THE WINSTON CHURCHILL MEMORIAL TRUST OF AUSTRALIA

Report by Brad Jackson

2011 Churchill Fellow

The Park Family Churchill Fellowship to study traditional ironwork; production, restoration and conservation – U.K. Italy, U.S.A.

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Signed: Date: 27th February 2012

INDEX

INTRODUCTION

I have been a blacksmith for over twelve years, and have been involved with many of Australia's more significant restorations on heritage ironwork. My career began with an intense blacksmithing apprenticeship in the heritage listed Eveleigh Locomotive Workshop, Redfern, Sydney. Being immersed in this history sparked an interest in the heritage ironwork that complimented it. Following this I travelled to Brisbane, again sourcing heritage based ironwork, then finally being lured to Perth, with the restoration of Fremantle Prison's "Wray Gates".

Heritage ironwork seems to be the focus of many of the skills I have acquired, as I believe these are the foundation skills that can then be built upon, into whichever specialisation is required. This exceptional national experience has also been complimented by exposure to international practice through conferences, and extensive travel to study ironwork designs through Europe, North and Central America, the U.K. and Cuba.

While training and seeking experience I found it was not possible to study my trade further in Australia, and there was no tuition available specifically regarding heritage ironwork. However there remained a vast amount of ironwork that was in dire need of preservation, much of which is 'of heritage', with historical significance. Further, there seemed no accreditation or method of assessing those conducting the work, often leaving conservation work to semi-skilled metal fabricators with little blacksmithing or heritage knowledge. This was causing irreversible damage to heritage ironwork, which I often witnessed firsthand. With this occurring nationwide, and with little education of those commissioning the restoration of ironwork, the result is a damaging and improvised approach that could continue unchecked.

I will be forever grateful to the Winston Churchill Memorial Trust, and particularly to the Park family for the opportunities the Fellowship has afforded me. The ability to study in the United States, Italy and the United Kingdom, whilst representing the Winston Churchill Trust was a privilege and an honour. The courses and experiences that were made available through this representation were exceptional and will stay with me throughout my career, with the knowledge passed on to many.

A special thankyou to;

Mr Alan Ball and Mr Craig Parsons, the two referees that assisted through the application process.

My mentor Lyn Williamson for her valued support

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Ms Meg Gilmartin, for the exceptional organisation of the Fellowship details

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Clay Spencer	Instructor-	John C Campbell Folk School
Bob Alexander	Instructor-	John C Campbell Folk School
Paul Garrett	Resident Blacksmith-	John C Campbell Folk School
Holly, Leila and the team	Blacksmith, Curator-	National Ornamental Metal Museum, USA
Patricia Les'	HRP Head of Collections-	Historic Royal Palaces
Susanne Groom	HRP Historian-	Historic Royal Palaces
Brian Hall	Blacksmith Conservator-	Hall Conservation
Brian Russell	Artist Blacksmith-	Little Newsham Forge
Chris Topp	Blacksmith-	Chris Topp & Co. Wrought Ironworks, NHIG
Bethan Griffiths	Blacksmith-	The Ironwork Studio, NHIG
Paul Allen FWCB	Blacksmith-	Motcombe Forge
Sophy Wills	Ironwork Conservator-	Victoria & Albert Museum
Simon Carter	Collections Curator-	St Paul's Cathedral
Teresa Heady	Collections Manager-	St Paul's Cathedral

And finally, my beautiful partner Kate and son Finn.

While the time away from you both was productive, it was also heartbreaking.

EXECUTIVE SUMMARY

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Fremantle, Western Australia.

The Park Family Churchill Fellowship to develop advanced techniques in the production, restoration and conservation of traditional ironwork – United States, Italy, United Kingdom

Highlights;

- Personal tour of the Victoria & Albert Museum ironwork gallery with iron conservator Sophy Wills
- Meeting with representatives from Historic Royal Palaces regarding current restoration of the Tijou Screens at Hampton Court Palace
- Extensive tour and study of Jean Tijou's ironwork within St Paul's Cathedral, London
- Two weeks of tuition in the Clay Spencer blacksmith shop, John C. Campbell Folk School
- Workshop visit and meeting with Chris Topp, regarding the puddled iron reclamation process, traditional skills in conservation, and the foundation of the National Heritage Ironwork Group
- Workshop visit and personal tour with Brian Russell of his many artworks throughout North Yorkshire
- Studying the incredible heritage ironwork of Venice and the surrounding mainland.

Recommendations;

- Heritage tenders for ironwork specifying adherence to conservation guidelines and ethics
- Commissioning only highly competent and specialist tradespeople for conservation work
- Formation of an easily accessible directory of those specialising in heritage trades
- The inclusion of heritage blacksmiths in the decision making process involving heritage ironwork
- Formation of a network of competent heritage based tradespeople to exchange information
- Promote informed decisions by those commissioning the conservation of heritage ironwork
- Traditional skills reintroduced into the TAFE Blacksmithing trade course curriculum
- CPD workshops for heritage and related professionals regarding heritage ironwork

Implementation and dissemination;

- Discuss experiences and knowledge with colleagues and related professions
- Supply of the Fellowship Report to heritage bodies and related professions
- Support the organisation of a CPD workshop relating to heritage trades
- Supply articles detailing the Fellowship experience and highlights for trade publications
- Featured articles in print media regarding the Fellowship, heritage ironwork and traditional skills
- Guest speaking to associated organisations and heritage open days
- Continue to work within heritage ironwork conservation promoting best practice

PROGRAMME

30TH October – 12th November 2011

John C. Campbell Folk School, North Carolina, U.S.A.

- Traditional Joinery course
- Appalacian chapter Artist Blacksmiths Association North America meeting
- Blacksmiths & Fine Art Auction
- 17th & 18th century hinges and latches course

14th – 17th November 2011

National Ornamental Metal Museum, Memphis, U.S.A.

- Tour of heritage ironwork and forged art collection
- Examined the United States ironworking print archives
- Workshop visit

20th – 26th November 2011

Venice and the Venito

- Visit traditional and unique ironwork in public setting
- Learn from in situ examples of factors governing traditional ironwork failure and results
- Study traditional ironwork's corrosion resistance in coastal environment
- Visit authentic exterior ironwork in castles and study corrosion resistance

28th November 2011

Victoria & Albert Museum, London

- Visit the V&A ironwork gallery

29th November 2011

Hampton Court Palace, U.K.

- Study significant Baroque ironwork by Jean Tijou
- Meeting with representatives from Historic Royal Palaces regarding conservation of ironwork

3rd December 2011

Little Newsham Forge, North Yorkshire, U.K.

- Workshop visit and tour of Brian Russell's work containing traditional techniques

7th December 2011

Chris Topp & co Wrought Ironworks, North Yorkshire, U.K.

- Workshop visit and meeting regarding heritage skills and N.H.I.G.
- View wrought iron reclamation process
- Discuss traditional ironwork and conservation techniques

9th December 2011

Ely Cathedral

- Study and record extensive traditional ironwork styles and evidence of corrosion

10th December 2011

Canterbury Cathedral

- Study and record traditional ironwork styles and evidence of corrosion

12th December 2011

Victoria & Albert Museum, London

- Meeting and tour of ironwork gallery with ironwork conservator

13th December 2011

St Paul's Cathedral, London

- Meeting and tour with collections curator regarding ironwork
- Discuss maintenance and ongoing issues with collection

Types of Iron

Differing largely from other crafts in the heritage field, the clients and specifiers of ironwork often have little understanding of wrought ironwork and the associated materials. Architects and other related professionals often have no training in this field, and do not understand the difference between fabrication and traditional methods, and between wrought iron and mild steel.

Historic wrought ironwork is likely to be made of either 'charcoal iron' or, more commonly, 'puddled iron'. This is the product a blacksmith traditionally works with. It is malleable, easily fire welded and has superior forging and fire welding abilities. Not to be confused with cast iron, where the iron is heated to a molten state and poured into moulds. Cast iron is a different material and not forgeable due to the very high level of carbon and enlarged grain.

Charcoal iron was the traditional iron that appeared before the late 18th century. It was mostly hand produced, without the use of rolling mills, and therefore lacked consistent straight lines.
The iron contains a slag content of around two percent distributed in fine layers or laminae. A small amount of carbon, typically 0.2 percent was introduced to harden the iron and make it more serviceable. The charcoal furnace could only achieve a temperature of around 700ºC at which temperature the iron coalesces into a solid sponge-like mass. This heat was sufficient for the charcoal to reduce the iron oxide to iron, but not to melt it. As a result the silicate slag was included, mainly iron oxide and iron silicate.

Puddled iron was produced in coke furnaces which could reach 1200ºC. This is the eutectic point where the iron, having become saturated with carbon (around 3.5 percent) becomes liquid and can be tapped from the furnace. The molten iron was then transferred to another furnace (a muffled furnace) which kept the metal and the carbon rich fuel separate. It was then stirred with rods "puddled" to expose the carbon and other impurities to the oxygen rich atmosphere (thereby reducing them), before being passed between rollers. The rollers formed a standard size product, while usually imperial in dimension, and increased the uniformity. The quality of puddled iron varied enormously and remained largely unregulated until the early 20th century, when standards were introduced defining the quality, with AAA being the finest, and grade D used for fencing.

Puddled iron is no longer produced commercially, however recycled iron is available from selected sources, and recommended for restorations.

Cast iron production is an ancient method, however significant commercial production only occurred in the late 18th century, following development of new processes driven by industry. Cast iron contains a large amount of carbon, up to 3.5% in some cases, and is excellent under compression, however breaks very easily when stress is applied. This brittleness is due to the high carbon content and the enlarged grain, easily seen in a new break.

Domestically, cast iron was in use in Britain in the 16th century, mainly for items like firebacks and cooking pots. It was not until after 1759 when the Adams brothers recognised cast iron had the ability to produce the classical forms for forged iron designs. It increased in popularity during Victorian times and was widely used for making gates, panels, railings and the decorative elements that adorned them. It is characterised by a detailed repetitive pattern with often larger and thicker detailing, as seen on the decorative finials of wrought iron railings. Cast iron is often easily identified by a seam running along the edge of the casting, which is evidence of the moulding join.

Mild steels quickly rose to prominence from 1856 as the preferred metal for many applications. It is the most common and cheapest metal available due largely to its mass production. Following this, inclusions of other metals led to various alloys for specific needs. These steels are classified by a 4 digit numerical code, identifying the carbon content and the alloying elements.

Iron History

The smelting of iron ore with charcoal must have been discovered independently in many parts of the world, as there remains significant evidence of the smelting process, the by-products and iron products. The first evidence of the smelting of iron has been dated from the 3rd millennium B.C.E. in Egypt and Anatola, Turkey. Throughout the majority of inhabited lands, with the exception of isolated islands (with no native iron ore) there was a relationship with iron. It was primarily used for tooling, weapons, domestic hardware and jewellery, and was often so highly regarded in some areas that its value equalled or surpassed that of gold.

The blacksmith was revered and in medieval Europe, was known as the “King Of the Trades” as every other trade utilised his skills for their tooling. He also had the unique ability to legally marry couples with a strike on the anvil and a few words, as Gretna Green in Scotland is still known for.

The first produced type of iron was Charcoal iron, owing its name to the fuel used for smelting, and is a highly carburised form of iron which was made by smelting the ore or “bloom” in a small furnace called a “bloomery”. This reduced the iron oxide bloom to iron, with the inclusion of many impurities, mostly iron silicate and carbon. The iron was then forged out into bars, cut into shorter lengths, stacked and reforged. This could be repeated many times, each time reducing the amount of slag included, with the fine residual slag becoming incorporated into the iron, forming a fibrous structure, giving the iron strength and corrosion resistance.

Charcoal iron production was laborious and inconsistent, with hand produced batches of iron differing in quality due to many factors, including the location of the smelting, impurities in the ore, charcoal used, air temperature and humidity. Charcoal iron differs from the later puddled irons and steels in forging characteristics and chemical and physical makeup.

Around 1400A.D. the Belgians introduced the blast furnace to the iron smelting process, which increased production and reduced the many impurities. The blast furnace also had the ability to decarburise the iron in a controlled manner, achieving a more consistent product.

