground. Photo: Philip Venning

Because lead (see figure 3) is highly ductile and lends itself to finely detailed ornamentation, it offers scope for decoration to be incorporated into rainwater goods and into other architectural items, ranging from fonts to glazing cames and fanlights. Its ability to withstand the effects of weather also makes it suitable for garden ornaments and other, purely decorative, uses.

Figure 3: Symbol for lead. The alchemists used the same symbol for lead and for Saturn – perhaps because Saturn is the father of the gods and lead one of the oldest metals. Illustration: SPAB

There already exist some excellent technical publications on underside lead corrosion, lead sheet roofing and the repair and conservation of lead sculpture. The SPAB Technical Advice Note on *Plumbing Leadwork: Joints and Pipes*, covers non-ornamental plumbing leadwork skills. The advice below is intended to complement existing publications by providing an introduction to decorative leadwork and some guidelines on techniques, principles and practice. Although the skills for repairing and conserving decorative leadwork may be beyond the scope of most readers, the Advice Note aims to help enable owners of old buildings understand the complexity of the subject before employing a skilled craftsperson; and also to give the plumbing leadworker an appreciation of the approaches that should be employed in conservation and repair.

Technical terms used in this guidance are defined in our online glossary.[1]

2 History

2.1 Uses

Lead has been mined and smelted since antiquity. Under the Romans, welding and casting techniques were used to construct lead water pipes in several standard lengths and diameters, as laid down by Sextus Julius Frontinus, Water Commissioner of the City of Rome, in AD 97. Archaeological excavations have shown that Romano-British builders made lead sheets to form water tanks, some of which bore inscriptions, string designs or monograms.

The Worshipful Company of Plumbers received its Ordinance in 1365 and was granted a royal charter by James I in 1611. In the medieval period, lead was used extensively, both for utilitarian purposes and, to great decorative effect, on high-status structures such as cathedrals, churches, monasteries, castles and royal palaces. In 12th-century Britain, beautiful baptismal fonts were made of lead; around 30 of these survive, their moulded designs still clearly discernible. At All Saints' Church in Shipdham, Norfolk, the medieval plumbers dressed lead sheet over the distinctive decorative wooden flèche for weather protection (see figure 4). Church roofs were also adorned with crests, weathervanes or figures of saints made from lead (see figure 5).

The stonework of some Norman castles was decoratively capped with lead sheet. In the 13th century, Henry III applied lead to the roofs and battlements at Dover Castle in Kent, and from the 14th century, all manner of towers and turrets in England and Scotland were clad with lead. Scottish castles maintained their characteristic 'tiled' leaden roofs until the 19th century. Lead helped preserve a string of castles belonging to Henry VIII, of which St Mawes, Cornwall remains the perfect example. George III had the gun platforms on his east and south coast Martello towers covered with lead.

The metal was also used extensively in grand country houses and their gardens. After the dissolution of the monasteries in the 1530s-40s, church and cloister roofs were stripped of their lead, which was then recast and used during the conversion of ecclesiastical buildings into houses, among them Lacock Abbey in Wiltshire, Leez Priory, Essex and Mottisford Abbey, Hampshire. Lead from the same source was also reused for ornamental urns, fountains, cisterns and statues.

Figure 4: Typical example of a country church flèche at All Saints', Shipdham, Norfolk. Lead was dressed over a complex timber frame to provide a distinctive silhouette to the skyline.
Photo: Peter T J Rumley

Figure 5: Lead angel on guttering at the Church of St Michael the Archangel, Framlingham, Suffolk.
Photo: Simon Barber /SPAB

Figure 6: Sand-cast lead cistern of 1774 embellished with strapwork and motifs. Photo: Douglas D Kent

On medieval cathedrals, churches and important secular buildings, rainwater was usually drained from the roof through carved stone gargoyles. However, as building fashions changed, there arose a distinctly British tradition of using lead for decorative rainwater heads. There is a reference to lead downpipes at the Tower of London in 1241 and the oldest surviving examples date from the mid-16th century. Towards the end of the 15th century, as red brick was becoming fashionable for fine houses in England and Wales, lead sheet was used to make stylish heads to carry rainwater from roofs into downpipes; in the 17th and 18th centuries, the water was fed via downpipes into ornate lead cisterns at lower levels (see figure 6).

In the 17th century, plumbers developed their decorative skills to the full. Haddon Hall, Derbyshire, built with the leadmining wealth of the Vernon and Manners families, has some of the earliest surviving decorative rainwater heads. The expansion of the house through successive generations has provided it with the finest historical series of decorative rainwater heads (c1580-1670) in England. The

Figure 7: Sixteenth-century rainwater head showing two castellated bartizans, cast Tudor rose and fleur-de-lis, Haddon Hall, Derbyshire. Photo: Peter T J Rumley

early examples incorporate repoussé work and bartizans (see figure 7); the later have elaborate and delicate pierced tracery with dentil courses, pendants and cast enrichments.

When Thomas Sackville enlarged his house, Knole in Kent, in the early 17th century, he beautified the severe exterior with richly delicate rainwater heads of pierced work interlaced with crests, dates, arms, initials and complex tinned patterns of chequers, chevrons, strapwork and stars. This is the finest group of rainwater heads of a single period on a country house: not only are the bartizans pierced, but solid cast pendants provide another dimension on sunny days, by throwing interesting, crisp shadows (see figure 8).

