THE CRUCIBLE

Historical Metallurgy Society News

Issue 111 Summer 2024

INSIDE THE CRUCIBLE

The HISTORICAL METALLURGY Society

Above: Trammel hook depicting a blacksmith at work with his anvil, hammers and tongs.

Right: Decorative wrought iron on display in the Iron Gallery of the Victoria and Albert Museum, London. *See Out and About on page 15*

From the Editors

Dear all, welcome to our summer edition of ***The Crucible***. There are exciting events coming up that have been organised by the Historical Metallurgy Society, which include a visit to the Ruhr region in Germany in September and the HMS Research in Progress conference in November. The Ruhr trip will include visits to the 20th century blast furnace at Duisburg, the open-air museum at Hagen, and the German Mining Museum in Bochum. The annual HMS Research in Progress Meeting will once again be a fantastic event for everyone working on projects related to historical metallurgy to present their research and network with others in the field. Further information can be found on page 6 of ***The Crucible***.

I apologise for the delay in sending out this edition of ***The Crucible***. We are still desperately seeking articles for future editions, as sourcing enough material does result in delays with publication. We are very grateful to all of the authors who have sent in articles for this edition and for the facinating variety of topics that they have covered. ***The Crucible*** remains a great place to update members on current research in our Archaeometallurgical News section, or to tell us about your Out and About discoveries. We always welcome reviews of recent publications and adverts for upcoming conferences. Despite the delay, I hope that you enjoy reading issue 111.

Jack

Editors: *Jack Cranfield and Raluca Lazarescu*

Submissions
Submissions to ***The Crucible*** are welcome at any time, and every attempt will be made to include them in the upcoming edition. Contributions can be sent in any format, but we prefer digital if possible. Images should be sent as high resolution jpeg or tiff files. We accept a maximum of 5 Harvard-style references per article only.

For consistency, we tend to use contributor's names without affiliations and email contacts. Anyone wishing to contact a contributor not known to them is welcome to forward a message in the first instance to the editors who will facilitate the contact.

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HMS at the Festival of Archaeology

Every summer the Council for British Archaeology organises a Festival of Archaeology with events held at many places all over the country. For the last two years the Ironbridge Gorge Museum Trust, with support from the Association for Industrial Archaeology, has run one of these events at the Coalbrookdale Museum of Iron which is free to enter on this day. This year's event was on Saturday 27th July and over 200 visitors were counted entering the Museum. Thirteen local and national groups had stalls scattered throughout the galleries and were able to engage with visitors in whatever way they wanted.

On both occasions HMS had been offered one of these stalls and some of our members have been able to talk to visitors about the Society and what it does, and also explain how archaeologists find out about the metals used in the past and the metallurgical techniques used then to produce metal objects. We also provided a flyer about where to look for more information on these subjects and offered free copies of back numbers of our Journal (Figs 1-2).

Figure 1: HMS Stand.

This year we were kept quite busy, especially by the families whose children enjoyed discovering the properties of metals and used my binocular microscope to see almost invisible details of the decoration on metal objects. Some people brought in objects they had found and asked us questions about them – what was it, how was it made, and what is it made of? This year we had borrowed a portable XRF machine from UCL and were able to answer the last question down to a fraction of a percent – modern science can help make our work so much easier.

We had a wide range of samples on display, from mineral ores to slags and raw metal, as well as things like crucibles that had been used in archaeological experiments and a collection of metalwork I'd dug up in my garden. The favourites though were definitely the real archaeological finds; it's not every day our visitors could hold a Bronze Age crucible in their hands or judge from their weight how much metal was present in medieval slags.

I found some of the more interesting visitors those who wanted to talk about how things were done when they used to work in the metal industries, or delighted in telling me the shockingly dangerous things they used to do … Thank goodness for Health and Safety legislation, but it has also removed some of the fun and adventure we all used to have!

Justine Bayley

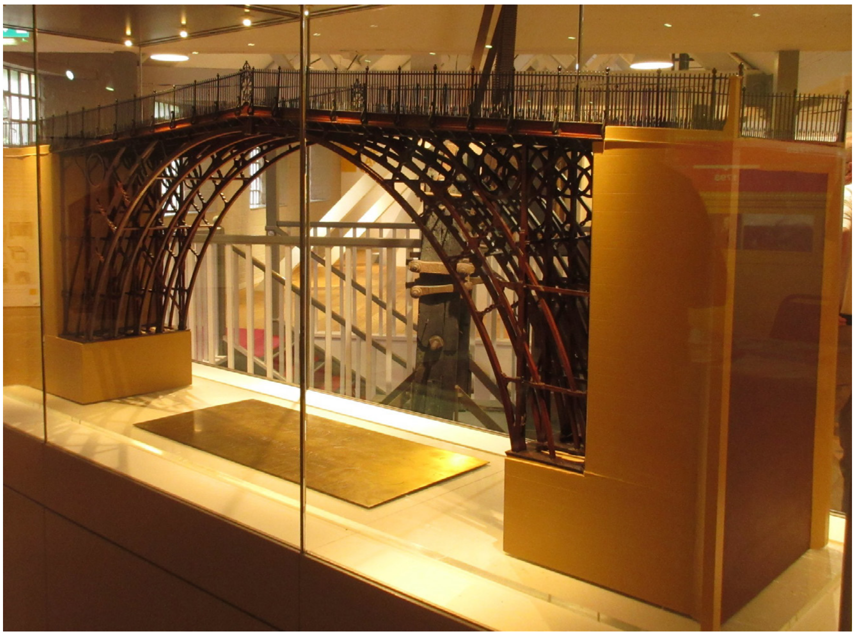

Figure 2: A model of the Iron Bridge made by Thomas Gregory in 1785. Thomas Gregory was the foreman pattern maker for the Coalbrookdale Company and oversaw the erection of the Iron Bridge in 1779.

Archaeometallurgy in Europe 2024

The sixth Archaeometallurgy in Europe conference was held just over a month ago at Falun in Sweden. It was organised by the Historical Metallurgy Group at the Jernkontoret, the Swedish iron and steel producers' association, and attracted nearly 200 participants, many of whom presented a poster or talked about their research. The abstract book can be downloaded from https://www.trippus.se/eventus/userfiles/253085.pdf. There were four parallel sessions to accommodate as many presentations as possible, divided by subject matter – not only the expected topics of Iron, Copper and its alloys, and Precious metals but other sessions on Metals, metallurgy and societies, Technology transfers over space and time, Mines, mining and mining heritage, The long and historical perspective: mining and environmental impact, and Latest experiences of related archaeometric methods and technologies. This eclectic mix clearly demonstrates the breadth of archaeometallurgical research and the innovative nature of the discipline.