In 1709, with charcoal production slowing as the resource dwindles, iron founder Abraham Darby pioneered the use of coke for smelting the iron. This new fuel became more efficient at smelting ore than the traditional charcoal production (due to the higher temperatures achieved) and made wrought and cast irons more affordable, which in turn helped drive Britain's industrial Revolution.

In 1784, Henry Cort introduced the puddling process to iron production, which kept the fuel and iron separate in a muffled furnace. This molten, viscous mass of iron was stirred or "puddled", combining the silicate and reducing further the impurities. The mass was then forged out in bars and stacked, as previously. The amount these masses were reworked defined the quality with the higher grades being reworked many more times. This newer method, although still time consuming, was preferred and far cheaper than Charcoal iron production had become.

In 1856, Henry Bessemer was experimenting with a method to mass produce wrought iron without the need for hand puddling. He discovered that by passing air through cheap molten iron at high temperature, he could remove impurities by oxidisation. This method produced an iron with a consistently fine homogenous structure, relatively free from impurities and led to the mass production of mild steel or "merchant bar".

By 1876 mild steel had become cheaper than wrought iron to produce, and was embraced by engineers for many projects, however puddled iron remained the preferred material for ships chains due to the strength, weld-ability and corrosion resistance.

With the production of mild steel came the ability to alloy the material with other metals, giving specific requirements, such as increased corrosion resistance (stainless steel). This development of materials and their application was driven by the large engineering institutions, such as the railways and shipbuilding, and increased during the wars to provide better armaments and defences.

Production of puddled iron continued until 1974, when the final manufacturer closed in England.

Ironworking Skills Peak

As the role of the blacksmith developed, so too did the need to specialise in aspects of the trade. Heavy industry had specialist equipment and led to Industrial Blacksmiths, known as "Hammersmiths". Blacksmiths specialising in shoeing horses became Farrier's. Those producing cutlery and finer domestic forgings became whitesmiths. Finally, those that chose to specialise in the decorative architectural forgings associated with domestic and municipal buildings became Architectural Blacksmiths. The preceding title is also known as "decorative", "ornamental", "domestic" and "artistic".

The skills and technique of the Architectural blacksmith reached its zenith from 1690 to the mid 19th century. During this time, the smiths trained in an environment of forging excellence, and many turned their focus to the high class decorative ironwork that adorned the corporate and municipal buildings and public areas of cities and towns. These skills were taught by generations of tradition,

where there remained an education of careful appreciation of the fine classical forms. This provided the stimulus for ironwork of superior calibre and competition was for the finest work, not for the lowest rate.

Traditionally, blacksmiths and founders served long apprenticeships, at times up to 8 years in duration. These apprenticeships were funded not by the employer, but by the parents, guardians or patrons of the apprentice who paid for their tuition. Following the end of the indenture period, the craftsman would travel between workshops for several years and became known as a "Journeyman". In Germany, this programme still exists, and "Journeymen" retain the traditional clothes associated with this training.

After this length of training, if a craftsman wanted to open his own business and employ an apprentice, he would be required to produce a "masterpiece". This would be submitted to the associated guild, who would judge it on many aspects, including; design, technique, difficulty, materials, faults and the variety of skills employed. If passed by the guild, the craftsman would be considered a "master" of the craft.

Often the work from this era was of such high calibre and complexity, that it is difficult to appreciate how it was produced. There are many examples of the fine work created in during this time of forged iron perfection. These include the famous works of Jean Tijou.

Skills Downturn / Cast Iron

With the rise and unrelenting drive of the industrial revolution came the mass production of iron wares. These became more affordable to the general public, and the use of iron for domestic purposes was increased. This led to a downturn in the fashion and need of the expert skills and the one off individualism of forged iron provided by the blacksmith. The introduction of cast iron to the general public also lowered the perception of the value of iron. As the cast iron was cheaper to produce at every stage of production, the end result was a product that could be reproduced indefinitely, produced on an enormous scale at a fraction of the cost of hand produced wrought iron.

Cast iron was also favoured by national, civil and municipal bodies as the preferred material for railings, balconies, gates, hardware and many of the other products previously allotted to wrought iron. The producers of wrought iron, in order to remain competitive, began to produce designs of a simple nature, with few of the ornate flourishes of previous generations. This is demonstrated in the Victorian ironwork throughout London.

This financial strain and shrinking client base placed downward pressure on the blacksmiths skills, as these require an enormous investment in training, expert tuition and a continuation of high calibre work to retain them.

Post War Austerity and Skills Loss

The two World Wars spelled the end of expert manual skill throughout Western Europe and the Commonwealth in many ways.

Firstly the wars generated a technical development that displaced these skills due to the newly developed methods and technology. This technology became easier to use with consistent results, however the skill of the operator became almost negligible by comparison to the previous trades, as did the wealth of knowledge required.

Following the long years of war began a general acceptance of austerity, which had an adverse effect on the appreciation of quality across the entire range of craft skills. The general fall in standards following the Wars, led to the motive behind the work no longer being “is it beautiful ?”, but “does it work ?”. While this mentality would have provided the Blacksmiths with income via the modification of iron to newer needs and reworking old stock, the quality decorative work was not appreciated and rarely forthcoming.

There was an entire generation of the working trades involved in the conflict, many of whom perished, were severely injured or returned and took up other trades or professions. This severed the continuation of knowledge and passing of skills through instruction and demonstration that had continued from the 3rd millennium B.C.E.

With the changes in architectural fashion mostly driven by austerity and the new techniques and methods having removed the demand for ornamental ironwork, there was a significant decline for the smiths themselves. This new austere focus not only helped end the production of wrought iron, but almost caused the loss of the art and skills critical to the working of the material. The environment of an educated appreciation of the classical details had been replaced by the concerns of the financial costs of such attention. The skill and pride that had given rise to the works no longer existed.

Current Situation

The producers and restorers of forged ironwork who care about the standard they set, the quality of the material they use, their technique and the training and skills they employ are being forced to compete with those who have very little understanding of the materials and skills required to initially create the work. This is producing a downward pressure on those practitioners, and forcing a compromise between remaining competitive against those with lower standards and producing the best work possible.

The ability to acquire appropriate skills through any formal avenue is hampered by a lack of training facilities and the need to an “on the job” approach to education. This can often lead to a “blind leading the blind” approach with on the job training, as bad practice and technique is copied and implemented without check. The architectural forging skills themselves are not taught to any trade

standard in Australia, rather the single trade course available is focused on the industrial aspect of blacksmithing. Those courses aimed at architectural forging are mostly directed at hobbyists and are not sufficient to acquire adequate knowledge to conduct professional restorations. The accumulation and furthering of these skills is dependent on the practitioners own drive for knowledge and technique.

Nationally, there remains a lack of expertise in traditional ironwork, so that when heritage ironwork does come up for repair or restoration there is confusion as to the best treatment and method. Often the advice is sought from the nearest metalworker, irrespective of any qualifications or adherence to any guidelines, so that the majority of damage is in fact done by ignorance and poorly executed repairs or attempted restorations with inappropriate methods and materials.

Once reinstated, the repair work commissioned is often of an inferior quality and quickly corrodes or breaks, which requires further work at a later time. This then becomes a costly exercise, and far surpasses the slightly higher cost of the skilled labour and materials to conduct the work expertly in the initial instance.

Poor quality repairs, resulting from this lack of training, skills or bad practice can detrimentally affect the ironwork and the associated history of the piece. Often this repair work is irreversible without significant loss or damage of the original material and damage to the surrounding fabric.

This often occurs with items of national importance, which would otherwise demand the highest standards in other conservation disciplines.

There is currently an enormous amount of heritage ironwork in every Australian city and town that has been subject to very little maintenance and attention since installation. While this work is often considered plain by international standards, it has played and remains a significant part of our history and culture, and is worthy of preservation.

Australian Ironwork Heritage

There is a significant amount of history relating to ironworking in Australia. From the early forges of the colonists, to the industrial expanses of the railway workshops. Shipbuilding at Cockatoo Island in Sydney, Lithgow's forging traditions and the iconic construction of the Sydney Harbour Bridge. The Wray Gates at Fremantle Gaol, and the small blacksmith's shops servicing the Murray River trade. Even the rural stations blacksmith's providing the iron wares for the station and locals forms a significant part of Australia's early history following colonisation.

In Inner-City Sydney, many generations have vivid memories of the Eveleigh Locomotive Workshops at Redfern. The locomotives looming from the darkened belly of the workshops, steam billowing, and the incessant and unrelenting thumping of the blacksmiths hammers. These workshops were a significant part of Sydney's landscape employing thousands every year, with apprentices of many trades passing through the workshops since establishment in 1887. These workshops are currently under management by the Australian Technology Park, with National Trust protecting a substantial

amount of the remaining heritage machinery. However, previous to this protection there had been a period of neglect and vandalism, resulting in the loss of considerable amounts of the heritage fabric.

The “Wray Gates” at Fremantle Gaol have an interesting history linked to Australia’s convict past. Originally, the Swan River Colony was not destined for convicts, but as the other colonies ceased importation of convicts, a need arose. Within the new colony of free settlers, there was a dire need for labour and supplies, so the decision was made, with the first convicts arriving from Parkhurst Prison for juveniles in 1843. These convicts were housed in a temporary prison while construction of a more permanent establishment was undertaken on the present site. The “Wray Gates” were constructed for this site in 1846, and have remained ever since. The iron used to make the gates was brought over on the convict ships as ballast, and retain several of their manufacturers touchmarks from England. The blacksmith that produced the gate, Joseph Nelson, was actually a Royal Miner and Sapper and formed part of the prison personnel. The standard of the iron was apparently of such poor quality, or the maker’s fire welding skills so poor, that no effective fire welding was able to be done. This led to the unique use of traditional carpentry joining techniques for construction.

Another fine example of Western Australia’s ironwork heritage is the East Perth Cemetery. The cemetery is Western Australia’s oldest colonial cemetery, and gives an insight into the colonists hardships and lives. Unfortunately, it is an effective example of neglect and vandalism with around 90% of the original cemetery destroyed or buried under buildings, and the remaining the common target of vandals.

Ironwork and the associated history, form an integral part of the heritage fabric that relates to Australian people and places. While it may not have the lengthy history of other countries, or the ornate flourishes of a Baroque masterpiece, it is a vital aspect of our history and worthy of the best efforts of conservation.

Heritage Ironwork Abundance

With the decline of traditional skills and the emphasis on university education, comes the problem of having few with the ability and skills to work on, and restore heritage pieces. With the loss of traditional techniques and methods comes the inability to reproduce in the original manner, and our heritage suffers. Those with few skills and little appreciation of heritage are often tasked with this work, and it remains merely a commercial undertaking, with little care taken, and few guidelines adhered to.

The remaining ironwork that requires care and restoration is prolific. Most towns and every city in Australia contains traditional ironwork with associated history. This ironwork has a limited lifespan without intervention and in most cases is in an advanced state of decay.

A brief walk around Sydney demonstrates the amount of significant ironwork that exists in a heavily corroded state with extensive rust expansion or “rust jacking”. In some cases, horizontal bars are corroded through, with no attempt to halt or remedy this. This was the case in a recent visit to the

Sydney CBD, with the highly technical ironwork at the entrance to Sydney Hand Hospital being among the worst. The nearby church opposite Hyde Park, displayed corrosion so advanced, the horizontal bars were either missing, structurally unsound, or heavily pitted, with heavy rust jacking affecting the remaining ironwork.

Perth also has many easily identifiable cases. These include the original ironwork found throughout Fremantle which requires attention to prevent corrosion reaching the extent previously mentioned. Another example is the Perth Institute of Contemporary Arts exterior boundary fence which shows signs of both rust jacking and severe corrosion which affects most of the ironwork, but more worryingly the supports maintaining its structural integrity.

With a significant amount of ironwork having previously been neglected or otherwise never properly maintained, there is the requirement for adequate practitioners to conduct restoration and other conservative measures on this heritage iron before the loss of material is too great to warrant conservation.

Production

As previously mentioned, the production of traditional ironwork decreased in popularity due to changes in fashion, the rise in cheaper cast iron wares, the loss of advanced skills and an atmosphere of austerity. This was at its lowest point during the 1970's, where traditional forging techniques were rapidly being replaced by the newer technologies and developments that emerged following the wars. The level of skills and technique was reduced under the pressure of competing with the newer technologies, and the public perception of cost and value. This led to a decline in not only those practicing the production of traditional ironwork, but also the skills and designs of the ornate and flourish filled ironwork predating the First World War. The tuition and training almost ended for this discipline, and few in Australia could see a future for the retention of these skills.