Figure 8: Tinning of stars, chequerwork, strapwork and, far right, fleur-de-lis on a rainwater head that incorporates eight battlemented bartizans, the third from the right pierced. The date, initials, crest and leopard rampant are cast and soldered. Stone Court, Knole, Kent, 1605. Photo: Peter T J Rumley

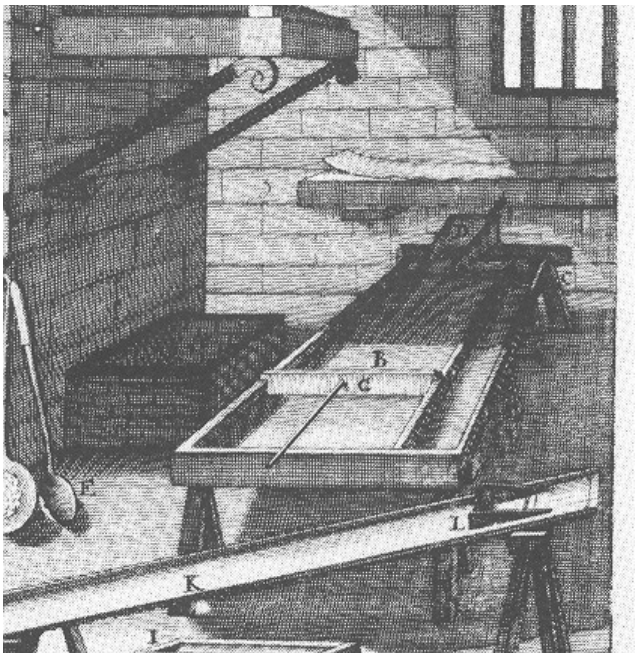

Figure 9: Engraving showing a plumber's workshop of 1676 with the furnace, sand bed and strickle – essentially the same as those still used in the manufacture of sand-cast sheet lead (Félibien, 1676)

In Britain, lead statutes were cast as early as the 15th century but the technique was used most prolifically between the 17th and 19th centuries. Significant decorative leadwork was used at Hatfield, Herfordshire – not only on the house but in Robert Cecil's fantastic lost water garden. The centrepiece of the garden was a lead statue of Neptune. It took 1 100 kg of plaster to make the mould and 140 kg of 'solder' for the casting, which was executed by the Dutchman, Garret Christmas. Cecil's decorator, Rowland Buckett, painted the statue to resemble copper and he may well have had something to do with the decoration of Hatfield's rainwater heads (see front cover).

William Peele, plumber, was engaged to cast lead snakes, fishes and leaves, to be painted and scattered around the fountain.

The late 17th-century resurgence of the founder's craft was led by artists such as John van Nost, who came to England during the reign of William III (1689-1702) and set up a foundry in Piccadilly, London. At Canons Ashby, Northamptonshire, there is a unique baroque cartouche made of lead above the door entrance of Green Court. It was commissioned by Edward Dryden in 1710 and attributed to van Nost, who may well have completed the elaborate cast rainwater heads and downpipes. On the south front are two sets of rainwater heads and downpipes, also dated 1710, which display a floral motif reminiscent of tulip leaves at each pipe socket. Nost's business was carried on into the 18th century by the sculptors John Cheere and Sir Henry Cheere.

The casting of lead sculpture by the lost-wax technique was, on the whole, the province of the artist/sculptor. The secrets of the technique were published in French, which few plumbers could read.[2] The skills of the leadworker and the sculptor were passed on only to those who were apprenticed in a protectionist trade society (see figure 9). Plumbers, on the whole, kept to simple open sand or metal chill moulds to form their enrichments. Manufacturers in the 19th century, such as Henry Hope of Birmingham, developed cast iron closed moulds to produce an array of intricate lead rainwater heads, downpipes, gutters and collars.

The revival of traditional building materials and methods prompted by the practical example of Gothic Revival architects and by the writings of John Ruskin and William Morris, led to a resurgence in decorative architectural leadwork, which was used to complement the solid, impressive character of Arts and Crafts buildings in the late 19th and early 20th centuries.

2.2 Colour

The attractive dull, silvery-grey surface finish of ornamental architectural leadwork is so familiar that few people realise that originally, the leadwork may well have had a highly colourful surface treatment. Surface decoration would have taken the form of tinning, gilding, painting and, sometimes, artificial patination, mastic inlays, etching and leadburning (see figure 10).

In medieval England and Europe, numerous ecclesiastical and important secular buildings had whole roofs, girouettes, flèches, ogee domes, lanterns, pennons and spires gilded, painted or tinned to provide a dazzling display of chevrons or chequered polychrome patterns. The tradition persisted beyond the medieval period: Félibien, writing in 1676, informs us that plumbers wishing to tin whole sheets of lead use a tinning furnace of hot charcoal, 'on each side of which a man stands holding up and heating the sheets of lead. Leaves of tin foil are laid over these, and as the sheets get hot and the tin melts the tinning accomplished by rubbing and spreading it over the surface with tallow and resin.'[3]

At Windsor Castle in Berkshire, a colossal fountain, mostly in led, was erected in the centre of the Great Upper Court for Mary I in 1555, under the control of John Puncherdown, Sergeant Plumber. Carpenters made wooden patterns for the moulds used in the plumbery to make the royal coat of arms and the great Beasts Royal. The latter included an eagle, a

Figure 10: Colourful surface treatment: **(a)** Gilded rainwater head, Upnor Castle, Kent, 1718. **(b)** Painted rainwater head, Tilbury Fort, Essex, 1719. **(c)** Gilded and painted pipe collar, St John's College, Oxford, 1635. **(d)** Tinning of circles and chevrons, Knole, 1605. Photos: Peter T J Rumley

lion, an antelope, a greyhound and a griffin, all some 2 m tall, and a dragon 3.5 m long at the base, which spouted water to a height of 4 m. John Nicholas Lyzard, Sergeant Painter, decorated the royal coat of arms, first priming the heraldic beasts and painting them with red lead, then gilding them.

