Wrought Iron:

Heritage Ironwork

Restoration and New Work

TOPP & CO.
GREAT BRITAIN

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Contents

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Front Cover Images - Wrought Iron Micrograph: Mike Meiers
- Assembling Wrought Iron Panels: Chris Topp

Introduction

Natural History Museum, London; Shutterstock

For over 30 years The Real Wrought Iron Company and Topp & Co. have been privileged to carry forward the baton of wrought iron production from the nineteenth century into the future. Over the years we have acquired considerable expertise in the production of wrought iron, and have been able, with the support of our customers, to install the equipment to enable us to produce finished bars entirely in house. This booklet is a distillation of all that experience, and that of the application of wrought iron to the restoration of and the creation of new heritage ironwork. We hope that we will be able to inspire you with our passion for this wonderful material.

Restoration of the gates and railings for The Natural History Museum in London

Passion and expertise

Facts about us

- We are a leading authority on the craft of blacksmithing.
- We help set the standards for our industry.
- We are a world authority on wrought iron.
- We are the world's only supplier of new, puddled wrought iron.
- We have one of the best-equipped workshops in the UK.
- We thrive on demanding creative and technical challenges.
- We have 40 years' experience.

Facts about our wrought iron

- Corrosion resistant - Withstands atmospheric pollutants and even continuous immersion in salt water far longer than mild steel due to its fibrous nature.
- Easy to form - High ductility makes it soft under the hammer, so it forges quickly. Traditional smithing techniques were developed specifically for wrought iron.
- Easy to fire-weld - Withstands higher welding heats than mild steel and has its own built-in flux (iron silicate).
- Matches closely the materials used in historic ironwork - If authenticity in restoration concerns you, there is no better choice.
- Available in both standard and bespoke sections - Available in square, flat and round sections plus special sections such as handrails and glazing bar. We operate our own rolling mill and are the only company in the world expert in rolling wrought iron.
- Best quality - The puddled wrought iron we supply is of high quality and checked rigorously for anything that makes it not fit for purpose.

The original workshop at Chris Topps' house

TOPP & CO.

GREAT BRITAIN

Wrought Iron

Arek hot punching holes in wrought iron for a new gate

What Is wrought iron?

In its simplest definition 'wrought iron' is a specific type of iron, and the traditional material of the blacksmith, the clue is in the word 'wrought', which is the medieval past tense of the verb 'to work'. Wrought iron literally means 'worked iron', which refers to the method of manufacturing the metal by working repeatedly under the hammer. In the past the work of the blacksmith therefore became known as 'wrought ironwork', a name that has persisted for the art form even though the metal in use may not actually be wrought iron. Today the common material of the blacksmith is mild steel which is a cheap industrial product lacking many of the virtues of its ancestor.

Wrought iron is best described as a two-component metal consisting of iron and a glass-like slag. The slags are in effect an impurity, the iron and the slag being in physical association, as contrasted to the chemical alloy relationship that generally exists between the constituents of other metals. Wrought iron is the only ferrous metal that contains siliceous slag and it is to this slag that wrought iron owes the properties, which are of interest to the conservator and the blacksmith.

There are essentially two types of wrought iron:

- 'Charcoal iron' – made in a charcoal fire and used from the Iron Age to the end of the eighteenth century.
- 'Puddled iron' - made from cast iron in an indirect coal fired furnace and used since the dawn of the modern industrial era.

Historically wrought iron has been worked by blacksmiths, using traditional techniques in both forging and construction, to make high end decorative wrought ironwork. Today however, the term wrought iron is becoming debased and misinterpreted, as demonstrated by any Internet search, to cover all ornamental ironwork, including cast iron and mild steel as well as incorporating modern construction techniques. The difference in quality and value is enormous. Whereas it would be unthinkable to repair historic stonework with concrete or cast stone and Portland cement, it is common for historic wrought iron to be repaired using mild steel and electric welding.

For those involved in conservation work it is therefore necessary to ensure the correct use of the term wrought iron and that both the material and the working methods are properly specified in order to ensure appropriate repairs and like for like quotations. A specification for such work is available free of charge for use in tender documents from www.realwroughtiron.com

Why Use Wrought iron?

To the naked eye there is no visible difference between forged bars of wrought iron and mild steel (its modern day equivalent), however wrought iron is not distinguished by its looks but by its working properties and its resistance to corrosion. Wrought iron is softer to forge, as it is workable at a higher heat than mild steel, making it more 'malleable' under the hammer. However it is wrought iron's superior weathering properties that are most notable.

While wrought iron does, in common with all ferrous metals, corrode in certain circumstances, (see maintenance), evidence of its durability and long life expectancy is commonplace in our towns and countryside. Victorian town house railings – wrought iron two hundred years old. Vast ornamental gateways to eighteenth century great houses – wrought iron three hundred years old. Stone cramps on Tudor bridges – wrought iron five hundred years old. The simple fact that so much ornamental wrought ironwork survives, often with little or no maintenance, speaks volumes for the material.

Problems with the rapid corrosion of mild steel in comparison with wrought iron were well known by the beginning of the twentieth century and this prompted Matthew Verity, in USA to investigate. He concluded that the carbon in steel is responsible for its corrodability; leading to

the theory that removing the carbon removes the problem of corrosion. His efforts to produce pure iron resulted, not in a metal which was proven to have any resistance to corrosion, but which was very tough and malleable and found favour in the emerging markets for mass-produced cold pressings; ARMCO iron. No convincing evidence was ever produced to back up claims of the non-corrodability of pure iron and in fact pure iron manufacturers themselves make no claims to its corrosion resistance. In fact these same manufacturers offer other materials known as 'Weathering Steel' in Britain, or 'Corten Steel' in the USA, for which they do make such claims. One of the chief uses for pure iron in today's industry is as sacrificial anodes to protect steelwork tanks and ships as it has been found to corrode preferentially to mild steel.

Verity's examination of puddled wrought iron and mild steel was a chemical analysis, which appears to have overlooked the presence of the slags. During the manufacturing process, wrought iron does not become molten, as do more highly refined metals, so that impurities are included in the matrix of the iron rather than being separated and disposed of. At these high temperatures the impurities are turned to glass, and are commonly known as 'slag' consisting of carbides and silicates which give wrought iron its fibrous structure; approximately 250,000 siliceous fibres appear in each cross-sectional square inch of good quality wrought iron. A specific test is required to discover slag of which wrought iron contains up to 5% however it is this slag which provides wrought iron its corrosion resistant properties.

Top: Wrought iron stile and rail: - 1858 - material sections still intact

Bottom: Arc welded insert- mild steel stile and rail: circa 1950's - material sections heavily corroded

The slag present in the structure of wrought iron inhibits corrosion in a number of ways:

1. Slags themselves are non-corrodible and serve as an effective mechanical barrier against the progress of corrosion.
2. The structure of the iron gives rise to a very rough (microscopically speaking) surface texture, which interlocks with the oxide layer, be it rust or mill scale, preventing it from flaking off the surface. The oxides therefore act as a protective coating preventing further corrosion.
3. Electrically speaking, where the slag appears on the surface it acts an insulator between the areas of reactive iron, retarding electrolytic action.

The important corrosion properties of wrought iron are therefore due to its impurities in the form of slag. It follows that iron and steel without the slag will not exhibit the same corrosion resistance, and this is what is found in practise. Furthermore the slag has additional advantageous in relation to traditional forging techniques, especially fire welding.

When wrought Iron is heated in the fire to a high temperature the slag melts and covers the surface of the iron in a rather similar manner to flux. This glassy layer retards oxidation to the extent that the iron can be heated rather more than purer metal without burning this is why it is so beautiful to fire weld, the slag acting as a flux. Smiths often comment on a property of wrought iron, which renders it softer to forge than even pure iron. This is brought about by the slags, which melt within the iron at forging temperatures and act as an internal lubricant, reducing internal friction and hence resistance to distortion under the hammer.

Restoration of the huge entrance gates to Commissioners Yard in London

Choosing wrought iron

Given its limited availability and high price compared to mild steel, wrought iron is not always the first or right choice for all metalwork projects. Wrought iron is ideally suited for external and traditionally forged work and although a number of blacksmiths and commissioners utilise these properties in new work, its prime use today is in the restoration and conservation of historic ironwork.

Modern conservation practice insists on the replacement of materials with like materials (BS7913: 1998 7.3.2.4). As wrought Iron is available for the repair and replication of wrought ironwork, it is not appropriate to use mild steel or pure Iron. It would, for example, be considered wrong to repair historic stonework with concrete or cast stone and a similar principle applies to Wrought Iron. Furthermore it is generally accepted that mild steel be used on external work should be zinc coating by galvanizing or hot spraying. The intricate forms and water traps of traditional decorative 'wrought ironwork' are notorious hotspots for corrosion and as neither of these zinc treatments is permissible nor effective (explained under protection and finishing in technical information 3, Workshop Techniques) with ancient work, the use of mild steel is effectively ruled out.

Wrought iron is available from:

Topp & Co,
Lyndhurst, Carlton Husthwaite, Thirsk, North Yorkshire, YO7 2BJ
T: 01347 833173
E: enquiry@toppandco.com
W; www.toppandco.com

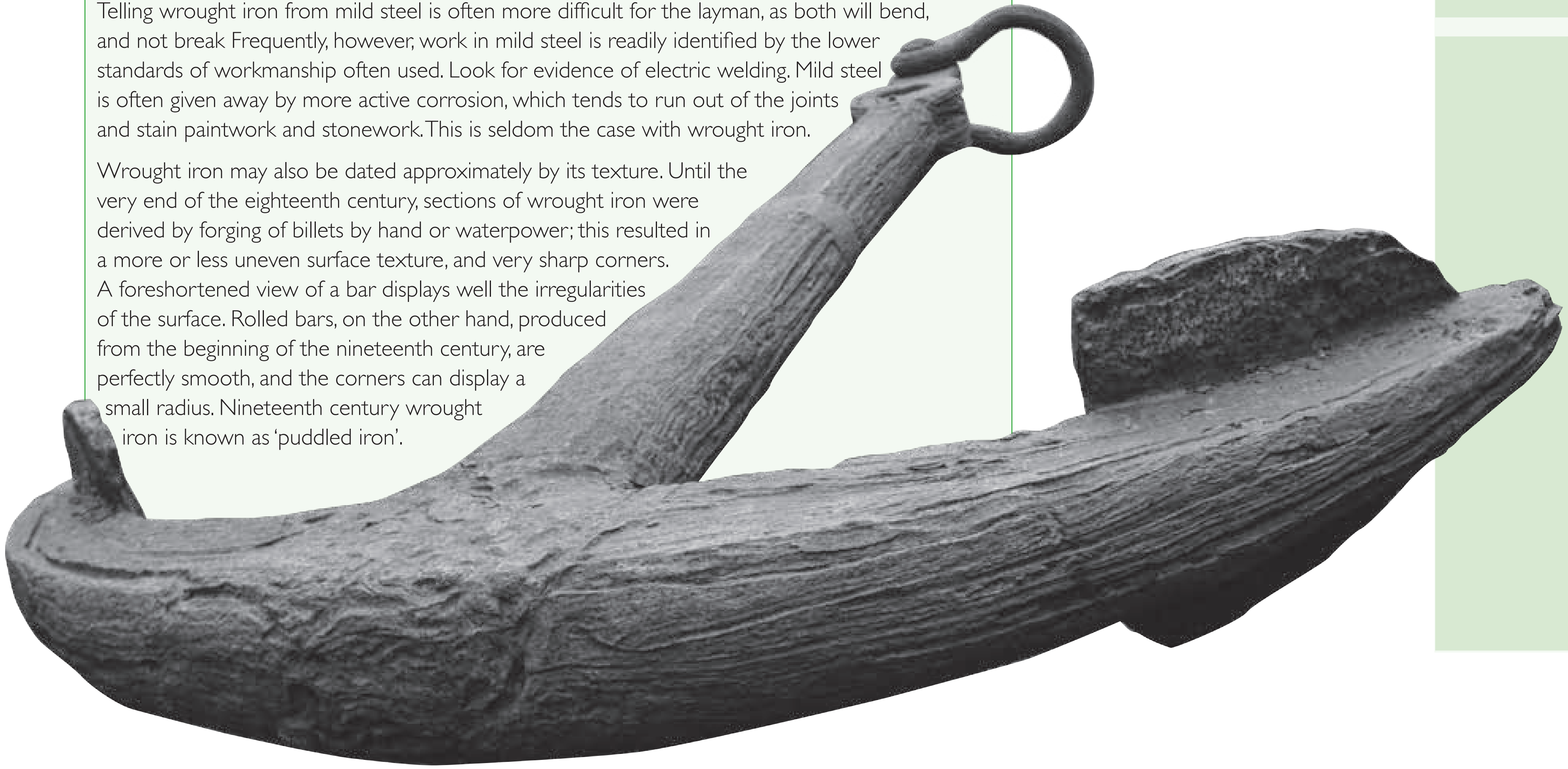
Weathering of the wrought iron anchor below shows the fibrous structure of the material

How To Identify Wrought Iron

Wrought iron is unlike cast, in that it is not brittle, and will bend rather than break. For this reason, wrought ironwork is frequently far more delicate, although years of paint can obscure this. Cast iron is most frequently identified by its repetitive nature and forms, which could be carved into a wooden pattern, but not made by hammer and anvil.