Fortunately there continued to be a need for these skills, and the regal and distinguished traditional ironwork forms remained. The methods for producing ironwork also adapted, and became easier to learn, with little tuition or skill development required. However the traditional methods with laborious, detailed and exacting forging requirements continued to be practiced. These skills are readily applied to restoration and reconstruction processes, as these were the skills and techniques employed during the original construction.

Today, there are few in Australia with the skills required to construct ironwork in the previous manner, however throughout Western Europe it is common to see a traditionally assembled garden gate, fire grill or railing. The material too, will occasionally be the traditional puddled iron reclaimed from previous ironwork. This is a result of the retention and value placed on the traditional skills and materials, and the amount of restoration required in these heritage filled countries. This helps retain the techniques and skills required, and has them used almost daily, resulting in a high degree of accomplishment.

Throughout the United Kingdom, blacksmiths employ these techniques in their construction methods and clients readily specify their use, seeing the value placed on the ironwork with its inclusion and an increased aesthetic appeal. Traditional techniques used in the production of ironwork increase the real and perceived value of the piece. This is evident in not only the quality of workmanship required to manufacture a piece in this manner, but also the clients connection with the manufacturer and the methods. This can be displayed aesthetically as hammer marks, and rivets displaying the method of assembly. Even in the present global market situation, there is evidence of the market resurging towards hand made goods, and perceiving the cheaper, mass produced goods as impersonal and of a lower quality than a traditionally made piece.

Traditionally produced ironwork is also often seen as a heritage piece, to be retained and cherished, rather than a passing artistic statement. The expense of the initial purchase retains value, (if maintained) as the craftsmanship is evident, and the execution is often high. This work then becomes the antiques of the future, with experts willingly assessing and appreciating the craftsmanship and techniques used, and valuing the piece accordingly.

The production of traditionally assembled ironwork is rare in Australia, and it is difficult to find evidence of these methods in modern production. Welding and fabrication is the standard process, however traditional elements are often used to give the appearance of a traditionally crafted piece. The most common is the rivet and collar. These are easily formed and generally do not demonstrate a high level of skill, nor does their inclusion increase the value of the work.

The lowering of skill levels, cast iron competition and perceived value of ironwork have a large impact on the use of traditional methods, more in this country than many others throughout Western Europe. In time, hopefully there will be an appreciation of the quality and uniqueness of a traditionally crafted piece, and the market for this type of ironwork will regain popularity as it has internationally.

Conservation

The conservation of heritage ironwork is the broader term for the preservation, stabilisation, restoration and reconstruction of the heritage fabric. The term is defined within the Burra Charter as "*… all the processes of looking after a **place** so as to retain its **cultural significance***."

In practical terms it is the stabilisation and preservation of an object, with the minimal amount of interference beyond the halt of further decay and to retain the object in the current condition. This allows for the application of non intrusive reversible coatings, and processes aimed at prolonging the life of the object indefinitely, often made without any attempts at reconstructing or altering the piece beyond that of a purely 'retention of existing' aim. The term is mostly associated with interior ironwork and museum collections.

The term 'blacksmith conservator' is often used in reference to a blacksmith specialising in the many aspects of ironwork conservation, and not purely in the conservation of ironwork to a museum

standard, in a museum environment. A blacksmith conservator may undertake repairs, reconstructions and alterations to a piece during a general conservation or restoration role, without jeopardising an ethical standard. These modifications all retain the primary goal of conserving the fabric in the best method for the longest period, however take into account the piece may be in its original position, being used for the original purpose, such as gates, and therefore the ability to operate them effectively (and safely) is a vital aspect of their heritage fabric. This again, resonates with the Burra Charter definition of conservation, "… *all the processes of looking after a **place** so as to retain its **cultural significance***."

The ironwork gallery at the Victoria & Albert Museum, London, contains superb examples of the finest ironwork ever produced. While the conservators aim is to present the ironwork in the best unaltered manner, the very fact it is to be openly exhibited to the public introduces safety concerns. The ironwork must be structurally sound, and free from elements that may injure the general public, however these alterations (bracing, dulling edges etc) are essentially a destructive and non-reversible process (however minor), damaging the very thing to be conserved, which offers no benefit to its actual conservation. This then introduces the ethical conundrum of alteration, which must be critically evaluated, case by case.

A vital aspect of good conservation methods is the adequate management and maintenance of the existing fabric. This should include a budgeted provision for short, medium and long term maintenance and safeguards preventing further vulnerability or neglect.

Stabilisation

Stabilisation is the retention of the ironwork in its existing state, and the temporary prevention of further deterioration. It is often used as a method of halting the deterioration until a subsequent full restoration or conservation can be undertaken. While it is not ideal in the long term, it is quite adequate for a stop gap measure while funding or other issues are addressed.

Within the heritage ironwork field, the main method of stabilisation is to identify and cease the aggressive corrosion often found in joins, in moisture traps and in areas that cannot shed moisture readily. Puddled iron has a superior corrosion resistance and will remain stable in the short term, as long as the moisture traps are addressed and if in a coastal or high salt area, are constantly flushed with rainwater to remove the salts. If paint remains on the ironwork, this will form a water trap and must be addressed, being mindful of the significance of traditional paint in the heritage fabric and the often encountered toxic lead based paints.

Any exterior work can be treated with Ensis oil or a similar product. These products temporarily bond with the surface of the material and displace moisture. This should be readily applied to any joins and moisture traps and will act as a short term preservative. Application should continue yearly until a more permanent solution can be arranged.

Other applicable products are organic based, reversible and have short life spans leaving minimal residue on the iron. These include select fish oils and Lanoline based products. Care must be issued with regard to the surrounding fabric, as some oils and products may seep, stain or damage material surrounding the ironwork .

Rust converters are a controversial product, and other methods seem more appropriate for exterior heritage ironwork.

Dr Rob Francis of Melbourne, did his PhD thesis on rust "conversion" materials at Monash University.
He is quoted;

> *'Tannic acid and other tannin based (so-called) rust converters are of limited use for treating rusted steel. There is a reaction between the tannin and ferric ions to produce a black-purple colouration on the surface, but the protection offered is limited. They do have the advantage that they are relatively safe to use, environmentally attractive and unlikely to damage adjacent materials such as wood. If the item is kept under dry conditions, such treatment may be acceptable. However, for exterior or other damp or wet environments, such coatings will quickly break down. They have no effect on salts in the rust, which is the major reason for continued rusting. They are porous and allow oxygen and moisture through the coating. Their adherence is poor, and subsequent coatings are not bonded strongly to the steel. Moreover, underneath a paint or coating, the unreacted tannin absorbs moisture causing osmotic blistering.'*

Restoration and Reconstruction

Restoration of heritage ironwork is the attempt to return an object to an earlier state by removing corrosive or detrimental products and reassembling the existing components without the introduction of new material. It differs from reconstruction, in that new materials are not permissible.

It is far more common for the process to be a reconstruction than restoration, as corrosion of the iron is often left until severe wastage has occurred before intervention, and the element requires replacement. This is also the case where hinges and other rotating parts are worn and require attention or complete replacement.

Heritage ironwork has often been subject to a misinformed, improvised approach to restoration. This has caused an enormous amount of loss of the original material and detail, and an incorporation of new and inappropriate materials and methods. This is opposed to the Burra Charter guidelines, where "changes to a place should not distort the physical or other evidence it provides, nor be based on conjecture".

The more commonly encountered problems facing the restorer are the loss of material and components through corrosion, impact or rust jacking, and the remediation of previous, poorly executed repairs.

Before restoration work has begun, those overseeing the work should have adequate knowledge of heritage ironwork to be able to specify the correct materials and methods. This restricts the winning of tenders by those unable to conduct an appropriate restoration, and ensures the most appropriate methods and materials are used, with the best results for the ironwork.

Also, before any work has commenced, it is vital to have a full outline of what is to occur, the recording methods to be used, restrictions, production methods, reports, what is hoped to be achieved, etc, so there is no ambiguity or hearsay later.

Extensive recording of the ironwork in situ, before anything is altered or moved, will assist the restorer during the restoration as a reference, and as evidence of the state of the ironwork before intervention. The restorer should also undertake thorough research of the history and issues relating to the piece and the previous techniques used, even going to the extent of using this research to reproduce original tooling for specific elements where possible. Internationally, there is a drive for this extensive research to be undertaken, as problems are often arising mid restoration that are irreversible and of significant detriment to the ironwork and its heritage.

The order of assembly of heritage ironwork often hampers the removal and reinstatement of one element, without the extensive dismantling of the entire piece. This is then an ethical dilemma, and the approach should be discussed and weighed against the possibility of causing unnecessary disturbance and damage to stable material. Other options may need to be discussed and a compromise reached.

Replacement components should be accurate replicas of the originals. They should be produced using the same material and techniques as the original. With the identification of new parts for future restorers, date stamping in an inconspicuous area can easily identify the part as a replacement. This allows for identical materials to be used, adhering to conservation guidelines, and the future restorers to identify previous reconstructions.

The use of modern materials may have their place, and should not be ruled out of use, however the risk of galvanic corrosion is increased. The choice of a substitute material must be of substantial benefit to the ironwork conservation for it to be permissible. It is also an ethical choice. Other conservation trades would not substitute high quality authentic materials for one of lower grade. It would not be acceptable, yet often mild steel is substituted for authentic puddled iron as a matter of course, with no benefit to the ironwork conservation other than a moderate financial saving.

The use of traditional methods and skills in reproducing components has many benefits for those commissioning the conservation. These techniques are authentic and when done well it is difficult or impossible to differentiate between a traditionally reproduced component and the original, and the work will therefore not detract from the overall ironwork as poor replacement parts often do. While corroded iron often seems irredeemably wasted and beyond repair, it is often salvageable and readily repaired. This offers both savings to the owner against the purchase of new iron, and the retention of the original iron, thereby retaining the character of the surroundings. However, bad repairs and restoration or reconstruction work will damage ironwork in the long term, can impact on the appearance of the surrounding fabric and be difficult and expensive to undo.

When elements are separated, before reassembly the parts can be coated in a corrosion inhibiting primer. This will reduce the encroachment of moisture and protect against the devastating effects of rust jacking.

The skills and knowledge required to conduct an authentic restoration on heritage ironwork are substantial and diverse. By conducting an authentic restoration with a skilled expert, these skills are retained for further generations and the end result is far superior and resilient than one conducted by a less skilled practitioner. The long term preservation of the object should be the motivation behind restoration and reconstruction based decisions.

Where funding is of concern, stabilisation may be considered, while a suitable conservation or restoration/reconstruction solution can be resolved, or the funding sourced. Where the funding for more expensive treatments is unlikely, such as with voluntary organisations or consistently tight budgets, the opportunity exists for the specialist to conduct their work (such as purely the ironwork) with voluntary labour supplied for the other aspects, such as the removal, reinstallation, and preventative treatments. While this is case specific, and not suitable in some cases, it may be an option. It may also be appropriate to frequently apply coatings with a lower durability (if the labour is voluntary), as long as the resistance to corrosion is maintained. This can save the outlay for expensive high performance coatings and labour.

The use of architectural salvage is common among reconstruction commissions. The alteration and adaption of the salvage is often a valuable chance to study the original methods of construction and technique. The source of the ironwork however, should be positively determined to avoid the dispersal of other heritage. At times the salvage is imported from ambiguous or false origins, at great detriment to the supplying nations heritage. The ironwork may also be the result of theft, common from unguarded worksites.

The restoration of heritage ironwork remains a commercial undertaking. While this should not be the motivation behind restoration attempts, it remains that the work must be economically viable to retain professional skills and skill levels. It must also be valued as a professional career if young blacksmiths are to be encouraged to specialise in this element of ironwork, with the appropriate financial return for a professional trade. This next generation of specialists will also continue to preserve our heritage ironwork for future generations to appreciate.

Cast Iron Restoration

While cast iron and forged iron are both derived from the same source (iron ore), and produced with similar equipment, there are striking differences in both application and material composition, which leads to different approaches during restoration and preservation.