John Stow's *A Survey of London* (1598) described the bell tower leadwork of the priory church of St John of Jerusalem, Clerkenwell, as 'a most curious piece of workmanship, graven, gilt, and enamelled, to the great beautifying of the city, and passing all other that I have seen.'[4] Stow was also impressed by the appearance of Goldsmith's Row:

'It containeth in number ten fair dwelling-houses and fourteen shops, all in one frame, uniformly built four stories [sic] high, beautified towards the street with the Goldsmiths' arms and the likeness of woodmen, in memory of his name [Thomas Wood, goldsmith], riding on monstrous beasts, all which is cast in lead, richly painted over and gilt.'[5]

London's lead-enriched skyline must have looked magnificent above the narrow, bustling, stench-ridden streets. Royal palaces, including Hampton Court and the Nonsuch Palace, were also abundantly decorated with lead.

Oil gilding of features such as dates, crests and owners' initials on lead rainwater heads and cisterns was popular in England from the 17th century. Historically, such decorative painting and gilding work was allocated to members of trade guilds, such as the Painter-Stainers Company. The great baroque lead cartouche of the Dryden arms, 1710, over the Green Court Hall door at Canons Ashby was at one time painted in bright heraldic colours, but more recently only the lead sculpture in Green Court has been painted a stone colour (see figure 11).

In contrast, the rainwater heads and pipes in Canterbury Quadrangle, St John's College, Oxford, have been gilded and painted many times since 1635 and the fresh, bright colours enhance these outstanding examples of the plumber's decorative craft, as well as conserving the original intention to the benefit of the architectural whole (see figure 12).

Figure 11: Cast lead statue painted to imitate stone, Canons Ashby, Northamptonshire, 1710. Photo: Peter T J Rumley

3 Fabrication

Two broad categories of work form the basis of all historic decorative leadwork. The first is the skilful fabrication of sheet lead using tools, and techniques that include repoussé work, carving and piercing, and wrought work. The second category is the casting of molten lead in moulds, either to embellish sheet lead or make individual ornaments to be applied separately. As well as these specialist decorative techniques, plumbing leadwork skills such as pipe fabrication and joint solder wiping are required (for further details see *Plumbing Leadwork: Joints and Pipes*. Finished pieces may be further embellished with tinning, gilding, painting and other forms of surface decoration (see section 6).

3.1 Sand-cast lead sheet: plain

Sand-cast lead has been used since antiquity. In all periods, it was customary for plumbers to cast their own lead sheet in the workshop or on site, by running molten lead over a bed of sand (see figure 13). At Exeter Cathedral, a 19th-century lead furnace remains in the roof of the south tower (see figure 14). Rolled lead – a cheaper lead produced in a rolling mill and supplied in uniformly even sheets – became available towards the end of the 17th century.

Items such as decorative rainwater heads can be fabricated from pieces cut from lead sheet. For instance, to fabricate a half-round rainwater head (see figure 15), a piece of wood has to be turned to the required pattern and then cut in half – a skill in itself. The wooden block is then fixed to the workbench and a piece of lead

Figure 12: Rainwater heads at St John's College, Oxford, 1635: **(a)** With gilded unicorn cut from sheet lead and set in front to provide depth and shadows. **(b)** Gilded and painted. Photos: Peter T J Rumley

Figure 13: Sand-casting of lead sheet.
Photo: Norman & Underwood Group Ltd

Figure 14: Nineteenth-century lead furnace (disused) at Exeter Cathedral. Photo: Peter T J Rumley

15(a)

15(b)

Figure 15: Formation of a decorative rainwater head: **(a)** Half-round wooden block over which lead is dressed. **(b)** Half-round 18th-century rainwater head having been dressed over wooden block at 16 Watling Street, Canterbury, Kent. Photos: Peter T J Rumley

sheet is gently dressed over it, using a variety of wooden dressers.

Another method of making up the front of a rainwater head is to use several pieces of sheet lead (see figure 16), which are soldered, wiped soldered or leadburnt together. A flat back is then attached, along with 'ears' for fixing to the wall. Various specialised decorative techniques (explained in sections 3.3 and 3.4) can be used to form more complex embellishments, according to the imagination and inventiveness of individual plumbers.

3.2 Sand-cast lead sheet: decorative

Decorative lead sheet is cast in the same way as plain lead sheet, except that moulds or patterns are pressed into the sand to provide decoration to the underside of the lead (which will, of course, be used on the face of the finished

Figure 16: Combination of sheet lead sections shaped over wooden block, soldered and wiped soldered with pierced work added. Note the shadows cast by the solid pendants. Knole, Kent, 1605. Photo: Peter T J Rumley

items). Leadworkers often make their own moulds or patterns. The deeper the mould, the more sand is required and the deeper the bed. Equally, more lead is required for the crucible and the completed piece is correspondingly heavier.

A great variety of decorative objects, including downpipes and gutters, may be formed in this way. Normally, decorative downpipes were cast in 2 m lengths (see figure 17), in a sand bed that was reduced from the normal 3-3.5 m length. Three or four designs may be cast in one go and the sections separated later. After casting, each lead strip may be folded around a square or cylindrical mandrel to form the pipe.

Figure 17: Sand-cast downpipe with a grape and vine motif (Weaver, 2002).
Photo: Courtesy of Donhead Publishing Ltd

Strapwork decoration is formed using strips of cast lead, which can easily be bent into curves and pressed into the sand to provide the design.

The great decorative lead cisterns of the 17th and 18th centuries were cast in this way. With cisterns, the shape of the casting bed may well have taken the cruciform shape of an opened-out cardboard box, the sides being folded and wiped jointed after the lead had set or 'frozen'.

On large cisterns, strengthening stays were soldered across the interior to help support the sides.