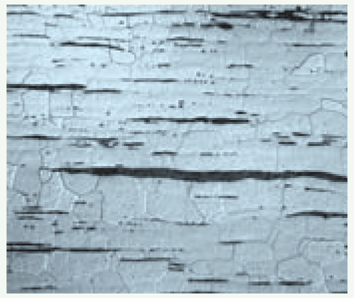
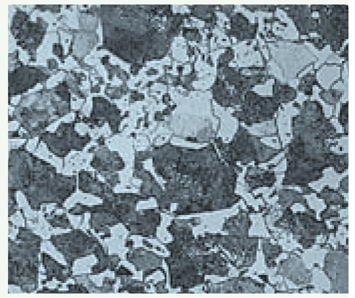
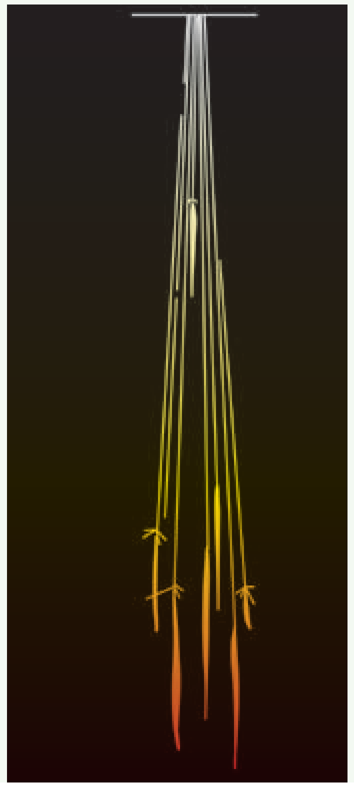
Telling wrought iron from mild steel is often more difficult for the layman, as both will bend, and not break Frequently, however, work in mild steel is readily identified by the lower standards of workmanship often used. Look for evidence of electric welding. Mild steel is often given away by more active corrosion, which tends to run out of the joints and stain paintwork and stonework. This is seldom the case with wrought iron.

Wrought iron may also be dated approximately by its texture. Until the very end of the eighteenth century, sections of wrought iron were derived by forging of billets by hand or waterpower; this resulted in a more or less uneven surface texture, and very sharp corners. A foreshortened view of a bar displays well the irregularities of the surface. Rolled bars, on the other hand, produced from the beginning of the nineteenth century, are perfectly smooth, and the corners can display a small radius. Nineteenth century wrought iron is known as 'puddled iron'.



Tests for wrought iron

1. **Nick bend test** The sample is nicked by cold chisel or sawing to approximately half depth and doubled back cold to show the fracture. Wrought iron will exhibit a 'green stick' fracture, showing the grain, whereas steel will exhibit a smooth fracture plain.
2. **Polish and examine for grain** The sample is polished in a plane parallel to the length of the bar, and the exposed bright surface examined for signs of a grain caused by linear slag inclusions.
3. **Spark test** The sample is brought to an engineer's grindstone and the resulting sparks examined for colour and nature. Typically a puddled Wrought Iron will exhibit a more or less dead reddish spark, whereas steel will have more or less bursting white sparks caused by the inclusion of carbon alloyed with the constituent iron. Charcoal irons, however may be confused with steel in this test as they frequently contain large amounts of carbon. Pure iron, while containing no carbon, can be identified by the absence of grain in the nick bend test.

	Wrought iron	Mild steel
Nick bend test.		
Polish and examine for grain.		
Spark test.		

A Short History of Wrought Iron

Wrought iron has been used in building from the earliest days of civilisation, wrought iron door furniture being commonplace in Roman times. The structural use of iron dates from the Middle Ages, when bars of wrought iron would be used occasionally to tie masonry arches and domes. This use of wrought iron in tension guaranteed its use throughout the ascendancy of cast iron in the canal and railway ages, as cast iron is strong only in compression. The ill-fated first Tay Bridge was of cast iron beams tied with wrought iron. The demand for higher dynamic loads in bridges and warehouse buildings, and the ever greater spans of train sheds towards the end of the nineteenth century, led the designers of buildings to acquire the technology developed to build ships of iron, and create beams of riveted wrought iron rolled sections. By the turn of the century this had led to buildings completely framed in wrought iron, and later steel girder sections, and cast iron was once again relegated to an ornamental role.

Our main concern with wrought iron, however, will be in its application to gates and railings, frequently given an ornamental treatment by the blacksmith. There are wrought iron railings in Westminster Abbey from the thirteenth century, which, in essence display all the characteristics, which we have come to know as 'wrought ironwork', although often lacking modern refinements such as symmetry and sweetness of line. The great age of British ironwork, known as the English style, began at the end of the seventeenth century. A French fashion for the Baroque style in gates and railings, swept the country houses of Britain, following the import of craftsmen by William and Mary, and the greater part of our national stock of good ironwork dates from the early years of the eighteenth century. After the rise of cast iron as an ornamental medium, wrought iron tended often to take a secondary role, owing to its comparative expense, each piece being made by hand, while castings could be repeated infinitely once the patterns were made. Technically, however, the craftsmen of the age of machines bettered their forebears, as indeed they must while making mechanical components, so that the ornamental blacksmith work of the nineteenth century displays a perfection of manufacture not seen before or since.

After the introduction of mild steel, cheap because of its ability to be mass produced, wrought iron, and the craft skills associated with it, gradually disappeared in accordance with the general decline of craft standards in the twentieth century, until the last ironworks ceased production in 1974. From 1982 Topp & Co. and The Real Wrought Iron Company have made available a limited supply of puddled wrought iron. The subsequent years have brought a steadily increasing demand, as the blacksmiths of Britain have slowly taken up again the ancient skills.

Our rolling mill

Specification for new or replacement items in wrought iron

Quality Assurance

New gate traditionally made using wrought iron

There is a wide disparity in cost between the cheapest of work, and the best. Without a sufficiently tight specification, work acquired on a competitive basis will tend towards the lower order. There is a need for a standard form of words which can be use to specify ironwork of the highest order.

Definition of the materials is a good start, for example 'puddled wrought iron' rather than just 'wrought iron', which is often misinterpreted as there is no current British Standard specific to either the material or to workmanship. Our view is that a proper specification is essential for this work, because without one, invariably the work is quoted by fabricators using mild steel and electric welding or, because blacksmiths know this is likely to happen they may quote for a lower standard of work to that which is really required. At least if a standard specification is used, everybody knows what to price for. If subsequently the customer cannot afford the cost, a proper judgement can then be made if the piece warrants the expenditure, whether additional monies can be found or if a delay for a year or two may be appropriate in order to get funds in place. Currently without proper guidelines wrought ironwork can be poorly made by default.

Mention of specific techniques is important, 'all welding to be done in the fire' is often used, or less positively, 'no use of electric welding'. Assurance of quality, however, can only be guaranteed by examination of the track record of the contractor or from the submission of samples as explained in the specification below.

While the overall specification is essential, it is also vital that works are properly priced and that any bill of quantity is accurate. Wrought iron is a specialist material and therefore requires specialist knowledge.

Material costs, the high level craft skills needed and the labour required to undertake such work are not widely understood and we frequently find that bids for the ironwork element for major refurbishments are severely underestimated and poorly specified. This often results in insufficient funds being allocated for the works.

Specifying Purpose Made Forged Wrought Iron

It is strongly recommended that the following specification, or something very similar, is used by specifiers to ensure that there is no confusion over the term wrought iron which is often mistaken to mean mild steel by tenderers and results in numerous problems in respect of material usage, method of fabrication and cost. As far as we are aware, Topp & Company is the world's only supplier of wrought iron and therefore it is also suggested that we are put in specifications as nominated suppliers. If architects, smiths, etc. require advice on the use of wrought iron, working techniques and design considerations, we are always willing to offer assistance.

Please also read Workshop Techniques for the Restoration of Wrought and Cast Ironwork

New gates, contemporary design made using wrought iron & stainless steel

Specification

It must be fully realised by all contractors before estimating that the employer and architect are expecting the work to be carried out to the best traditions and methods of the blacksmith craft. The interest of the metal craftsmen in the execution of this work must be that of an artist taking personal pride in his craft, and not merely a commercial undertaking. The architect will enforce the word and spirit of these specifications.

Samples

Samples of an executed piece of work done by the blacksmith may be required to accompany the tender. In all situations samples of appropriate details will be required prior to the work being carried out, specified shop drawings may also be required prior to manufacture.

Repair work to the entrance gates of The Houses Of Parliament

Materials and Workmanship

All work included herein shall be executed of true puddled or charcoal wrought iron. No mild steel or other substitute materials will be allowed without the prior approval of the Architect and employer. All wrought iron shall be best quality forged iron, tough, ductile and fibrous in character, of even texture. All work shall be executed by craftsmen skilled in the trade.

All ornamental work shall be carefully forged, hand wrought and incised where and as required to produce the design and effect desired. Under no circumstances in any part of this tender is ELECTRIC welding to be used.

All work shall be substantially framed together and closely fitted. All joinings shall be neatly and strongly tenoned and riveted together, or forge welded. Heads of rivets and tenons are to be finished appropriately to the spirit of the piece, viz. normally they will be expressed proud of the surface unless countersinking is specifically asked for.

All spindles shall be forged; collars where required shall be forge welded onto the spindles. All leaves, rosettes or other free ornament shall be forged from substantial iron and forge welded where connected with stems or other ironwork. All welding shall be done at the forge and all shall be clean and perfect. No cast parts will be accepted without prior consent from the architect. All solid ornamental works shall be worked and incised as required by approved design.

Prior to assembling/reassembling ironwork, joints and meeting surfaces will be coated with a suitable protective coating such as red lead, zinc phosphate, mastic, bitumastic, as appropriate.

Other considerations

Installing railings into stonework: see page 29.

Wrought iron is sold in imperial sizes – where possible the drawings should include this or at least a reference to the metric equivalent – i.e. 25mm = 1 inch.

Check you are not contradicting yourself by leaving in the tender document references to zinc spraying and galvanizing of the material. You do not do either to Wrought Iron. Remove all references to ELECTRIC WELDING (MIG and TIG).

Consideration should be given as to whether a condition survey and metal work specification needs to be commissioned from a specialist metal conservator prior to tender to ensure all elements of the project are covered.

Detailed recording is required where a full written report of the works carried out will be presented with the Operation and Maintenance Manual.

Removal of the ironwork's paint can reveal a host of unaccounted for repairs/work; this should be borne in mind when specifying the repair work.

It would be wise to allow for a reasonable provision for contingences.

Notes:

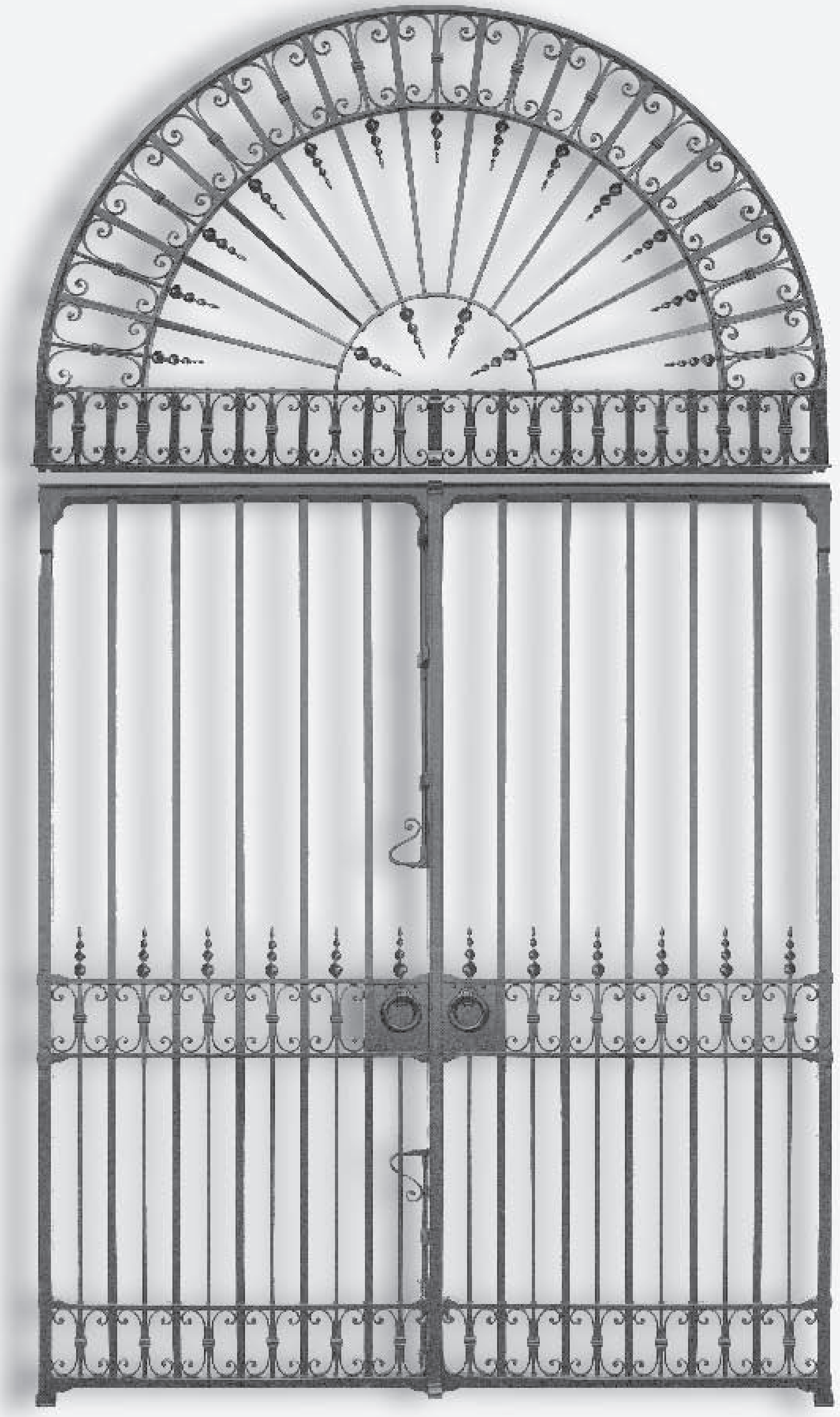
Inadequate specifications can lead to irreversible damage to heritage ironwork. The craftsman's intervention should be reversible; where this is not possible the intervention must respect the significance of the piece.