It is common to find both cast and forged iron featured in historic ironwork. Due to its strength and resilience forged iron was often used for the main framing and vertical bars, with cast iron used for the decorative elements. Unfortunately, the traditional cast irons were very brittle (due to impurities and very high carbon) and those before the 19th century often included a high amount of phosphorous, which was included to lower the molten metal viscosity and enable a finer degree of detail to be produced. The introduction of phosphorous only heightened the brittleness further leaving the castings susceptible to fracture.

Cast iron is highly susceptible to the results of rust jacking when used in combination with puddled iron. The cast iron has an almost impenetrable even surface, which prevents corrosion, however the

puddled iron often used in conjunction with it, will delaminate and expand with rust, particularly in fine cracks such as the sockets under cast iron finials.

When elements need replacing due to damage or absence, the moulding can be taken directly from an original, or if fractured and split, it can be fixed together so a mould may be taken. This can easily be done in situ with the use of resins, however there is a minor loss of detail during the moulding process, and a small amount of shrinkage due to cooling metal, which must be taken into consideration for critical dimensions.

Welding of traditional cast iron decorative elements is rarely satisfactory, as the weld material is not of the same metal composition, grain size and strength as the original casting, and will crack along the edge of the weld material (the heat affected zone). The heat stress introduced from the high temperature of electric welding will promote cracking elsewhere, and the resulting distortion or misalignment cannot be easily corrected. There is also the ethical issue of having to removing original material and introduce a metal of very different composition (which may lead to galvanic corrosion).

Brazing is an acceptable method of joining fractured cast iron and has the benefit of being reversible, thereby adhering to conservation guidelines. An oxy-acetylene welding torch is used with a brass filler rod, resulting in a strong bond with the introduction of less heat, thereby reducing the distortion and likelihood of further fracture.

The use of adhesives is a common method of fixing in modern ironwork, and offers a convenient method with often sound, waterproof seals, however these are not reversible or traditional and appear vastly different to the original methods used in heritage ironwork. There is significant benefit from not introducing the stress inducing heat, however an experienced braze welder can easily overcome this.

Pins of copper can be used to fix parts together and is a traditional method, often encountered during restoration work as the single method of fixing, or as extra support to other methods. The parts are assembled, and a hole is drilled through both elements, with a slight countersink on both sides. The pin is fixed and the protruding ends are hammered flush with the parent metal. In some cases, where the pin will not be a hindrance and is in fitting with the original work, it can be left in place without hammering flush. This is often encountered under horizontal bars in fencing. The copper, being soft and malleable will fail before the casting, and is far cheaper and easier to replace. The galvanic reaction between the dissimilar materials remains minor. Mild steel or stainless steel screws are not acceptable for many reasons.

Socket and tenon joints were frequently fixed in place with molten lead, and it remains the most common traditional method. Care must be taken with the heat introduced into the casting, however with lead having a relatively low melting point, this should not be significant. The joint must be caulked when cold to produce full strength, and exclude water and grit entering the fine shrinkage crack found alongside the metal after the lead cools.

Cast iron often needs little surface preparation and cleaning due to the even surface condition and lack of laminating rust. Without casting faults (cracks, cold shuts etc) it is more likely to produce a

fine iron oxide patina which is easily removed and the initial protective coatings applied. If the casting is free draining, that is, lacks water pockets or fine joins which retain moisture, it should weather well uncoated, or with an organic oil coating. This will be prolonged if the casting is flushed often with fresh water (rain), to remove salts, and other contaminants and corrosion inducers.

Preventative Methods

Preventing further deterioration of ironwork commences with the work ethic and skills of the practitioner. While the ironwork is being produced, restored, repaired or worked on in any other manner, there is the opportunity to prolong the life of the object without later intervention. If the object is a new commission, while it is being constructed the blacksmith should be coating all joining surfaces with a rust inhibitor, zinc etc. to discourage later ingress of moisture and rust jacking. New heel cups are often supplied as they can be prone to deterioration. Where this is the case nipples should be greased and preventative maintenance on hinges and swivels should be carried out (while in keeping with the style and restrictions on the fabric).

Once restoration has been completed or the new work finished, there is a need for a system or method to ensure the long term conservation of the ironwork. The first stage of this process is prevention.

Regular maintenance is paramount and will be highly beneficial to the long term preservation of any heritage ironwork. Case specific maintenance schedules detailing the prevention of corrosion and other damaging factors should be outlined for the client or commissioning body. Appropriate products and the methods of application should be explained and regular inspections scheduled for those conducting the maintenance. Likewise, actions or products that may damage the ironwork and coating should be acknowledged and preventative measures taken either physically, or by making those responsible aware of the affect. A long term plan can be supplied with appropriate annual, 5 yearly and 10 yearly actions implemented to ensure the fabric that was preserved will remain in that condition for the longest duration without intervention.

Understanding the manner in which the ironwork was maintained or neglected over its lifetime, remains a vital part of its history. Knowing how the object has been treated in the past can give insight into how best to protect it in the future. Knowledge of the works history combined with the present state of the piece allows an appreciation of what has worked, and what has not. This shapes future methods and product selection for the longevity of the piece.

Restoration Ethics and Guidelines

The restoration of heritage ironwork has often been based on an improvised approach, and only vague guides or outlines adhered to, by varying degrees depending upon the practitioner. They have also worked with their own methods and not adhered to the structured approach other heritage and conservation trades respect. This has been due to the lack of relevant expertise in the field of heritage iron, from both the architects and related professionals, but also by those commissioned with the work.

The **Burra Charter** is used by many professional conservators for the basic principles and procedures to be followed in the conservation of Australian heritage places. Following a revision in 1999, the Australian Heritage Council and a majority of state heritage bodies have adopted or recommended the charter.
Of the many Articles that relate to heritage ironwork, two exerts are particularly significant to ironwork restoration as effective guides to work with.

Article 4. Knowledge, skills and techniques
4.1 *Conservation* should make use of all the knowledge, skills and disciplines which can contribute to the study and care of the *place.*
4.2 Traditional techniques and materials are preferred for the *conservation* of significant *fabric.* In some circumstances modern techniques and materials which offer substantial conservation benefits may be appropriate.
(The use of modern materials and techniques must be supported by firm scientific evidence or by a body of experience).

The Australian Institute for the Conservation of Cultural Material (AICCM) provides an AICCM Code Of Ethics and AICCM Code Of Practice for members to abide by during conservation activities. These serve as another important guide to the correct approach for repair, restoration and conservation activities and serves as an outline of “best practice” in dealing with heritage ironwork.

The preservation of ironwork should take a cautious and well informed approach, changing only as much as necessary but as little as possible. When reproductions are to be made, it becomes an important endeavour to study and reproduce the style and techniques of the original smith and replace it as closely to the original as possible – both functionally and aesthetically. This should be done in a manner that, if we could consult the original maker, he would approve of.

A description of the work, as well as any repairs, replacements, alterations and previous treatments to the original ironwork will all become part of the history of the piece. Along with any possible previous uses, these things require recording as they are of historic significance and are worthy or recording for future reference.

The techniques, methods, materials and skills employed should be authentic and when required, specialist knowledge included in the decision making for the best possible outcome. The selection of material and methods should be specified to all contributing parties, to ensure authentic repairs and accurate quotations.

The Burra Charter

The Burra Charter defines the basic principles and procedures to be followed for the conservation of heritage places. These principals can be applied to a variety of heritage places, and have been adopted as the standard for best practice for the conservation of Australian heritage.

During an International Council on Monuments and Sites (ICOMOS) conference in Venice in 1966, a charter was drawn dealing with historic monuments, and their restoration and preservation. This charter was an international outline for the best practise applicable to heritage places and was known as the ICOMOS Venice Charter. In 1977 the Australian ICOMOS reviewed and revised the charter to apply to Australian practice. In 1979, the Australian *ICOMOS charter for the conservation of places of cultural significance* was adopted. This charter accepted the concepts and philosophy of the Venice charter, but made them more applicable to Australian Heritage.

Adherence to these charters is often favoured by governments awarding grants for heritage work, with an accepted conservation philosophy such as the Burra Charter, and practitioners following these guidelines are often favoured by government bodies awarding grants for heritage work.

"*To Australians, the Burra Charter is probably the most significant document of the last thirty years on the basic principles and procedures for the conservation of heritage places. It provides a guiding philosophy for the care of our heritage and has been widely adopted as the standard guidelines for heritage conservation practice not only in this county, but also in other parts of the world.*"

- Heritage Perth

Hazards of Traditional Ironwork (lead)

The use of lead played an important role in traditional ironwork. It was an additive in traditional paint, and ironwork was also fixed in place with lead, either poured molten, or rammed into horizontal cavities and tamped (rammed) to produce a tightly sealed anchor.

The use of lead paint continued until the 1960's, when the associated health risks were acknowledged and general production ceased. Small amounts of lead remain in common house paint, however since 1997, this has been restricted to 0.1%. Before 1965 the amount was nearer 50%.

The most common type of original coating on traditional ironwork is made up of turpentine solvent, a linseed oil binder, white lead (lead sulphates and carbonates), and other pigments. This coat was often applied over a corrosion inhibiting primer, which in the 17th and 18th century, was called "Spanish brown" and included a small amount of white lead. Red lead mixed with linseed oil was also used as a paint primer from the mid 18th century onwards and can be identified against "Spanish brown" by a lighter colour.
The use of white lead is highly restricted and is only available under strict regulations. Red lead is more readily available and remains appropriate for specific restorations.

When traditional paint is removed and becomes mobile, either by removal or ignition, it readily becomes airborne and poses a significant health risks to those in the vicinity. It can also travel distances and expose those downwind (or downstream) to associated risks. The airborne paint can also travel and settle on surfaces with other dusts, where it will remain until disturbed, thereby delaying the hazard.

Traditional paint therefore should be treated with a high amount of care and caution. Test kits are available to identify if lead is present, and if so, paint should be dealt with in an appropriate manner with the ironwork, health and the environment being at the forefront of decision making.

Lead is often used as a fixing material for ironwork due to the corrosion resistance, low melting point, availability and cost. A majority of exterior ironwork, including gates, railings and balustrades (a common adornment on masonry), will contain lead in these traditional fixings.

The removal of lead in horizontal fixings can be achieved by heating above the lead melting point, and allowing the metal to drain into a heat resistant container. Vertical fixings are more complex to release and require a different approach. The removal of both types of fixings present a variety of hazards in relation to the use of lead.

Heating the metal above its melting point (270*c) presents hazards with the airborne lead particles and often causes other impurities, old paint, silicon adhesive etc. to be inhaled or to settle on the skin and be either absorbed, or ingested. There is also the concern of handling a molten metal with the potential to cause devastating burns and ignite surrounding material. Another consequence of this removal method is that the masonry surrounding the lead fixing rapidly heats causing trapped moisture to expand violently. This expansion can cause an explosion of surprising force, directing masonry shards outwards at great speed. This can also occur when installing lead in the traditional manner, where by the moisture from the masonry expands aggressively and is unable to combine with the molten metal, exploding with the reaction. These explosions send a spray of extremely dangerous molten metal out from the hole at a great rate, with the potential to seriously burn, blind or ignite material it comes into contact with.

Caution is advised when dealing with lead. The material can cause significant harm if not used correctly and if the methods and techniques are not completely understood and adhered to. Expert advice is warranted to achieve the best result for the traditional fixings, heritage iron, surrounding material and safety of those conducting the work.

Material Choice

Significant debate surrounds the restoration of traditional ironwork in regards to almost every aspect, though none seem as contentious as the debate over which is the most appropriate material to use. With modern ironwork not being exposed to the elements (internal) the use of modern steel is acceptable and compatible with the traditional techniques used. The problem arises when elemental corrosion is possible, and the work being restored is of heritage value.

Recently there has been the introduction of pure iron. This material is chemically almost pure iron with little carbon and impurities. It comes with a British Standard, ensuring consistency. The grain is homogenous, and both forges at high heat and during forging, moves in a very similar way to puddled iron. With the lack of impurities and chemical similarity to that of charcoal iron it is an option for restoration work, however only if the paint system is to be applied and very well maintained, as the corrodibility of pure iron is debateable. It does not contain any of the fine laminations of silica that gives the traditional irons their corrosion resistance and if the paint system is corrupted, then without immediate intervention significant corrosion can and will occur.