Figure 18: Pierced work with tinning on bartizans, Hatfield House, Hertfordshire, 1610. Photo: Peter T J Rumley

3.3 Decorative techniques

In addition to casting (see sections 3.2 and 3.4) and surface decoration (see section 6), the following techniques were used to add decorative interest:

- **Repoussé work.** This term is often used in the narrow sense of hammering metal into relief from the reverse side, but is taken here in a broader sense that includes the simple dressing of lead over a mould to form shapes, such as faces.
- **Carving and pierced work.** Lead may be carved with gouges. The intricate pierced work used to form a valance or bartizan tracery is achieved by using sharp chisels, punches and knives to cut out patterns from sheet lead. The sheet lead is worked whilst on a soft block of lead or wood. Keeping the tools wet assists the action. At Knole, Hatfield House, Haddon Hall, Canons Ashby and St John's College, Oxford, it is possible to see not only surface decoration but also sumptuous forms of 'filigree' pierced work, which cast elegant, crisp shadows in bright sunlight (see figure 18).
- **Leadburning.** This form of surface decoration is the most recent, having been introduced in the early 20th century, following the development of the oxyacetylene torch. Leadburning may be used not only to weld two sections of sheet lead, but also to form bead patterns of lead across the surface by applying a number of loadings with excess lead from the lead filler stick. Depending on how the oxyacetylene torch is held, a bead or herringbone pattern may be achieved by skilful manipulation of the molten pool of lead.
- **Wiped soldered decoration.** When plastic solder is being applied to large soil or vent pipes and, occasionally, rainwater downpipes, it may be fluted with the finger or a shaped tool to provide some decorative interest on an otherwise plain joint. Examples may be seen at Upnor Castle in Kent, Lanhydrock in Cornwall and Firle Place, East Sussex. This form of decoration is characteristic of 18th-century pipework.
- **Wrought work.** This is the beating of cast sheet into highly decorative shapes for finials, crestings etc (see figure 19). Medieval plumbers worked their lead to perfection, their skill equalling that of the goldsmith working precious metal.

3.4 Applied lead castings

Beside the casting of molten lead to produce ornamental lead sheet as described in section 3.2, individual enrichments for soldering or leadburning can be made by the following methods:

- **Open sand moulds.** A pattern of wood or plaster is pressed into an open box or tray of fine, damp sand and lifted away, leaving a void of the required shape. Molten lead is poured into this mould, and when the metal has cooled and hardened, the casting is removed and the excess sand is brushed off back into the box, where it can be used again to make a fresh mould. This mould is used to make a variety of decorative castings, including crests, dates, initials, rope twists, battlements, cornices, downpipe collars or astragals.
- **Two-piece moulds.** A two-piece closed mould gives a solid lead casting within a sand box, which can be separated (see figure 20). The pattern may also be in two halves depending on the complexity of the design. One half of the pattern is placed on a flat surface; one half of the wooden box is placed around it. This is then rammed with casting sand (naturally bonded or oil-based) and the box is turned over. The other half of the pattern is located precisely on top of the half pattern remaining in the sand by register pins. The whole is then dusted with parting sand before placing the remaining half of the moulding box with its register pins in line. This is then rammed with moulding sand. The two boxes are parted, the pattern removed and two pouring holes, or 'gates', are made by pushing a sharp dowel through the sand: one gate is for pouring the molten lead into the mould and the other acts as an air vent.
- **Chill moulds.** Plumbers regularly used these when crafting sections for decorative rainwater heads. They are simple, open cast iron moulds, about 500 mm long, into which molten lead is poured to form astragals or battlements. When poured into the cold metal mould, the lead 'chills' and hardens rapidly. Unlike a sand mould, which has to be made afresh after each use, a chill mould can be used repeatedly.
- **Closed cast iron moulds.** Victorian and Edwardian foundries used these moulds to mass-produce decorative lead rainwater heads and other associated accessories, such as downpipe collars and cast ears.

Figure 19: Design for wrought leadwork in the shape of foliage and a rose bud. Illustration: Nicola Westbury

- **Waste moulds.** These are used for one-off castings, after which they are destroyed. In the past such moulds were made of plaster; today they are more likely to be made of heat-resistant vinyl.
- **Lost-wax casting.** This technique, also known as *cire perdu* or investment casting, produces a one-off piece, for the mould is destroyed to release the casting.

Figure 20: Casting molten lead in a two-piece mould. Photo: Douglas D Kent

Initially a solid model is made in wax. Plaster casts are then made from sections of this model; these are known as 'case moulds', which can be reused. These plaster moulds are then fitted together before hot wax is poured into the cavity they enclose; the superfluous wax is poured out, leaving a thin wax lining on the interior surface of the moulds.

The case moulds are removed, revealing various pieces formed in hollow wax. These separate pieces are then joined to create a copy of the original model, but in hollow, not solid, wax. A hole is cut into this hollow wax model, and sand and plaster are poured into it to form a solid core. Wax rods are fixed in appropriate places on the model, to allow molten lead to feed into it and gases to escape; a wax funnel is also created. Thin metal pins (chaplets) are pushed through the wax model into the core. The entire block is encased in fine plaster, then placed in a kiln and the heated wax is driven out. Molten lead is then funnelled into the thin cavity left by the wax, with the metal pins holding the core in place. The plaster is broken off and the rods, now formed of metal, are cut away, the pins removed and the model cleaned.

Sir Henry Cheere (1703-1787) used this method to cast his hollow sculptures. In this case, large sections would have been cast separately and then soldered together.

Figure 21: Moss and other organic matter lodged in pierced bartizans, prior to cleaning. Knole, Kent.
Photo: Peter T J Rumley

4 Identification of defects

Lead is a very durable material, and many architectural elements continue to function perfectly well as originally designed, three or four centuries after they were first installed. In certain conditions, however, decorative leadwork can develop defects.

