Woodcock Hammer 1748
(Mercers' Company, London)

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A BLOOMERY SITE IN BURWASH, EAST SUSSEX

DAVID BROWN

The stream which rises on the north side of the Dudwell valley at TQ 637228 was investigated, following it past Poundsford Farm down to the river Dudwell. A further search was made of both parts of the stream in Green Wood on the south side. In none of the streams searched was there conclusive evidence of ironworking. However, just above the level of limestone in Green Wood, at TQ 637214 on a small watercourse, what may have been a small sample of roasted ore was located. Unfortunately only one piece was found and it had been so permeated by water that it had deteriorated to the point where a positive interpretation could not be made. It resembled roasted ore only by its size and shape.

Searching on the west side of Green Wood, just above the limestone quarries, a bloomery site was located at TQ 6360 2156 with a slag heap covering approximately 40m^2. A brief search produced tap slag and some furnace lining on a fairly prominent slag heap having a level platform at its summit. Green Wood also had a number of charcoal burners' platforms close to one of the streams: TQ 6351 2129, TQ 6357 2135, TQ 6375 2148 (each of 8m diam.), and TQ 6361 2137 (7m diam.).

Two streams on the north side of the Dudwell valley, one originating at TQ 630230 and the other running through Milkhurst Wood from TQ 622228 were also searched. The streams were not traced to their source, but no slag was found in either stream. The geology was similar to that found further east and comprised bands of limestone and mudstone overlain by the Ashdown Beds. Pits for mineral extraction were particularly dense on the east bank of the first stream (starting at TQ

630230) and appeared to coincide with the bands of limestone and Purbeck Beds. One area contained some 18 pits in a 100m stretch of stream bank the most northerly point being at TQ 6298 2225. One sawpit was found at TQ 6295 2210 and two charcoal burners' platforms were noted at TQ 6299 2214 (8m diam.) and TQ 6257 2190 (10m diam.).

CROWHURST FORGE, SURREY – A NEW SITE IDENTIFIED

J. S. HODGKINSON

In his brief will, dated 8th August 1551, Thomas Gaynesford (b.1513), the lord of the manors of Crowhurst and Chellows, bequeathed the bulk of his property to his half-brother, Erasmus, with the rest to his daughter, Anne, and his son, John, the last being mentally incapable.[1] He appointed his brother-in-law, Sir George Harper, as executor and specifically charged him to take possession of his goods and his forge in the parish of Crowhurst until such time as his debts had been paid. Thomas Gaynesford died later in 1551.[2] His wife, Elizabeth, challenged the will and was made executor in Harper's place in 1552, but the other terms of the will remained.[3] On the 26th October 1553, Harper, together with another of Thomas Gaynesford's brothers-in-law, William Ayluphe (or Ayloffe),[4] as administrators, leased to John Cole and Thomas Holewaye (Holloway)[5] of Crowhurst, yeomen, John Tychborne, gent., and Regnold Holmeden, yeoman of Lingfield,

> *"All that fordge & hammersmyth in the p*[ar]*ish of Crowhurst late of Thomas Gaynesford with all manner of houses cottages buildings wayes bayes pondes waters streames & watercourses to the said fordge & hammersmyth belongynge"*

for a term of seven years from the preceding Michaelmas at a half-yearly rent of £80.[6] A supply of charcoal was assured by the "woods trees and underwood" in Hedgecourt Park, in Godstone, Tandridge and East Grinstead parishes for a half-yearly rent of £33 6s. 8d, the land having been purchased by Gaynesford from Sir John Gage on 4th March 1549/50, and possibly indicating when he had established the forge.

In 1554, John Gaynesford's mental state was the subject of an inquisition

to determine whether he was fit to be responsible for his property, the result of which was that his estates were placed in the wardship of the Crown.[7] The inquisition listed the parcels of land he held, including those he held as a tenant (in succession to his father), but made no mention of the forge which was already leased. John Gaynesford died in 1559 and a post-mortem inquisition in May of the following year again made no mention of the forge.[8] In 1560 the Crown relinquished the wardship.

Possible problems with the financing of the forge came to light in 1558 when, in a codicil to his will proved the following year, Thomas Holloway, one of the original lessees, accused Regnold Holmden of failing to contribute his part of the stock of the partnership, and threatening his expulsion therefrom.[9]

Thomas Gaynesford's will, in which he had left most of his estate to his brother, clearly caused considerable friction within the family, with Thomas's daughter and surviving natural heir, Anne, understandably aggrieved.[10] An accommodation was reached between Erasmus and Anne in the form of an agreement of 1st April 1560 whereby Erasmus handed over the manor of Chellows to Anne, keeping the manor of Crowhurst for himself. Erasmus, however, retained the forge despite the fact that it had been in the manor of Chellows.[11] The agreement noted that the forge had formerly been in the hands of John Cole and the other partners (although John Tychborne had been succeeded by Richard Tychborne), and named William Forder, gent, as the tenant of the "fordge or mill". In April 1560, the lease of 1553 still had five months to run, so it is not known how long Forder had been the tenant. The forge was not listed among those recorded by Richard Pedley, the Privy Council messenger, in 1574.[12] When Erasmus Gaynesford died in 1581, he left his capital messuage, Crowhurst Place, to his wife, noting that it and the demesne lands were still in the tenure of William Forder, although making no mention of the forge.[13]

Thomas Gaynesford has not been associated with the iron industry previously, save that he was named on his daughter's decorated cast-iron graveslab in the chancel of Crowhurst Church. She married William

Forster, whose family were also related to the Ayloffes, both being from Essex. John Tychborne, however, was of the family allegedly associated with one of the Cowden furnaces.[14] In his will of 1556 he left Crippenden in Cowden to his son, Richard, although the Crowhurst forge was not mentioned.[15] Sir George Harper also had an interest in ironworks: in 1552, he was the lessee, with Thomas Culpepper, of Vauxhall Furnace and Old Forge, Southborough, south east of Tonbridge.[16]

There are few sites in Crowhurst parish where a forge could have been located, and the transfer of the property from the manor of Chellows to the manor of Crowhurst in 1560 narrows down the potential locations even further. Perhaps the most obvious site is that of a former mill (TQ 4008 4694) shown as active on a map of Crowhurst manor of 1679 (Fig. 1).[17] Somewhat detached from the rest of Crowhurst manor, it lies

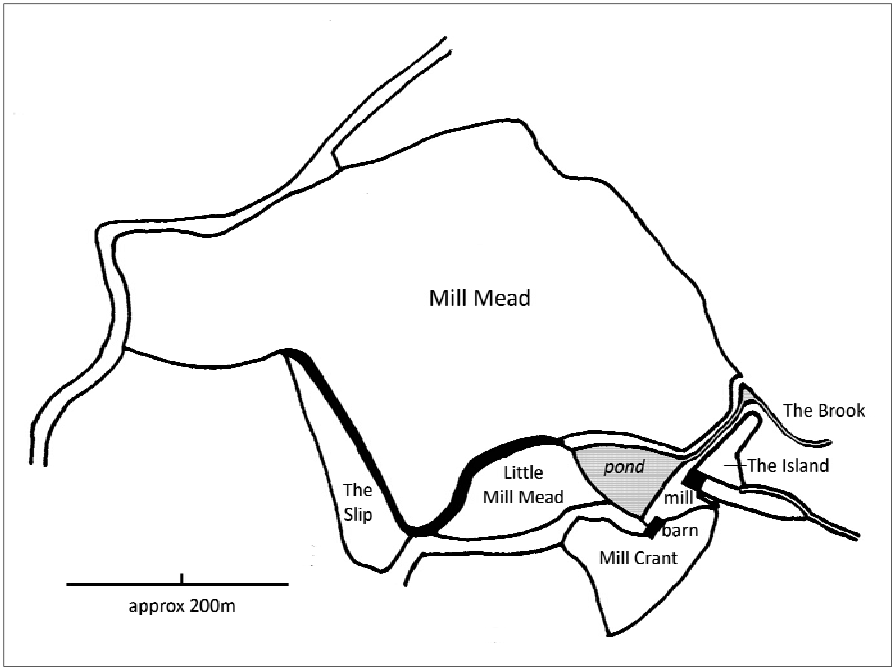


Figure 1 – Crowhurst Mill 1679: probable site of Crowhurst Forge (based on Surrey History Centre, Woking, 6960/1)

adjacent to the lands of Chellows manor as delineated on a map of 1739 (Fig. 2).[18] In a list of the bounds of the manor of Chellows of 1613, Millmead, one of the parcels that formed the mill property is noted as lying just to the north of the manor boundary.[19] The tenant in 1679 was George Holmden, who may have been a descendant of Regnold Holmden, one of the original tenants of the forge.