Ensure the companies you are asking to tender have the correct skilled craftsmen – for the theory and for the practical work

Build in the costs of visiting the company's workshop on a regular basis for inspection check and agreeing a way forward.

Both pages:

New gates, traditionally made using wrought iron



Forged vs Fabricated

If you are assessing the heritage value of an example of ironwork, you will need to first look at the methods used in its making.

Before the invention of electric power tools, hydraulic presses, and electric arc welding, the only way a craftsman had of gaining the power to work iron was to get it incandescently hot in a fire and then tool it - either directly with a hammer, or through an intermediary tool driven by the hammer such as a punch or chisel (among many others). This is the process of forging: it is fundamentally different from modern fabrication methods, and gives rise to an incredible variety of possible shapes. One key identifier is the presence of changes in the section of the metal: progressing in cross-sectional thickness and/or shape (see comparison of scrolls, opposite).

Fabricated work is made from stock sections of steel, mostly worked cold, though some heating may have been applied for bending and, rarely, twisting. Joining is pretty much limited to arc welding and bolting. It is quick and cheap compared to forging, and the results contrast sharply with heritage work.

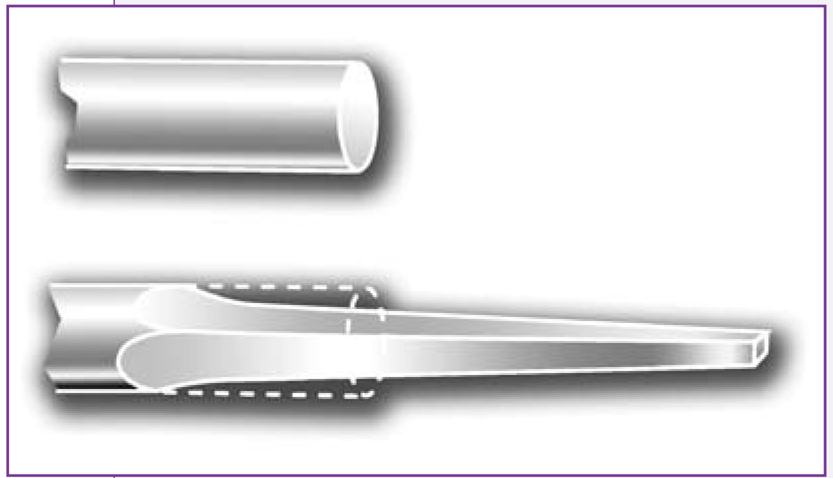
Note that many modern smiths use combinations of forging and fabricating to good effect, and use modern tools and techniques where these do not compromise quality. The use of modern methods does not automatically devalue the work.

Hot forging processes and their fabricated approximations

Smiths use arguably seven different basic processes, and many advanced permutations of these. Below are descriptions of these compared to processes used in fabrication. After you've gained an understanding of the processes of forging, ironwork made in the fire will tell you many of the secrets of its origin.

Drawing down

This is the most fundamental process, whereby the metal is hammered to make the piece longer and thinner. In doing this, the smith may change the section (from round to square, for instance) or work the bar into a taper. This process is key to giving the form being forged dynamics that cannot be achieved cold. There is no fabricated equivalent.

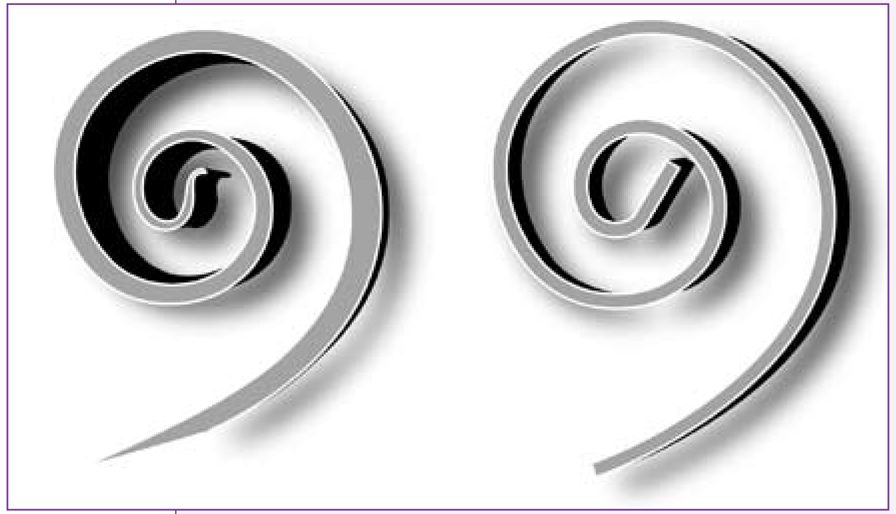


Top, round stock straight from the mill.

Bottom, the same stock, drawn to a square taper.

Bending

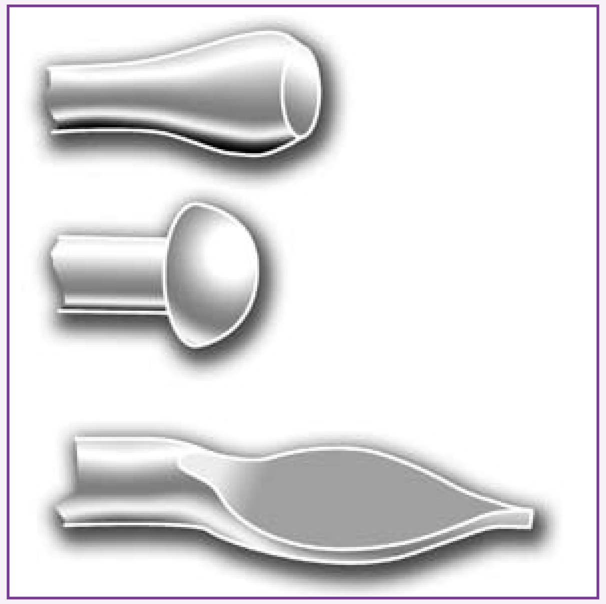
Although this needs no definition, smiths use a surprisingly large number of methods of getting the bend they want, depending on the nature of the work. This process is also available to the fabricator, and is sometimes done hot.



The scroll on the far left is made of stock that has been drawn to a taper and bent hot, free-hand. On the right is a scroll made of stock section, bent cold, with a typically straight centre where it was clamped to a scroll-forming jig.

Upsetting

Upsetting is the opposite of drawing, and involves thickening the metal by hammering it against its length. It is used most often to gain mass for rivet heads or decorative finials and to set tenons after they've been inserted into mortises. One more specialist use is to increase the mass at a sharp bend to make a squared corner. There is no fabricated equivalent to upsetting.



Top, bar-end, thickened by upsetting.

Middle, bar-end, upset and formed into rivet head.

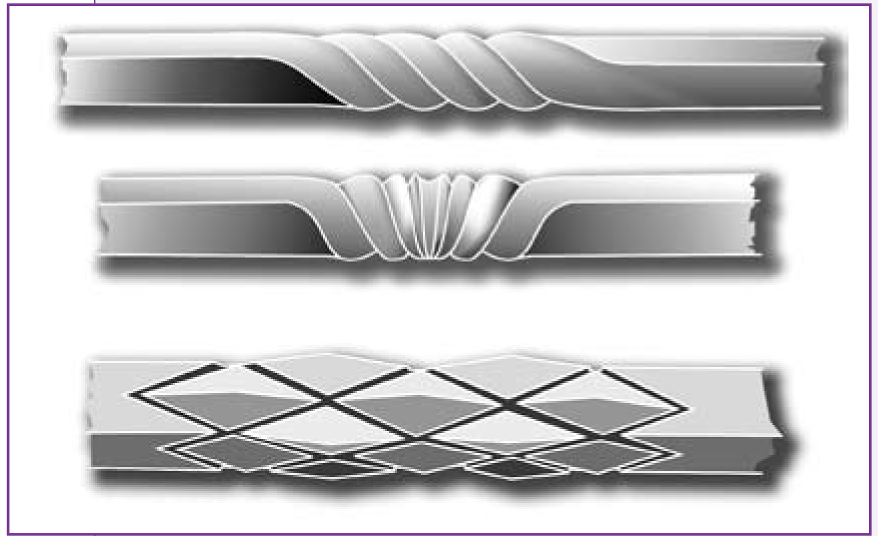
Bottom, bar-end, upset and formed into finial.

Cutting

Yes, this can be a forging process. The metal is heated and either laid on the anvil and pierced with a chisel or driven downward into a static chisel held upright in a hole in the anvil. This can be done cold for smaller sections. Usually other work is done after cutting, but in sheet metal elements, the beveled edge left by the chisel may be visible. Fabricators (and modern smiths) obviously have recourse to many different methods of cutting that would have made their ancestors green with envy!

Twisting

Again, an obvious process, there is a profound difference in the methods and results used by the two schools. Smiths may work the bar in many varieties of ways before and after twisting, may make extreme numbers of turns that vary along the bar, and may twist multiple pieces together. Cold twists are simple and without variation.



Top, simple cold twist.

Middle, progressive reverse twist, made hot.

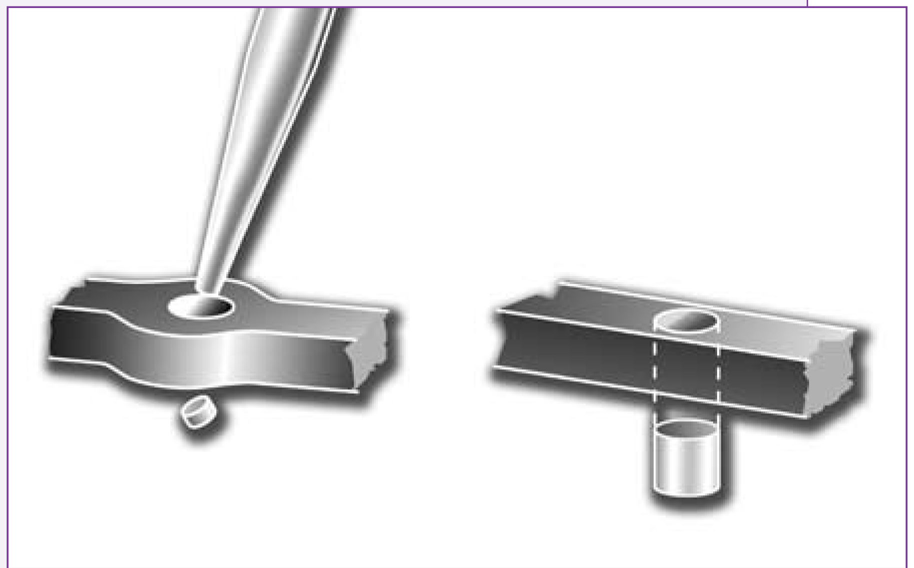
Bottom, pineapple twist, made by twisting, hammering and untwisting, all at an incandescent heat.

Punching

Hot punching to make a hole differs dramatically from cold punching or drilling in that there is much less loss of material, and the metal displaced by the punch swells the bar on either side. This swelling is very often an obvious clue to the method of manufacture.

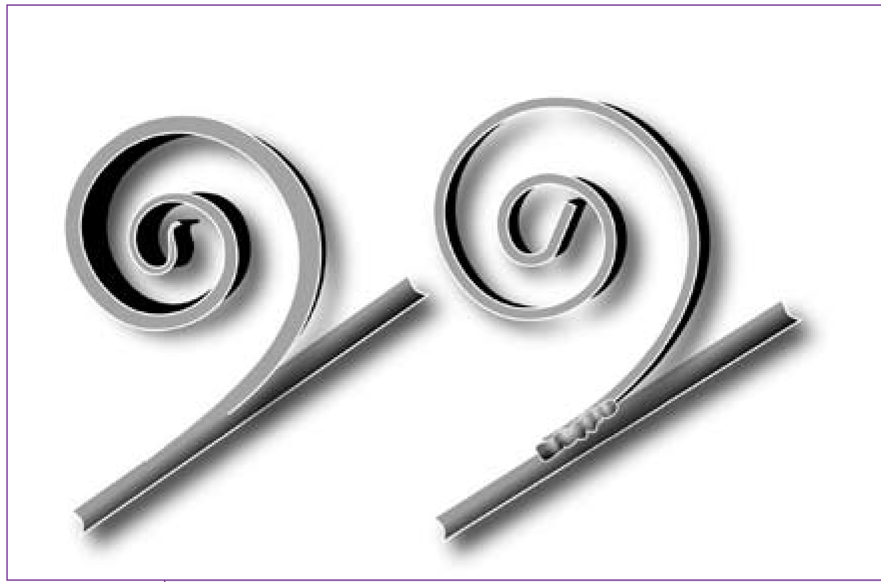
Right, the amount of material removed by hot punching is the diameter of the punch-tip, and much shorter than the depth of the hole. Most of the material moves aside. The final diameter is determined by the punch body, or by using a separate drift.