4.1 Corrosion

Although lead is highly resistant to corrosion, it is not immune to it. The metal is amphoteric: that is, it can be affected by both acids and alkalis, depending on interactions with other chemicals. Corrosion occurs at various rates in different environmental conditions. For example, lead reacts with water, oxygen and carbon dioxide in the air to form lead carbonate, which in itself forms a stable, protective white surface film. However, where certain acids, such as acetic, formic or nitric acid are present, corrosion may take place.

The principal environments in which lead is liable to corrode, albeit slowly, are:

- **Oak-shingled roofs.** Rainwater run-off is certain to contain tannic acid absorbed from the timber.
- **Lichen- and moss-covered roofs.** Organic acids from the plant life may leach into rainwater run-off (see figure 21).
- **Timber supports.** The use of modern laminates or timber such as oak as bearers to support cisterns, gutters or rainwater heads should be avoided: these materials contain organic acids that will corrode lead.
- **Insects.** A blocked rainwater head, pipe or gutter that contains, say, a colony of ants, can produce enough formic acid to attack the lead, especially if the host organic material is peat-based and enriched with bird droppings.
- **Industrial environments.** The vapours emitted from breweries and tanneries may be corrosive.
- **Masonry cleaning agents.** Hydrochloric and hydrofluoric acids are normal building cleaning agents, which will corrode unprotected lead.
- **Fluxes.** Only mild, non-corrosive fluxes such as tallow or rosin should be used when soldering or wiping lead.

Figure 22: Common failure of a lead soil pipe, prior to repair. Ightham Mote, Kent. Photo: Peter T J Rumley

Figure 23: Torn lead cornice of rainwater head, prior to repair. Tilbury Fort, Essex. Photo: Peter T J Rumley

- **Lime and cement.** Alkalis have a moderately corrosive effect, depending on moisture, aeration, temperature and concentration. Calcium hydroxide solutions, perhaps from water that has been in contact with fresh Portland cement, are damaging.
- **Storage.** If any decorative leadwork is going to be stored for long periods, it is important to cushion and support the pieces on crumpled, acid-free paper in dry conditions. Plastic wrappings should be avoided, as they may trap moisture, creating corrosive micro-environments.

There appears to have been an unexplained increase recently in brown-red surface discoloration on leadwork. This phenomenon is not believed to shorten the life of lead.[6] It is possible to remove the staining chemically.

4.2 Thermal stress failure

Lead has a high linear coefficient of thermal expansion (approximately three times that of steel) which may cause it to buckle and crack. Items such as rainwater heads, pipes, gutters and cisterns are less likely than lead sheet roofing to suffer from thermal fatigue because they are usually fabricated from smaller sheets of heavier-gauge lead.

The solder used for wiping joints is an alloy of lead and tin and exhibits different thermal characteristics from the body of lead being joined; but it is wrong to imagine that this causes failure. The splitting or tearing of the lead that can appear next to a wiped joint is normally a result of lead corrosion or mishandling; it is particularly important to move large, heavy items with care.

4.3 Frost damage

Rainwater systems should be checked for blockages and cleared as part of normal maintenance routines. If water is trapped in a pipe, gutter or cistern in frosty conditions it will turn to ice. As it freezes, it expands and causes the lead to split. For this reason, the joints in downpipes were not usually caulked, allowing water to escape at the open spigot joints to indicate a blockage in the next section of pipe below. Continuous lengths of soil pipe were joined by solder wiping; they tend to fail on bends, and rarely at the wiped joints (see figure 22).

4.4 Insufficient support

Rainwater heads and pipes were usually fixed into place by wrought iron pipe nails driven through purpose-made lead ears into wooden blocks built into the brick or stonework – or, worse, driven into the mortar joints. The lead band was cut long enough so that after the nails had been hammered into the walls the ends could be folded back over their heads. The plumber in the workshop normally cast these ears, or they could be purchased from suppliers. Ears came in all shapes and sizes and were soldered or leadburnt onto the pipe at regular intervals to suit the work in hand.


24(a)


24(b)

Figure 24: Avoidable loss of a rainwater head: **(a)** Eighteenth-century original. **(b)** Inappropriate replacement.

Photos: Douglas Kent

The iron nails invariably become corroded, and the wooden block may also rot, so that eventually, only the downpipe supports the rainwater head. In time, the downpipe begins to buckle under its own weight and becomes deformed.

The deterioration of internal wrought iron armatures or solid cores in cast lead components can also lead to deformation. Cast ornaments that have simply been soldered onto the front and not also pinned through to the back, may become detached.

4.5 Failure of surface decoration

Tinning is the most common of all the surface decorative treatments applied to leadwork. It is rare to find painted and gilded rainwater heads and pipes, and all such examples should be treated with great care:

- Tinning. This treatment rarely fails. Any peeling of the surface tinning that has occurred will be due to poor workmanship – failure to clean the lead surface or the use of insufficient flux.
- Gilding. The action of rain, frost and heat is the main cause of gilding degradation.
- Painting. Weather also erodes paint finishes, which simply wear away over time.

4.6 Vandalism and theft

The theft of lead from isolated churches and other buildings has long been a serious threat to historic decorative leadwork stock. Rainwater heads, pipes and roof sheet may be stolen for their scrap value, whilst urns and garden sculptures made of lead are also vulnerable. Prudent owners now ensure that lead garden ornaments are protected by alarms and other security measures.

In extreme circumstances, where there is genuine, serous risk to historic decorative leadwork, consideration may be given to moving an item into safekeeping for a time. This should only be considered as a last resort. Any leadwork removed for this reason should be handled and stored with care (see section 5.1).