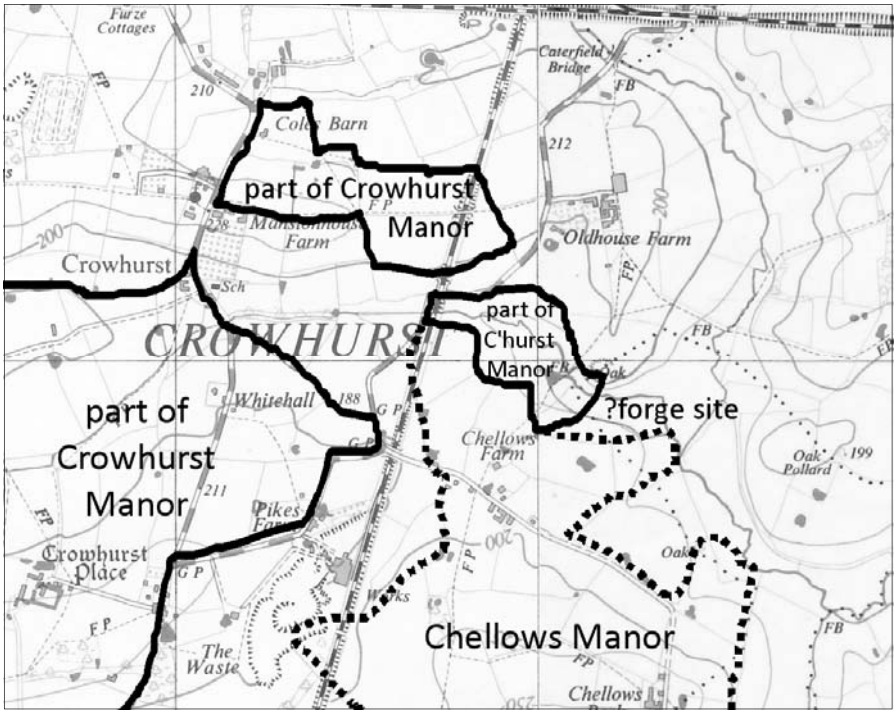


Figure 2 – Parts of the manors of Crowhurst and Chellows 1739 (based on SHC, 204/2/5 and Ordnance Survey 1:25,000 map 1957)

As recorded on the 1679 map, the mill site was unconventionally organised, an arrangement that is still evident on the ground to this day. The mill was fed by a small pond formed by embankments on two sides, and above the south side of the valley whose small stream flows eastwards from south of Crowhurst church towards the River Eden.

However, the water supply for the pond came not from a natural stream that flowed into it but from a leat, about 1.37km long, that was run off a different tributary of the Eden in the north of the parish about 130m upstream of Caterfield Bridge (TQ 4010 4791). Referred to as "The Brook" on the 1679 map, this channel follows the hillside to the east of Oldhouse Farm, parallel to its parent stream, and then curves westwards on the north side of the adjacent valley to a point where it is shown crossing the valley and flowing into the mill pond. There is no evidence of a pond bay across this valley, so it must be assumed that the water was carried on an aqueduct, presumably of wood. While the water supply was clearly adequate for a corn mill, it remains a matter for conjecture whether the demands of a Walloon finery forge with at least three waterwheels, although not all working at once, would have been met. Nevertheless, geophysical detecting over the area described on the 1679 map as "The Island" has enabled a small number of forge bottoms to be discovered.[20]

That a forge existed in Crowhurst from about 1549 until at least 1560 is, on the evidence of four separate documents, indisputable. Its location is less certain. None of the people directly involved in its operation has any other known connection with the iron industry. On this basis it is likely to have been a short-lived venture.

Notes and references

1. The National Archives (hereafter TNA), PROB 11/34/285.
2. Sir George Harper (d.1558) had married Awdre (Audrey), half-sister of Thomas Gaynesford (British Library (hereafter BL), Harl. 897, p. 26.).
3. TNA, PROB 11/35/112; I am indebted to Christopher Whittick for translating the Sentence to Thomas Gaynesford's will, which is in Latin.
4. William Ayloffe, of Hornchurch, Essex, whose sister, Elizabeth (but sometimes named as Agnes or Ann), had married Thomas Gaynesford.
5. Mistranscribed as 'Holerage' by Uvedale Lambert, Surrey History Centre, Woking (hereafter SHC), 3924/11/55.

6. BL, Harleian Charters, 79 F 33; I am indebted to Jeremy Clarke, of the Felbridge & District History Group, for drawing my attention to this document.

7. TNA, C 142/101/111 and E 150/1100/1.

8. Transcribed in Gainsford, W. D., *Annals of the House of Gainsford* (Horncastle, 1909), 53.

9. TNA, PROB 11/42a/528; I am grateful to the staff of the Surrey History Centre for their help in transcribing this document.

10. The statement on the 1591(/2) iron memorial to Anne Forster (née Gaynesford) in Crowhurst church, that she was "daughter and heir to Thomas Gaynesford" shows that it still rankled more than 30 years later.

11. SHC, 2186/30/59.

12. Teesdale, E., 'The 1574 Lists of Ironworks in the Weald: A Re-examination', WIRG *Wealden Iron*, 2nd ser., **6** (1986), 7-41.

13. Transcribed in Webb. C. (ed.), *Archdeaconry Court of Surrey Will Abstracts, Vol. 16: Filed and Unregistered Wills 1572-1581* (West Surrey Family History Society, 1999).

14. Straker, E., *Wealden Iron* (London, Bell, 1931), 226.

15. TNA, PROB 11/39/69. No ironworks are mentioned in this will.

16. Jack, S., 'Sources in the Public Record Office for the History of the Wealden iron industry – Pt. 3', WIRG *Wealden Iron*, 2nd ser. **2** (1982), 23-5.

17. SHC, 6960/1.

18. SHC, 204/2/5.

19. SHC, 204/3/5.

20. I am most grateful to Brian Herbert for his help in locating these relics.

NOTICES OF WEALDEN IRONWORKS IN EARLY ENGLISH NEWSPAPERS

J. S. HODGKINSON

Some years ago a selection of extracts relating to the iron industry from the *Sussex Weekly Advertiser or Lewes Journal* were published in *Wealden Iron*.[1] The British Library has now made available, to readers at its premises and to certain institutional subscribers, scans of several early newspapers and periodicals and the means to search them. Because of the variety of ways references to the iron industry are phrased, and indeed spelled, and given that scanning early printed texts is subject to inconsistencies of letter size and variable inking, designing suitable criteria for searches can never be very precise. Identical searches do not always yield the same results. Searches for the phrases, iron furnace, iron forge, iron mine and iron works, as well as the various spellings of foundry, have yielded several notices relating to ironworking in the Weald which complement those noted earlier. Most are notices of sales and several relate to bankruptcies. Such notices were often repeated in successive editions as well as in other papers; only a single example of each is given below. Original spelling and punctuation have been retained.

The eighteenth century was a precarious time for the furnaces and forges in the Weald, with profitability largely dependent on ordnance production, and forges increasingly reliant on purely local markets for their viability. The vicissitudes of the ordnance trade, and, in particular, the tardy payment by the Board of Ordnance, meant that gun founders were particularly at risk of bankruptcy. The recurrence of notices of particular ironworks reinforces this conclusion.

1. Collection of Improvement of Husbandry and Trade, 22 February 1695

> *Near Pemsey in Sussex is fell'd and felling upward of a Thousand Beeches, many whereof are large. Some are fit for Keels for Ships; some for Plank, Stoks, and some for Bellows-Boards us'd at the Iron Works, and some for other uses. Such as desire to buy all or Part, may enquire of Mr Richard Pope at the Blackmoor's Head in Southwark, or of Mr. Thomas Rowe Bayliff of Pemsey aforesaid.*

The particular mention of bellows boards for ironworks is testament to the continuing importance of the iron industry in the South East in the late seventeenth century, and also an indication of the specific demand for scantling that their use implied. Half a century earlier Sir James Hope had noted that the bellows at Barden furnace measured thirteen or fourteen feet long, and two feet across at their widest end.[2] If boards of 2 ft. (0.6m) x 14 ft. (4.2m) were required, only certain trees would have been suitable.

2. London Gazette, 22-25 March 1708

> *Whereas Notice was given in the Gazette of the 15th of January last, That a Freehold-Estate in Rotherfield and Wytheham in Sussex, within 3 Miles of Tunbridge-Wells, consisting of a large New built Brick-House, called Birchden-Place, pleasantly situated with a small Park or Padock and Warren, and several Farms, and about 650 Acres of Wood-Land, with great quantities of Timber and Under-woods now fellable; also a Furnace and Forge for Iron-works well supplied with Water, being the Estate of Mr. Robert Baker, was to be sold; Particulars of which were to be had of Mr. John Baker, Haberdasher on Fish-street Hill, Mr. Bember in Billiter Square, London, Mr. George Hooper of Mayfield in Sussex, and Mr. John Hooker of East-Peckham in Kent. The Assignees under the Commission of Bankrupt against said Baker, give Notice, That they; with the acting Commissioners, will meet at the Irish-Chamber in Guildhall,*

London, on Thursday and Friday the 1st and 2nd Days of April next, at 3 in the Afternoon of […] day, to treat and agree for Sale of the said Estate together, or in Parcels; Particulars may, in the mean time, be had at the Places aforesaid.