Given that restorations are most often requires as a result of corrosion, stainless steel is occasionally mentioned as a good restoration choice. With stainless steels superior resistance to aggressive corrosion it is an option, although introducing a new and dissimilar material can lead to a new type of corrosion. It has however been used successfully in masonry as an anchor for the ironwork in particularly corrosion prone situations, as the stainless steel would not corrode and expand, thereby saving the masonry.

Mild steel is the most abundant material available and the low cost is attractive for the client, however the only guaranteed way to protect this material from corrosion is to hot dip galvanise or hot zinc spray. Neither of which meet the criteria for methods being reversible. Once applied both galvanising and zinc spraying cannot be reversed without significantly abrading the surface, which is worthy of conservation in its own right. With mild steel being chemically and structurally different to the puddled iron, a galvanic circuit would begin without the galvanised or zinc sprayed protective coating.

Puddled iron seems to be the favoured material in restorations for many reasons. It is chemically and structurally identical to the iron to be restored, and has a proven record of corrosion resistance. It is consistent with the “like for like” ethics of restoration. Its forge weld ability is superb for reproducing components using identical methods, and sources of the iron are available from demolished or dismantled structures with the quality being easily assessed by an experienced blacksmith.
While there is an argument against its use, as future generations and a subsequent restorer will not be able to identify the newer addition and the ability to assess the original work is therefore lost. It is however permissible, and generally acceptable to date stamp the replacement in an unobtrusive area.

With regard to the ethics of restoration, and respect for the ironwork, it seems that reclaimed puddled iron is the appropriate choice for any significant heritage ironwork restoration. To compare

with other heritage trades, a carpenter would not restore a hardwood piece with pine, nor would stonework be restored with cast stone.
While the cost of the material for authentic restorations may be considered high against more abundant materials, it is small compared to the cost of skilled labour. Both seem almost insignificant against commissioning a second restoration to correct the first conducted with poor workmanship, inappropriate materials or with a lack of significant knowledge.

The Burra Charter defines best practice among Australian conservation professionals and outlines the choice of materials and technique;

Article

4.2 Traditional techniques and materials are preferred for the *conservation* of significant *fabric.* In some circumstances modern techniques and materials which offer substantial conservation benefits may be appropriate.

(*The use of modern materials and techniques must be supported by firm scientific evidence or by a body of experience*.)

Wrought Iron Reclamation and Production

The reclamation of wrought iron on a commercial scale is only provided by one company in North Yorkshire, England. The Real Wrought Iron Company was founded by Chris Topp in 1985 to provide authentic material for the true restoration of heritage wrought iron.

The primary source of the iron for reclamation is heavy admiralty chain from shipyards, with each link weighing around 100kg. This chain was originally produced using a superior grade of iron, was well refined and is of sufficient supply to service the industry for many decades.

Each link is cut in half along the shorter axis, and bent open at heat. The stock is then forged out at high heat to form rough bars. These bars are then passed through a water cooled rolling mill, that incrementally reduces the size to a required dimension. During the rolling process, the iron remains above approximately 600°c, and is passed through the mill several times during one heat. The use of 2 mills assists the production, as one dimension is achieved in one plane, the second mill will refine the other dimension, ensuring a true standard dimension of the bar.

Sheet iron is produced by cutting the rolled or forged bars into shorter lengths and stacking them several layers high. Each layer is stacked 90°c to the previous, which gives cross grain strength in the final sheet. The stack is then brought to a high heat and “smited”, that is, struck with force to weld the iron pieces together. The stack is then forged down to sufficient size for the mill to begin the rolling process. The furnace used in this process is a muffled furnace that separates the iron from the fuel source by a physical barrier, thereby reducing the carbon absorption in the iron and retaining ductility. The fuel used is kerosene, as it easily achieves the required temperature of 1500°c, however this fuel remains costly.

With quality puddled iron being scarce in Australia, this process of reclamation is an interesting and viable option. Not only does it reclaim the iron and effectively increase its volume, it also retains the

corrosion resistant properties and characteristics of the material. The process however is time consuming and laborious, and must be judged against importing the material from Britain.

Professional Blacksmith / Metal Fabricator

Puddled iron, which makes up most of the heritage ironwork in Australia, is a specialist material and requires specialist knowledge and skills to work with. This is the work of the blacksmith, who works almost exclusively with forged iron and often specialises in the traditional methods required to work this material. These skills take a considerable amount of time and tuition to develop and require consistent high calibre work to be maintained. The tooling and methods required to produce work that adheres to the original in technique, materials and style are uniquely those of an architectural blacksmith.

Unfortunately, too few owners and heritage professionals have sufficient knowledge of traditional ironwork to evaluate and specify an appropriate method of repair, and in turn award tenders to those most capable of carrying out the work.

Metal fabricators are not trained in traditional blacksmithing techniques and often have no knowledge of authentic blacksmithing. They will generally work in steel and it is highly unlikely they will have the relevant expertise and equipment to perform an adequate repair or reconstruction on traditional ironwork. Care must be taken when trying to differentiate between the two trades, as any metalworker can call themselves a blacksmith, irrelevant of any qualifications, as the professional term is not protected by law the way the terms Architect or Lawyer are.

Subjecting heritage ironwork to those without specialist knowledge can have devastating consequences. Many of these consequences are irreversible without significant loss of material, loss of relationship between components or the complete loss of detail on critical elements. Electric welding is an example whereby the original joining method is discarded, removing material for the application of the weld, then applying a dissimilar material, thus promoting a galvanic reaction. This is an extremely poor substitute for an authentic repair with traditional methods. The weld will often break and tear the puddled iron laminations apart, promoting corrosion. These poor methods may be the cheaper alternative initially, however they quickly deteriorate, break or rust and will require further restoration and reversal at a later date, presenting a much more costly exercise than had a specialist originally undertaken the restoration work. Often, the harm done by a modern electric arc welder consumes the majority of the restoration time, with the original material requiring minimal intervention.

When heritage ironwork is put to tender in a competitive market, the trained architectural blacksmith must win the work against those with lower skills and knowledge and consequently a lower price. This places downward pressure on the high quality work of the trained blacksmith and on the profitability of the trade. This is compounded by the fact that there is general difficulty in identifying between the blacksmith and metal fabricator, with the assumption being that all bidding parties must possess the same abilities. Lower quotes are therefore favoured, out pricing the skilled and specialised architectural blacksmith who is the most capable bidder to conduct the work in the correct manner. This use of untrained fabricators combined with a lack of appreciation for the skills

required to conduct restoration offers little incentive for people to seek specialist training. Both nationally and internationally, and with alarming consistency, this has resulted in semi skilled metal fabricators conducting work on heritage iron becoming the status quo.

There is the need for such tenders to be awarded on the basis of practitioners meeting a set of criteria and guidelines that promotes good practice and makes it difficult for those less skilled or trained in heritage iron to win the tenders. This must become a priority as quality ironwork with significant heritage is being damaged by semi skilled metal workers or handymen, often irreversibly and rarely with an acceptable outcome. These guidelines could also be used by clients seeking heritage ironwork specialism on private pieces that may not come under heritage protection or advisement. In addition to ensuring that the ironwork is properly restored, setting such standards also acts as an incentive for those less skilled to develop and train in this area, thereby improving the general standard and awareness of these skills.

The guidelines could include the adherence to relevant heritage charters, binding heritage association ethics, the use of trade certificates, trade association representation, research paper authorship, industry standing, heritage body acknowledgment, experience, tuition, skill development, prior heritage work examples, and physical demonstrations of reproduction and traditional techniques.

There is an enormous amount of heritage ironwork requiring restoration in every city and major town in the country. This work is an essential part of Australia's heritage fabric and is worthy of adequate preservation, as are the skills and traditions of the blacksmith which are needed to preserve this history.

Traditional Skills in Modern Designs

Traditional blacksmithing skills and methods are often associated with traditional styles of ironwork, and it is rare to find examples in modern Australian designs. These skills are commonly identified by the methods of joinery employed in the construction of a piece.

With the improvement of technology during the World Wars, came the decline of the more time consuming methods. These methods, while more aesthetically pleasing, were an avoidable expense in a time of austerity. The modern methods were cheap, quick and easily learned, and as technology progressed further, this became more so. Electric welding became (and remained) the primary method for the assembly of ironwork.

Joinery examples such as punching and drifting, riveting, splitting, collaring, wedging, wrapping, tenoning and fire-welding are all methods being used internationally to display the difference between what a professional blacksmith has created and what a general metal fabricator has produced.

Traditionally, during construction, ironwork elements were laid out cold, with the rivets and tenons aligning, but not securing the ironwork in place (The frame would be prevented from moving by

clamps or ‘dogs’). This was to ensure all of the pieces would fit and align effectively, and allowed minor alterations as further details were produced and included. As production and construction progressed, the internal fill would be fixed in place, and finally, the exterior frame. While this was a very effective method of assembly, it proved to be a problem when attempting to remove one element, as the method of construction often prevents this without significant dismantling.

These traditional methods require significant training, practice and ability to apply well. With the exception of basic riveting, the forging processes for this type of construction are complex and require a great amount of accuracy and skill. They are also very difficult for someone with little skills to reproduce or fake effectively which makes the employment of these methods the benchmark for the skill level of the constructing blacksmith.

The heel joins on traditional construction are particularly complex. They involve many forging processes and a high degree of accuracy, and if done incorrectly, will result in the frame being out of square or twisted. They are mostly found in the corners of the frame, and occasionally (on large frames) at the ends of the horizontal middle brace. The tenon passes through the exterior frame, and is riveted on the outside, forcing material back against the frame and forming a strong joint.

Increasingly, these methods and many other traditional processes are included in modern designs for aesthetic reasons and to display the skills of the constructing blacksmith. When used effectively, they can form another focal point on a piece, and add further depth to the ironwork.

Traditional skills and methods form the foundation of blacksmithing skills and are one of the factors which differentiate the trained blacksmith from a metal fabricator. Once obtained, these skills and methods can then be developed into a diverse range of techniques, designs and specialisms.

Forged Iron Art

Forged iron has long been an avenue of artistic expression, originally used for jewellery and other decorative and noble objects of antiquity. Following the bronze age, iron products became more commonplace and widespread, as the technology and skills for its production improved. As ironworking methods and techniques progressed, the chiefly utilitarian products began the evolution to high ornamentation. At first, this may have been a decorative twist or subtle stamping of a pattern, borrowed heavily from earlier bronze and other metal working techniques, and gradually this progression and development of ironworking skills and knowledge led to the opulent decorative ironwork such as that of the Baroque and Rococco periods.

As art styles changed and the global attitude towards art shifted, there too was a shift in the concept of an artist, and what an artist does. Blacksmithing and in particular the forging of iron, emerged from the Arts & Crafts movement promoting a new awareness of metal art. The techniques and beautiful ornamentation on traditional ironwork, so well known from the likes of Samuel Yellin and earlier masters, could become appreciated as art without the requirement for a utilitarian purpose. So began an opportunity for the skilled blacksmith to produce abstract and beautiful forged iron, and extend the techniques and methods that had previously been focused on other avenues.

The term “Artist Blacksmith” is often taken by those specialising in architectural ironwork, as the ability to design and produce superb ironwork founds itself on the 7 artistic principals of design. Architectural Blacksmiths are often artistic by nature, and the forging of iron for purely aesthetic results becomes another aspect to their portfolio. The forging methods, techniques and equipment used to produce art are often identical to the production of forged iron products, so the two aspects are at times, interchangeable.

Forging techniques are taught in art colleges with many specialising solely in forged art without the requirement for a background in architectural blacksmithing, such as in the Hereford College of Art Blacksmithing Course. This promotes forged iron skills and the professional endeavour of an artistic career in forged iron. This artistic aspect of the trade retains, teaches, promotes and utilises many of the skills and techniques required to produce traditional ironwork, ensuring their continued use, and leads to the development of new styles and movements within the industry.

There are many modern blacksmiths with incredible forged iron artwork. These include Albert Paley, Guiseppe Lund, Francesco Gazitau, Brian Russell, Helmut Hillenkamp, Terrence Clark and the Australian Pete Mattila. There are also many organisations promoting the artistic forging of metals. These include the Artist Blacksmithing Association of North America (ABANA), Southern Ohio Forging Association (SOFA), British Artist Blacksmithing Association (BABA) amongst many others. These groups have gained an international membership, organising conferences with international demonstrators who share skills and techniques, and impart a wealth of knowledge upon those eager to learn.