Figure 1 (right): Justine Bayley (HMS President) and Vana Orfanou (SAS) with Bart Cornelius. (Photo courtesy of Catarina Karlsson).

The Organising Committee must be thanked for all the hard work they put into making this such a pleasant, rewarding and memorable occasion; they must have been pleased at how many aspects of their Group's remit were met by the conference: it definitely promoted historical research concerning mining and metallurgy and enabled collaboration between researchers through the talks, informal discussion outside the sessions, and field trips that they arranged.

Figure 2: Justine Bayley (HMS President) and Vana Orfanou (SAS) with Kristine Urhøj Møller. (Photo courtesy of Catarina Karlsson).

As usual, HMS provided prizes for the best student presentations, and this year we were joined by the American Society for Archaeological Sciences. The judging panel was impressed by the high quality of many of the presentations so it was quite a challenge to select the outright winners. In the end the joint prize for the best oral presentation went to Bart Cornelis for his talk on *'The cutting edge: giving shape to the Sögel-Wohlde blade tradition and the breakthrough of the Nordic Bronze Age via a multi-proxy approach'* while the best poster presentation prize went to Kristine Urhøj Møller for *'A novel approach to differentiate Icelandic iron production slags from other Viking sources combining Sr isotopes and trace elements'* (Figs 1-2).

Figure 4: The replica furnace at New Laphyttan (with a temporary roof); the waterwheel driving the bellows is to the left and the charging ramp in front.

Many may wonder why the fairly small town of Falun was chosen as the conference venue, but it becomes obvious once you know that it and the surrounding area were inscribed as a World Heritage site in 2001 because of its very productive copper mine. This metallurgical heritage provided many places to visit in and around the town, and the mine itself was the venue for the welcome reception where we were serenaded by local musicians. The mine had been worked for nearly 1000 years when it closed in 1992, and at it's peak in the mid 17th century it produced nearly two-thirds of Europe's copper (Fig. 3).

Figure 5: One of the many large slag heaps near Falun.

Figure 3 (left): The Falun mine's maze of galleries collapsed in 1687 leaving this pit, over 90m deep.

Figure 6: Conference delegates at New Laphyttan. (Photo courtesy of AiE2024).

Because of the large scale of production much of the ore was transported to the areas surrounding the town where it was roasted and smelted as this was more economic than transporting the charcoal to near the mine. The result was many estates owned by the free miners where elegant 18th-century buildings survive alongside the massive slag heaps.

On the final day of the conference there was a coach tour of various metallurgical sites between Falun and Stockholm (Figs 4-6). The high point was a visit to New Laphyttan where a replica of the very early blast furnace has been built to allow replication experiments. It wasn't operating when we were there but the scale of the structure was far larger than most experimental replicas!

Justine Bayley

HMS and WebCollect

As we've moved into the 21st century and have members scattered round the globe we need to improve our interactions with people. We are going to start using software called WebCollect.

WebCollect is a membership and event management software solution designed to streamline administrative processes, manage memberships, handle event registrations, and facilitate payment collection. It caters to organisations of all sizes, including sports clubs, professional associations, non-profit organisations, community groups and educational institutions.

The HMS home page on WebCollect has the short name 'histmetsoc' and will be accessed through the HMS website by clicking a link. Members not using a computer continue to correspond via Royal Mail. The transfer to WebCollect represents a significant saving in time and effort as well as an improvement in communications. It also has a security advantage in separating members' financial actions from the main website.

In September or October HMS members will receive an email inviting them to use WebCollect. For security when communicating and accessing membership accounts each member will be asked to set up a password using a link in the email. Each member will have full control of their personal details.

The invitation email will have been sent by WebCollect on behalf of The Historical Metallurgy Society, so may end in junk mail as WebCollect could be an unidentified sender. Notification of the invitation will be sent by the current HMS email route at the same time. As soon as a member has set up log-in details they will be able to communicate with the HMS via WebCollect. HISTMETSOC on WebCollect will not be fully active until 90% of the membership are set up, which is hoped to be by 2025.

Any questions or concerns should be addressed to me, Vanessa, at secretary@historicalmetallurgy.org.

Vanessa Cheel

Mike Corfield

We are sorry to report that Mike Corfield, who served on HMS Council in the early 1990s and was Chairman from 1993-95, passed away in March this year. Mike worked as a conservator for Wiltshire Museums Service and joined English Heritage as Head of Conservation in 1991. He subsequently became their Chief Scientist and formed the team of Regional Science Advisors. He oversaw the move of the Ancient Monuments Laboratory to Fort Cumberland in Portsmouth in 1999 where it is now part of Historic England's heritage science and archaeology team.

HMS Research in Progress

Friday 22nd of November 2024

Call for Papers

The Research in Progress Meeting 2024 of the Historical Metallurgy Society will take place online on Friday, 22nd of November. It provides a forum for everyone working on topics related to ancient and historical metallurgical practices, the past use of metal objects, and related fields. We are keen to learn more about your ongoing or recently finished projects! The meeting aims to foster links between the different disciplines and geographical regions. Therefore, we particularly encourage submissions from early career researchers, contract archaeologists/conservators, and colleagues from outside Europe. There will be an HMS prize for the best student presentation.

Abstracts (up to 200 words) can be submitted from until 1st of October via the submission form. Please note that there won't be an extension of the submission deadline.

Presentations can be either 6 min or 15 min long (with time for questions added). We encourage all presenters to take full advantage of the flexibility a virtual event provides and present their project in a way that suits them and their project best. Pre-recorded contributions are possible but the presenter must be present in the meeting to answer any questions. Presentations will be scheduled in a way that considers the different presenter's time zones.

The programme and any updates will be announced on the HMS Website and circulated by email. General enquiries can be directed to Thomas Rose (thomas.rose@bergbaumuseum.de).

We are looking forward to seeing you in November!

Registration

Participation is free of charge. Please register for the event between 1st of September and 18th of November using the registration form. The link to the meeting room will be displayed once you have successfully registered.