The entry in the *London Gazette* for 12-15 January 1708, referred to at the beginning of this notice, gives the same information but in less detail, so has been omitted. Robert Baker, whose family had held Birchden for nearly a century, was first declared bankrupt in June 1705 but complications with the first assignees meant that a new commission had to be put in place, which delayed the disposal of the estate. An inventory of Robert Baker's ironworks at Hamsell and Birchden at the time was published in *Wealden Iron* in 1983.[3]

3. Post Boy, 16-19 June 1711

To be Sold, the Manors of Birchden and Oresnarsh, Sussex, consisting of several Farms, about 350l. per Ann. whereupon is a large Brick-House, Coach-House, Stables, and Out-Houses, lately built, good Gardens, and Orchards, with a Paddock for Deer, new Paled, a Furnace and Forge for Iron Works, with plenty of Water, several Fish-Ponds, and River well stored with Fish, between 6 and 700 Acres of Coppice, or Wood-ground, with a good quantity of Timber, great part of it fellible, all near the said Furnace and Forge, within Three Miles of Tunbridge-Wells. Farther Particulars may be had of Mr. Rich. Baker, and Mr. George Hooper, of Mayfield, in Sussex, and of Mr. Robert Bicknell, at his Chambers in the Inner-Temple, London.

Baker, Hooper and Bicknell remained in possession of the Birchden estate after 1711.[4] There is no indication as to who worked the furnace and forge at this time. In 1739, the manor and its ironworks were purchased by William Harrison, merchant and gunfounder.[5]

4. Weekly Journal or Saturday's Post, 5 March 1720

> *Whereas William Bowen, Iron-Founder, did, in April last, leave off his Trade, by Reason of his then ill State of Health; and now having erected a Foundery at Marigold Stairs on the upper Ground, near the Faulcon in Southwark; he there makes and sells all sorts of Cast Iron Works, viz. Boxes for Coach, Cart and Waggon Wheels, Plates and Nails for Paper Mills, Banisters, Balls, Aqua Fortis Pots, Pans, Cockles, Stows, Anvills, Rowls, Cross-Bar and Round Shot, Backs for Chimneys, with all Sorts of Cast Iron Work for Refiners and Chymists, or any Piece of Work made to any Model, in a short Time, and at very reasonable Rates. His Prices not being proper to mention in this or any other publick Paper; he doubts not but those Persons who will favour him with their Custom once, of giving them such a Satisfaction, both in Goodness and Price, as may continue them his constant Customers.*

William Bowen would subsequently occupy the ironworks at Barden, in Bidborough, and at Cowden, and a house at Southborough.[6] He leased the site at Marigold Stairs, which would have been located next to where Blackfriars Bridge was subsequently built, from the Edward Edwardes Charity, renewing the lease in 1722.[7] The foundry he erected in 1720 would have been an air furnace, i.e. one where the heat was obtained by a natural draught rather than by the use of bellows. These would have been ideal for urban settings as no water supply was required. Bowen, together with Anthony Ireland jun., had, in 1717, advertised similar products for sale at White Fryers Dock, on the north bank of the Thames (near the modern Blackfriars Pier).[8] Other foundries on the southern shore of the River Thames, at Bankside and Vauxhall, were also noted in papers of this period, advertising similar products.

5. Daily Courant, 12 December 1732

> *To be Lett*
> *On very easy Terms for three Years,*
> *To be entered upon immediately,*
> *The Furnace and Forge late of James Nicol Esq; in Montfield near Battle in Sussex. Enquire for Particulars of Mr William Hancock, Attorney in Abchurch Lane; or Mr William Nicol, of Montfield aforesaid.*
> *N. B. There is Plenty of Wood and Iron Mine to be had cheap and with great Conveniency.*

This notice relates to the Darwell ironworks in Mountfield (see also below, 1742). Ambrose Crowley leased the works shortly before 1739,[9] retaining them until at least the end of the next decade, so it is not known whether these works were let at this time. The period of the proposed tenancy seems unusually short, suggesting that the three years were for the uncompleted term of a longer agreement. The clear reference to a forge confirms the dual use first mentioned in the 16th century.[10]

6. General Evening Post, 29 November – 2 December 1735

> *A few days since died of a Mortification in his Leg, at Burwash in Sussex, Thomas Hussey, Esq; one of the three Gentlemen nominated for Sheriffs of that County for the ensuing Year. He was a Gentleman of very fair Character, and concerned in a great Iron Foundary in that Place; he had just finished a Family Vault, where his Wife was buried a few Months since, and he had cast the iron Rails to set round the same, which are not yet put up.*

Worcestershire born, Thomas Hussey had risen from being clerk at Ashburnham ironworks in the early 1700s to leaseholder and ironmaster of several furnaces and forges, in partnership with John Legas, William Harrison, William Jukes and Maximilian Gott.[11] Hussey had married Frances Lake (bur. 16 Nov 1734), of Goudhurst, whose younger sister,

Elizabeth, was Gott's second wife. Hussey's grandson, Edward, was to purchase Scotney Castle from the Darrells, his descendants living there until 1970.

7. London Evening Post, 17-19 April 1740

> *To be Lett, at Midsummer next,*
> *An Iron Forge or Hammer at Paddington in the Parish of Abinger in the County of Surrey. Enquire of Mr. Sherwood, Attorney, at his House in Dorking in Surrey.*

Abinger Hammer lay within the manor of Paddington, which belonged to the Evelyn family of Wootton. A Mr Dibble was in occupation during the first few decades of the eighteenth century and a Mr Delonsae was paying the Poor Rate for the works in 1734, but it is not known who acquired the lease of the forge at this time.[12]

8. London Evening Post, 15-17 April 1742

> *To be Sold*
> *A Farm in Westfield, in the County of Sussex, at the yearly Rent of 25l. besides the profits arising from Iron Ore.*
> *Particulars may be had of Mr. Calverley, in Three Crown Court, Southwark.*

The nearest active blast furnace to Westfield at this time would have been Brede, operated by William Harrison.[13]

9. London Gazette, 14-18 September 1742

> *To be sold the great Darvell Iron Works, near Battel, in the County of Sussex: A Freehold Estate consisting of a furnace for casting Cannon, &c. Let on Lease; An Iron Forge with all manner of Conveniencies, and several Houses for Workmen; with a Farm of near an Hundred Acres, also on Lease; And about a*

Thousand Acres of Woodland well stocked with Timber; The whole lying together within Ten Miles of the Sea, and of between three and four Hundred Pounds yearly Value. Enquire of Mr. Whitchurch, Attorney in Threadneedle-street, London.

Unlike the previous notice relating to these works (see above, 1732), the sale on this occasion was for the freehold. Josiah Wordsworth, a London ironmonger, then a partner of William Harrison, contemplated purchase at this time but did not proceed.[14] Ambrose Crowley may have remained the lessee at this time, the works subsequently being leased by John Churchill.[15] A deed of 1793 implies that the Nicoll family, of Court Lodge, Mountfield, retained the freehold of Darvell furnace and that the sale advertised here never took place.[16]

10. London Evening Post, 22-23 August 1747

To be Lett

And enter'd upon immediately

An old and well accustom'd Forge Hammer, in very good Repair, known by the name of Woodcock Iron Forge; it is very conveniently situated in the Parish of Godstone in the County of Surrey, about 26 Miles from London; it has upwards of fourscore Acres of Water to work it, and will be lett with or without 500 Acres of Wood-Land.

For further Particulars enquire of Edw. Evelyn, Esq; at Felbridge in the Parish of Godstone, Surrey.

N. B. There is some ready-work'd Iron to be sold.

Since at least 1742, the forge had been in the hands of Samuel Baker, and he may have continued to operate the forge as a sub-tenant, the works being let to Sir John Evelyn by the executors of William Gage, whose family had owned the site since it was built in the 1560s.[17] Sir John's kinsman, Edward Evelyn, purchased the estate from the Gages in 1748.

11. Gazette and Daily Advertiser, 29 October 1765

To be Sold by Auction by Mr. Harding
By order of the Assignees of Mess. Master and Raby,
On the premises, on Monday the 4th of November, and the three following days, at their late farm house, forges, and furnaces for casting of canon &c. near East Grinstead, in Sussex, and at New Chapel in Surrey, near the aforesaid place,

All the genuine and entire remaining stock and utensils in trade; consisting of upwards of 20 pair of forge bellows; some bar and rolled iron, square, and other steel, wagon and cart boxes, iron pots, anvils, maundrells, bick irons, sheers, forge, sledge and other hammers; a large parcel of nailing and slitting tools. old wrought and cast iron, boreing bars, pump rods, pullies, blocks, ropes, several iron beams, scales, and weights, and great variety of gun, and other patterns, moulds, &c. a parcel of winds or bricks, and tiles, saw plates, spindles cans, iron chain rowl barrels; a large parcel of charcoal and ore, sacks, baskets, wheelbarrows, second-hand guns, grindstones, and variety of other utensils in the forge and furnace way; some ricks of hay, oats, waggons, carts, &c. Together with all the household furniture, linen, china, &c. consisting of good beds and bedding, mahogany and walnut-tree chairs, tables, buroes, desks, book-case, glass doors, a smoak-jack, two coppers, an iron furnace, a Dutch oven, a cider mill and press; a garden seat, and some kitchen furniture; a large parcel iron-bound beer casks, and brewing utensils, &c.

The whole to be viewed on Thursday next, and till the time of sale which will begin at ten o'clock precisely each day. The household goods to be sold the first day's sale.