4.7 Other defects

Mechanical damage may be caused by ladders being rested against rainwater heads and gutters (see figure 23), mishandling or even by heavy birds landing on delicate tracery. Unprotected, pipes at low level are also vulnerable to knocks from passers-by.

5 Conservation

The basic principle of good architectural conservation is to preserve as much of the original fabric as possible by undertaking only work that is essential to a building's survival. Regular preventative maintenance is the most practical and economical form of conservation, and will reduce (or even obviate) the need for repairs later.

Where fabric has deteriorated, effective and honest repair should be the first consideration. Replacement is the last resort. Many lead rainwater heads and downpipes have been unnecessarily replaced with plastic or cast iron substitutes (see figure 24). Even the smallest lead strainer placed over a lead box gutter outlet, unseen behind a parapet, should be conserved *in situ*. Similarly, just because a decorative lead soil pipe finial is hidden is no reason to replace it, since in doing so, a valuable historic element is lost.

5.1 Preliminaries

It is not unusual for the repair of historic decorative leadwork to be carried out as part of a larger building conservation contract where statutory consent has been granted.

Before survey or repair work is begun, a risk assessment may have to be completed and approved. Access to leadwork at high level is gained via scaffolding, which affords a safe way to carry out a preliminary survey and any subsequent handling of lead items.

If an item is to be removed from site for cleaning, repair or decoration, it should first be photographed *in situ* and carefully labelled (see section 5.2). Items such as rainwater heads can be extremely heavy, and the method of removal, handling and transportation should be planned in advance.

Delicate and fragile tracery or enrichments may become damaged when moved, so they should be protected by being placed in a rigid wooden box and cushioned with bubble wrap and crumpled, acid-free paper. Very heavy pieces may require a metal cradle to be specially made, and perhaps the use of a crane.

5.2 Recording

It is good practice to record the condition and appearance of decorative leadwork before commencing repairs. Photographs are satisfactory in some cases, but a written survey or drawings may also be required. By providing information about an item's design and history, location, construction, decoration, and method of fixing, the leadwork survey will be a meaningful aid to repair and conservation:

The record should comprise a:

- Location plan.
- Unique reference number (for example, the first downpipe on the north-east elevation of Hatfield House might be identified as: HHNEE1 rainwater head/pipe 1/pipe 2/pipe 3/pipe 4/pipe shoe).
- Drawing.
- Set of photographs.
- Historical summary.
- Description of the item, its condition, method of fixing and any surface decoration.
- Conservation and repair summary.

All records should be kept on site as a permanent archive to which reference may be made.

5.3 Paint analysis

Even where decorative finishes appear to have been completely lost, traces of paint, gilding and coloured mastics may be discovered in crevices and folds. This valuable evidence of the original decorative scheme should be noted in the written record. Samples may be submitted to a specialist for detailed paint analysis to determine the composition of the paint, which will assist understanding of the original decoration.

5.4 Cleaning

Painted and gilded surfaces of decorative leadwork that are coated with dirt may be gently cleaned with a soft cloth rinsed in water containing a few drops of washing-up liquid per bucket of water. Use warm water for painted areas and cold water on gilding. A soft toothbrush may be used for awkward corners and pierced work. If more stringent methods are required to remove heavily polluted build-ups then it is important to remember that aggressive cleaning agents are likely to damage painted decoration.

For the removal of paint, a proprietary poultice paint stripper may be used, particularly on details such as bartizans, and applied dates, heraldic devices or ciphers that may embellish rainwater heads on complicated pieces. Follow the manufacturer's instructions carefully.

Do not under any circumstances use a blowtorch to remove paint that has been used to decorate leadwork. The fumes given off by hot lead are highly toxic, and may paralyse the operative if inhaled. Heat can distort the piece or, more drastically cause the soldered or wiped joints to run, and the piece to disintegrate.

Areas of leadwork that are neither painted nor gilded may become encrusted with sulfates. In such cases, the piece may be scrubbed hard with a stiff brush and hot water containing detergents. The water should be changed frequently.

The use of microblasting is potentially hazardous unless a fume cupboard is used, or the operative is completely covered by protective clothing incorporating a separate oxygen supply.

5.5 Repairs

A thorough understanding of old buildings and their components is a prerequisite for successful repair work. Considerable damage has been inflicted on delicate and decorative leadwork through 'repairs' carried out by operatives who lacked sufficient understanding of historic fabrication and jointing methods, or were unfamiliar with historic decorative surface techniques.

Lead lends itself well to repair, because it is possible to cut out a damaged section and leadburn in a new section, and clean the seam of the joints to produce an invisible mend. The metal can equally well be soldered or solder wiped; these techniques are particularly useful for repairing small pinholes and splits. Fillers such as epoxy resins, or any other foreign material, should not be used to repair such defects in leadwork.

Sometimes a solution can be devised that avoids cutting out. For example, a new lead reservoir might be fabricated in Code 4 sheet lead and fixed inside the old reservoir of a rainwater head in poor condition, taking care to provide further reinforcement stays and remembering that further weight is added.

Occasionally, a case exists for easing distorted leadwork back into shape, for example, when a piece no longer functions as intended (obstructing water flow etc). However, if the leadwork is functioning and fixed properly and all that is wrong is some deformation to one side, then it is best left well alone. Misshapen rainwater heads and pipes do have a charm of their own and to reshape them so that they look like new detracts from this appeal. It can be advisable to provide additional protection – for instance, a metal sleeve or grille to shield a downpipe at low level in a location where it is vulnerable to knocks (see figure 25). An alternative method is to split the back of the downpipe and insert a stainless steel lining before re-making the joint.