For further information please see: https://archaeothommy.github.io/hms-rip-meeting/

Key Dates

01 September – Abstract submission and registration opens

01 October – Deadline for abstracts (there won't be any extension!)

15 October – Announcement of abstracts decisions

01 November – Announcement of programme

18 November – Deadline for registration

20 November – Reminder with meeting details sent to participants

22 November – Research in Progress Meeting

25 November – Attendance certificates sent to presenters

A History of the British Zinc Industry

A Story of Technical Inovation and Industrial Decline

The production of metallic zinc began in Britain in the 1740s, although zinc minerals had been mined previously for the production of brass by the cementation process where copper was reacted directly with the calcined zinc ore. Indeed, the primary objective of producing zinc metal was to make a superior brass. The Champion family ran a successful and innovative brass making concern at Bristol and William Champion developed a method of smelting and condensing the zinc vapour. He used the local zinc carbonate, smithsonite ores, applying for a patent in 1743 (Day 1973), although as early as 1758 a process for using the much more abundant sphalerite, zinc sulphide ore was patented, but only from the early 20th century did sphalerite become the dominant ore. The method was by downward distillation based on an incomplete understanding of the principles of the long established Indian process. Champion adapted the local glass-making furnaces to hold six large retorts with the zinc vapour condensing in iron necks protruding vertically into a cool chamber below (Fig. 1).

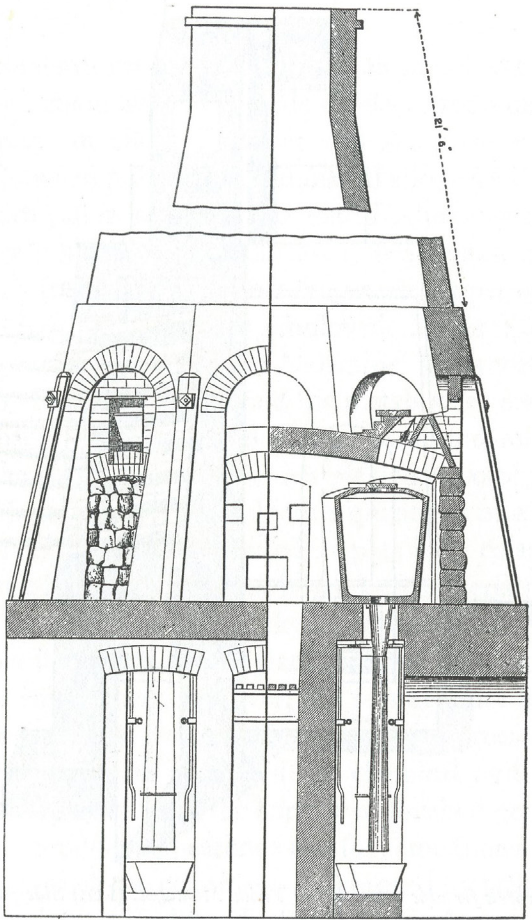

Figure 1: Champion's zinc smelting furnace.

Champion expanded his operations at Warmsley, then just outside Bristol, in the 1760s, establishing a very ambitious large integrated works for the smelting of copper and zinc ores to produce brass which was then cast and rolled as required. This venture proved financially unstable and was declared bankrupt in 1769. Zinc production using his process continued with other entrepreneurs in Bristol until the 1830s, but by this time production had been overtaken by developments elsewhere in Europe.

The initial commercial success of Champion's process aroused widespread interest, and industrial spies, including one from Germany masquerading as a wandering minstrel, had ascertained the technical basis of the process. The first commercial process outside Britain was set up in 1798 in Carinthia, which although based on operations observed in Bristol was actually closer to the original Indian process. It was soon realised that retorts set horizontally were much more efficient than those set vertically, and soon afterwards versions appeared, including the Silesian and Dony, or Belgian, processes (Fig. 2). These were not introduced into Britain until 1836, at Swansea in South Wales, and only slowly displaced the British vertical retort process, the last finally ceased production in 1859.

Thereafter, as elsewhere, the Dony process became dominant by the end of the 19th century with South Wales, especially Swansea, together with Avonmouth near Bristol, becoming the centres of British zinc production

The market for zinc was initially very limited. It was found to be brittle and difficult to work and until the beginning of the 19th century the metal was used almost solely for brass making. Although this produced a much purer alloy, there was only a limited demand for it, brass made by the cementation process being much cheaper.

This was to change in the early 19th century, first when Sylvester and Hudson of Sheffield, patented their hot working process in 1805 which enabled sheet zinc to be hammered, rolled and drawn. They used zinc smelted locally but using zinc ore from Nenthead on Alston Moor in the northern Pennines. Thus almost coincident with the improved distillation methods there was an increasing demand for zinc metal, joined from the 1830s by galvanising.

British production remained insufficient to meet local demand, and instead became increasingly reliant on imports for the majority of its requirements, mainly coming from Belgium and Germany.

The inherent dangers in this were starkly revealed to Britain in 1914. Lones (1919) described the sudden realisation at the outbreak of the First World War that Britain faced serious shortages and 'these circumstances show how during a long period of peace, control of an important industry may be lost to a dangerous extent.' First there was the immediate problem of obtaining zinc for the war effort and second the need for long term planning to create a viable permanent industry. The first was met partly by imports from the United States and also by increased home production, supporting existing producers to build modern retort smelters.

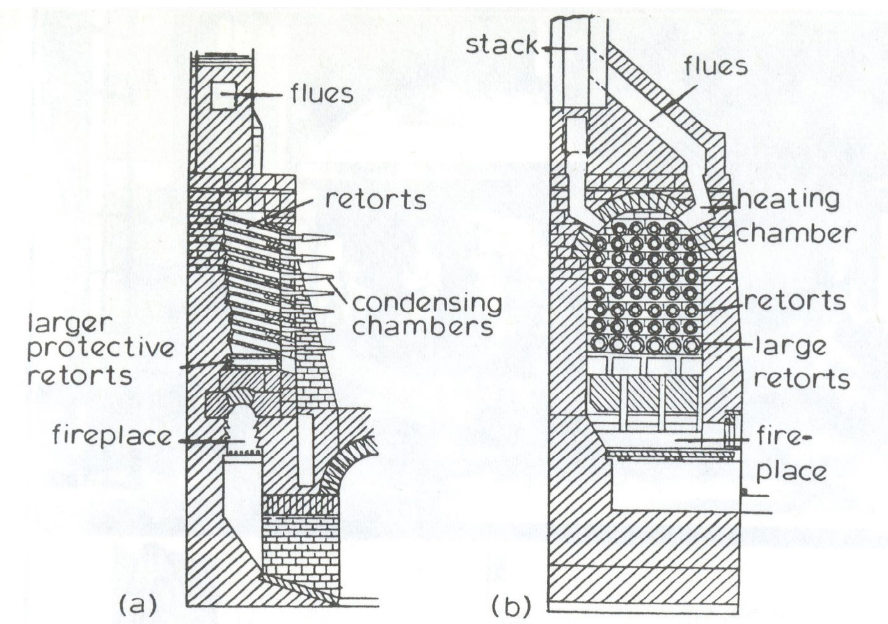

Figure 2: The Dony horizontal retort process.