Catalogues to be had at the Greyhound at Croydon; the Bell at Godstone; the Cat at East Greenstead; the White-hart at Lewes; the Castle at Brighthelmstone; the Bull at Kingston; the White-lion at Cobham; the George at Godalming; the Crown at Guilford; at the place of sale; at the Rainbow coffee-house in Cornhill; and of Mr. Robert Harding, Sworn Exchange Broker

and Auctioneer, in the Minories, London.

Edward Raby and Alexander Master had started in partnership as ironmongers in West Smithfield, London, and had acquired a lease of Warren Furnace and Woodcock Hammer in about 1758. Their ordnance business in Sussex is well documented.[18] What this notice reveals is the extent of the stock at a Wealden furnace and forge of the period, and, by implication, the range of manufacturing processes that were undertaken there. The 20 pairs of forge bellows alone testify to intensive working. A forge with two fineries would require six pairs of bellows at any one time. Spare pairs for each hearth, and broken pairs or those undergoing repair might account for the rest. The existence of nailing and slitting tools is evidence of secondary processes that have largely been absent from records of Wealden forges, giving the impression of a regional industry that did not diversify. Woodcock Hammer became a wire-mill late in the very late eighteenth century after indigenous iron production in the district had ceased; this evidence suggests that it may have already been tooled up for such operation more than 30 years earlier.

What is also apparent from this and other ironworks described in these notices is the, at least partial, attempt at self sufficiency in these operations. The presence of farm stock with the ironworking tackle, both here and at Darvell, mentioned above, reveal such works as much more than mere industrial plant, but as a community in which the workforce needed to be sustained.

The sale of Master's and Raby's stock in the Weald had been preceded by similar sales at their premises in Smithfield and in Southwark. The winding up of their bankruptcy took the best part of ten years, by which time Raby had died, but it had not prevented Raby, at least, re-commencing his business at the Warren furnace the year after the above sale, the lease presumably remaining unexpired.

12. St James's Chronicle & The British Evening Post, 19-21 July 1768

To be Sold, together or in Parcels, the following Estates in the County of Sussex, viz.

In the Parish of Chiddingly, a Farm, called Chiddinglye-Place Farm, containing 218 Acres, In Tenure of Peter Pelling; also 38 Acres of Wood-land thereto adjoining. A Farm called Hilder's Farm, containing 164 Acres, in Tenure of Thomas Hicks; and 18 Acres of Wood-land thereto adjoining.

In the Parishes of Ripe and Firle, a Farm, containing 211 Acres, in Tenure of John Erle.

In the Parish of Mayfield, a Farm, called Batt's Wood and Forge-Land Farm, containing 180 Acres, in Tenure of David Collins; also 453 Acres of good growing Woodlands, contiguous to the above, and well planted with Timber. Also an Iron Forge, called Bivelham Forge, late in the Tenure of the Assignees of Richard Tapsell. Also the Manor of Bivelham, extending into the Parishes of Mayfield and Wadhurst, and consisting of many copyhold Tenements, subject to Fines at the Lord's Will, Heriots, &c. and annual Quit Rents, in the whole, of 13l. 10s. 6d. Halfpenny.

The above Estates are all Freehold, except about seven Acres in the Parish of Ripe. The Farms are all lett to Tenants at Will upon very old Rents, and are capable of considerable Improvement.

For further Particulars enquire of Mr. Baley, in Clare -court, London; or at Halland, Sussex.

Richard Tapsell had succeeded John Legas in 1752, and the profitable demand for ordnance that the Seven Years' War stimulated sustained his partnership with William Harrison's sons and Robert Bagshaw, which had formally come to an end in 1757, until the end of hostilities in 1763. Following the decline in orders thereafter, Tapsell mismanaged the Sussex works that had come into his hands and, despite the fortune that Legas had accumulated, became over-indebted and fell into bankruptcy. All of the former partnership's ironworks, at Lamberhurst, Waldron, Brede, Beckley, Hawksden, Bivelham and Westfield, either ceased to operate or had to be leased to new tenants.[19] The Glynde estate papers show that David Collins had the tenancy of the forge from this time.[20] A later notice of sale was reported in the papers of the time, including the

Sussex Weekly Advertiser, in late 1770.[21]

13. General Evening Post, 5-7 May 1772

> *Iron Works*
> *To be Lett,*
> *And entered on immediately, or at Michaelmas next,*
> *The Warren Furnace, together with two Forges contiguous upon the same stream. The said works are situated upon the borders of the counties of Surry and Sussex, about 27 miles from London, and three miles from East-Grinstead, on an excellent good turnpike-road. In the year 1758 the landlord expended on the premises upwards of 800l. The said works were occupied until Lady-day last, when they were suddenly quitted, and left on the landlord's hands.*
>
> *A good Farm and House, adjacent to the premises, may be had with them if required; and they also are very capable of being easily converted to the use of any business that requires water and water-wheels, and spacious room under cover.*
>
> *For further particulars inquire at Felbridge, near East -Grinstead; or of Mr. Wakeham, East-Grinstead, in Sussex.*

Edward Raby, who had occupied the Warren Furnace and Woodcock Hammer since 1758, and whose bankruptcy has been noted above, managed to re-commence ironworking at the sites after a short interval until his death in 1771. His son, Alexander, took over temporarily but clearly abandoned the attempt abruptly. The investment by the landlord, James Evelyn, was not lost, the works being taken on by Joseph Wright and Thomas Prickett.

In light of the variety of equipment listed in the advertisement for sale of the forge in 1765, above, the reference to two forges may suggest both a Walloon (i.e. finery/chafery) forge and a separate slitting and rolling mill. The farm and house referred to are likely to be Felcot Farm, where a previous owner found much debris associated with ironmaking.[22]

14. Middlesex Journal or Universal Evening Post, 6-8 October 1772

> *Lately has been discovered, near Horsmonden church, on the estate of – Merrick, Esq. an iron mine, for the vein of which workmen are now digging, and expect to find out. Several broken pieces have been discovered already; and these, upon trial, have been found to produce 13 ounces of solid iron from 16 ounces of ore.*

15. Lloyd's Evening Post, 3-5 March 1773

> *They write from Lamberhurst, that the Iron mine lately discovered, near Horsmonden church, turns out to the best advantage; and that a Foundery is going to be erected in the neighbourhood for the working thereof.*

The quality of this ore was in excess of 80%, far above the normal yield for Wealden siderite ironstone. Horsmonden Furnace had long ceased being used to smelt iron, its last function being a boring mill for the gun foundries of John Legas and William Harrison in the 1740s and early 50s. Lamberhurst, the nearest working furnace at this time, had recently been let, but there is no evidence that any other works were established in the area at this time.

16. Daily Advertiser, 2 July 1774

> *To be sold, all that Messuage or Tenement, Farm Lands and Premises, called the Princle Farm, situate in the Parish of Wartling, in Sussex, and contains by Estimation 80 Acres, more or less; and also that Farm Lands and premises called Chilthurst, situate in the Parishes of Hurstmonceux and Wartling aforesaid, and adjoining to the Princle Farm, and contains by Estimation 103 Acres, more or less, and now in the occupation of Wm. Newman, who holds the said Premises under Lease, which will expire on Lady-Day 1779. The tenant will shew the premises. The*

above Farms are well stocked with young Timber, and there is a large Quantity of Iron Mine which may be dug thereon. For Particulars enquire of Wm. Mercer, Esq. of Hawkhurst, in Kent; Mr. Wm, Grayling, of East-bourn; Mr. Rapley, of Dallington; Mess. Nairn and Wise, of Battle, in Sussex; and Mr. Isaac Bargrave, of Gate-Street, Lincoln's Inn Fields.

Prinkle Farm lies south east of Bodle Street Green, on a ridge capped with Wadhurst Clay. Another clay-capped ridge runs south from Bodle Street towards Windmill Hill; Chilthurst formerly occupied a site where the ridge ends at the Pebsham Stream. Despite the late date, the presence of iron was seen as a saleable commodity. Ashburnham was probably the only surviving furnace within economic reach of this source or iron.

17. Gazetteer and Daily News Advertiser, 6 November 1777

To be Sold by Private Contract

The Lease of an Iron Forge and Wire Mill, situated at Abinger, near Dorking, in Surry.

For particulars apply to Mr. Richard Crawshay, London; Mr. Samuel Ayling, Petworth; or Mr. James Goodyer, Gildford.

18. Morning Chronicle and London Advertiser, 26th December 1778

Sales by Auction

By Mr. Harding By Order of the Assignees of James Goodyer, late of Guildford, in the county of Surry, Ironmonger, a Bankrupt On Wednesday the 6th of January And the following Day Brought, for convenience of sale, to Mr. Harding's Sale Warehouse, at 69 in the Minories; at Mess. Crawshaw and Co's Warehouse at Bull-wharf; and Iron-yard at St Paul's wharf, Upper Thames-street;

All the remaining part of his Stock and Utensils in Trade: Consisting of jack bar, iron, share mould, horse shoe

ditto, salamander ditto, sodering and fagotting iron; English squares, Bath stove metal, sundry cast-iron plates, four large casks of iron wire and flat steel and slit rod wire, iron plate, hooks and hinges, rose, cap, house and clout nail, bullen tacks, &c. garnet, hammers, five iron and brass door locks, cupboard and rill ditto, padlocks, gunlocks, shovels, spades, shovel pans, emory, cast iron boxes and patten rings, sash and jack lines, brass and iron rod bolts, sundry cabinet work, 8 pair furnace forge and smiths bellows, anvils, a large iron beam, and stilliards, a turning latch and sundry sorts of other Ironmongery ware.