Figure 25: Protection for a decorative lead downpipe.
Photo: Douglas Kent

Stainless steel may also be used to replace wrought iron armatures where these have become corroded, leading to the deformation of a cast lead component. Similarly, when a downpipe or rainwater head is being repaired there is an opportunity to consider the method of fixing and replace corroded wrought iron pipe nails with stainless steel bolts set in plastic plugs.

When re-making joints, it is important to copy the original jointing methods (leadburnt, soldered or wiped soldered) and not to 'improve' upon them, as to do so is to change the fundamental nature of the historic piece. (For further details see *Plumbing Leadwork: Joints and Pipes*,. Take care not to follow inappropriate examples set by earlier repair work. There are many instances where unskilled individuals have tried to replace soldered joints by leadburning (welding) inside restricted rainwater head reservoirs, leaving unsightly globules of molten led, which hamper the flow of water and cause debris to accumulate. Smooth wiped joints would have been easier to perform in such cases, and would not have impeded water flow.

Hot work is a serious fire hazard and a permit may be required to undertake this operation (see section 8.4).

5.6 Replacement

Replacement should not be undertaken simply because decoration is showing signs of wear or a piece is no longer perfectly shaped. Figure 26 shows unusual decorative lead items that give additional interest to buildings but could so easily be replaced with bland modern equivalents or substitute materials. Replacing original material should be done only when it can be fully justified; sometimes, for example, the replacement of lead sheet is unavoidable because it is seriously degraded with microcracks that are impossible to repair.

Any replacement should be on a like-for-like basis. Where lead sheet is replaced, sand-cast lead should be used for all conservation work unless the original piece was constructed with the milled variety. Sand-cast lead is specified because of its inherent unevenness and characterful appearance, which result

26(a)


26(b)

Figure 26: Unusual items of decorative leadwork: (a) A canopy fascia, date numerals and plaque with gilded initials and oak leaf splays. The Art Workers' Guild, Queen Square, London, 1914. (b) Victorian fascia advertising a builder's business in Stour Street, Canterbury, Kent. It is fabricated in lead sheet, with cast elements. Photos: Douglas Kent

from the handcrafted manufacturing process. In addition, experienced leadworkers seem to find the sand-cast material more ductile and malleable for working to neat details. In rainwater heads, pipes etc the sand face is normally used facing outwards, whereas in roofing it often faces inwards. In both cases, the smooth side tends to be placed to facilitate water flow.

Underside lead corrosion is essentially a potential problem confined to sheet lead roofing but where lead is in contact with timbers or walls it is advisable to use a chalk-enriched emulsion as a precautionary measure.

The fabrication of replacement pipe sections is covered in *Plumbing Leadwork: Joints and Pipes*.

Cast ornaments should, if possible, be preserved by transferring them onto the new sheets of lead.

Where seriously corroded, damaged or missing decoration needs to be replaced, the new work should complement, not parody, the existing. A design that echoes the spirit of the original but is not a slavish copy, or an attempt to 'pass' as original work, is best. Sometimes in repair work it is appropriate to use a section of an existing component as a pattern; this may be achieved by taking a vinyl mould from it and making a plaster cast, which is pressed into the sand bed. The casting is then soldered or leadburnt into position.

It is often desirable to show the date of new work; such information can be helpful both to historians and to those working on the repair of the building in the future.

5.7 Maintenance

Rainwater heads, downpipes and gutters are functional elements of a building. However decorative their appearance, their primary purpose is to remove water, so regular maintenance is essential to ensure that they are performing properly (see figure 27).

Clear rainwater fittings regularly: the best time to check and clear gutters and downpipes is at the end of each autumn, when the trees are bare.

In addition, try to inspect gutters and downpipes in heavy rain, as this is when signs of blockage may be most obvious. Stains on walls and plant growth also show where rainwater fittings have failed.

Figure 27: Vegetation growing in lead rainwater head: an obvious problem with a simple remedy.
Photo: James Boutwood

6 Surface decoration

Reinstatement of gilding, painting and other forms of surface decoration might be contemplated where it is known to have existed originally and would be of benefit to the architectural whole. Our eyes have become accustomed to the grey patina of weathered lead, but that is no reason to reject bright decoration where it would be appropriate.

The decision about whether or not to redecorate historic leadwork should be made on the merits of each case. For example, where there is exceptional degraded surface decoration on a rainwater head, that has not been touched for a long time, it would probably be best not to repaint this but to let the decoration continue to weather (but record it and possibly make a copy that can be retained as a museum piece).

Statutory consent may be required for work on listed buildings and scheduled monuments or in conservation areas, and it is essential to check whether or not this is the case before starting work.

6.1 Tinning

Tinning is the most common form of surface decoration found on rainwater heads, pipes and gutters. It provides a slightly raised pattern with a brightly tinned appearance that is well set off against the dull oxidised lead. The piece to be tinned is first painted, or soiled, with the plumber's black – a mixture of lamp black pigment, chalk and glue size. The pattern is traced or 'pounced' onto the surface and a shave hook is used to remove the black soiling and reveal the clean lead areas to be tinned. A little tallow or crushed rosin is sprinkled across the exposed lead to provide a flux to prevent oxidation.

With a moderately hot copper soldering iron, the solder is run from the tinman's stick (1 part lead:1 part tin) onto the cleaned lead surface of the pattern. The solder fuses with the lead, but not in the blackened masked areas.

It is possible, with tinning, to create three colour effects: the bright tinning, the black soiling and the dull lead (which will turn silvery as it oxidises). Indeed, there is no reason why the plumber's black cannot be made up of other coloured ground pigments and applied. The bright tinned area may also be glazed over with transparent oil colours to give a brilliant metallic lustre.

The plumber's black acts, then, as both a masking fluid and a decorative element. On certain rainwater heads, as at Hatfield House, the method of masking was to use a pattern cut out of paper as a stencil and then tinning. The tinning process would have taken place in the workshop prior to fixing.