There were two basic underlying and apparently contradictory considerations. Firstly, it was still felt, and increasingly so through the 1930s, that Britain must retain the ability to produce zinc in quantity, but secondly there was the growing realisation that the retort processes could never compete with the now fast growing electrolytic processes. Through the 19th century several processes for the production of zinc by electrolysis had been investigated but success only came in 1916 at Trail in Canada, followed by Australia, probably initially prompted by the shortage of zinc within the British Empire during the First World War. Both were viable because of abundant cheap hydroelectricity (Lones 1919, 100-14). Ultimately electrolytic zinc would dominate world production, being both cheaper and of the high purity which many of the applications using zinc, such as die-casting now required.

The second long term solution was to form the National Smelter Co. in 1917 to establish major plants at Swansea and at Avonmouth, near Bristol. The latter was chosen because it had good port facilities and already had a large government munitions plant which could use the sulphuric acid byproduct of zinc production from the sphalerite ores. The main source of the ore was to be from the Broken Hill mines in Australia which had previously been sent to Belgium and Germany, the British government placing large long term orders at a fixed high price. Inevitably development was slow such that by 1923 the new smelters were still under construction but the political and economic situation had completely changed. There was no longer an immediate need for increased local production of zinc and sulphuric acid, and accordingly the price had collapsed. Large quantities of what was now very expensive Australian ore continued to arrive at Avonmouth, to be roasted to produce sulphuric acid that no-one wanted and the zinc sinter that had to be sent to Belgium to be smelted.

Clearly a new process was required. The New Jersey vertical retort process was investigated and a plant installed at Swansea in 1934 and operated for many years, but it was still a complex process operating on relatively small scale. The Swansea zinc smelters must have looked at the nearby huge blast furnaces and wondered how they could be adapted for zinc production. The problem was that smelting iron in a blast furnace produced a pool of chemically stable iron at the furnace base, whereas smelting zinc would produce a highly reactive vapour emitting from the top of the furnace. How could this be transformed into liquid zinc metal without a condenser? Various attempts were made in the 1930s to shock cool the zinc vapour before it could re-oxidise, but without great success. The answer was to spray molten lead droplets into the vapour which not only cooled and condensed the zinc, but then dissolved it (Fig. 3).

Somehow through the 1920s the new Belgian horizontal retort smelters were installed, but the financial crash of 1929, and subsequent depression once again threw the future of the British Industry in doubt. At this juncture a new enterprise was formed out of the National Smelter Co. This was named the Imperial Smelting Corporation and brought together all the British smelting activities using ore from the British Empire, under the Imperial Preference System, established at the Ottawa Conference in 1932 (Cocks and Walters 1968).

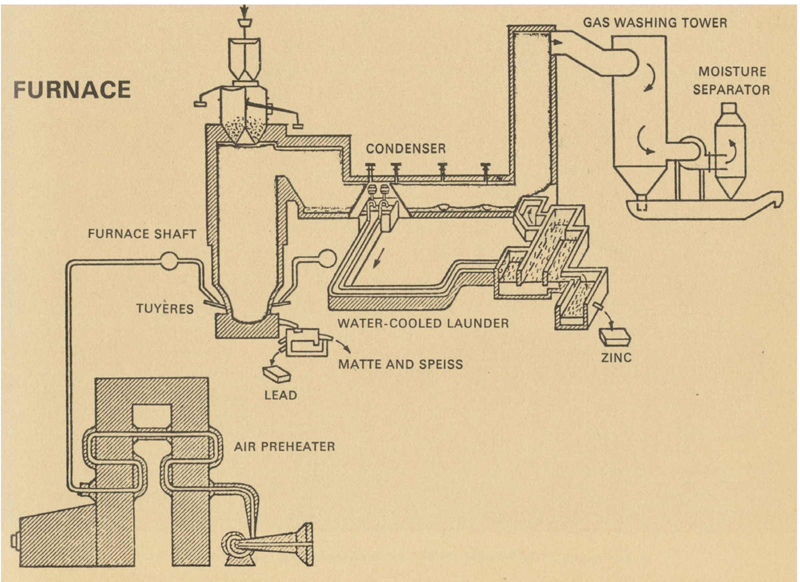

Figure 3 (right): The Imperial or Blast furnace process.

The zinc-rich lead was then led to a cooler chamber where, as the solubility of zinc in lead is sharply temperature dependent, it separated into a zinc-rich phase sat on a lead-rich phase (Morgan 1985). The principles of what became known as the Imperial or Blast Furnace process were worked out in the late 1940s, the development and construction of a major smelter at Avonmouth completed by the mid 1950s, and by the mid 1960s all zinc production in Britain was by the Blast Furnace process. When Cocks and Walters published their account of the Imperial Smelting Corporation in 1968 the future seemed assured, but ultimately competition from the electrolytic process proved too much and the company ceased operations in 2003 and with it, after 260 years, the production of zinc in Britain.

Paul Craddock

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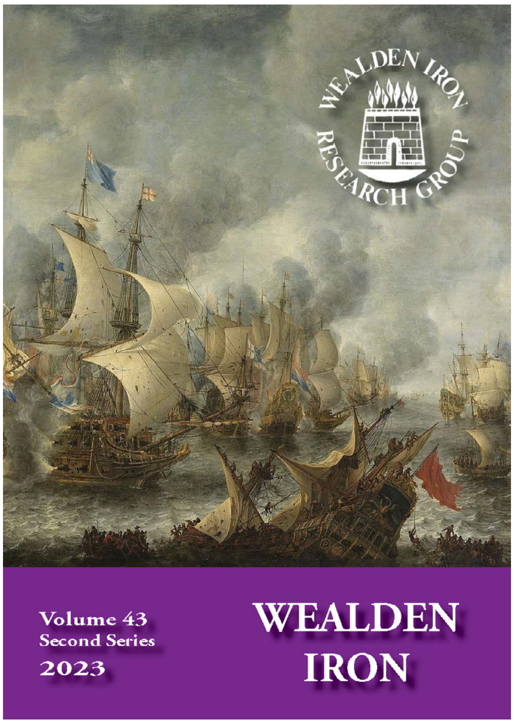
WEALDEN IRON, Second Series, 43, 2023

Bulletin of the Wealden Iron Research Group

The Wealden Iron Research Group is now in its 56th year and continues to publish an annual Bulletin of research into what was, during the Roman and Early Modern periods, the most densely exploited iron production region in Britain.