Also a Patent granted to the said James Goodyer for the making of steel from Cast or Pig Iron, which remains in force until the 20th of December 1785.

The whole to be viewed on Monday the 4th of January, and till the time of sale, which will begin at twelve o'clock precisely.

Catalogues to be had the days of viewing at the Rainbow coffee-house, Cornhill; at Mess. Crawshaw and Co. Thames-street; and at the place of sale.

The Patent will be put up to sale at One o'clock precisely on the First day's sale.

James Goodyer, whose works were in Castle Street, Guildford, had been in occupation at Abinger Hammer since 1756 but the sale of the lease in 1777 coincides with his bankruptcy, for which Crawshay, who was later prominent in the iron industry in South Wales, was one of his assignees. A wire mill has not been noted before at Abinger and may have been established by Goodyer in connection with his ironmongery business in Guildford. He also ran North Park Furnace, at Fernhurst, from 1769, and Pophole Hammer near Haslemere, both of which had been put up for sale in January 1777.[23] His steel-making patent has been discussed elsewhere.[24]

19. Lloyd's Evening Post and British Chronicle, 12-14 September 1781

> *To be Lett,*
> *And entered upon at Lady-day next,*
> *All that Furnace, called Lamberhurst Furnace, with the Boreing-house, Work-shops, and all other Conveniences belonging to a Furnace; together with a good Dwelling-house, Gardens, Stables, Hay-Lofts, and Seven Acres of very good Meadow-Land.*
> *The above Premises are in good Repair, and well supplied with Water, situate in the Parish of Lamberhurst,* in the *County of Sussex, and in the Possession of Mess. Wright and Prickett.*
> *For further Particulars apply to Edmund Chitterden, at Northiam, in Sussex; or John Barling, Attorney, at Feversham, In Kent.*

Wright and Prickett, who were based at the Falcon Foundry in Southwark, had previously leased North Park Furnace at Fernhurst until 1769, and had then taken on Gloucester Furnace, Lamberhurst, and Warren Furnace, Worth, as noted above.[25] At Lamberhurst they cast some iron mortars for service at Gibraltar.[26] Prickett was to remain at Lamberhurst, occupying Hoadley Farm, from where the new tenants, William Collens and George Mathews, sought to obtain supplies of iron ore.[27] In 1782 Collens, of Brenchley, tendered for orders from the Board of Ordnance for guns cast from solid (a requirement since 1775), and payment for 25 18-pounders was authorised in 1784. However, there is some doubt as to whether the guns in question were actually cast at Lamberhurst, the George Mathews who was Collens's partner being active in the iron trade at Calcutts in Shropshire.[28] When Sir John Filmer was re-acquiring the Lamberhurst furnace site from the descendants of the Gotts in 1795, Thomas Prickett wrote to him that, although Collens had occupied the site for eleven or twelve years, the furnace had only been in blast for about five months during that time.[29]

The use of horses for most haulage at ironworks necessitated the

provision of appropriate accommodation for them, and the means for feeding them; hence the advertising of stabling and meadow.

References

1. Hodgkinson, J. S., 'Some extracts from The Sussex Weekly Advertiser, 1772-5', WIRG *Wealden Iron* (hereafter *WI*), 2nd Series, **1** (1981), 14-16; 'The Sussex Weekly Advertiser – Some extracts', *WI*, 2nd Series, **2** (1982), 30-6; 'The Sussex Weekly Advertiser - further extracts relating to the iron industry', *WI*, 2nd Series, **21** (2001), 27-30.
2. Marshall, P., 'The Diary of Sir James Hope', *Miscellany of the Scottish History Society vol. 9* (Edinburgh, Constable, 1958), 147.
3. Dalton, A., 'Inventory of the ironworks at Hamsell in 1708', *WI*, 2nd ser., **3** (1983), 8 -11.
4. East Sussex Record Office, Lewes (hereafter ESRO), KIR15/1.
5. Dunkin, E. H. W., *Sussex Manors, Advowsons, etc*., (Lewes, Sussex Record Society vol. 19, 1914), 42.
6. Hodgkinson, J. S., The Wealden iron industry in the period of the Seven Years' War, 1750-1770 (University of Brighton MA dissertation, 1993); http:// wealdeniron.org.uk/Thesis/Appendix%201.pdf, pp.96-7.
7. Southwark Local Studies Library, 8287.
8. *Post Man and the Historical Account*, August 15-17, 1717.
9. King, P. W., 'Ashburnham furnace in the early 18th century', *Sussex Archaeological Collections*, **133** (1995), 260.
10. Cleere, H. F. & Crossley, D. W., *The Iron Industry of the Weald* (2nd. ed. Cardiff, Merton Priory Press, 1995), 328.
11. Hodgkinson, J. S., 'The Legas – Remnant Letters', *WI*, 2nd Series, **29 (**2009), 22.
12. Cleere & Crossley, 382.
13. Cleere & Crossley, 318.
14. Hodgkinson, Legas-Remnant Letters, 27.
15. Hodgkinson, Dissertation; http://wealdeniron.org.uk/thesis.htm#7YW), 99.
16. ESRO, SAS/G34/127-128.
17. Cleere & Crossley, 392. Surrey History Centre, Woking, Box 3151/2.

18. Hodgkinson, J. S., 'The Raby Background: The Midlands, London and the Weald', in Crocker, G. (ed.), *Alexander Raby, Ironmaster* (Guildford, Surrey Industrial History Group, 2000), 1-8.
19. Hodgkinson, J. S., 'The decline in the ordnance trade in the Weald- the Seven Years' War and its aftermath', *Sussex Archaeological Collections*, **134** (1996), 163-4
20. ESRO, GLY2825-2847.
21. Hodgkinson, Sussex Weekly Advertiser, 1982, 34-5.
22. The late K. Housman (pers. comm.)
23. Hodgkinson, Sussex Weekly Advertiser, 1982, 35.
24. Hodgkinson, J. S., 'A Wealden steel making patent', *WI*, 2nd Series, **16** (1996), 9-12.
25. Brown, R. R., 'Wealden ironmasters and the Board of Ordnance after 1770', *WI*, 2nd ser., **14** (1994), 33.
26. Brown, R. R., 'Mortars cast for Gibraltar', *WI*, 2nd ser., **21** (2001), 31-5.
27. Melling, E. (ed.), *Kentish Sources III. Aspects of Agriculture and Industry* (Maidstone, Kent County Council, 1961), 99.
28. Brown, 1994, 42-3.
29. Centre for Kentish Studies, Maidstone, U840 EB317.

THE LOCATION OF ETCHINGHAM FORGE

BRIAN HERBERT AND TIM CORNISH

For over a century cartographers placed Etchingham Forge to the S of the railway from Hastings to London. The modern O.S. 1:25,000 map has followed this tradition, along with Straker[1] and Cleere & Crossley.[2] They have placed the forge at TQ 701266 near Forge Cottages (Forge House), and their Gazetteer entries cast doubt on whether a bay ever existed, since the railway passes through the site. The pond "if any", they say, is dry and the working area has "some incomprehensible banks". Recent fieldwork has shown that the working area of the site has been misplaced and was N of the railway, which runs through the pond. In fact, Etchingham Women's Institute identified the location correctly in their 1957 pamphlet.

The forge had an operational history of about 200 years, being mentioned in records from 1521 until Budgen's map of 1724. The forge was owned by the Tyrwhitt family and it seems likely that pigs and sows came from their furnace at Darwell. There is a later connection with the Pelham furnace at Waldron. The forge produced 50 tons of iron in 1717. Christopher Whittick's discovery in the Huntington Library in California shows how extensive were the buildings. The 1773 account reads: "*Messuage, iron-forge and mill at Etchingham and the outhouses, storehouses, warehouses and buildings belonging to it."* There is also reference to the water system: "*Land covered with water and ponds...and all waters, watercourses, sluices and easements."*[3] The hammer and anvil from the forge are preserved at Anne of Cleves House in Lewes. Straker says that the 1549 commission placed Etchingham "*within 5 miles of the salt water"*, which refers to the tidal limit of the Rother at Bodiam.

THE SITE

The true position of the forge is N of the railway at TQ 7016 2667. The working area is adjacent to a semi-circular bay reinforced with forge bottoms that has allowed a small, silted and overgrown pond to survive. The pond is estimated at an acre in extent. There are two anomalous banks, at right-angles to the main bay, stretching towards the railway and apparently associated with the latter's construction. There is a low area just S of the railway which is probably a remnant of the pond. The pond level is c.7.25m above the Rother water level, with the finery, chafery and hammer located in a restricted area between the pond, river and tail race. The pond bay is 12m from the Rother and vulnerable to flooding, although the river is still embanked in places. Two semicircular brick culverts can be seen between the pond and the Rother: the E culvert takes water under the railway to the tail race.