Far right, the amount of material removed by drilling is obviously equal to the size of the hole, with a corresponding weakening of the structure.



Fire (or forge) welding:

This is a joining method, but it is also the prince of processes, in which it is possible to achieve sculptural excellence rarely rivaled by modern methods. The pieces are heated to fusion temperatures and hammered together while hot. It requires preparation, timing, skill and a clean fire. There is often no sign of the weld in the finished product other than the evidential impossibility that the shape could not have been forged in one piece. Fabricators weld by adding metal to the joint, and this is usually quite visible.

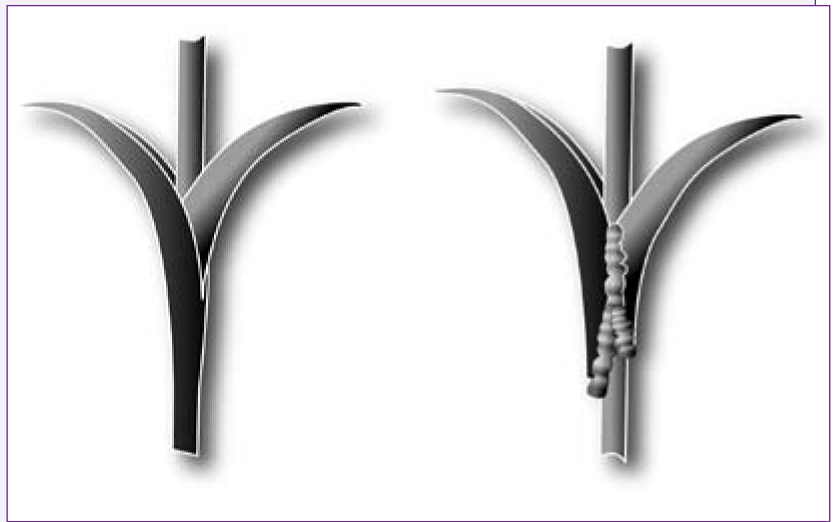


Far left, forged scroll fire-welded to a round bar.

Right, cold-bent scroll arc welded to a round bar.

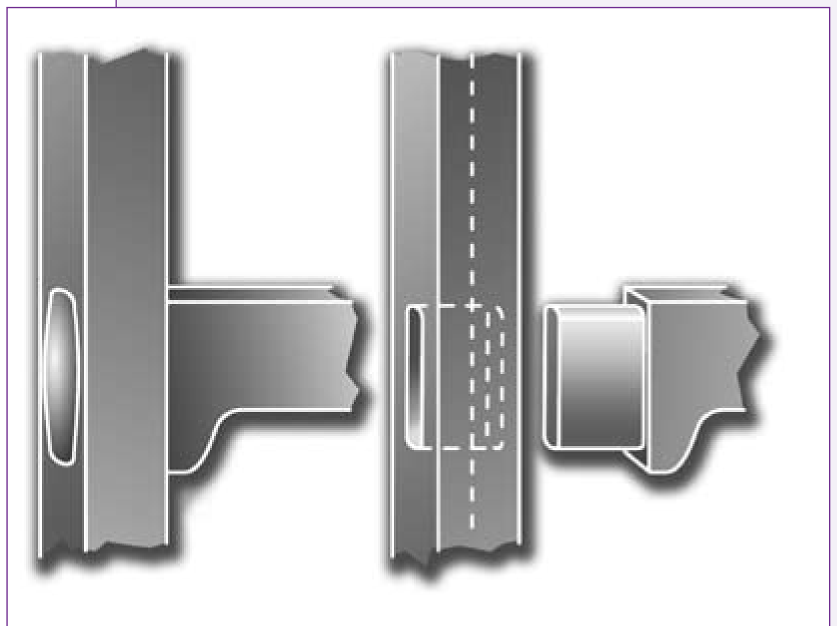
Right, leaf detail fire-welded to a round bar.

Far right, leaf detail arc welded to a round bar.

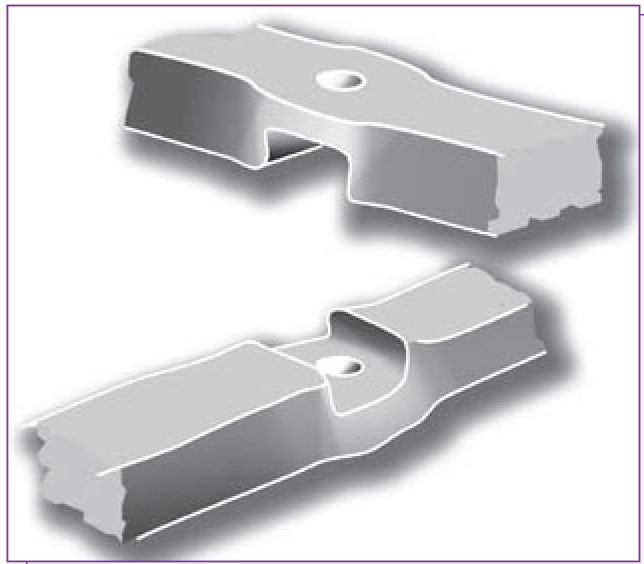


Other joining methods:

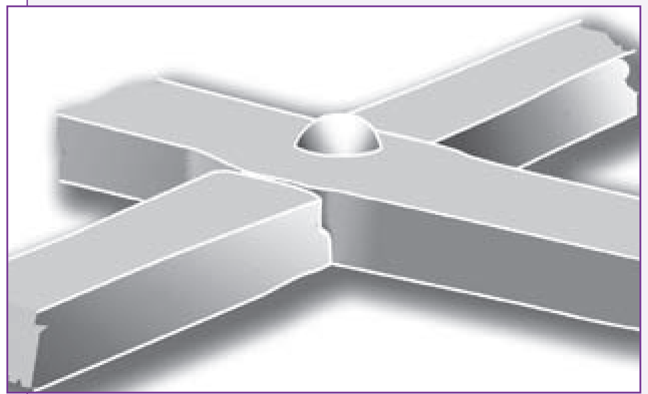
Only one of the above processes joins elements together, but there are a host of ways to securely fasten pieces - in fact nearly as many ways as there are smiths. This is one of the unique aspects of blacksmithing.



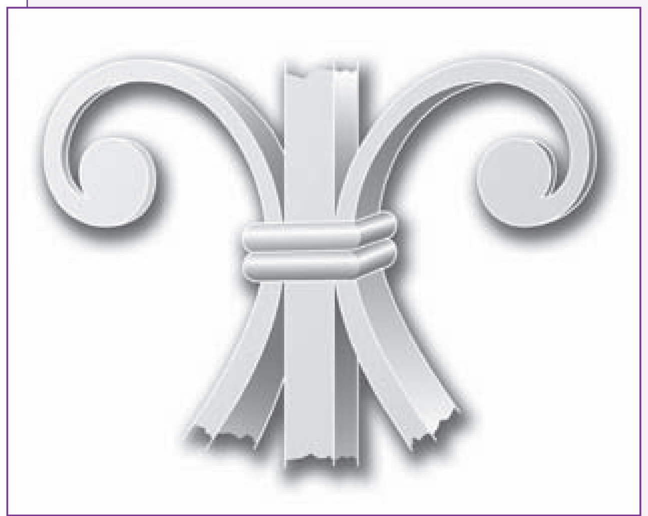
Mortises and tenons resemble their wooden counterparts. In this example, the tenon is made longer than the mortise, and peined or headed like a rivet to draw the joint tight and secure it. Sometimes captive wedges are used.



Halving is used where bars are lapped over each other, or where two pieces are joined for a run longer than the stock. These joints can be secured by rivets, which may be countersunk and difficult to see under layers of paint.



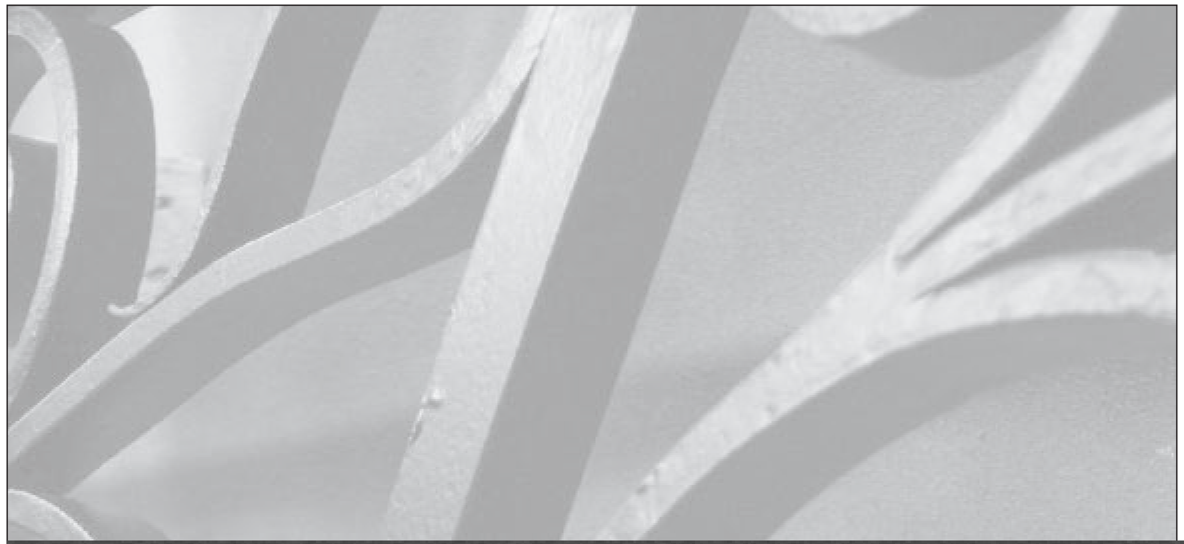
The joint above riveted. Rivets are often used where nuts and bolts would be used in modern work.



Collars are shaped sections of bar which are wrapped while hot around bundled elements.

Other forging processes

- Often closed dies are used under power-hammers to get consistent repeating shapes.
- Rolling is used to make bars with constant sections.
- Sheet metal is formed from the back (repoussé) or the front (chasing) using shaped punches to make ornamental elements, and this can be done either cold (usually) or hot.



Ferrous Metals Evaluation
in terms of wrought ironwork

Straightening a chain link under the hammer before rolling

Wrought iron

There are essentially two types of wrought iron:

Charcoal Iron

Before the dawn of the industrial age, the metal of the blacksmith was wrought iron, made and refined in charcoal fires. The iron combined with the elements of the fire to make an individual material whose properties have never been equalled for ornamental ironwork. The great wrought ironwork of the eighteenth century was done in such metal, and very many examples exist today. For example the Screens at Hampton Court by Jean Tijou, the work of Thomas Bakewell and the Davies Brothers' gates at Chirk Castle, to name a few.

Charcoal iron can withstand corrosion for hundreds of years as proven by the fact that there is a wealth of heritage ironwork in existence. Traditional ironwork is not easy to maintain, as elements of design are frequently difficult or even impossible to paint. This applies particularly to leaf work and repoussé sheet metalwork, especially where elements are back-to-back or three-dimensional. The only material to use for replacements during conservation is one that is intrinsically proof against corrosion.

Charcoal iron sheet is soft and malleable when annealed, so that a good depth of cold working and sharp detail is possible without cracking. It is softer and more pleasant to work than mild steel, and responds well to both lead block and pitch block repoussé techniques.

Charcoal iron sheet has a smooth surface, largely free of scale, and responds well to planishing and abrasive polishing making it ideal for the accurate replication of armour and weaponry.

The Real Wrought Iron Company – a branch of Topp & Co - recycles old charcoal iron and has pleasure in making it available once again. Sheet is available in standard rolled thicknesses or in billet form for your own reduction.

Puddled Iron

The close of the eighteenth century brought mass -produced puddled irons. Made in a coal-fired furnace, remote from the fire itself, puddled iron is the typical engineering material of the nineteenth century, works well hot and resists corrosion. It has, however restrictions for cold working, particularly in sheet form.

Wrought iron owes its rust proof properties to its fibrous nature. In modern terms, the refining of wrought iron is a crude process, and results in the inclusion of non-corrodible slags in the structure of the metal. These slags, and the softness of the material when hot, led to an ease of working by hand, which gave rise to a great art form 'Wrought Ironwork'.

The Real Wrought Iron Company are able to offer genuine puddled wrought iron rolled into all sizes of square, round and flat bars from stock or to your requirements. They specialise in the production of iron for the purposes of restoration and can match any existing section. They also make charcoal iron in sheet form for cold repoussé work and armour etc. and manufacture special mouldings in puddled iron.

New gates for the Royal Hospital, Chelsea

Mild steel

An alloy of iron and carbon which was discovered in 1856 in an attempt to mass-produce wrought iron and became cheaper than puddled iron after 1876. Mild steel is made by melting scrap steel and cast iron with the removal of carbon (leaving a small residual content) and slag before casting into ingots ready to be rolled into sections. Mild steel can be forged and forge welded in skilled hands. It has higher strength and better consistency than wrought iron but has poor resistance to corrosion as is evident by an insistence on zinc coating for work to be used externally.