There are also many classes and instruction available on the forging of iron for an artistic outcome. They are numerous in both the United States and England, however it is difficult to source tuition within Australia.

Career Awareness

The most common perception of a blacksmith is generally of someone who shoes horses (farrier), or a demonstrator at a local fair, producing small S-hooks or metal snakes for a few dollars. There is often little acknowledgment of it being a trade with true career value and a professional status. This is a result of many factors;

~ The wide use of the terms ‘wrought iron’ and ‘blacksmith’,
~ Very few professional practitioners
~ Machine made components
~ Under-appreciation of traditional skills and craftsmanship
~ Over-representation of poor quality work
~ Many poorly skilled ‘blacksmiths’ devaluing the term

There is the perception in Australia that if you're a tradesman, you were unable to enter into further academic study following secondary education, due to poor results or other factors. The fact that some choose the trade path is often attributed to lack of ability and seen as the easy option. With the lack of appreciation of these skills comes a lack of respect and admiration for the creator, and the time, skills and knowledge required to produce the object.

During Secondary education, the 'hands on' courses are viewed as options for those 'less able' academically, or to keep the 'problem children' occupied while the others learn. This is instead of being presented as a worthwhile course of study with a potentially fulfilling career.

The result of the push to enter university, is that there are many people that have the academic knowledge of *what* should be done, but little of the practical skill and ability of *how* to do it. Emphasis is often placed on the academic path, detracting from the importance of trades and practical skills. This, among many other factors, has led to the skills shortage in Australia. The focus is to gain tertiary qualifications rather than undertake trade courses and gain practical skills and experience. In other countries, however, the crafts and trades are viewed as a professional career and there is a social acknowledgment of this.

In Germany, the skills and dedication required to achieve a tradesman qualification is equal to that of a university degree. In Japan, traditional craftsmen are treasured by the population and seen as of national importance. Their immaculate wares reach high prices, often with years of orders to fill. In Venice, the traditional crafts and skills are viewed with admiration. In the 1970's a training centre for traditional crafts was formed to protect these valued skills named Pro Venetia Viva. This training centre was the foundation for the modern European network of traditional crafts training. In the countries where the traditional trades are treated as professional careers, the training and level of expertise is high. This results in a higher level of wares being exposed to the public, and with greater exposure comes better appreciation of quality craftsmanship.

Within Australia there is a need for improved publicity of and exposure to traditional trades in order to help elevate their status, and increase appreciation for the craftsmanship involved. The publicity could be through local and national government initiatives, or promotion through guild and association networks. Marketing similar to that of organic farming, where customers recognise the quality and work involved and expect to pay more for this. However the end user needs to be educated about the value of craftsmanship, otherwise the cost disparity will result in a continual lowering of standards, professionalism and therefore ending traditional trade careers.

Professional blacksmiths are very rare, due to many factors, however those that do gain advanced skills and experiences are rewarded with a varied and fulfilling career. With a better appreciation of blacksmithing as a career, will come better standards and greater distinction between professional and semi-skilled practitioners, and good and bad practise.

Guilds

The guilds throughout the 17th and 18th century retained much power and provided a set of standards for those working in most trades. The blacksmiths guild, (whose symbol was crossing keys and hounds) were able to admit and omit members for a variety of reasons, according to their defined set of ethics. The main purposes of these guilds was to retain and advance the level of craftsmanship, educate and train future blacksmiths, and provide a reference and guide for those wishing to commission ironwork. As members were bound to the standards of the guild, those commissioning ironwork that held any grievance regarding dubious business practices or poor craftsmanship by a member, could take up the issue with the guild who would judge the accusation in its own right, and act accordingly.

Very few blacksmith guilds remain, and none have the authority that previous guilds held.

In London, however there is a guild like structure called the Worshipful Company. Each Company has an associated trade and acts somewhat like a guild, with standards on craftsmanship and hierarchy built on merit. The Worshipful Company of Blacksmiths being one of the oldest, with over 500 years of recorded history. The Company provides training by way of bursary's to the students to attend colleges, with several of the members being actively involved in the training. The Company has several levels a member can achieve whilst involved, some of which are Freemen, Liverymen, and Licenciate.

Training For The Future

The blacksmithing apprenticeships that were once abundant are now incredibly rare. Rarer too, is an appropriate company with which the training can be coupled.

With the downturn in the manual manufacture of components, the increased globalisation of companies, improvements in technology and cheap readily imported parts, the requirement for advanced manual trade skills that once existed in blacksmithing institutes like the railways and ship building yards, has been negated by computer programming and automatic processes. Where manual labour is required for manufacture, the products are often sourced from other countries with lower wages and standards of living and thus lower overheads creating a cheaper product.

As these large blacksmithing institutes closed their manual manufacture arm, many tradesmen changed career or diversified from the trade. This has left a generational gap in the tuition of modern blacksmithing apprentices. The consistent tuition and 'learning by example' that has occurred from the earliest 'smiting' of iron and culminated in the breathtakingly ornate ironwork of the Rococco period is slowly being lost.

As the experienced craftsmen retire, there are few entering the industry with the same understanding of the traditional techniques to replace them. As a consequence, the tuition that is supplied to this new generation of apprentices is not the broad tuition by that was previously given

by many, but teaching by one or two sole tutors with narrow interest, knowledge or experience in aspects of what is a very extensive trade.

Companies that do actively train apprentices in blacksmithing to a trade recognised level face the geographical barrier of only one TAFE in Australia offering the trade course at Ultimo, Sydney. This TAFE tuition is a vital part of the trade certificate, and attendance is mandatory to receive the qualification. This often restricts the level of training those in other cities can experience without significant investment in travel.

In addition to a loss of teachers and geographical barriers there are also issues with the content of the trade course itself. The course focuses on the industrial processes associated with the trade and has no heritage ironwork component or traditional techniques tuition. This leaves a significant gap in the training apprentices receive in the trade and relies on the work placement component of the training to focus on these aspects. This results in an often very basic level of expertise in traditional ironwork and in an all round un-standardised approach to the learning of these essential trade components.

Those hoping to gain advanced traditional skills and techniques are forced to travel internationally for their tuition. This is found in either work placements, conferences, courses or volunteering in experts businesses.

NHIG

There are many fine examples of heritage ironwork throughout Australia, many with unique links to our history following colonisation. The United Kingdom however has a further reaching history of both iron production and ironworking. Often ironwork remains in good condition that was produced three centuries ago, and some far older. There is ironwork that exhibits such superb mastery of material and technique, and was so influential at the time that they are classed as of national importance. Many monuments and palaces contain such ironwork.

Unfortunately, there is no mechanism or process to ensure that the people that conduct restoration and preservation on these objects, are in any way qualified or skilled in blacksmithing techniques or hold adequate knowledge of heritage iron. There are no codes of practice and practitioners do not need to be properly trained or qualified in any way to undertake this work. It remains one of the only conservation specialisations that currently has no regulations governing who may work on the heritage graded objects. In other conservation disciplines, practitioners are expected to prove themselves by achieving a qualification or accreditation but with heritage ironwork anyone can tender to carry out the work. This is also the case in Australia.

There is a need for those that tender for restoration and conservation work to possess skills, knowledge, and ability that rest above a minimum threshold. This minimum skill set is necessary to ensure that low cost does not become the priority especially considering that low cost often reflects low standards or skills or in the case of ironwork, the use of non traditional methods and practices which jeopardise the heritage value of the piece to be restored and conserved.

Recently in the United Kingdom, a group consisting of blacksmiths, conservator/restorers, conservation architects, metalwork consultants, training providers and commissioning bodies formed under the title of the National Heritage Ironwork Group (NHIG). The members recognised the need to improve the current standards of the restoration and conservation of ironwork, and their combined expertise is used to discuss, formalise, lobby for, and distribute information relating to heritage iron.

NHIG is hoping to establish a set of training and skill standards that will be accepted and enforced by the practitioners, clients and owners and those that specify and fund the conservation and restoration work. This will act to prevent further deterioration and unacceptable practice involved with heritage iron. The most effective method for this is to establish courses and qualifications, and to educate those specifying ironwork to recognise good and bad practice, and to adjust their specifications to reflect this.

In 2011 the first eight trainees of the NHIG's Heritage Blacksmith Bursary, began one year of specialised Blacksmith Conservator training as part of the Heritage Lottery Fund (HLF) 'Skills for the Future' programme. The training is vocational, and all of the students are hosted within the blacksmithing & conservation sector, with the aim being to gain invaluable training in the heritage aspect of the trade. The training is provided within existing blacksmithing and conservation workshops where heritage ironwork and other specialist training is supplied, all underpinned with a five week intensive course at the Hereford College of Technology. As a significant part of the programme, all the students were involved in the current conservation programme of the Tijou Screens, at Hampton Court Palace. The screens are a fantastic example of exquisite Baroque ironwork, and illustrate the result of an improvised approach to restoration being detrimental to the fabric.

Information regarding heritage ironwork and the aims of NHIG is distributed amongst associated professionals involved in the heritage sector, and other interested parties, by way of Continued Professional Development courses (CPD). These are presented throughout the U.K., providing an easily accessible platform for interested parties to learn, interact, question and access specialised advice on many aspects of the current situation.

Well-known supporters of the NHIG aims include.

- English Heritage
- National Trust
- Historic Royal Palaces
- Society for the Protection of Ancient Buildings
- Historic Houses Association
- Institute for Historic Building Conservation
- British Artist Blacksmith Association

In an Australian context, it would be incredibly difficult to form a group that resembles that of the NHIG, as the number of professional blacksmiths to draw support from is extremely limited. Therefore the ability to develop courses and accreditations is also near impossible.

Education of related professionals is, however, an achievable goal and with this education comes an awareness of good and bad practices. This will help shape the appointment of tenders, develop the associated specifications that apply, and strengthen the working relationships between heritage specifiers and those blacksmiths capable of heritage conservation work. This can only be beneficial to all concerned, and of immense benefit to the ironwork.

Types of Corrosion

Corrosion can have a devastating effect on ironwork and is the only natural cause of iron loss. It can also have a beneficial effect, and if stable, can help preserve iron almost indefinitely.

Corrosion presents itself in two ways; chemical and galvanic.

Chemical corrosion occurs when the iron is in contact with both oxygen and moisture. The iron oxidises, and effectively loses part of itself, as the iron molecules (electrons) combine with the oxygen in the air. The moisture and the variable amount of salts in the solution act as the electrolyte, enabling the release of electrons. The higher the salt content in the electrolyte, the more active the electron loss and the faster and more aggressive the corrosion.

Chemical corrosion occurs when iron oxidises (part of the iron molecules – the electrons – combine with oxygen in the air). The metal literally 'loses' parts of itself when it corrodes. This process produces the corrosion product – rust. For corrosion to occur there must usually be both water and air present. Air contains the oxygen with which the electrons form the iron combine. The water acts as an electrolyte – this is a solution containing salts which enables the release of electrons from the iron. Any form of moisture can act as an electrolyte – dew, condensation, or moisture in soil.

Galvanic corrosion occurs when two dissimilar metals remain in direct contact, or are in contact via the addition of an electrolyte. The metal will corrode sacrificially to the other. Different metals will lose or gain electrons more readily depending on their "electrode potential". All metals are shown in the Electrochemical Series, which provides a guide on where metals sit in relationship to each other and how readily they will lose their electrons. For example, when zinc and iron are in contact, with the addition of oxygen (present in the air), the zinc will corrode sacrificially to the iron.
This can be of benefit when protecting iron, and zinc rich paint primers make use of this. Another example is aluminium boats with iron engine clamps using zinc sacrificial anodes for their corrosion resistance.

The most common galvanic corrosion example within traditional ironwork is the preferential rusting of mild steel, when welded to puddled iron. When a metal filler rod is welded to iron the point at which the rod and iron meet is readily corrodible with the rod reacting sacrificially to the iron. If left unattended, this will continue and failure will result.

As rust oxidises, it expands up to 8 times its original dimensions. This can exert enormous pressure on the surrounding masonry or joining metal elements. This is often seen in iron handrails and

balustrades, and as the rust develops, expands and delaminates, it becomes a moisture trap which will, in turn, accelerate the formation of more rust until there is an absolute loss of material.