There are many forge bottoms around the working area and near the tail race S of the river. This race is initially embanked, and continues for 850m before joining the Rother downstream from the road bridge on Church Hill. A few metres beyond the start of the tail race an unexplained narrow cut allows some water from the Rother, to the N, to flow into the tail race. Around 1957 Etchingham Women's Institute published a pamphlet (available in Barbican House Library, Lewes) which gives the tail race the name 'Hammer Dyke'. They reported:

> *"The bank surrounding the pond has been levelled but the site of the forge, north of the railway, between the dyke and the main stream (now less in volume than the dyke), can be plainly recognised from the quantities of pieces of iron slag that can be picked up there. An interesting feature that was noticed when the site was visited on March 2nd 1957, is the height to which the bank has risen owing to the overflow of the stream. A dark line of pieces of slag can be seen at a distance of about three feet below the present level of the bank."* (Etchingham Village Records)

These pieces of slag are forge bottoms, some of which have become detached by erosion and have fallen into this narrow cut relatively recently.

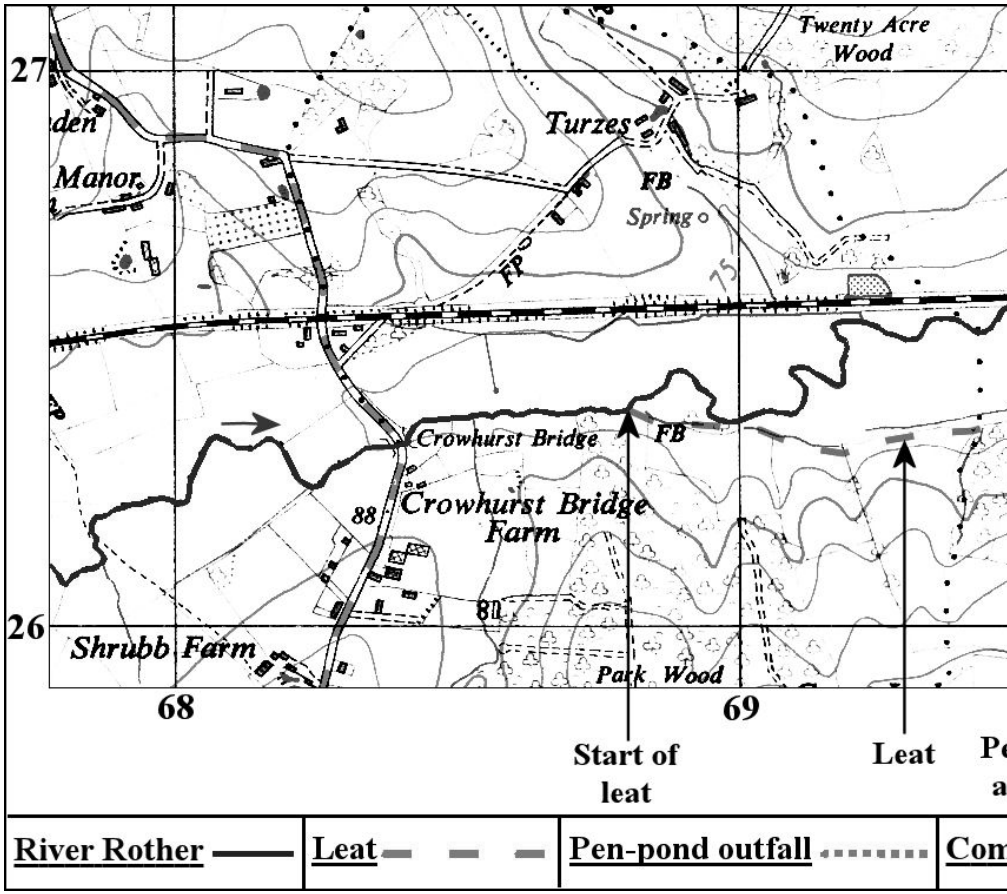
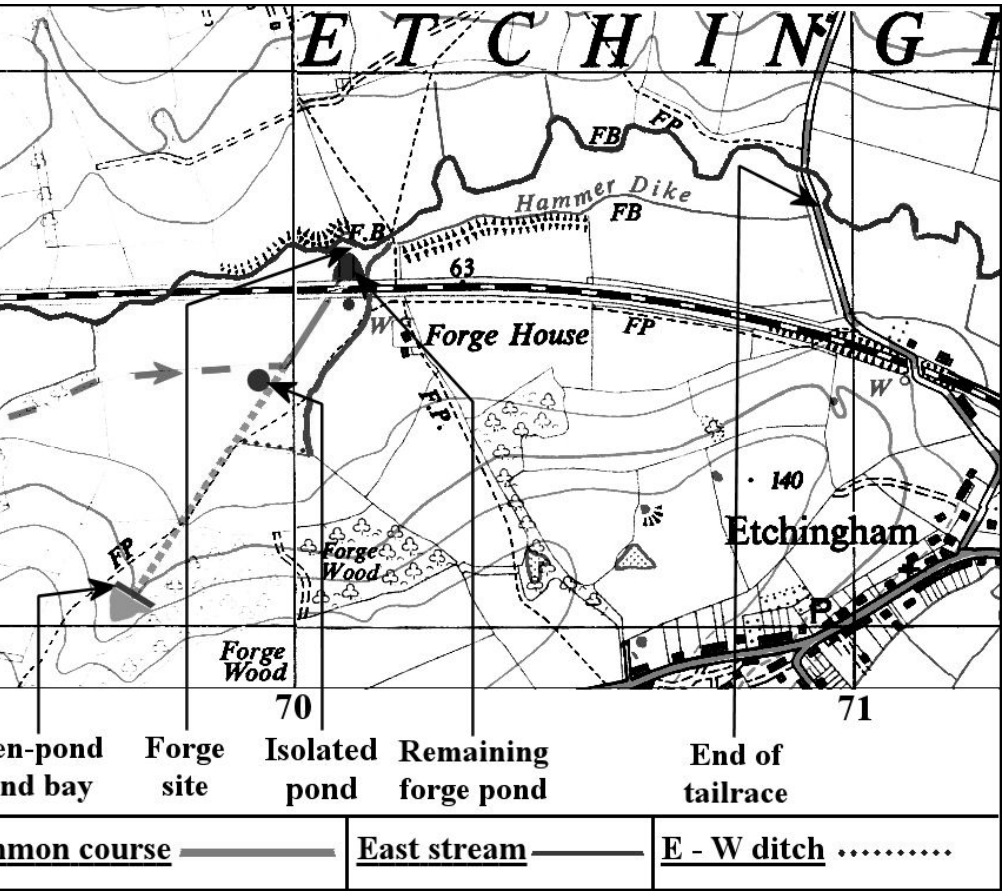


Figure 1 – Map showing the location and watercourses associated wit



h Etchingham Forge (based on Ordnance Survey 1:25,000 map 1959)

WATER SOURCES

The siting of Etchingham Forge, in the bottom of the wide, flat valley of the Rother, provided a water supply at a workable head to drive the water wheels. Returning the water to the river without backing up was important. The water arrangements for this are complex and extensive. It is possible that the siting of the forge was influenced by the prior existence of a straight cut, perhaps dug for medieval navigation, which was used as the forge tail race. It is a substantial watercourse that rejoins the main river 800m E of the Church Hill road. Mark Gardiner has discovered evidence of medieval navigation in a 1325/6 account for the delivery of a millstone by water to Bivelham, 8km upstream.[4] There is evidence for the straightening of the course of the Rother which is difficult to date.

The most extensive and expensive part of developing the forge would have been the construction of the leat which took water from the main river 850m upstream of the site, to give sufficient head to drive the wheels. The leat is delineated on the Etchingham tithe map (1840s) and on the earlier map drawn by John Rennie in 1813 for the planned Rother Canal.[5] However, the survey shows a line which it would not now be possible for the leat to follow. The leat left the Rother 430m downstream from Crowhurst Bridge. It started behind a dam set within the deeply-incised Rother, at that point c.3m deep and 3-4m wide: the flood plain is too wide for a bay across the valley. Vertical stakes and a horizontal timber just below the water level (seen in a time of drought in May 2011) probably show the last vestiges of the dam, which would have been as high as the river bank. The first few metres of the leat show only as a slight depression beside some bushes, due to many years of flooding. The leat gradually becomes deeper as it approaches the S edge of the flood plain and then follows a course E along the transition between flood plain and hillside, allowing it to escape floodwater erosion. For most of its course the leat is cut into the gently rising hillside to the S, with the waste being thrown aside to raise the leat's lower bank. Its course follows the N boundary of Park Wood, thence to the N side of Sweetmeadow Coppice: a length, so far, of 900m. The penultimate section of leat is well hidden

for 310m, within a hedgerow where the hillside has been dug into, to eliminate the need for a deep cut. The leat is, initially, up to 1m wide but of unknown depth. This eastward course of the leat abruptly changes to a straight course flowing NE across the floodplain for 170m, under the railway, to fill the forge pond.

At this junction, the leat becomes much wider (3m), dug like a canal. This wide channel can be traced SW, still following a straight course, to the NW corner of Forge Wood, where it is fed by a small stream. This long, wide water supply channel can be explained by the discovery of a pen-pond at TQ 6973 2608. The bay is quite distinct although no water-control mechanism remains, but the outflow water channel indicates water erosion. The water flows for 640m to the forge pond via the same straight, wide watercourse that the leat finally follows.