New sites are still being discovered and concentrations of bloomery slag have been noted in Tunbridge Wells in Kent and near Wadhurst in East Sussex. Archaeological evaluation in advance of building development at Framfield in East Sussex has uncovered the remains of a bloomery furnace dating from the Late Iron Age or early Roman period. A report is expected in due course.

In 2014 an ad hoc group of enthusiasts uncovered the remains of a bloomery furnace at Southborough, north of Tunbridge Wells, which radiocarbon dating placed in the 3rd century BC, making it one of the earliest furnaces identified in the Weald. Although the excavation has not been published the excavator made available two blooms and an iron fragment found at the time and their analyses are published here. Both of the blooms had carbon contents ranging between 0.12% and 0.18%, well within the modern specification of steel, and the evidence indicates that this was probably deliberate.

Documentary references to iron production in the Weald in the Middle Ages are rare and articles in previous Bulletins have examined the evidence for an iron 'mine' in the 11th and 13th century, and the works at Tudeley in Kent in the mid-14th century. The struggle between Edward II and the 'contrariants' to his rule in the early-1320s led to the confiscation of land in Withyham parish, in East Sussex, on which there was an iron works with its source of ore belonging to 'John de Lynleghe'. An article in the current Bulletin identifies this person as John Culpeper and examines the circumstances that led to his imprisonment and the seizure of his lands, as well as the possible location of his works.

A series of articles published in Bulletins between 20 and 30 years ago traced the records of Wealden gun founders in the archives of the Office of Ordnance, and in particular production by John Browne in the first half of the 17th century. A revival of these studies has focused on the output of his son George during the Commonwealth and the demands by the navy for ordnance during the First Anglo-Dutch War.

Finally, a series of probate inventories made between 1660 and 1700 are preserved in the National Archives. An article reproduces those relating to people involved in iron production in the Weald which provide information about the equipment and stock of several furnaces and forges, together with information about the operation of ironworks not recorded elsewhere.

www.wealdeniron.org.uk

Jeremy Hodgkinson

Evidence of Scythian Trade Iron Bars from the Boguslavsky Hoard, Ukraine?

For the past ten years, after my retirement from a career as a physicist at the Institute of Semiconductor Physics of the Academy of Sciences of Ukraine, Kyiv, I have been systematically collecting information from the Violity auction site about metal-detector finds of Scythian iron axes and other objects.

Only 52 axes had been recorded previously from archaeological sources (Bugay 2020a). The new information has resulted in over 2500 records of axes, with some 10 new types of axe being defined. This work is recorded in a series of nine illustrated notes on my Academia.edu and Research Gate pages.

These are written in Russian, but the Academia versions can be downloaded as reasonable quality and useful translations https://independent.academia.edu/OBugay. It is intended in due course to publish a summary of these important finds in *Historical Metallurgy*.

One of the most interesting and unusual discoveries was a find in 2018 of a small hoard of eight axes and thirteen square bars in the so-called Boguslavsky Hoard, found about 100 km south of Kyiv. This is important as the first evidence for possible Scythian trade iron bar production in Ukraine.

This short article will highlight the most important information about the hoard. It was found by an experienced antiquities hunter using a metal detector. He has sold his finds through the auction site for several years and his reputation is highly rated by the auction administration at +61 points.

He gives a brief description this find and its location, with 20 photographs. One photograph was taken at the actual place of discovery next to a deep hole (Fig. 1). All the photographs and details of the find are given in my 2023 note (Bugay 2023b).

Figure 1: The Violity auction site photograph of the axes and bars from the Boguslavsky Hoard laid out at the site where they were found, with the axes and bars numbered for reference. The bars are about 400mm long.

The first part of Boguslavsky Hoard consists of eight nearly identical large axes. They were identified as Scythian, and are called "Elongated wide-bladed thin butted axes" (Bugay 2020c). These are the largest (up to 365 mm long) and heaviest (1.8 to 2 kg) Scythian axes. The Boguslavsky axes all have the same shape, size, proportions and weight. One of the axes, No. 5, is shown in Figure 2. The main dimensions of the parts of axe were measured from photographs using the paving slabs as a scale: L=310 mm, B=110 mm, W=60 mm, T=23 mm, W/T =2.6. The dimensions of the remaining 7 axes of the hoard are similar and are listed in Bugay 2023b.

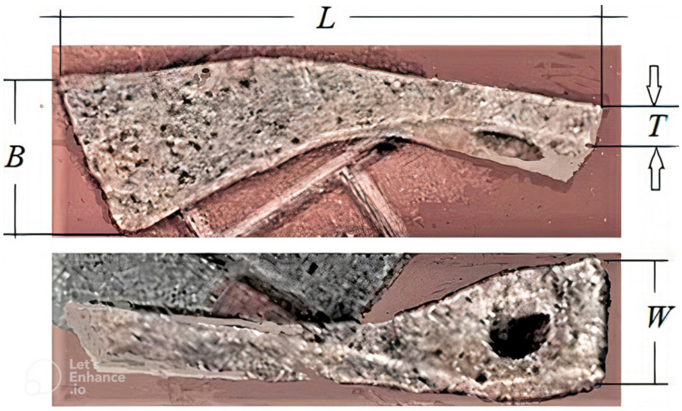


Figure 2: Axe No. 5 against the background of the paving slabs 200 x 100 mm each.

Analysis of the images of the axes in the hoard shows that the manufacturing of Nos. 1, 4, 6 and 7 has not been completed. Two of them have unfinished holes, being smaller and sub-circular, one has an unfinished butt and blade and one has a poorly shaped blade. Unfinished axes make up about 4% of all the auction lots. They are useful for reconstructing the forging technology and are described in some detail in Bugay 2020b. The completed axes, Nos. 2, 3, 5 and 8, have unsharpened blades, which is typical for axes from "merchant hoards".

The second part of the Boguslavsky Hoard consists of 13 bars of almost equal length. Six bars have a square cross-section of 14 by 14 mm and their length ranges from 370 to 430 mm. Seven bars are about 800 to 860 mm long and have been folded in the centre to a cross-section of 14 by 28 mm and a length of 370 to 430 mm (Fig. 3.1). The bars weigh about 550g and 1200g respectively. This bending is clearly a way of showing the quality of the iron as well as making it a suitable size for transport. After bending, some of the bars appear to have been partly welded together.