Pure iron

Chemically pure iron is made for use in the electrical industries for its low hysteresis. It also finds a use in the chemical and shipbuilding industries for sacrificial anodes as it corrodes preferentially to mild steel and hence protects it. Pure iron is claimed by its suppliers to have properties of resistance to corrosion, but its manufacturers make no such claim, and indeed manufacture other steels with corrosion resistance in mind, such as Corten, or Weathering Steel. Pure iron can be forged and forge-welded, as can mild steel but is rather more expensive.

Weathering steels

Manufactured for use in aggressive environments, or for external use without painting, weathering steels (Corten) are made in structural sections, typically for bridge girders etc. They have lately become less fashionable as they have been found to suffer badly from crevice corrosion. This is not a material used by blacksmiths.

Stainless steels

Widely available in various grades, and used extensively in a modern context, stainless steels are not as forgeable as other ferrous metals, being very hard and cannot practically be forge welded. There is a growing awareness of the limitations of stainless steels as their resistance to crevice corrosion is not always good, to the extent that mild steel is preferred in some circumstances. For this reason stainless steel should not be used as a substitute for wrought iron in lead sockets in stonework etc.

Cast iron

The other classic metal of the nineteenth century, cast iron is famous for its ability to resist weathering, and in normal situations in the external environment cannot be faulted. The traditional form of cast iron, known as 'grey iron' is however notable for its brittleness and has to be used with care. Grey irons have very low tensile strength. There is a modern variant of cast iron known as SG Iron', which has very good tensional properties, is not brittle and can in fact be bent cold to some extent. It cannot be forged and, being relatively modern, its weathering properties are as yet unknown.

Cast iron finial from work done at Bethesda Chapel

Materials For The Refurbishment Of Heritage Ironwork

Mild steel is often considered as the modern replacement for wrought iron and many metalworkers are perfectly content to use this much cheaper metal both for new work and the refurbishment of old. We would like to suggest the reasons why this is not acceptable in the context of historic work, especially while wrought iron is still available.

1. **Weathering properties** The weathering properties of wrought iron are well known. While it does of course rust in time; with reasonable maintenance this can indeed be a very long time. The fact that so much ornamental work survives from three hundred years ago says a lot for the material. On the other hand, steel is well known for its corrodability, and the intricate forms and water traps of 'wrought ironwork', only encourage corrosion. Hence it is normal practice to coat steelwork with zinc, which does indeed delay corrosion, but neither galvanizing nor zinc spraying can effectively be applied to complex forms. Zinc coating of historic work is unacceptable as not only does its application require the destruction of the original surface, which often survives after several centuries, but it is completely irreversible.
2. **Conservation Practice** Modern conservation practice insists on the replacement of materials .with like materials. When wrought iron is available for the repair and replication of wrought ironwork, why use other metals?
3. **Traditional skills** Only by using the traditional methods and materials can restoration work of an appropriate standard be produced. The craft of the ornamental blacksmith, as previously practised to a high degree of skill, was virtually eradicated by the shift to mild steel with its ready application to 'high tech' techniques such as electric welding. Heritage ironwork deserves appropriate repairs by skilled blacksmiths using traditional materials and as such both should be specified in project refurbishments

Warning signs of deterioration

Corrosion and general deterioration are not always immediately evident, but there are a number of warning signs that can indicate problems are beginning to occur.

These include:

1. Uneven surface known as 'pitting': Where this occurs on ironwork that is painted, this usually indicates that the surface of the iron is corroding beneath the paint.
2. Iron work in masonry may have rust-coloured staining which has been washed down from ironwork.
3. Oily residue visible on the surface of the paint indicates that corrosion is occurring on iron beneath the paint surface and/or that the oil based paint is breaking down.
4. Blistering paint work is a sign that corrosion is occurring beneath paintwork.
5. Plant growth can indicate the presence of water and dirt traps, plants can hasten the onset of corrosion by preventing water from draining away.

Iron is a durable material, but a number of factors can contribute to, and accelerate decay.

These include:

1. Lack of regular maintenance.
2. Damaged or flaking paint can trap and hold water, preventing ironwork from drying out and leaving it more disposed to corrosion.
3. If iron has not been correctly prepared before painting, the paint is less likely to provide protection. Paint which has been applied too thickly is less effective and will obscure the detail. Incompatible paints, or inadequate number of coats, can provide unsatisfactory protection.
4. Design flaws in ironwork can create water traps and corrosion tends to occur more commonly at these points. Water traps can also be caused by unsealed joints and holes, the accumulation of dirt, and where corrosion has developed.
5. Plant growth can also trap and hold water. Roots and tendrils can damage ironwork as they grow, and developing corrosion may be hidden from view.

Ferrous metals rust and can expand (the volume of rust is up to 10 times greater than that of iron). This can distort the design of ironwork by forcing the pieces apart (rust-jacking). Fracturing can occur to stone work where the ironwork has been fixed into masonry sockets.

Blistering, pitting and rust-jacking

Rust-jacking

The detail above repaired

As deterioration developments, wrought iron will usually bend and distort due to its malleability, whereas cast iron, a hard and brittle material, can break under stress.

Unsuitable, poorly designed and carried repairs and replacements can be severely damaging to ironwork and will detract from the character and appearance of historic ironwork. Inserted sections made from unrelated metals, such as aluminium or mild steel, corrode at a faster rate when in direct contact with iron. Repairs carried out using poor-quality welding techniques, in place of traditional mechanical fixings or fire welding, severely detract from the historical value of the ironwork, and can also lead to corrosion.

Top: Repoussé work from St. Paul's Cathedral, London in as-found state.

Middle: Reproduction being manufactured.

Bottom: Virtually indistinguishable from the original as it would have been new, we installed this at the Cathedral as part of major work done to the ironwork of this landmark.

Workshop techniques

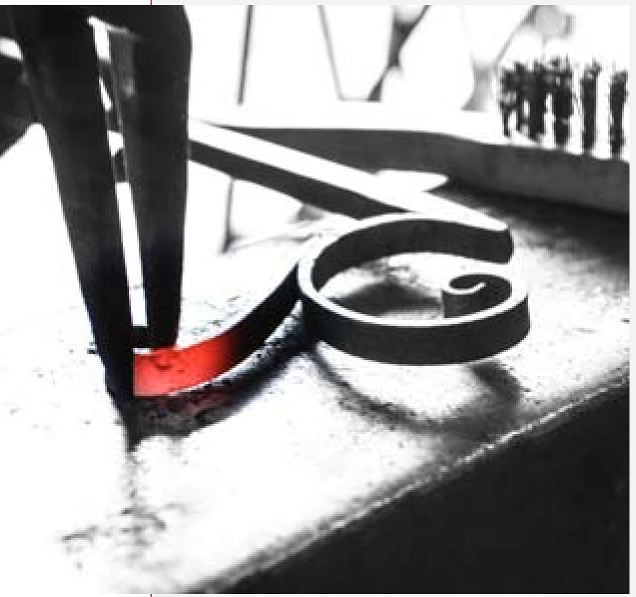
for the restoration of wrought and cast ironwork

Working With Puddled Wrought Iron

Puddled iron is a mixture of iron and up to 5% siliceous (glassy) slags, which take the form of linear fibres - giving the metal its characteristic grain. Puddled iron is for the more advanced forger, more so than steel or homogeneous pure irons. Care must be taken to respect the properties of the material. It is necessary, when forging puddled iron always to do heavy forging at a high temperature - around 1350 to 1450 degrees Centigrade (bright to sparkling white heat). At these temperatures, the iron will move very quickly, whilst doing no damage to the grain structure.

Finishing work, bending etc., can be done at red heat. Should heavy working at lower temperatures result in splitting along the grain boundaries, it is necessary only to heat the iron to a welding temperature to close the split under the hammer. At a white heat it will be found that wrought irons are far softer to forge than even pure iron. This is due to the internal slags melting and providing an internal lubricant that reduces friction during distortion under the hammer.

There is nothing to beat the forge-welding ability of puddled iron, as the enclosed slags form a natural flux, allowing the iron to be heated rather more than can pure irons or steel, this extends considerably the heat range over which the iron can be welded.



Wrought iron is the traditional material of the blacksmith. Due to the siliceous slags combined with its fibrous structure, it resists corrosion far better than modern steels or pure irons, as is amply shown by the survival of much of our heritage of wrought ironwork, in many cases centuries old. It is neither necessary nor recommended to galvanise or zinc spray wrought iron.

In the event of any further queries on working techniques advice is readily available from www.realwroughtiron.com

Conservation Reports

Please note that good conservation practice demands the recording of the item as found and details of the work done to it. Provision for funding of reports should be taken at the pricing stage. Reports when completed should be deposited with the client, the listing authority and a copy should be retained by the contractor. This will inform future maintenance particularly as relevant to paint type and colour etc.

Wrought Iron - Techniques of Renovation

There are two types of wrought iron. The irons of antiquity, now known collectively as "charcoal iron", and a mass-produced iron, produced in the 19th century and early 20th century, known as "puddled iron". Although pre-18th century wrought ironwork is, of course composed of charcoal iron, it is normal to make repairs and replacements in Puddled iron, owing to its similar properties. On no account should mild steel be used on external work without zinc coating by galvanizing or hot metal spraying. As neither of these treatments is permissible nor effective with ancient work, the use of mild steel is effectively ruled out.

Removal from Site.

Most work is ideally carried out in workshop conditions, and it is frequently the case that iron components can be removed easily from site. In the case, however, of railings, gate piers etc that may be fixed into stonework, usually in lead filled sockets, removal may not be possible without sacrificing expensive stonework. Lead may be removed from sockets by mechanical means, but this is very laborious and any attempt to melt the lead will inevitably result in failure and damaged stonework unless the socket can be held horizontally to enable the lead to run out.

Paint Removal

Ironwork is generally covered in paint and frequently a build-up of rust in water traps etc. Commonly, paint and some of the rust are removed by grit blasting. There is, however good arguments against grit blasting, as follows, so that it should be regarded as a last resort.

Grit blasting will remove the outer surface of the iron, known as mill scale. This mill scale, which is typically 90% intact on work 300 years old or more, is the original surface to which paint was applied, and as such is as worthy of conservation as the rest of the iron. Further, the mill scale, in such a case has a proven record of keeping corrosion at bay. It is a protective surface in its own right, and hence of value. Further still, grit blasting will render all of the iron surfaces the same, thus removing permanently any evidence, which may be present on the surface of the iron. For example, a component, which has been renewed, and is thus not original, will exhibit a different colour of mill scale to the original. It is often the case that successive generations of repair can be detected, on the basis of colour alone. A surface which was originally polished for, say, indoor use, may still retain its bright appearance under the paint, giving us evidence, perhaps of a former use. Likewise, file marks etc, giving evidence of techniques of manufacture, will be removed by grit blasting.

Where possible, we will always recommend paint stripping by chemical means, with a thorough removal of the chemical agents, usually by steam cleaning. This will result, for the most part in the restoration of the piece to its original appearance as it was immediately prior to painting. Rust deposits are normally dealt with by the application of heat. Rust scale does not expand when heated to the same extent as does the iron. The differential in expansion causes the rust to lose its grip, when it may be shaken or brushed off. Heating the area to a red heat also results in the reduction of the surface layer of the metal to an oxide layer similar to mill scale. Often, where there has been a considerable accumulation of rust, the application of heat is needed anyway as part of the remedial process.

Safety Note: Wrought iron is frequently coated with lead based paints; often with a 75% lead content. Care must therefore be taken, particularly with grit blasting, to ensure that both operatives and the public are protected and that the lead working regulations are adhered to.

Colour Analysis

Nowadays ironwork is often painted black. This was predominantly not the case in histroical times, as can often be revealed by an analysis of the paintwork.

For well over four hundred years paint finishes have repeatedly been applied to gates and railings and other structures, an investigation of the accumulated layers of paint provides an insight into the items decorative history. This information can be used to establish previous colour schemes and act as a historical record for future reference. It is often a requirement that architectural paint research is carried out for listed building consent or obtaining grant aid.

We work closely with paint analysts to provide a full range of analytical skills and techniques for the study of paint and decorative finishes for historical structures. These include the identification of pigments and media as well as archival research. Full reports are prepared to provide a detailed insight into historical development of interior and exterior schemes, for documentation purposes, conservation or accurate restoration.

We highly recommend a report of this nature is commissioned as part of the restoration process. Please see Lisa's website for further information and contact details; www.historicpaint.com

Dismantling Components

Ironwork is often fastened together with riveted, or tenoned joints. It is not possible to part such joints without at least some damage, or weakening becoming evident on re-assembly. It is worth avoiding the parting of frame joints etc, merely to gain access to corroded components, as the frame will never be as strong again. Where tenoned joints must be parted, it is nearly always necessary to replace the tenon with a screw or screwed tenon, in order to regain adequate strength.

Repairs and Replacements

As a matter of course, the replication of components should be carried out in a manner similar to that which was used for the original creation of the piece, and in similar materials. Ideally, all work to an ancient piece should use the old techniques of forge welding, tenoning, riveting and collaring etc. so that a high degree of blacksmithing skill is generally required.

However, it is often the case that components cannot be completely removed from the job, or that only small work is need to a large component. In this case, recourse must be taken to more modern techniques.