The E stream is c.2m wide, suggesting that it has been especially dug out, as it only comes a short distance down the hillside. This might be explained by the deep, E-W ditch between the 'straight watercourse' and E stream allowing excess water to pass into the E stream that is culverted under the railway, thence into the tail race, so producing a spillway for the forge.

One further anomaly is a small pond on the S side of the leat where it flows into the straight watercourse, as shown on the map (Fig 1).

It has been clear in this fieldwork that understanding the former pattern of water supply and disposal is crucial for the identification of the features of ironworking sites. Destruction by works on the scale of railway building can lead to misunderstanding, and dating of watercourse engineering is difficult. However, much work remains, particularly in view of new knowledge of medieval navigation in the upper reaches of the Rother, which until recently was considered impossible.

References

1. Straker, E., *Wealden Iron* (London, Bell, 1931), 298.
2. Cleere, H. & Crossley, D., *The Iron Industry of the Weald* (Cardiff, Merton Priory Press, 1995), 330.
3. Whittick, C., 1992, 'Wealden iron in California', WIRG *Wealden Iron*, 2nd Series (1992), **12**, 41.
4. The National Archives, SC6/1148/13.
5. East Sussex Record Office, QDP/50 or ASH/4409.

MODELLING BUSINESS PERFORMANCE OF A MID 18TH-CENTURY CANNON MANUFACTURER

ALAN F. DAVIES

Introduction

Even though historical iron cannon-making technology is widely described, very little information is published about overall business performance of cannon manufacturers. Instances of surviving trade and financial records provide insights into iron production and consumption.[1,2,3,4] Unfortunately they give neither a sufficiently broad picture nor information uniquely about gun manufacturing. Furthermore mid 18th-century business financial recording methods were aligned more towards estate accounting practices focusing on recording and managing payments and receipts, reporting trading margins and cash accumulation in excess of any initial investment.[5,6]

Fortunately *The Fuller Letters 1728-1755*,[7] of which some 300 relate to their gun business, provide insights into the practicalities, problems and people involved in cannon making. They show how their cannon business's financial performance depended on prevailing political environment, commercial constraints and many relationships. These included their main customer, the Office of Ordnance and other customers, agents, other ironmasters, raw materials suppliers as well as their manufacturing skills and maintaining a good reputation for honest dealing.

Whilst the letters describe operational successes, contentions, problems and decisions, very little is offered about collective measurable effects of interactions on overall business performance. So this study uses these historical records to explore how business, commercial and technical environments influence financial results.

Computer Modelling

To reduce and unravel this general problem of interactions between very many variables a deterministic computer model has been created to integrate quantitative information dispersed throughout the historical record. The model is implemented using Microsoft™ 2010 Excel. The aim is to use this model as a general research tool to explore systematically operational interactions between combinations of variables for cannon making campaigns and report illustrative financial trading results.

Business variables include labour types and costs, raw materials mix and costs, liquid iron costs, production capacity, cannon programmes, cannon selling prices, transport costs, quality issues and management decisions.

Different combinations of variables may be selected as a 'business scenario' and trialled to give immediately a set of output results. Although an abstraction and interpretation of a reality, results provide a snapshot of likely financial performance or trend in performance under a set of then current commercial and technical conditions.

A campaign year is the unit of time for reporting performance measures. Annual performance measures are £ Campaign Income, principal £ Direct Costs and by difference, £ Gross Trading Margin. Offsetting projected general overheads against Gross Trading Margin gives £ Campaign Surplus as a proxy for 'Profit' representing cash creation.

Other unattributed plant investments, cash flows, stock and work in progress value changes and depreciation information, unfortunately, are not readily available in *Letters*. Also *Letters* are unclear about whether some relevant gun-related costs may be included within general estate

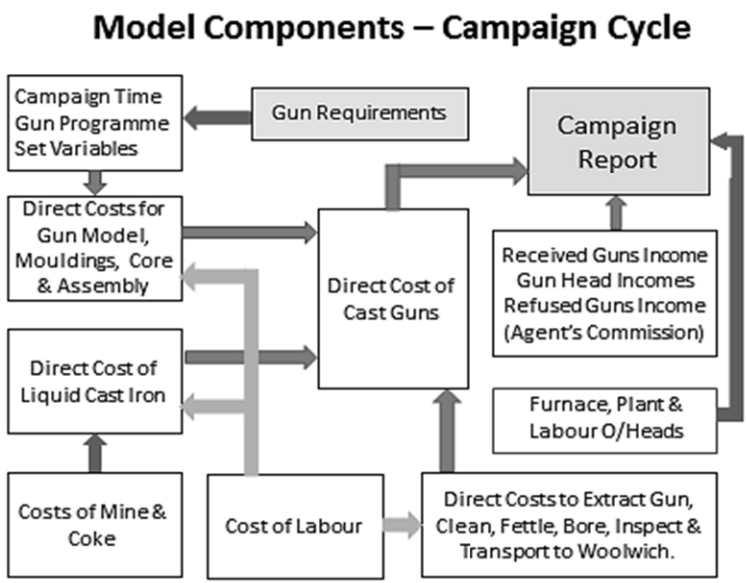


Fig. 1 Key Modules in Campaign Cycle

running expenses. However even with these boundaries the model provides a powerful and adaptable representation of conditions for how Fuller's cannon business contributed to estate prosperity.

The next section provides an introduction to model structure, inputs, content and key variables relationships and output Campaign Report. Subsequent sections describe early trials of several business scenarios showing how management decisions and operational conditions can influence business efficiency and effectiveness. From these some initial general conclusions are drawn about Fuller's business performance along with comments on future model developments and uses.

Model Inputs and Variables Content

Key input for the model is an annual campaign cannon programme. This comprises a mix of cannon sizes determined by calibre, length (ft.) and numbers of each. The model includes from 3- to 32-pounder guns in lengths from four feet and 7 cwt. each up to ten feet long for the larger or great guns and 59 cwt. each, all generally in 6 inch gun length increments. Owing to difficulty in handling very large guns Fuller produced no 42 pounder guns and this calibre is not used in the model.

The model calculates the total weight of liquid metal required for pouring including additional weight for great guns, gun heads as a proportion of basic gun weight plus gun bore reaming metal loss. A separate factor is applied to offset increased furnace metal loss when producing great guns (Letter 674).

Furnace 'warm up' time in weeks is deducted from planned annual campaign weeks to give a maximum value for gun production weeks. This is multiplied by weekly furnace metal output tons to give a gun making total annual available liquid metal tonnage capacity under normal operating conditions.

The model uses numbers of craft and labourer workers and their daily wage rates to enable manufacturing costs to be allocated to or absorbed by gun manufacturing activities.

Input quantities and costs for mine and charcoal to produce one ton of cast metal are used to calculate the raw materials cost of producing a gun. To this is added direct furnace labour cost to produce one ton of metal. The model replicates Fuller's cost of iron (Letter 765).

The model calculates a value for programme campaign absorbed direct costs for cast metal, moulding, fettling, boring, inspection, gun transport to Woolwich and agent's commission. Moulding, fettling and inspection direct costs are estimated using synthetic times as a function of man time and rate to work on a given gun weight multiplied by number of guns.

Boring direct labour costs are calculated using a subsidiary model.

The Office of Ordnance set the manufacturer's selling price per ton of gun of a particular size proved successfully. For example the pre 1750 price per ton for a 9-pounder gun was £13.65 and for a 24-pounder it was £15.00 per ton. Post 1750 these prices were £16.00 and £20.00 respectively. The model enables either pre- or post-1750 selling prices to be applied (or any other trial pricing) to a programme.

Each cannon was moulded with a gun head set, as a variable, at a notional 10% of gun weight in the model. After casting these heads are cut off and sold for a nominal price of £5 per ton in 1731/2 (Letter 121) or even £6 per ton in 1752 (Letter 765). This gives some offset income against furnace metal cost of around £6 per ton or around £8 per ton for great guns.

Guns failing proof testing at Woolwich were either disposed of via air furnace operators for remelting for other uses or if failed for some dimensional errors, sold clandestinely to privateers less discriminating of gun quality. Fuller avoided this latter option to protect his integrity with Office of Ordnance. An open market price of £5 per ton for great guns and £10 per ton for other gun sizes was paid. The model holds the disposal price for each calibre. Like gun heads, refused guns still provided some return income to Fuller.

The model enables a percentage proofing refusal factor to be switched on or off for each calibre gun. Proofing refusal rates were extracted from *Letters* giving refused gun numbers by calibre from a number of guns delivered for proofing.

Model Outputs

For a given business scenario the model calculates *expected* Achieved Income from total numbers and prices for campaign Received guns, Gun Heads and Refused Gun sales. Difference between expected campaign Achieved Income and estimated Direct Costs provides the campaign

CAMPAIGN REPORT

INCOME	£	
Income from Received Guns	851	
Disposal Income - Refused Guns	98	
Income from Gun head sales	38	
TOTAL Achieved Income	**987**	
Nett Lost Income of Refused Guns	109	Info.
Target Debenture Income	851	Info.
Achieved 'income/ton' metal cast =	11.73	Info.