One of the single bars has a hook at the end. This may be a failed attempt to fold a long bar or it may also be an indication of its quality (Fig. 3.2). All the bars have a series of sharp parallel "notches" on their side faces (Fig. 3.3). This may be a result of the bars being drawn down over the edge of an anvil, but this would need a very sharp edge to make those marks and it would not create a good smooth surface.

Figure 3: 1: Folded bars. 2: hook on bar No 2; 3: notches on the face of bars.

In addition the notches seem too regular to be from drawing down. One alternative is that the notches are a result of hammering with a very sharp cross-peen to even out any irregularities in the thickness of the bars.

These features of the bars from the Boguslavsky Hoard all indicate that they are a form of trade iron, intended to demonstrate the quality of the iron, in a similar way to the so-called currency bars and other forms of trade iron (Crew 1994).

This raises the possibility that the axes in the hoard are also a rather more sophisticated form of trade iron, indicated by the unfinished nature of four of the axes. This is supported by two other small hoards, both with three unfinished axes of this type. Axe-shaped trade iron of a variety of different shapes and sizes occur widely in other countries and at different dates. This topic will be discussed in more detail in a future paper.

Hoards of axes are in fact quite rare, with some 99% of all axes being recorded as single finds. It is possible of course that some hoards could have been reported on the auction site as individual finds, to enhance their value, but this information cannot now be recovered.

How confident can we be that both the axes and bars were deposited together? There are three points which strongly indicate that this was the case; the photographs taken at the time of discovery show both the axes and the bars laid out together adjacent to a large hole from which the hoard had been excavated; the corrosion products are very similar suggesting similar deposition conditions; and most important is that there would be no incentive to add the bars to the hoard to increase its value at auction, as collectors are only interested in specific types of artefact, like the axes. Thus we can conclude that the hoard of the axes and bars is indeed a single and contemporary deposit (Fig. 4).

The latter point also has implications for the occurrence of other square bars of trade iron. If these had been discovered without axes or other objects, they would not have any value to collectors and so would not have been reported on the Violity auction site.

Figure 4: The Violity auction photograph of the hoard displayed on paving slabs 200 x 100mm.

All the new recorded axes have been found by metal detecting and none of the new types are known from archaeological contexts, so dating is a problem. The earliest types of axe studied by Illiskaya and Shramko in the 1970's are conventionally dated to the early and mid-6th century BC (Bugay 2023a).

The new types of elongated axes, as in the Boguslavsky Hoard, are more complex and better made and thus are probably later in date, say from the 4th and 3rd centuries BC (Bugay 2023b). As with the undated currency bars and other forms of trade iron, a datable hoard or a workshop producing such bars may eventually be discovered.

So, assuming as argued above that the bars are truly contemporary with the axes, these are the earliest record of plain square bars being produced as trade iron, some centuries before they become common in the Roman period.

Oleksandr Bugay, Kyiv

Acknowledgements

I thank my son Dmitry Bugai. This work appeared only thanks to him as it was he who suggested the idea of trade iron bars.

Thanks to Marion Berranger for the articles on trade iron which began my acquaintance with this topic.

Thanks also to Peter Crew for his advice and help in preparing this article, and to Hector Cole, Master Blacksmith, for his comments on the bars.

I am especially grateful to the cardiac surgeon Alexei Krikunov, who restored my heart and functionality some months ago.

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Postscript

Since this article was completed, I have had the opportunity to examine three publications by Boris Shramko, concerning an unusual bronze artefact. This is first mentioned in his 1975 article and called a spatula-type tool. In his 1987 monograph on the Bilsk Scythian settlement the artefact is identified as a bronze measuring ruler. To quote Shramko "Trade, like handicraft, required in some cases precise linear measurements of goods. In this respect, the discovery of a 41.6cm long bronze measuring ruler at the Bilsk settlement is significant. Obviously the ruler was one of the variants of the elbow measure widespread in antiquity." The object was drawn again in Shramko's 1987 paper on the recent work on the Bilsk settlement and called a Scythian elbow measuring ruler (Fig. 5). These publications are all conveniently re-printed in the 2016 volume for Shramko's 95th anniversary, compiled by S. A. Zadnikov and Iryna Shramko, which is available at https://www.academia.edu/31493269.

Figure 5. The Scythian bronze measuring elbow, Scale 40cm, after Shramko 1987a, Fig. 44.4 and Shramko 1987b, Fig. 1.15.

The average length of the 13 square bars of the Boguslavky hoard is 41.3cm. The length of the "Scythian Elbow" is 41.6cm. Is this simply coincidence or an indication that the Boguslavsky bars were indeed made to a traditional measure?

Unfortunately there are no descriptions in the publications mentioned of the context of this measuring elbow, but Shramko was certain that the artefact belongs to the Scythian period of the Bilsk hillfort, late 7th to early 3rd century BC.

Oleksandr Bugay, Kyiv

HIPPO HIDE FOR CORNISH PUMPING ENGINE

I was alarmed to read a headline in a recent Trade journal referring to 'Rhino Hyde liners' supplied by Haver & Boeker of Niagara, Canada. The skin of an endangered species, I thought – how can this be allowed? Fortunately, reading on, I discovered this was a synthetic thermoset polyurethane, designed for hard wearing applications in materials handling and hauling.

However, it reminded me of a visit to a Cornish pumping engine where a spare clack valve was on display, made from hippopotamus hide (Figs 1-2). The Cornish pumping engine was a steam driven beam engine used to dewater mines throughout the world in the 19th and mid-20th centuries during which time Cornwall boasted some 1500 mines, mainly extracting copper and later tin, but also lesser quantities of tungsten, manganese, iron ore and silver, and, as a by-product, arsenic. In all, some 3000 engine houses were built, with engines moved from one to a new site as a mine was depleted or failed to find ore.

Figure 2: Clack valve made of Hippopotamus hide, a superior material to cow leather.

The clack valve was a non-return valve in the pump riser made of cow leather, which opened with each upwards stroke of the engine to bring water to a higher level, and then closed on the downward stroke to prevent the water descending back to the lower level.

Following a decline in the copper and tin markets in 1866, and the discovery of similar ores in North America, Australasia, South America and gold in South Africa, Cornish miners migrated to these areas in large numbers forming a diaspora known as 'Cousin Jack', taking with them their mining technology, including the Cornish beam engine. Such was its versatility that it could also be used as a winding engine, and even on-board ships, such as ferries across San Fransisco Bay.

Cornish mining engineers, working in Africa, discovered hippo hide, and even rhino hide, to last much longer than cow leather as it was much thicker and more water proof. Hence, it was generally adopted wherever a Cornish pumping engine was in action, evidently also at surviving mines in Cornwall.