For structural purposes, where part replacement is required, as, for example in the case of a gate back stile, which may be rusted away at the bottom, arc, MIG or TIG welding is used to join on the new part. No special equipment is required for the electric welding of wrought iron, only that normally used for the welding of mild steel; however, mild steel electrodes or MIG wire are not acceptable, a ferrous non-corrodible alloy must be used. Care must be taken in preparation however, as wrought iron is a laminar material, and welding must be carried out through the full depth of the section. Attaching components to the surface of wrought iron sections is not very strong. Alternatively brazing may be used, and is often useful for the attachment of components such as waterleaves, where the original method of forge welding or riveting cannot be done.

Sections which are heavily pitted, or wasted, but which are still structurally sound, may be repaired by the puddling in of new wrought iron, in the form of thin rods by the gas welding process. Iron thus deposited has no laminar structure, and hence little tensile strength, but otherwise appears to exhibit the properties of the parent metal. Alternatively, these sections can be built up by electric welding, but again use must be made of a suitable alloy. Care should be taken to avoid distortion of any section so treated.

Sheet work, such as leaves, being often impossible to access for the painting of both sides, is the usual candidate for replacement. For many years, there was no commercially available supply of

iron suitable for the often-deep distortion necessary in repoussé work. Copper was often used, but it is soft enough to be easily bent, and will not hold paint well, while mild steel and pure iron, particularly in thin sheet form will soon rust away. Topp & Co, a few years ago addressed this need, and by recycling the scrap iron resulting from the restoration of pre-19th century wrought ironwork, now produce a sheet charcoal iron of superior quality, for repoussé work etc.

It must be said that often, the repoussé leaf work found on ancient work, is of such a high standard of craftsmanship, which one cannot hope to accurately replicate it. In this case, we often make a point of preserving, at all costs, at least one of the originals, in order to give future students at least a clue. When a piece of sheet work is reduced virtually to lace, it may still be conserved, by scrupulous cleaning and the application of a layer of epoxy-resin to the rear surface. The detail can then often be restored by careful carving into any resin protruding on the front surface, with files etc.

Reassembly

The most common reason for the rusting of wrought ironwork is the gathering of water in places that will not dry. Wrought iron will last indefinitely, with reasonable maintenance if rainwater is kept at bay. Such bad places are the joints between members which lie alongside one another, for example, between a shadow bar and its mate, touching points of scrolls, particularly on a horizontal surface, water leaf sockets which are upward facing, and any area which is constantly submerged in vegetation.

When work is assembled, care should be taken to ensure that mating surfaces are protected by paint, as well as are visible surfaces, and that suitable mastic filler is applied before the work is assembled. Accepted practice is to use modern silicone mastic, which sticks very well, and is totally waterproof. Red lead putty is the traditional one, and if well sealed with paint, at regular intervals, will serve well. Waterleaf sockets may be filled with epoxy resin, poured in until it overflows, or pitch can be used, on the basis that in the summer, it will melt and renew its seal with the iron. Lead poured hot was often used, but as this does not stick to the iron, and water will be able to penetrate, it is no longer advised.

Re-Installing Railings into Stonework

There are three ways to fit ironwork into stone as follows:

1. **Hot poured and caulked or cold caulked lead** Advantages are that these are traditional methods, and that they are instant, requiring no setting time and it looks good. Disadvantages are that the lead does not stick to the iron, leaving the potential for water to enter the joint if the joint isn't sealed with paint. This seal needs to be re-made at intervals as a part of the maintenance of the ironwork. Looking to the future, lead is almost impossible to get out without damaging either the stone or the iron. Another consideration is that the hole in the stone must be water tight (lead tight), or a blind hole for hot pouring. If the caulking is too vigorous the stone can be fractured, especially if green.
2. **Grout** A poured grout of white cement or similar lime based mortar. Advantages, also traditional, stress free, easy to extract later with hammer and chisel, sticks to iron so excludes moisture. Disadvantages are the setting time, which can necessitate propping of the railings etc overnight.
3. **Resin** Advantages are convenience as applied usually by gun or cartridge, although this can result in incomplete filling of holes, and in this case a poured resin is better. Sticks very well to the iron to exclude moisture provided that the hole is properly filled. Resins will have a degree of flexibility which would serve to protect the stone against expansion/contraction stresses. Quick setting except in cold weather. Disadvantages are that resin is not guaranteed forever and long-term beahviour is unknown. Also it is not always easy to make a good appearance of the surface of the resin. Resin could prove difficult to remove without damage to stone or iron.

Cast Iron - Techniques Of Renovation

The cast irons used for highly detailed work in the nineteenth century were frequently rather high in phosphorous, which lowers the viscosity of the molten metal to enable a high degree of detail to be reproduced. The result is; however, extremely brittle and the greatest care should always be taken to avoid breakage, especially at the dismantling stage.

Fixings are usually of wrought iron, and if flush with the finished surface, will normally be impossible to release. Heating of the component to release fixings is usually not an option, as local heating of a thin casting can also result in breakage. Resort must be taken to mechanical means, i.e. drilling out of the wrought iron fixing. Care must be taken to drill centrally to the bolt or stud, as the wrought iron will often be harder than the cast and the drill will tend to drift off away from centre, also drills will be prone to breakage as they cross the even harder zone of rust between the cast and the wrought iron. The usual technique is to drill an initial hole of a small diameter to locate the centre, and to open this out by degrees until the remains of the fixing can be removed and the hole re-tapped etc.

Repair of broken castings.

Experience has indicated that welding repairs of cast iron decorative components are seldom satisfactory. The welds are not of the same strength as the casting and can crack, while heat stress can cause cracking elsewhere. Resulting distortion or misalignment cannot be rectified.

Alternative methods are;

1. Brazing, using oxy-acetylene and a brass filler rod. A good bond can be achieved with a lesser heat input than welding methods, but care must be taken that the surfaces to be brazed are tinned prior to filling the joint. Excess brass can be dressed by grinding or filing.
2. Bonding with an epoxy adhesive. Modern adhesives can give a very sound repair, with no need for heating of the components. Added security can be given to a joint, in some cases, by the use of iron or stainless pins located in holes drilled into the mating surfaces. If difficulty is experienced in getting alignment, one or both of the holes may be drilled oversize, and the gaps filled with the epoxy adhesive.
3. Plating with cast iron or non-ferrous plates or straps on the back of the broken casting. This is applicable to thin castings, but only where the backside is not going to be visible. Plates may be attached with screws or copper rivets, and a bonding agent should be used between casting and plate. Mild steel screws are not acceptable.
4. Metal Stitching. A specialist repair method consisting of bridging the crack with high strength non corrodible alloy
5. Welding. A repair technique that needs to be carried out by trained specialist technicians with experience of working on cast iron (not your normal fabricators)
6. Pinning. A useful method for repairing factures and attaching two castings together

New castings and components.

Where castings are to be replaced, new components can often be made by moulding from an original, however, shrinkage will occur to render the copy slightly smaller

than the original, which may be unacceptable. Also there is often, in common with all copies, a loss of detail between pattern and casting, which, on work of high quality may be unfortunate; however intermediate patterns can often be made from an original, in resin or aluminium, to improve the finish. Ultimately, the quality of the final product will depend upon the skill of the moulder, and examples of their work should always be inspected before engaging a new moulder. Where a casting is reusable, except for the absence of a small part, a rubber mould may frequently be taken from a similar part and just the missing part cast, as a patch, which must then be joined into the casting by one of the above methods. Old work was sometimes done, in iron, by lost wax methods; a technique not often employed nowadays in ferrous materials. This was done to overcome problems of drawing from the mould of complex, undercut patterns. The more able foundries will still be able to undertake this work, but beware at the pricing stage as the cost is of a different order to that of conventional moulding.

Where an old component exhibits a brittle failure through ordinary use, the temptation may be to replace it with a new one in malleable or SG. iron, which are much stronger than the original grey irons. There is no track record with SG due to it being a relatively new material, and its long-term performance is unknown however, there is some evidence that the old malleable irons corrode rather more readily than grey iron. Also difficulty may be achieved in obtaining an acceptable quality in SG iron, particularly in thin castings, owing to its greater molten viscosity and hence reluctance to run into a complex mould.

Fixings

Cast iron was often joined by wrought iron fixings, which are frequently seen to have done good service. However, lack of maintenance can lead to water ingress, and eventually failure of the casting due to rust heave. The same comments would apply to mild steel fixings, where the effect would be seen sooner. Stainless steel is often used nowadays, and will give good results, but water must also be excluded here, as stainless steels are just as prone to anoxic corrosion as their more prosaic brothers. The best fixings are made with non-ferrous materials, bronze, brass or copper.

In the case of copper, being soft, the fixing is likely to fail before the casting, resulting in less breakage of iron. Precautions should be borne in mind against electrolytic action, but in practice, this does not seem to occur in situations remote from an electrolyte, i.e. where the joint is more often dry than wet.

Joint surfaces should be painted prior to mating, and filling with non-setting bituminous mastic is a good plan if possible. Attention should be taken, in heritage work, of the shapes of the heads of the fixing screws, as these were frequently used for ornamental effect. Any shape of screw head can be obtained as a special from the fixing manufacturer, and attention to detail such as this is often justified.

Sockets, and tenon joints etc, were frequently fixed by running hot lead between the components. This is a good and neglected method of fixing castings together, but the joint must be caulked cold for full strength to be achieved, and to exclude water from the joint.

Reinstatement into stonework

As above for wrought iron railings.

Protection and Finishing

Galvanizing and zinc spraying have been mentioned and there are good reasons why these will not do. Galvanizing depends upon dipping the work after cleaning in acid, in a bath of molten zinc, which leaves a rather thick layer of zinc on the surface. Drips frequently form which must be ground off. If you add to this that the small joints will remain full of acid after the treatment, it is easy to see why this process is not appropriate to delicate and complex wrought ironwork. Additionally, in certain circumstances, the galvanizing process can deeply etch the surface of wrought iron causing irreversible damage to the piece.

Zinc spraying is a far less brutal process. It is a hand method, which consists of removal of all mill scale by grit blasting, and the immediate application of a zinc coating with a type of flame gun. The objections to grit blasting have been enumerated above. Further, it is not possible to clean very small joints by grit blasting, from the physical restrictions imposed by the size of a grain of grit, neither is it possible to clean nor spray material which is not accessible to line of sight. The water traps in wrought ironwork are just such small joints and out-of-the-way places.

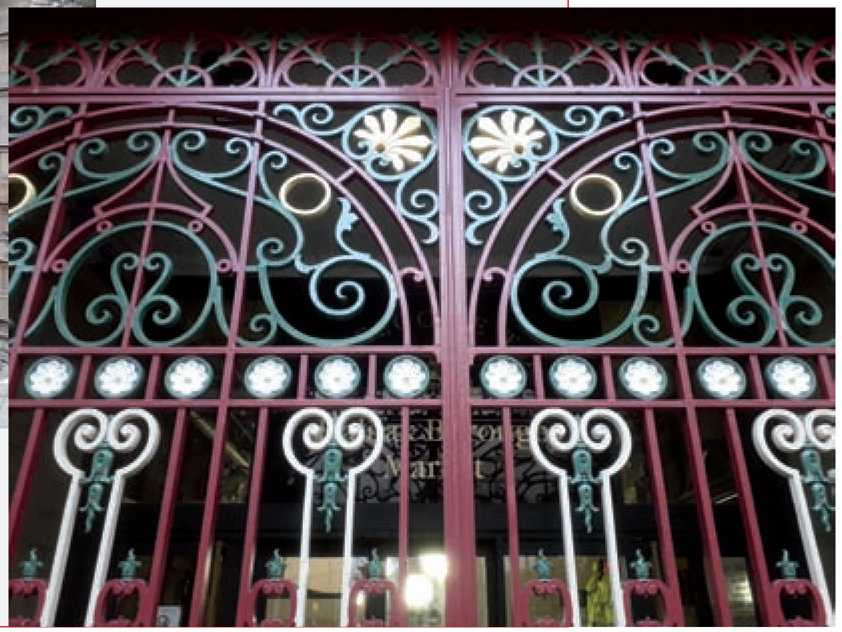
Owing to the natural ability of wrought irons to resist corrosion, it is sufficient to protect ironwork by a good coating of paint. However, we cannot stress too strongly that, in common with other items placed out of doors, such as woodwork, wrought ironwork needs regular maintenance. Chips and developing problems should be dealt with at the earliest dry opportunity, and the work should be painted at least every five years.

Protection of railings when being re-instated into stone work - ensure that the paint fully covers the joint area between the bar and the lead to protect again water penetration into the socket.

Painting:

Appropriate paint systems will vary depending on each individual job so any recommendations we give may be subject to change. You are welcome to phone us for advice or contact your paint supplier and discuss your requirements with them.

Note: All ironwork should be adequately protected during transport and installation with any grazes or chips to paintwork made good on site, using primer on any exposed steel prior to topcoat.



Restoration of 8 pairs of gates for Halifax Borough Market

Maintenance Of Wrought and Cast Ironwork

Ironwork is commonly supposed to be nearly free of maintenance and as such is frequently left to rust undisturbed for long periods resulting in periodic major overhauls, at great expense. This could be avoided by insistence on annual inspection with immediate and usually trivial remedial work to arrest any developing problems.

Suggested establishment of a rolling programme of maintenance, of all items of ironwork, based upon the following schedule.