Alternatively, whole sheets can be tinned: a sheet of tin foil may be laid over a sheet of heated lead, causing the tin to melt onto the lead.

6.2 Gilding

Like tinning, this is an accepted method of surface decoration on lead. For exterior work, the method is that of oil (mordant) gilding, with the disadvantage that it cannot be burnished like water gilding. Gold size is applied to the areas to be gilded: the size is essentially linseed oil with dryers, such as lead oxide, added. The drying time of gold size varies between two and twenty-four hours according to different recipes and weather conditions. For exterior work it is better to use a faster drying gold size. Gold size may be purchased clear or yellow, to provide a coloured body. If yellow gold size is hard to find, it is possible to make a batch from clear gold size by adding artist's oil colour, such as yellow ochre, but this may alter the drying time.

When the gold size has reached the right stage of tackiness, the gold leaf is pressed onto the sized surface. Gold leaf comes in two forms: transfer leaf, which has a backing and is easier to manipulate; and loose gold leaf, which requires more skill if it is to be used correctly.

Gilding is not restricted to gold leaf, for silver and bronze leaf may also be applied using the same technique.

Bronze patination

8 oz (227 g copper nitrate)

4 oz (113 g) ammonium chloride

4 oz (113 g) acetic acid

1 oz (28 g) chromic acid

1 gal (4.5 l) water

6.3 Painting

The principal reason for painting rainwater heads, pipes and gutters was to beautify, rather than to protect, them. White lead, or basic lead sulfate, is the oldest white paint pigment, having been in use since antiquity. The preferred method of production was the 'old Dutch' process, which produced a pigment with good colour and covering power. The white lead mixed with linseed oil provided a durable, flexible film, compatible with the leadwork, for both a priming and a finishing coat. The pure white lead paints could be easily tinted to practically any colour desired.

In England and Wales, legislation now restricts the sale of lead-based paints to use on Grade I and II* listed buildings, scheduled monuments and also works of art – a category which might include some decorative lead objects. Given that these rare decorative architectural elements are made of lead, obtaining lead-based paint for the purpose of repair and maintenance should not present a problem, whether the building is listed or not. (Similar restrictions apply elsewhere in the UK.) Acrylic paint, although not historically accurate, could be employed, particularly on new work.

6.4 Artificial patination

Old recipes for artificially inducing a bronze and a green antique effect to the surface of the lead are known (see boxout on 'Bronze patination'). To date, however, no surviving examples of this form of historic decoration have been found.

6.5 Mastic inlay

References to 'mastics' may be found in texts relating to historic decorative leadwork. These have no relationship to modern mastics and refer to various compounds of linseed oil, turpentine, wax and natural resins, such as copal, rosin, amber etc, which are mixed with pigments into a putty and applied to channels gouged into the lead by chisels. When dry, these residues are scraped with a shave hook, leaving a neat coloured inlay design. No recipes have been discovered to date, as individual plumbers tended to keep their methods secret. Mastics are also used as varnishes. Other materials for inlays include white and red lead oxide and black asphaltum.

6.6 Etching

This method of surface decoration is known to have been used, but no examples have been located to date. The method is to mask the whole of the piece with an acid resist, such as varnish, and expose the areas to be etched to the acid. **Always** add acid to water (not water to acid).

7 References

1 See https://www.spab.org.uk/advice/glossary

2 Félibien, 1676

3 *Ibid*

4 Stow, 2005, p364

5 *Ibid*, pp294-295

6 English Heritage, 2020, p271

8 Other advice

8.1 Contacts

Where repairs to decorative leadwork are being considered, the SPAB may be able to suggest suitable specialists. If paint analysis is required, the SPAB may be able to provide the names of conservators in your region.

8.2 Further reading

British Standards Institution (2006) BS EN 12588: 2006 *Lead and Lead Alloys: Rolled Lead Sheet for Building Purposes*, London: British Standards Institution

Butler, V (1997) *Casting for Sculptors*, London: A & C Black

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Weaver, L (2002) *English Leadwork: Its Art and History*, Shaftesbury: Donhead Publishing Ltd. First published in 1909

Young, A J (2000) *History of the Worshipful Company of Plumbers,* London: The Worshipful Company of Plumbers

The Manifesto of the Society for the Protection of Ancient Buildings. Available at: https://www.spab.org.uk/about-us/spab-manifesto

8.3 Other organisations

- **Amberley Museum and Heritage Centre**
  www.amberleymuseum.co.uk
  01798 831370

The Worshipful Company of Plumbers has a display dedicated to traditional plumbing methods in the Gin Building at this open-air industrial heritage museum in West Sussex. There are a number of exhibits here of ceremonial leadwork, as well as fine examples of the plumber's craft

8.4 Health and safety

In most cases, the use of lead in buildings does not create a significant hazard, although it is essential not to eat, drink or smoke in a place liable to be contaminated by lead and also to wash your hands, arms and face thoroughly at the end of each working session. When stripping old lead sheet where the underside is heavily corroded or when undertaking hot works in unventilated conditions, additional precautions must be observed.

Hot work is a serious fire hazard and a permit may be required to undertake this operation.

You are strongly advised to consult the following publications before undertaking work with lead:

Lead Sheet Training Academy (no date) *Working with Rolled Lead Sheet in Construction: A Guide to Health, Safety and Environmental Care*, East Peckham: Lead Sheet Training Academy. Available at: https://leadsheet.co.uk/app/uploads/2018/05/LSTA-WWLIC-0518.pdf (Accessed 14 February 2020)

Health and Safety Commission (2002) Control of Lead at Work: Approved Code of Practice and Guidance, 3rd edition, Sudbury: HSE Books

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