Severe corrosion on historic ironwork is typically localised around those areas that are difficult to paint. These areas also tend to be those which are liable to retain moisture due to shape or position etc and in conjunction with the difficulty of painting such areas mean that corrosion often occurs. Often the underside of horizontal sections, the lower sections of balustrade or fencing, joins that are unable to shed water and any iron submerged in soil will be susceptible to corrosion. Vegetation will also be a factor, as it not only hinders regular inspection, but some vegetable matter will accelerate corrosion.

If a painting system is compromised and broken, moisture can remain in contact with the iron and corrosion will result. The flaking paint will retain the moisture and often hide it from view while the hidden rust continues to corrode.

Where the rust forms a continuous glossy coating, it will in fact act as a protective barrier against further oxidisation. This is often seen on well used iron handrails where the oils from passing pedestrians have over time been rubbed into the surface and effectively sealed it from further oxidisation. While the oxides are present, they remain stable giving the dull rust appearance.

Chemical corrosion only becomes an issue when regular preventative maintenance is not admitted. While iron may be left in the elements if it can freely shed moisture or remain dry, it will still require regular maintenance. If a thorough paint system is applied, the maintenance should focus on damage to the coating and possible exposure of the underlying iron to moisture. Any blistering or bubbling is an indicator of this subsurface corrosion.

Galvanic corrosion in heritage ironwork is the result of several things including poor modern workmanship and knowledge, the use of substitute materials or the addition of a new ill-suited element. If the cause of the corrosion is irreversible, a sacrificial anode may be used to absorb the corrosive results.

Surface Preparation

The surface preparation and cleaning of heritage ironwork must be carefully considered before commencement of restoration, as an incorrect process, once implemented can have devastating, irreversible affects. The surface of puddled iron often contains scale from the original forging process, and is beneficial to the corrosion resistance of the iron, forming a hardened skin. Regularly encountered are original scribe, assembly and surface conditions e.g. polishing or filing marks that will be removed if surface preparation is carried out incorrectly.

The goal of cleaning and preparing the surface is to remove all corroding products, previous oil and paint layers and provide a suitable surface for the new coating to adhere to. Therefore the final coating and the requirements must be considered. The final surface condition (corroded material and damage aside) should be as it was before the original paint system was applied.

It is common practice to sample the heritage paint before intervention, to assess the previous layers and colours. This may reveal important historical information that provides an insight into previous colour schemes and technology and these colours may wish to be reinstated. It may be achievable to retain as much of the original coatings as possible and simply target the areas affected by corrosion and the immediate surrounding area, thereby limiting the amount of intervention of sound material and coatings.

Samples are taken by way of a cross slice (to bare metal) in an unobtrusive area, which is then sent for analysis. It is also a method of assessing if lead is present in the paint (often the case) which is vital in deciding upon the appropriate methods, while adhering to the specific environmental and safe working practices.

Removal of paint layers and the preparation of surfaces are often achieved with the one process of dry blast cleaning. It is a modern industrial process where a medium of shot, sand or forms of mica, will be directed at high pressure through a nozzle onto the steel. This renders all surfaces to an abraded uniformity and aids in the application of subsequent primer and paint layers. Of significant concern however is that with this uniformity and abrasion of the surface, almost all fine details of the manufacture that appear on the surface e.g. file, punch and scribe marks will be removed. It will also be far more difficult to detect previous repairs and replacements, details of which require observation and analysis of the original surface condition. An object may have been polished for, or by a previous use, before being adapted and hidden under paint, and this detail and historical evidence will be lost. Bead blasting uses the same technique with hard wearing plastic beads for the compound and is less damaging to the surface, however the use of this technique is restricted by the size of the beads used and the ability to of these to penetrate small gaps where rust is prone to generate.

Another option with heritage iron is wire brush cleaning. This method uses a power tool with a wheel of coarse steel wire attached to remove any loose material. It is far less damaging to the surface, and manages to retain some of the previous details. While the wire brush is quick and effective, it is limited to the areas easily accessed, as the size of the tooling limits its ability to work in confined areas. Fragile ironwork will be damaged by the wire wheel, and complex forms with high relief are not possible to clean in this manner.

The use of a needle gun should be selected solely to remove heavy build up of corrosion, and is not suitable for large areas, or primarily for paint removal. The steel needles damage the surface with indentations and should be used with caution for this reason.

Flame cleaning is an appropriate method of removing heavy corrosion. With the use of an LPG or oxy-acetylene torch, the area is heated. As the steel expands the corrosion loses the bond and is easily removed with the use of compressed air, wire brush or mechanical means. Care must be taken to control the amount of distortion caused, particularly on long sections. Appropriate breathing apparatus and ventilation must be considered when using a flame with heritage ironwork, as there are many toxic elements associated with traditional ironwork coatings and their ignition prompts airborne contamination.

Acid dipping is an effective method of removing corrosion from an entire object without damaging the surface of the iron. This method involves submerging the ironwork in a bath of dilute phosphoric or sulphuric acid until the corrosion is removed. Attention must be paid to the duration of the submersion, with the object removed as soon as the surface is clean. Prolonged exposure to the chemical agents can have detrimental effects on the iron, and a thorough water based cleaning must follow the bath, with a focus on joins and crevices where the acid solution may remain.

Paint stripping by chemical means is the most effective method of removing coatings while retaining all of the surface detail. This can be either localised or by dipping in a bath of the solution,

The removal of traditional oil coatings can be achieved with the use of a strong alkaline sodium hydroxide (caustic soda) solution. This can be either mixed into a paste like consistency and applied, or diluted for a bath application, with the bath application having the benefit of a thorough and even penetration of every crevice and surface.

Oil and resin based paints and bitumen can be removed with products based on dichloromethane (methylene chloride), however with the extensive range and varied uses of modern paints and coatings, the supplier specifications should be referred to when considering the modern coating removal, and each case should be evaluated before commencement.

Chemical agents used during coating removal, if left on the ironwork, are detrimental to both the application and longevity of the new coating system. Steam cleaning the ironwork thoroughly is the most effective method of ensuring these agents are entirely removed without using further chemicals. Care should be taken to ensure all joins, crevices and surfaces are free of residue. Portable high pressure steam cleaners are available and effective, however runoff should be captured and disposed of appropriately, as it could be hazardous to the environment.

If an abrasive method of cleaning was used, it is important that the exposed iron is free of moisture and coated as promptly as possible, to reduce the chance of atmospheric contaminants and moisture corrupting the surface and affecting the new coatings. These contaminants are often sulphates and chlorides (from salts), which being hygroscopic will attract moisture from the atmosphere and establish, or re-establish the corrosion. These contaminants often appear as a black to dark brown stain on the exposed surface.

The need for intervention and cleaning must be weighed against the risk of accelerated decay and possible loss of the historic material if the cleaning is not conducted expertly. Individual case should be analysed and decisions made as to whether more damage is likely to occur as a result of the cleaning and if so, whether the work should be left in its current state.

Utilising the appropriate surface preparation, accompanied by the correct coating system will increase the durability and longevity of the coating, and reduce the need for further intervention prematurely.

Cathodic Protection

Cathodic protection is a process of protecting a metal object by introducing a more corrodible metal that will sacrificially waste in preference to the parent metal, thereby halting the corrosion which occurs, and retaining the original material.

When the parent metal (cathode) is placed in contact with a metal that will corrode sacrificially (anode) in an atmosphere containing oxygen and an electrolyte (moisture), an electrochemical reaction will occur, whereby the anode loses material in the reaction, in preference to the parent metal until the anode requires replacement. If the electrolyte contains dissolved salts, the reaction rate will increase in relation with the electrical conductivity.

Cathodic protection was first described by Humphry Davy in London in 1824. That year it was applied to the copper sheathed hull of HMS Samarang, with an anode of iron, and reduced the corrosion of the copper dramatically. Unfortunately, while the trial was a success, it was discontinued for that specific purpose, as the reaction increased the marine growth present on the copper sheathing.

There are two systems of cathodic protection available. Sacrificial anode cathodic protection (SACP) and impressed current cathodic protection (ICCP). In SACP, it is simple to fix and replace the wasted anode, and this method is effective for small areas requiring protection. More complex is the ICCP system which involves the attachment of wiring and the use of controlled direct current electricity to operate. While the current is small, it must be constant to retain the protection. Complex ICCP systems are used on oilrigs and pipelines for large scale protection.

Both of these systems have been used for protecting heritage ironwork. ICCP is often used for the protection of building facades, where the original fixing cramps and imbedded iron have corroded and expanded, compromising the entire structure, and fracturing heritage masonry. It seems to work most effectively where the metal is submerged or encased, with adequate moisture to carry the current successfully over the distance. One notable example of ICCP protection is Wellington Arch in London, where the concrete encased I-beams supporting the roof suffered significant corrosion previous to the ICCP systems introduction. On the other hand, SACP has the benefit of being a simple and discrete method of protection over the more complex ICCP system. Anodes can be small and easily hidden, readily changed and there is minimal disturbance of the heritage material. The system also works most effectively when the material is imbedded in a moist environment.

While there are many benefits to this form of protection for heritage ironwork, there seems little practical use of it among international traditional ironwork practitioners, many of whom have never used it or been asked to. CP specialists are often involved in large scale preservation work, while the smaller projects are often restricted with budget constraints that can’t extend to these expensive technologies and methods.

Theoretically, there seems to be the ability to enhance traditional ironworks corrosion resistance with the use of SACP, when coupled with traditional coatings. As the coating begins to fade and fail, the bare iron is exposed and the object nears repainting, the anode would activate with the contact

of the electrolyte, thereby halting further corrosion until the coat is re-applied. This could be very beneficial to heritage iron as there would be the ability to retain the original coating methods and conserve all of the material with minimal maintenance. While the need to re-coat is not eliminated there is a grace period, in the interim, where the iron is not corroding without check.

Finishing

Originally ironwork was not coated, with protection instead left to the corrosion inhibiting silica laminations contained within the iron itself. Of the original iron, perhaps 90% remains in good condition, sometimes centuries after it was installed, demonstrating the natural durability of the iron. An example of this durability is the Delhi Pillar in India. Originally produced in the 4th century C.E., it stands over 7m high and weighs more than 6 tonne. The condition is so remarkable that the original Sanskrit writing is clearly visible. This longevity is the result of the pillars ability to shed moisture readily, a regular flushing of fresh water and a fine stable iron oxide layer, preventing further corrosion.

With the introduction of coating systems came the ability to colour iron with many shades, and it was not until quite recently that black was the primary colour for forged iron. Previously, blues, greens, yellows and whites made up the colouring, to beautiful effect. Analysis of these previous coatings can be used to reinstate the traditional colour schemes and retain the items decorative history.

Traditional;

Originally, almost any type of oil coating would be applied to ironwork to displace moisture. Depending on the geographical location, this could include vegetable oils, animal fats, fish oils and organic crude fossil oils. Whale blubber was also a common and readily available rust inhibitor for many generations.

The structure of most commonly encountered traditional paint finishes were based on a linseed oil binder, turpentine solvent and white lead (lead carbonates and sulphates), with various other pigments added for colour. The primer was typically red ochre referred to as “Spanish Brown” with a small amount of white lead. Another common coating on smaller iron objects was burned linseed oil. The object was heated to several hundred degrees, and linseed oil applied, either by submerging, or physical application. The oil would be absorbed into the very exterior of the iron surface and provide a semi permanent coating.

The traditional coating products are also likely to be the most compatible products for over-coating original materials. Their application on iron with rough, unprepared surfaces still exhibiting forged iron oxide scale and other less desirable surfaces conforms to the ethics of minimum intervention, and reduces the need for rigorous (potentially damaging) surface preparation.

Care should be taken in the application of traditional coatings, as there is the potential for runoff into surrounding heritage fabric and the environment. The surrounding masonry or timber may

absorb excess oil and permanently stain, discolour or be affect in a detrimental and unacceptable way.