Initially

1. Initial attention in the form of repair or restoration.

Annually

2. Thorough inspection of ironwork – Identify any areas of foliage, debris or moss build up and in particular any areas showing loose and damaged paintwork or signs of rust seeping from, or water lodging in, joints. Any chipping of paint in well-ventilated areas is not too significant.
3. Attend to identified problem areas at the earliest opportunity - Clean ironwork and immediate surrounding area of any build ups and ensure all ironwork is kept well ventilated. When the paintwork is dry remove dust, contaminants or loose coatings by sanding or wire brushing and then locally re-seal all areas identified in the inspection by touch-up paintwork. Bare metal should be primed with suitable primer before applying topcoat. Run paint into any joints where water is known to lodge to make sure these areas are completely sealed. Note that this work can only be carried out in periods of warm and dry weather when the problem joints are thoroughly dried out. Railings in stone work – attention to detail needs to be given the area around the railings where they enter the stonework, checking for damage to the paint work that could allow water to penetrate into the joint.
4. Lubricate to ensure freedom of movement – Hinges; fill all grease nipples on bottom hinge sockets and lightly oil pin inside top strap hinges. Shoot Bolts; lubricate as necessary. Lock; lightly oil the top of the protruding locking bolt and then slide in and out a couple of times to disperse the oil.

Every five years

5. Thoroughly re-paint ironwork with original (or equivalent) high performance paint system as proposed under 'finishing'. Prior to painting the ironwork should be thoroughly cleaned with hot soapy water and a scrubbing brush then degreased. When the paintwork is dry remove dust, contaminants or loose coatings by sanding. Bare metal should be primed with suitable primer. Apply full topcoat as required.

Every 10 to 15 years

6. Inspect gate locks and determine if needs replacing.

Long term

7. Decorative ironwork made of genuine wrought iron should be free of long-term damage if the maintenance regime outlined above is adhered to. However, should it be necessary to remove thick layers of paint the ironwork should be grit blasted only as a last resort as this removes the iron's own original protective layer of oxide. Instead all wrought ironwork should be striped by chemical means. Wrought iron should under no circumstances be galvanized or hot zinc sprayed as both cause irreversible damage to the natural corrosion resistant properties of wrought iron.
8. Then back again etcetera ad infinitum

Natural History Museum:
Restoration of iron railings and gates
by Topp & Co

Terminology explained

ANNEALED / ANNEALING

Annealing is a softening process whereby a metal is heated to a specific temperature /colour and cooled..The softened metal can be cut and shaped more easily. Ferrous metals are heated to a red heat and allowed to cool slowly, while non-ferrous metals are annealed by rapid cooling.

BAR STRAIGHTENING

When the bar can be removed (to the workshop), if the bend is slight use a hydraulic press; if severe use heat and straighten at the anvil.

Bars that cannot be removed (in situ repair needed) it is very often necessary to make up a special jig to suit the dimensions of the bar in question (one jig will serve for any number of similar bars). As above, if the bend is slight, use a portable hydraulic power pack, if severe then use heat and leverage as appropriate. In extreme cases it may be necessary to cut out the bar and replace with a new one in the appropriate material.

BRAZING

Brazing or bronze welding uses an oxy-acetylene flame and a brass filler rod. It is necessary to thoroughly clean the components before brazing and a flux is necessary to prevent premature oxidation of the surfaces to be joined. A good bond can be achieved with a lesser heat input than welding methods, but care must be taken that the surfaces to be brazed are tinned prior to filling the joint. Excess brass can be dressed by grinding or filing. Brazing is appropriate to a range of metals: wrought iron, mild steel, cast iron, brass, copper and bronze. With care brazing can be used to fill gaps and is often used to fill perforations in water leaves etc. This has the advantage of conserving the original component while the different colour of the filler metal gives evidence of the repair.

CAST IRON:
Plating of cast iron

Plating is useful for joining together larger sections of cast iron that have been fractured, enabling the original casting to be retained. Plate repairs can also be a useful method of structural reinforcement.

Plating is carried out by bolting a flat section of stainless steel or wrought iron to the fractured cast iron plate. The cast iron should be clean and painted (including the fractured surfaces). The plate should also be well painted. Stainless steel bolts or copper rivets should be used to fix the plate in place.

Another version of this repair uses a steel tube rather than flat plate. This is particularly useful for fractured columns. The steel tube is inserted in to the central hollow of the column and bolted in place.

CAST IRON:
Stitching of cast iron

Metal stitching is another method of joining two parts of a fractured casting together. To form a stitch, a chain of holes is drilled through a jig across the crack A special "key" is inserted into this line of holes to bridge the gap made by the fracture and is hammered into place. This is done at regularly spaced intervals along the length of the fracture. If the repair is to be

water or gas tight, a chain of overlapping screwed plugs is then inserted along the length of the crack. All plugs and keys are ground flush resulting in a repair which can be invisible when painted. Strength can be up to 85% of that of the original casting.

CAST IRON
Welding of weldable cast iron

Cast work composed of a number of individual castings is most commonly joined by interlocking via lugs or bolts rather than by welds. These jointing techniques are part of the character of cast ironwork and it is important to preserve and replicate these during repair works.

Generally, welding is not a good solution for fine or delicate cast iron, although it can in some circumstances work well - usually in heavier castings. Welding is a difficult and specialised repair technique that should be carried out only by a professional with experience of working with historic cast ironwork. If a weld repair is not avoidable: preheat the castings slowly and uniformly. This helps to reduce the risk of thermal 'shock' on cooling.

CLEANING PROCESSES

The choice of cleaning method should depend on:

- Degree of corrosion
- Location and accessibility of ironwork
- Significance of existing coatings
- Age and significance of the ironwork
- Thickness and strength of the ironwork

Cleaning Methods (from least to most aggressive)

- By hand – bronze wire brush, chisel and hammer, emery paper
- Power tools (not recommended)
- Needle gunning
- Flame cleaning (use with caution, experienced professional required)
- Chemical cleaning: topical preparations / dipping in chemical bath
- Dry ice
- High pressure water blasting
- Blast cleaning (wet and dry, various blast mediums available)

Cleaning by hand

If ironwork is generally in good condition it may be sufficient to clean it by hand, as more aggressive methods, such as power tools, can cause damage by scoring the surface of the iron.

Begin with hot, soapy water and a cloth to remove general dirt and grime or moss growth. Light areas of corrosion can be removed using a wire brush, taking care to remove any residue before applying paint.

Areas of chipped paint should be sanded down using emery paper, feathering the edges into good surrounding paint in preparation for paint application.

Vary cleaning techniques on different areas of the ironwork according to need. It may be sufficient to remove upper layers of paint until a stable layer is reached, then apply fresh paint. Avoid painting over rust scale as corrosion will continue to develop under paint. The weather is of critical importance in cleaning and coating iron - low temperature and high moisture content in the atmosphere will often lead to failure.

Flame cleaning

Hand cleaning using an oxy-propane heating gun to soften the paint, which is the removed by wire brush and scraper. Does not work if bitumen paint, tar etc are present. A slow method which requires the use of breathing protection. Suitable only for outdoor use.

Needle gunning

This is a noninvasive method which involves chipping the paint off with a set of vibrating needles. To avoid marking the work, the needles should not be sharp. It is a hand process and relatively slow, but it does leave the original oxide layer intact. As the paint chips are relatively large there is little danger from lead dust. As with all vibrating tools there are limits on operator exposure times.

Chemical dipping

Immersion of the whole piece of ironwork in a solvent, e.g. caustic soda. This requires the use of a tank sufficiently large to be able to submerge the whole piece for as long as it takes to dissolve the paint layers. This can be up to three weeks, although the reaction can be speeded up by heating the fluid by means of gas burners beneath the tank. When the paint is dissolved the work is taken from the tank and thoroughly cleaned to remove any trace of the caustic. It may still be necessary to scrape or chip off in places where the paint was particularly thick. Great care should be taken to wash or steam clean ironwork thoroughly after treatment to prevent chemicals from lodging in the joints of the ironwork and compromising subsequent paint layers.. Note: if the paint has been dissolved out of joints etc, particular care should be taken to load the joints with paint prior to applying primer.

Hydro-blasting / high pressure water blasting

Water under high pressure (pressures greater than 30,000 psi) is blasted onto the surface of the ironwork to remove paint and corrosion. The advantage of this method is that it is relatively effective at removing surface salts, and there are no blast particles to become lodged in the surface of the ironwork. However, the moisture can sometimes cause rapid gingering (light, flash corrosion that occurs in damp or humid conditions)

to the ironwork surface.

Grit blasting;

...regarded as a last resort. Grit blasting becomes the only feasible method of paint stripping when the work must be done on site and the budget precludes the use of other methods. Unless soft blasting media such as ice or granulated plastic – which render the process rather slow – are used, the usual media such as steel shot or aluminium oxide are very effective but difficult to control. Thus the original oxide surface is usually lost with any evidence this might carry. This process is non-reversible and so not recommended by the principals of conservation. Blasted surfaces should be coated within four hours on a dry day, or with wrought or cast iron, left for a period to develop a stable oxide coating prior to painting. Care must be taken to prevent dust migration in the case of lead based paints.

Chemical poultice

Overnight application of a thick layer of paint stripping gel, wrapped in cling film. Preserves the original surface. Works well on site, but care must be taken to remove all chemical residues prior to painting. Slow and expensive.

FLUX

In metallurgy terms, a chemical cleaning agent, flowing agent, or purifying agent used in the welding process. It combines with metal oxides to lower their melting temperature to below that of the base metal, so they liquify at a welding heat and can be squeezed out, and additionally forms a barrier to further oxidation.

FORGED BARS

Forging is the process where hot metal is deformed under a hammer or press, without any loss of material. Typically forged bars will exhibit a slightly uneven texture and very sharp corners when compared with rolled bar

FORGED COLLARS

Collars are used to hold two or more pieces of metal together. They are often the easiest and most attractive way to attach curved surfaces together, as in scrolls.

Collars can be simple bands or have fancy moulded profiles.

Hot collars are forged from one piece and fitted hot, whereas cold collars are made in two of more pieces and riveted together in place

FIRE / FORGE WELDING

Forge Welding is a solid-state welding process that joins two pieces of metal by heating them to a high temperature and then hammering them together. The process is one of the simplest methods of joining metals and has been used since ancient times. It is one of the most fundamental techniques of blacksmithing, but one of the trickiest to master. It requires speed, precision, and practice.

GALVANIZING AND ZINC SPRAYING

Offers a level of corrosion protection. Both processes coat the metal with a thin skin of metallic zinc which electrolytically protects the steel underneath. The choice depends on the on design of the metal work and the overall finish. Zinc spraying gives a finer finished surface as long as there are no inaccessible crevices which the spray cannot reach.

Galvanizing involves the chemical stripping of the metal in an acid bath, followed by immersion in a tank of molten zinc. The nature of the process ensures better penetration into crevices. The galvanized surface needs to be t-washed (in a zinc phosphate solution) and an etch primer applied before painting. The galvanizing process can leave the metal very' rough' and time is needed to remove the roughness and the 'snots'. This process removes some of the surface galvanized coating

Neither process should be used on wrought iron, nor is either necessary.

JOINTING

Where original joints have been parted, every attempt must be made to re-fix components using similar methods – collars, rivets, screws, tenons etc., taking care to coat components with primer paint where possible before re-assembly. Where new parts have to be fitted by cutting out original material, in order to avoid too much dismantling of original sound joints – e.g. sections of branched scrollwork - new components may be attached by brazing or electric welding as appropriate, provided that the joints thus formed are dressed back to a fair surface prior to painting.

LAMINAR MATERIAL

Metal made by forge-welding different layers.

LEAD
Removal of leaded-in joints

Where ironwork has been fixed into sockets cut in stonework – a common method of fixing historic ironwork –great difficulty is associated with any attempt to dismantle the joint. Options are as follows:

1. Melt out lead. This is not normally possible unless the orientation of the socket will allow the molten lead to flow clear of the socket. This can sometimes be arranged by tipping the copings with railings attached through 90 degrees. Even so the greatest care must be taken to avoid heating the stone.
2. Smash copings to release ironwork.
3. Cut ironwork just above coping, remove railings to a workshop and extend to original length. Stubs in stone can be removed by core-drilling.
4. Attempt to remove the lead mechanically by drilling and chiseling. This can take up to two hours per hole and invariably results in damage to the stone. Often the sockets are not sufficiently accessible for this method.

LOST-WAX CASTING

Also known as investment casting. An original pattern, usually of wax, is melted out of the mould prior to pouring hot metal. Enables complex shapes and undercuts which may be difficult to achieve by the usual process of withdrawal of a timber pattern

PINNING

A process used for repairs to cast iron work.

Pinning is a useful method for repairing fractures or attaching two castings to each other. This method results in a barely-visible join, with none of the raised material left by welding. Pinning is achieved by drilling a hole into each of the castings that are to be joined together. A stainless steel threaded pin, bedded in epoxy, is used to join the two halves together. Once the two sections have been joined by the pin, no brazing or welding is required to secure or seal the joint. The joint should be thoroughly painted and kept well maintained. This type of repair is ideal for decorative castings and is typically used for repairs such as attaching finials to bars, reattaching missing sections of cast panels or the broken arms of finials. If the cast iron is too thin in section it is not possible to carry out this type of repair, brazing is an alternative repair method in this instance. The disadvantage of this method is that it requires holes to be drilled, but this is likely to be outweighed by the benefit of being able to retain the original casting.