The example pictured was a spare for the 90" (2.28m) cylinder diameter steam engine at East Poole Mine at Redruth in Cornwall, one of the centres of tin and copper mining in the County (Fig. 3). This was the largest engine in Cornwall, but by no means the largest built in the county, a 144" (3.65m) diameter engine having been one of several exported to Holland for draining the Dutch polders.

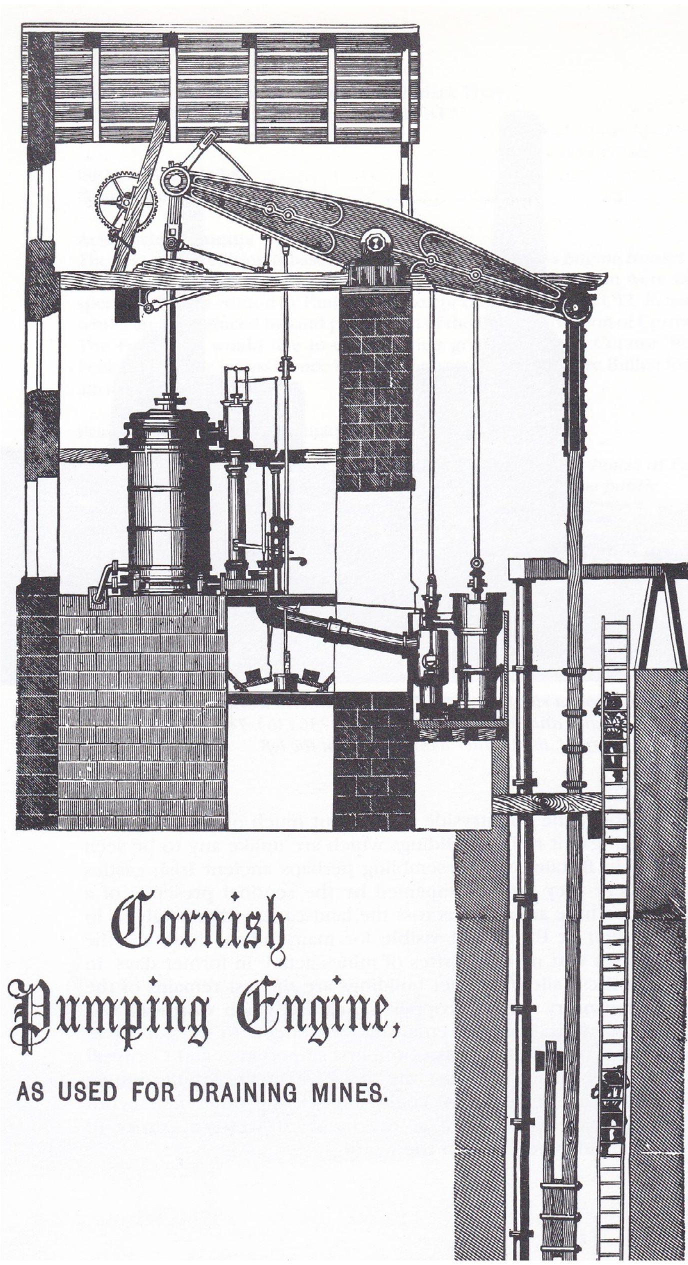


Figure 1 (left): Illustration of a Cornish Pumping Engine from Harveys catalogue.

Cornish engines were built in foundries such as Harveys of Hayle and Fox of Falmouth who undertook these ambitious castings, as well as constructing all the valve gear and massive beams, weighing 50 tons or more (Fig. 4).

Cornish engines arrived in the 1830s as an improvement in efficiency of the first Newcomen atmospheric engines, invented in the adjacent county of Devon in 1712. These first came to Cornwall in the 1730s. The low efficiency of these engines, which was barely half a percent, required prodigious amounts of coal, one of the few minerals absent in the rich mineralization of the county. Coal, to feed the engines had to be imported by sea from South Wales, a journey frequently disrupted by winter storms. Next came the Boulton and Watt engines of 1765, which, were more efficient, at some 5%, reducing consumption of coal close to 75%, but the mine owners had to pay a royalty to Bolton & Watt on the savings in coal. In 1834, the Cornish beam engine arrived. Working at a higher steam pressure, typically 50psi (240kPa) which improved efficiency, it burnt even less coal and the steam was raised by the more efficient 'Cornish Boiler', which had a single flue tube but recycled the hot air via a side flue to maximise heat transfer to the water to raise steam. Equally as important was the release from paying Boulton & Watt a royalty on coal saved.

Despite electric motors being introduced to the mines in 1906, the last Cornish beam engine to work was the 90" engine at East Pool that pumped until 1954.

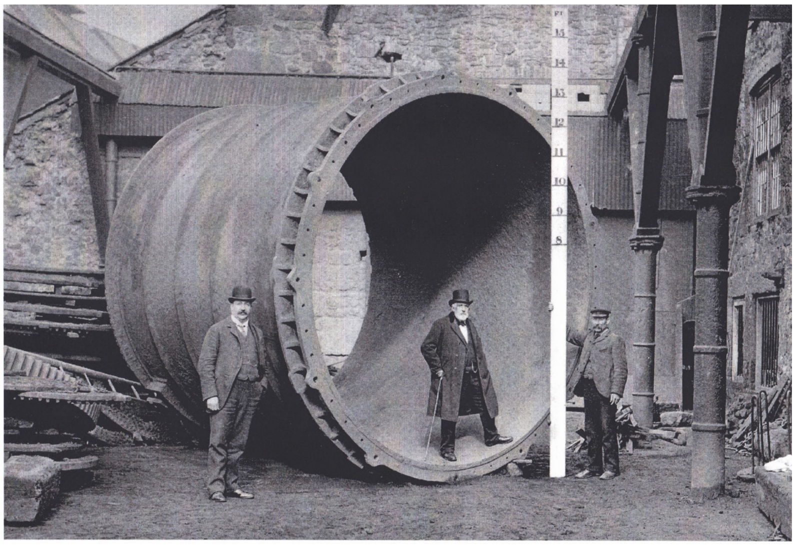
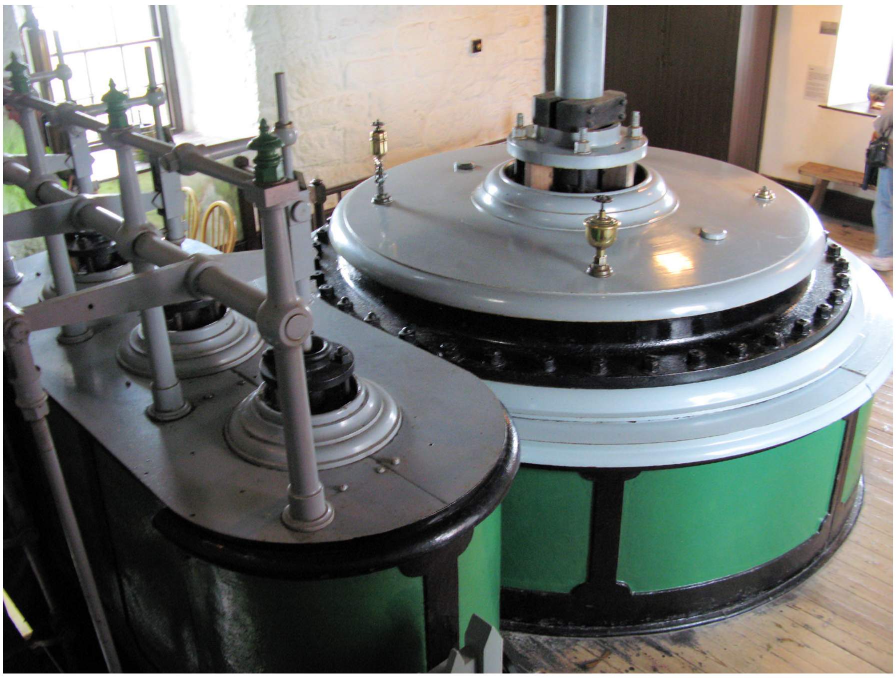