Some internationally recommended traditional style coatings include;

~ Wattyl's 'Killrust Fishoilene'
~ Castrol's 'Rustilo DWX'
~ Shell's 'Ensis' oils
~ Altex's 'RIPO (Rust Inhibiting Penetrating Oil)'

Modern;

There appears to be an almost infinite choice of coating systems available for modern ironwork. All coatings are permeable to a degree, and will require repainting, patching of damaged paint and eventual removal and replacement. The length between intervention is dependent on many aspects including proximity to coastal areas, surrounding moisture, passing abrasion, atmospheric pollutants and U.V. exposure among others.

While hot dip galvanising is the fastest and most effective method of protecting ironwork against corrosion, it is the most difficult to remove, as the process will leave a layer of zinc alloy chemically bonded to the iron surface. It is also not effective for distributing an even coat on the complex forms that traditional ironwork styles are known for.

Zinc based "spray-on" primers are the most commonly encountered among ironwork, with the zinc corroding sacrificially to the iron if the outer layers are compromised. There are many available products, and selection may be case specific.

Micaceous Iron Oxide (MIO) is well known for durability and commonly used internationally. It can be used as a reliable build coat, or topcoat on iron and steelwork.

Internationally recommended primer/MIO finish coats for ironwork include;

Resene's 'Rust Arrest'/ 'Mica Bond'
Aszo Nobel's 'Interprime 198'/ 'Interlac 192'
Altex's 'High Build Rust Barrier'/ 'Isotal Ferrox'

MIO versions of acrylic coatings are also available.

Another highly reliable modern coating system includes;

~ A single coat of 'Amercoat 4189', an alkyd primer undercoat

~ Two coats of ' Amercoat 4613', a MIO urethane alkyd undercoat / topcoat

~ Single coat of 'Amercoat 5405', a protective topcoat

The principals of minimum intervention and reversibility are best achieved with the use of oil and wax coatings, as they are simple to remove with no surface damage. The maintenance though is

regular and while interior applications are durable and long lasting, exterior applications coated in this manner will require regular attention. This may be no more than a further coat applied annually, but while this was common and expected traditionally, by modern “low maintenance” standards this is very regular.

Case Study:

The Tijou Screens of Hampton Court Palace.

Jean Tijou was a French Huguenot blacksmith and designer of decorative wrought iron and repoussé. He emigrated to England around 1688, and began an incredible career producing exquisite ironwork for some of England’s most notable buildings.

Following the great Fire of London in 1666, Sir Christopher Wren was appointed as the designer and head of works for much of the cities re-build. Already adept in many fields, supremely intelligent and an architectural visionary, he was prolific in his work and readily adopted highly skilled craftsmen from Western Europe to head the various trades. Once appointed, Wren allowed these craftsmen to utilise their specific expertise for all of the design and construction requirements for their individual projects. Jean Tijou was employed to head the wrought iron production for Wren masterpieces such as St Paul’s Cathedral, and his work is still abundant in places such as Hampton Court, Kensington Palace, Chatsworth, Burghley and Marleborough.

There is little known of Jean Tijou in his native France, and there is contention as to whether Wren sought him out there, or whether he emigrated and came to the attention of both Christopher Wren and his long-term patrons, William III and Mary when in England. Perhaps it was as a result of the royal patronage that he was appointed by Wren?

Nonetheless, he is responsible for introducing the Baroque style to English metalwork. This style was then adopted by English blacksmith’s eager to learn new European styles and techniques, and be part of the new extravagant Baroque movement.

One of the earliest commissions bestowed on Tijou, was the Baroque masterpiece of the Hampton Court Screens. Produced around 1692 the screens were twelve in total and unfortunately became well known as an excellent example of a poor, improvised approach to restoration and conservation.

Their original position at Hampton Court is not known, but there is a record of them remaining in Tijou’s workshop for a lengthy time before installation. They were then installed in the Privy Garden on the turn of the 17/18th century, however many elements of the work do not correspond to this site, implying they were commissioned for another location.

Once installed, the complex and exuberant design held inherent problems regarding rusting. Many of the ornate flourishes and leaf work easily became water traps, accelerating corrosion, and it

appears too many that Tijou was attempting to achieve monumental visuals over practicality. With such obvious problems in the design, it is assumed he thought the patronage would fund the maintenance and it would not become an issue.

Following installation, there was inconsistent and unstructured maintenance and repairs, and by the mid 19th century, the condition of the screens was so poor that significant debate surrounded a final attempt at conservation. The two arguments were to either conserve in situ, or remove and conserve in a museum environment. The museum conservation was chosen for several reason, but largely as it was determined that the museum environment would result in a more thorough conservation. Once conserved however, the screens were to be separated and spread through English museums and manufacturing centres where they were to be used as teaching aids and references for ironwork designers and producers.

By the late 19th Century, it was felt that reinstallation would be the only way they could be fully appreciated in the landscape they were designed for. In 1902, this occurred upon the condition there was to be regular inspection and maintenance, however by 1908, they had returned to a poor condition with elements detaching and pronounced rust occurring.

Following re-installation, there were many subsequent repairs by competent blacksmiths, however while skilled, they lacked the required degree of training, heritage knowledge and artistic talent, to make accurate reproductions of parts which were deemed damaged beyond restoration.

The screens in their present condition are not accurate representations of Tijou's original work, style, technique or design. They are a result of much alteration, adaption, interpretation and speculation over the centuries since production and as such, research on the pieces themselves does not provide the information necessary to carry out subsequent restorations. With the work itself providing such unreliable information, other avenues have been sought to determine the best methods of restoring the work. The most significant sources have been Tijou's other interior work that remains original and uncorrupted. This work is present in St Paul's Cathedral, and another recent find in Hampton Court, is thought to have been 'worked by his own hand'. These have become reliable sources for research and comparison to elements on the Hampton Court Screens. Also available is a book of designs called 'A New Book of Drawings Invented and Designed by Jean Tijou' published in 1693. This book was published around the same time the screens were to be installed, and many of the designs similar to those of Hampton Court appear. While the illustrated designs seem incredibly fanciful and exaggerated by comparison to the current screens, many have concluded that this was their original design as they correspond more closely to other existing works, than to the present state of the screens.

In 1896, J. Starkie Gardner, blacksmith to King Edward VII and ironwork historian, commenting on the screens said that "Had Tijou's original embossed work been preserved it would have been among the finest extant of wrought iron".

Following the last major restoration in the 1990's, came the continuation of the cycle of ambitious restoration, followed by little maintenance and again the deterioration of the screens. This clearly demonstrates that unless adequate and regular maintenance occurs in conjunction with an

authentic restoration, the ultimate result is a waste of money, authenticity, heritage and resources. Practical and regular maintenance is the key to the conservation of exterior ironwork.

The screens history of restoration has been a "Chinese Whispers" version of the original work and with each interpretation of the screens, the version is removed further from the original vibrant and exquisite Baroque masterpiece, and we are left with a mere ghost of the original flamboyant ironwork. It is a legacy of poorly researched, low quality restoration and makes current restoration increasingly difficult.

Due to the extent of the loss and alteration of the original material, the screens now seem to be in a highly corrupted state, and conservation would merely be an exercise in preserving an object that has lost all former significance and original detailing through bad restoration and maintenance. Final decisions are still pending but in this case, further restoration seems the likely course of action, however halting the previous cycle is only achievable through a highly skilled and quality restoration project which adheres to conservation guidelines and ethics. This should be backed with sound research, effective grasp on the heritage fabric and advanced skills which will lead to an effective representation of the original.

The attempted restoration is very ambitious and will require adequate financial assistance, however, once completed, will result in an authentic representation of the original work. This will require regular maintenance if it is to remain in an acceptable condition, however, this is a small financial outlay by comparison to another complete restoration.

In order to expose and train young blacksmiths who hope to specialise in heritage iron to a project they would never normally have access to, the National Heritage Ironwork Group has included an element of their blacksmith conservator training to be on site during the restoration process. Students will assist the trained conservators and learn the practical skills associated with work of this size and calibre. This experience is coupled with other heritage ironwork training, to result in students having the practical and theoretical knowledge to conduct effective restorations.

Adrian Phillips, Surveyor of the Fabric for Historic Royal Palaces is quoted:

> "With further conservation work to do on the Tijou Screen at Hampton Court Palace over a number of years, we are keenly aware not only of the philosophical complexities involved but of the scarcity of appropriately skilled crafts people to carry out the work. We believe that this project will make a difference to us and to the heritage sector as a whole, by making those skills more widely available"

To avoid further inaccurate interpretation of designs and methods, exhaustive and thorough research of the original style, detail and form will be conducted during the restoration. This will determine not only the techniques employed in the construction of the original work, but also establish the types of tooling used and the dimensions. These tools can then be produced to ensure that subsequent forgings are as accurate to the originals as possible.

The Tijou Screens at Hampton Court Palace provide a fascinating example of the terrible results of an improvised approach to restoration and the issues surrounding this. For a piece that was designed with little thought as to future corrosion, and with such a long history of neglect, it is surprising that some of the original material survives. It is a prime example of how well intentioned restorations have caused enormous difficulties by incorrectly evaluating the original elements, and of the disparity between modern skills and the skills of those who created the screens. Fortunately there has been recent awareness of the value of such history, its place in modern society, and of the traditional skills required to work on heritage. The inclusion of the NHIG trainees in the restoration work heightens this awareness, and highlights the need to provide adequate tuition to those in the ironwork heritage sector and also to traditional trades.

With such a worthwhile restoration underway, and the combined experience of so many involved, this may well be an example that is referenced in the future as the best approach possible.

Conclusion

The Park Family Winston Churchill Memorial Trust Fellowship has allowed me the chance to study international practice and learn from the best in the industry. I feel incredibly privileged and honoured to be involved with the Trust, and to have met with the incredible and passionate people that I did. Meeting, learning and exchanging ideas with these experts has allowed me to gain a better appreciation of the many aspects of heritage ironwork, and to acquire skills and knowledge that can now be dispersed and applied in Australia.

During the Fellowship, further opportunities arose which expanded on a great itinerary and turned the trip into an experience of a lifetime. The report too expanded with the extra knowledge gained from these experiences.

Traditional ironwork and the skills required to work on this heritage is currently in a state of ambiguity in Australia. There has been a general downward pressure on professional blacksmiths and a subsequent loss of the skills and techniques of the trade. This loss has led a general vagueness and loss of understanding about the profession in all areas of the domestic population, trades and even heritage bodies and related professionals.

There are many factors which this pressure and skill loss can be attributed to. My hope is that this report will go some way towards reversing these trends by helping to define what a professional blacksmith is and helping to establish their rightful place in the production, restoration and conservation of traditional ironwork.

If a skill is not practiced it will be forgotten, and lost with this skill will be the ability to create in the manner of the past and to conserve that which has already been created. The conservation of these skills is just as important as the conservation of the artefacts.

Recommendations

The following recommendations have been established as a result of both my Fellowship, and a need within the trade for skills based guidelines or structure which will govern the conservation of heritage ironwork. During the fellowship, all of these points were discussed with international colleagues, and many have been previously implemented overseas.

- Heritage tenders for ironwork specifying adherence to conservation guidelines and ethics
- Commissioning only highly competent and specialist tradespeople for conservation work
- Formation of an easily accessible directory of those specialising in heritage trades
- The inclusion of heritage blacksmiths in the decision making process involving heritage ironwork
- Formation of a network of competent heritage based tradespeople to exchange information
- Promotion of informed decisions by those commissioning the conservation of heritage ironwork
- Traditional skills reintroduced into the TAFE Blacksmithing trade course curriculum
- Education of homeowners to the importance of regular ironwork maintenance
- CPD workshops for heritage and related professionals regarding heritage ironwork
- Restrictions on the professional term 'blacksmith'
- Imposing a set of minimum standards regarding training, experience and skills on those able to tender for heritage ironwork restoration and conservation

Implementation and Dissemination;

- Discuss experiences and knowledge with colleagues and related professions
- Inclusion of excerpts of the report in trade association publications
- Supply the report to heritage bodies and related professions
- Support the organisation of a CPD workshop relating to heritage trades
- Supply articles detailing the Fellowship experience and highlights for trade publications
- Guest speaking at public group meetings; Rotary, Menshed, Apex
- Featured articles in print media regarding the Fellowship, heritage ironwork and traditional skills
- Guest speaking to associated organisations and heritage open days
- Encourage other blacksmiths to pursue international experience and knowledge
- Continue to work within heritage ironwork conservation promoting best practice