REPLACING PARTS WITHOUT DISMANTLING

When it will be necessary to create a component or a part of a component, use techniques and materials identical to the originals. This new component can then be assembled into the whole by bonding, riveting or welding as appropriate. Welds etc. are dressed back to a fair surface.

REPOUSSEÉ

Repoussé is a metalworking technique in which a malleable sheet metal is ornamented or shaped by hammering from the either side to create a design in low relief. Historically the method whereby masks and leafwork were made, usually in wrought (charcoal) iron.

RIVETED JOINTS

Rivets have traditionally been used by blacksmiths to make strong and secure joint, they can also be used as a design feature in their own right.

Holes are first punched or drilled in the pieces of metal being joined. They are then clamped together and a rivet inserted through these holes. One end of the rivet is supported by a heavy piece of metal called a bucking bar and the other end is then hammered flat, or domed over, to about one and a half times the width of the rivet body. The heads on both sides can be sharped in dies. The rivet is usually inserted hot and the hammering causes it to swell up inside the holes which take up any play. Additionally, the rivet will shrink as it cools down and this causes it to pull together the pieces being joined. As a result a rivet makes a very strong and tight joint. Often done cold in the smaller sizes.

ROLLING	The process where metal is deformed by repeatedly passing between rolls – sometimes plain, sometimes grooved – in order to form a smaller, but longer section. Rolled bars exhibit a totally even surface, as opposed to forged bars
TIG and MIG	As variants of electric welding, similar comments will apply. They are both applicable in certain situations but the use of mild steel as a filler wire should be avoided in favour of non-corrodible wires of nickel or bronze.
WROUGHT IRON BILLET	The rough block used as the starting point for hot rolling or forging, normally 2 or 3 inch diameter bars, some two to three feet in length.

National Heritage Ironwork Group

Conservation principles for heritage forged and cast ironwork

Introduction

The National Heritage Ironwork Group (NHIG) was formed in 2009 to raise awareness and understanding of the importance of the various forms of heritage ironwork in the historic environment, as opposed to other types of fabrication which involve different skills and techniques.

All heritage forged and cast ironwork is an integral part of the historic environment, both in terms of functional parts and decorative elements.

To ensure that the skills of the Heritage Ironworker and Blacksmith are recognised, preserved and promoted, the NHIG intend to set up a nationally accredited training and development programme.

It is the duty of all professionals and practitioners to promote good conservation practice in order to safeguard the long term survival and integrity of heritage ironwork. This document has been developed to enable blacksmiths to uphold best practice in the care and conservation of heritage ironwork, and to be shared with clients in the commissioning process.

The following principles have been endorsed by the membership of the NHIG and leading conservation organizations as set out in Appendix B, and have been peer reviewed.

Core Principles:

- To analyse, understand and assess the significance of the object prior to undertaking any decisions regarding intervention.
- To record the object as found and at all stages of work.
- To care for and maintain the object to halt or minimise ongoing deterioration.
- To retain maximum original / existing material.
- Interventions should be reversible, but where this is impossible, interventions must respect the significance of the object.
- Professionals and practitioners must be competent in ironwork conservation and source specific expertise where needed.

Good Practice

1 Consideration and understanding of significance

This is fundamental to the practical application of our Core Principles.

Significance is the historic, aesthetic, technological or social value for past, present or future generations in terms of:

- Age.
- Uniqueness of design, scale, materials, etc. when originally made.
- Rarity as a survivor of its type.
- Example of past style, design, innovation, use of materials, constructional practice, etc.
- Association with people, places or events.
- Contribution to its setting or context.
- Spiritual, political, or cultural significance.
- Exceptional aesthetic qualities of form, colour, decoration, etc. and the contribution made to the immediate environment or landscape.
- Condition, extent of the original material and ability to perform its function.

2. Retention of as much existing material as possible

This is a fundamental requirement of conservation work and takes priority over cost, serviceability and aesthetics

The following increasing degrees of intervention should be followed:

- Minimal intervention or alteration of existing material, form and evidence.
- Minimal disturbance, with work carried out in-situ where practical.
- Stabilization (e.g. propping, improving the environment, removal of rust and similar holding operations).
- Strengthening where structurally inadequate.
- Restoration should only be undertaken where all other options have been discounted.
- If all options for treatment of the original have been exhausted an object may be retired and archived, and only then may new or replica elements be considered.
- Wasted, holed and cracked components must be repaired by patching or reinforcing in preference to being renewed. Fastenings must be repaired and re-used where possible.
- Non-reversible techniques may be used only where this is unavoidable, to allow retention of a component or assembly of greater significance.

3. Use of techniques and materials as originally used

Details of the original materials and techniques used should be identified and preferably adopted for new parts. However, if the original type, section, or grade of material is permanently unobtainable, or service requirements make its use inappropriate, the material with the nearest physical properties may be used. Decisions on the use of materials and techniques must at all times respect the principles of minimal intrusion and loss of evidence.

New components should exactly replicate the method of construction, form and detail of originals, including joint and fixing details, and should be identified by discreet date stamps were possible.

Castings should be replicated in the same method and grade as originals and cast in sand moulds using originals as patterns where possible.

Fixings should be by the method and material used originally where possible.

The recipe of bedding and 'rust-joint' compounds must be analysed and re-used wherever possible.

4. New material should be identifiable

The name of the Conservator and the date of the work should be identified on replacement components where practical.

For example:

- By stamping onto replacement forged components.
- By raised lettering and numerals on new castings.
- By use of brazing to distinguish a new patch from original wrought iron.

This information must also be recorded in conservation records.

5. Parts and materials that cannot be re-used

Components, including wasted / rusted fragments, and samples of original materials that cannot be retained in use, must be stored in a secure and stable environment, preferably close to where they originated. Where possible entire parts should be stored; otherwise good representative samples.

The original location of stored items must be identified by individual tags or labels, and full details included in the conservation record.

6. Improvement of immediate environment

Where practicable, the environment of historic ironwork should be improved by protection from the elements, covering, coating, packing, dehumidification, reduction of pollutants, control / removal of vegetation, debris etc, and by measures to prevent destabilization or theft.

7. Relocation to a less destructive environment

Historic ironwork should be retained in its original location, protected from damage, deterioration and theft.

If, after extensive efforts at preservation in situ it is generally agreed that relocation is the only practical means of ensuring medium-term survival, ironwork and its context should be recorded fully, fixings carefully released , and ironwork moved as short a distance as practicable to stable and secure conditions by skilled operatives.

Ironwork should be moved in sections as large as practicable with minimal dis-assembly. Components must be tagged, recorded and reassembled fully at the new location without delay.

All stages of the work should be recorded fully and records archived.

8. Protection of surfaces.

The corrosion of surfaces is a threat to the survival of ironwork in an exposed environment. Surface coatings were commonly used and are historically important, so past coatings should be retained if sound, and localized defects made good where possible.

Paint samples should be taken and analyzed before any intrusive work takes place, and samples should be retained as part of the conservation record.

In general the original type and colour of coating should be used.

However, if difficult access or severe conditions make it unlikely that the medium-term preservation of historic ironwork will be achieved using traditional paints, a modern substitute may be used, preferably retaining existing coatings in full or part if sound. Past finish colour, decoration and level of sheen should be adopted.

Where removal of existing coatings is unavoidable, only techniques that minimise the risk to the surfaces may be used. The least intrusive/risky cleaning method consistent with achieving a stable, clean surface should be selected.

Soundly adhering forge-scale on wrought ironwork, foundry scale on castings and surface evidence generally should be retained where possible.

Paints must be applied in accordance with the manufacturer's instructions by skilled operatives. Where modern-specification paint is applied over a traditional paint, adhesion and stability should be tested by sample areas left to weather over several months.

9. Use of additional materials or structure for strength or support

Where ironwork is weakened or subject to increased stresses that cannot be relieved, structures may be strengthened by applying additional props, stays, ties or materials bonded on. These should be minimally intrusive and reversible where possible.

Care must be taken to avoid water traps and damaging point-loads where the new structure fixes to the original. Stiffening flexible structures and changing stress regimes in a way potentially damaging to the ironwork must be avoided.

10. Use of replicas

In exceptional circumstances use of replicas may be considered, for example where ironwork is subject to wear, or is at risk of serious damage and corrosion or theft, its on-going preservation may best be achieved by creating a replica, and retiring the original from service.

This must not be promoted if it is liable to result in the care and maintenance of the original being neglected.

A replica must remain distinguishable from the original after it has aged or weathered, so may need to be stamped or signed and dated with the new installation date. Replicas are of particular value where service-requirements have increased, compromising the integrity or safety of the original object, or originals are missing.

11. Planned maintenance

Maintenance is vital to minimise the rate of deterioration of historic materials, and should be:

- Planned to allow advance allocation of resources.
- Regular, so that it is not forgotten.
- Adequately funded.
- Thorough and effective.

The long term preservation of ironwork can only be achieved through regular and thorough inspection by competent practitioners.

A condition survey should be undertaken to:

- Identify present and potential deterioration, damage and loss.
- Recommend a course of action.
- Facilitate the budgeting and carrying out of maintenance and conservation work.

Inspection and maintenance should include:

Annually

- Thoroughly inspect all ironwork for defective coatings, corrosion, discolouration, damage, distortion, instability, build up of water, dirt, debris and biological matter.
- Remove dirt, debris and biological matter.
- Clear hopper-heads, rainwater pipes, drains, etc.
- Clean local defects in coatings, fill as necessary, prime and re-coat.
- Fill water-traps and joints, ensure interiors are drained and ventilated.
- Record the work carried out and materials used, archive the records.

Every five years

- As Annually, and;
- Carefully inspect, prepare and re-coat the object if necessary.
- Record the work carried out and materials used, archive the records.

Longer term

In the long term more intrusive work may be required including repairs to components and removal of accumulated coatings. Advance warning of this should be given to the ironwork's owner / guardian.

12. Selection and proper training of suitable practitioners

Craftspeople, managers and professionals must be competent in the theory and practice of ironwork conservation and have good knowledge of:

- Core principles and good practice in conservation.
- The properties and uses of historic and contemporary materials.
- The manufacture, designs and applications of traditional metals and associated materials.
- Historic ironworkers and the designs / techniques they used and design history of the period.
- The mechanism of corrosion and methods of controlling it.
- Repair and conservation techniques.
- Coating / finishing traditional ironwork.

Practitioners must continually update their knowledge and understanding of best conservation practice.

13. Detailed recording

An historic object, and all work to it, must be recorded before, during and after conservation to enable our successors to:

- Understand the object's history prior to our intervention.
- Understand its current condition.
- Understand the changes we implement.
- Understand the nature and rate of deterioration the object is subject to over a long period.
- Make wise and informed decisions on the on-going care of the object.

Photographs and sketches supported by notes and dimensions are recommended as quick and effective methods of recording.

Records are to be stored in a registered archive such as the County Records Office, or the registered archive of the organisation commissioning the work. Records are of no value if they deteriorate or are lost, so must be stored securely in stable conditions, preferably close to the object to which they refer.

Technology advances and digital records may become difficult to read, so should be backed up by paper, the most long-lived recording technology to date.

14. Comprehensive written maintenance schedules and operation guidelines.

These are needed to:

- Facilitate planned maintenance (see Clause 11).
- Minimise the potential deterioration and damage to historic ironwork.
- Minimise the danger to those who use or come into contact with the ironwork.

15. Specification of all stages of work in accordance with good conservation practice

Specifications, drawings and schedules of work define the scope and standard of work required and provide a basis for payment. Documents forming the basis of a contract must be:

- Based on good ironwork conservation principles and practice.
- Sufficiently detailed to avoid misunderstandings.
- Supported by adequate funding and terms of contract.
- Based on adequate knowledge of current condition.

If the current condition of ironwork or the scope of conservation work is not fully known, a preliminary survey at the Client's expense may be needed. It is the responsibility of the conservation specialist to highlight this need.

Inadequate specifications risk damage being done to the ironwork and strained contractual relations between employer and ironworker.

Clients would be wise to allow for reasonable provision for contingencies.

Appendix A: Definitions

Cast iron is a form of iron whose shape is produced by pouring liquid metal into moulds.

Conservation is the careful management of change, ensuring that the significance of an object are understood and protected with minimal loss of evidence, to be enjoyed by present and future generations. Conservation stabilises the object in its existing state, maintaining its materials and slowing deterioration.

Maintenance is the periodic inspection and care of an object, with routine attention to defects as they occur.

Material is the physical substance of which the object is made, including its surface finish.

An object is an historical item which may be anything from a single small detail to a monumental structure.

Pure iron is pure metallic iron with traces of carbon, manganese and other elements.

Restoration is returning the object to a known earlier state with minimal introduction of new material.

Stabilisation is the prevention of on-going degradation by removal of, or protection from, adverse conditions.

Stainless steel is a form of iron with alloying elements to provide some degree of resistance to corrosion.

Steel is a highly refined alloy of iron and carbon, commonly available for structural purposes from the late nineteenth century.

Strengthening means providing structural adequacy.

Wrought iron is a mixture of iron and slags produced by direct reduction in a charcoal furnace or by puddling in a reverberatory furnace

Wrought ironwork refers to decorative objects made by a Blacksmith.

Appendix B: Endorsing Organizations

The NHIG Conservation Principles have been endorsed by the following:

ENGLISH HERITAGE

National Trust

The Ironmongers' Company

BABA

TOPP & CO.

GREAT BRITAIN

Unit 5, The Airfield
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