Figure 4: Believed to be the largest cylinder ever cast, this cylinder cast by Harveys was destined for the Cruquius engine in Holland used to drain the Haarlemmermeer.

In later years, although the mine had ceased operating to win ore, it was necessary to continue pumping to keep the nearby South Crofty mine from flooding via a network of interconnecting underground galleries.

South Crofty eventually closed in 1998 but is presently being de-watered following a resurgence in the price of tin as a result of an increasing need of lead-free solders to meet the growing electronics and batteries industries. The discovery of a tin rich lode missed by the earlier miners, coupled with XRF to sort every piece of rock raised from the mine, thereby discarding barren rock without processing it, offers good prospects for the resurgence of mining in Cornwall. The county still boasts an active china clay industry and two start-up companies to extract lithium, one from mine water and the other from mica, a by-product of china clay refining.

Figure 3 (below): The 90" steam cylinder and valve bank of the East Pool steam engine.



Probably unique to anywhere in Britain is the only surviving beam engine in situ that is still run under steam. It is the winding engine at Levant Mine originally preserved by the forerunner of the Trevithick Society Trust and now under the ownership of the National Trust. www.nationaltrust.org.uk/visit/cornwall/levant-mine-and-beam-engine

Today, 200 engine houses survive in the county giving Cornwall the largest concentration of industrial heritage in Europe, a factor recognised by UNESCO by awarding mining areas as 'World Heritage Sites'.

Tim Smith

How a Cornish Beam Engine works -You Tube

To understand the complete workings of a Cornish pumping engine follow this excellent animation by Goy Janssen and Damian Nance on You Tube.

https://www.youtube.com/watch?v=CUyQFFAtkC0&t=122s

The video starts with a description of the Thomas Shaft pumping engine at Wheal West Kitty, St Agnes, Cornwall with the animated graphic explaining how a pumping engine works commencing after 5 minutes. Total run time 18 minutes.

Figure 5 (left): The preserved pumping engine at Michell shaft, South Crofty, Redruth.

A BLACKSMITH'S TRAMMEL HOOK

The Victoria and Albert Museum, London, is home to one of the largest collections of historic metalwork in the world, and its Ironworks Gallery displays many fine artefacts that range from domestic objects to architectural features (Fig. 1). One piece particularly demonstrates the skill of the blacksmith in more ways than one. Object 496-1902 is a wrought iron pot-hook or 'trammel hook', which was used to suspend cooking pots and kettles over an open hearth (Fig. 2 and front cover image).

Figure 1: The Ironworks Gallery at the V&A.

Figure 2: The blacksmith's trammel hook on display in the Ironworks Gallery.

The series of teeth or notches along its outer edge allowed the height of the hook on which the cooking pot was suspended to be raised and lowered over the hearth to regulate the cooking temperature.

Trammel hooks were an important utensil in kitchens of the 17th and 18th centuries and are found in a variety of sizes that reflect the proportions of the hearths in which they were used. While typical examples lack decoration, the example in the V&A is unusually ornate with a perforated design of a blacksmith working at an anvil along with his tools that include hammers and tongs. While the reason for its more elaborate design is unknown, it was perhaps created by the blacksmith as a demonstration of their expert metalworking skills.

Further information can be found at: https://collections.vam.ac.uk/item/O324744/pot-hook-unknown/

Jack Cranfield

Forthcoming events & Virtual content

Conference, date & locations	Description	Website, emails and prices
Historical Metallurgy Society visit to the Ruhr region, Germany 20th – 22nd September 2024 Duisburg – Hagen – Bochum, Germany	As the Historical Metallurgy Society has become more international in recent years, we are planning to undertake short visits to various areas with metallurgical history throughout Europe. Our first such visit is planned for September to the Ruhr region in Germany. The highlights of the visit are: The 20th century blast furnace at Duisburg re-invented as a recreational area with cinema, diving, climbing areas and much more. Guided tour of the furnace with torches in the evening. Presentations on current research in Germany on historical metallurgy by some of the leading professionals in their fields. To be held in the old control room of the blast furnace. Open-air museum at Hagen with working 18th and 19th century metalworking mills. Also, the last chance to see the experimental Iron Age domed iron smelting furnace, to be demolished shortly after our visit. The German Mining Museum in Bochum	https://historicalmetallurgy.org/
International Materials, Applications and Technologies (MIAT) 2024 Conference 30th September – 3rd October 2024 Cleveland, Ohio, USA	With a session on Archaeometallurgy and Ancient Metalworking organised by the ASM Archaeometallurgy Committee.	https://www.asminternational.org/imat-2024/cfp/
HMS Research in Progress Meeting 2024 22nd November 2024 Online	The Research in Progress Meeting provides a forum for everyone working on topics related to ancient and historical metallurgical practices, the past use of metal objects, and related fields. See page 6 for further details.	https://archaeothommy.github.io/hms-rip-meeting/ General enquiries can be directed to Thomas Rose (thomas.rose@bergbaumuseum.de)

For the latest conferences and events please see the HMS Website at ***https://historicalmetallurgy.org/hms-events/***