COSTS

Direct	£	% Dir. Cost
Moulding (labour + loam)	23.60	2.99
Cast Metal (including raw materials & Furnace labour)	628.60	79.55
Mould Breaking/Gun Cleaning/Fettling (Labour)	7.93	1.00
Boring (Labour)	3.10	0.39
Dispatch Inspection/Search (Labour)	1.98	0.25
Transport to Woolwich	75.60	9.57
Agent Commission on Achieved Income	49.35	6.25
Direct Cost Total =	**790**	**100%**

GROSS TRADING MARGIN

Campaign Gross Margin =	**£197**	
Gross Margin % on Achieved Income =	20%	Info.
Gross margin % on RECEIVED GUNS Income =	23%	Info.
Indirect (Semi Variable & Fixed) Costs	£	
Labour Wages O/H	121	XS Labour!
Furnace Wages O/H not absorbed in gun cast iron	332	
Equipment/Plant/Furnace Refurb. (Provision)	71	
Unabsorbed Costs £ =	**524**	**40%**

CAMPAIGN SURPLUS

SURPLUS =	***-£327***	***Loss***
Campaign Surplus % of Achieved Income	-33%	Info.

Figure 2 – Example Campaign Report from Model

Gross Trading Margin.

Unrecovered Overhead Costs, estimated plant and refurbishment cost provisions for the furnace (including a hearth usage erosion factor) are set as Indirect costs against Gross Trading Margin to give an indicative Campaign Surplus. Numbers of non-furnace craft and labour workers not absorbed as direct costs of manufacture are included as overhead costs to be set against Trading Margin. A warning is given for either excess numbers or shortage of workers to complete the programme so worker numbers as an input variable can be adjusted. This gives flexibility for setting resource levels for the campaign where any excess numbers are carried as overhead so reducing Campaign Surplus.

Campaign Report

Figure 2 shows an example model output Campaign Report for a programme of 42 guns (21 x 18-pdr. plus 21 x 12-pdr. guns, giving a programme average of 15-pdr. guns) requiring 84 tons of cast iron representing 23% of campaign furnace metal capacity of 370 tons (i.e. 37 manufacturing weeks @ 10 tons average furnace metal per week).

Achieved Income from 34 Received guns plus sale of gun heads and refused guns totals £987 giving a Trading Gross Margin over Direct Costs of 20%. However Campaign Surplus, as the proxy for 'Profit', shows a *loss* of £327 on Achieved Income from insufficient income to cover fully Indirect Costs.

Trialling 'Business Scenarios'

Model structure provides an opportunity to investigate many technical, business and managerial aspects of gun making and how interactions between these affect performance. Following examples show how the model is used to explore financial effects of scenarios. These scenarios include actual campaign programmes taken from the *Letters* with and without effects of proofing failures, calculated Break Even Analyses to assess manufacturing outputs needed to achieve business profitability and

	Gun Length in Feet								
Pounder	4.5	5.5	6	7	7.5	8	8.5	9	9.5
3	3								
4		5							
6			10	7	7				
9				8		13			
12							6		
24								6	7

Table 1 – Example Campaign Gun Programme for 1744

finally the effects of a change in gun selling price on achieving profit.

Scenario 1 – Performance of Actual Campaign Programmes

Six representative campaign gun programmes spanning the period 1732 to 1750 were extracted from *Letters* and used as sample gun programmes.

Fuller Letter No.>	164	302	386	589	594	724
Year	**1732**	**1739**	**1741**	**1744**	**1745**	**1750**
Nos. of Guns	169	82	161	72	136	64
Weighted Avg. Pounder	7.3	6.2	12.3	10.4	21.5	20.9
Tons Metal Cast	237	100	269	100	336	157
% Campaign Capacity	64%	27%	73%	27%	91%	42%
Received £	2897	1226	3348	1273	4384	2056
Total £	3003	1271	3469	1318	4536	2126
£ Margin on Total	1019	430	1035	431	1238	599
% Margin on Total	34	34	30	31	27	28
Avg. Total £ Income/gun	17.8	15.5	21.5	18.3	33.4	33.2
Avg. £ Margin/gun	6.0	5.2	6.4	6.0	9.1	9.4
£ Margin/gun metal cast	4.3	4.3	3.8	4.3	3.7	3.8

Table 2 – Model Outputs and Subsidiary Calculations

An example programme for 1744, given in Letter 589, is shown in Table 1.
Table entries show 72 guns were required in a number of calibres and lengths. Calculated weighted average pounder value for delivered guns in this programme is 10.4 making it a 'medium' sized pounder programme. In turn each of the six programmes was entered into the model, outputs calculated for 'no refused' guns and recorded to give Table 2. Performance graphs were produced from this table data.

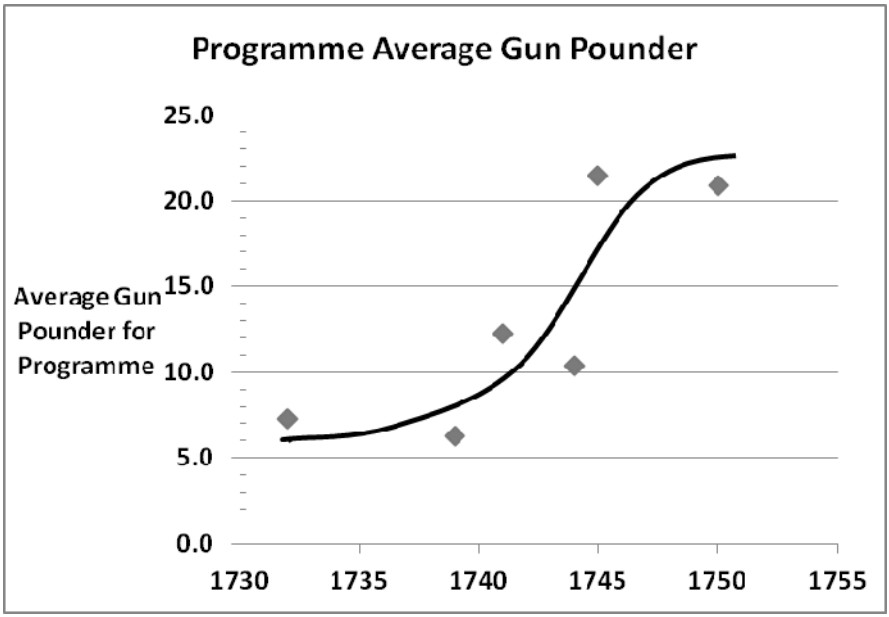


Figure 3 – Average Campaign Gun Pounder over Period

The table records how campaign average programme weight increased generally after 1740 and the effect is displayed as Figure 3.
This trend shows how Fuller's objectives for supplying a higher proportion of larger guns, over previous 9-pounder maximum size guns, were met by Office of Ordnance warrants in campaigns post-1740 (Letter 316). The model shows, Figure 4, how a higher proportion of larger guns in later programmes gave a corresponding doubling of income per gun

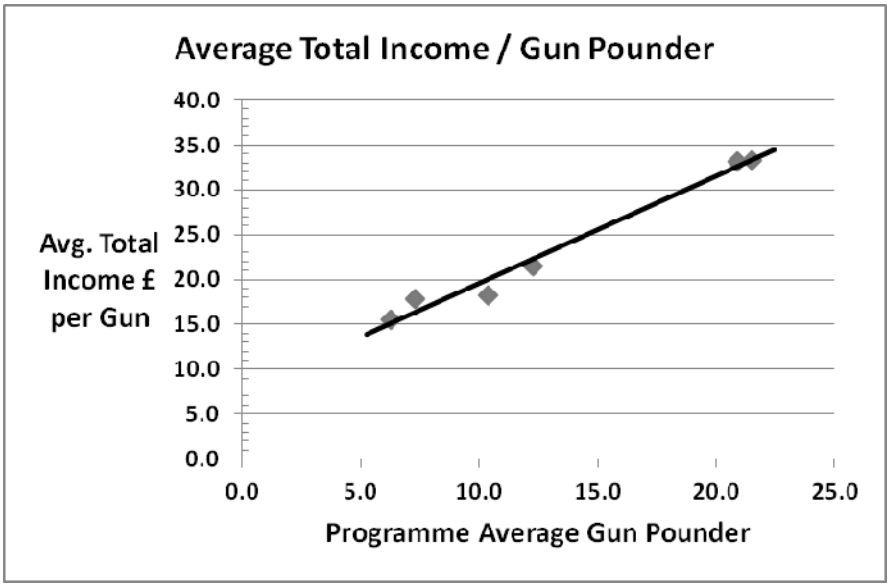


Figure 4 – Average Total Income per Gun in Campaigns – No Refused Guns

(around £15 to around £33) at constant pre-1750 selling prices and No Refusals.

Importantly, however, Figure 5 shows a progressive trend of lower margins for the same programmes. This shows the business was becoming strategically less 'profitable' as average programme weight increased .

The underlying causes for this trend of lower profitability are twofold. Firstly and the main source, is great guns incur higher direct metal costs of about £8 per ton (against about £6 per ton). Smelting additional ore and charcoal plus associated labour is needed to offset increased metal burn off when producing and holding a larger quantity of furnace metal (possibly for up to about 2½ days) before casting each great gun. A secondary contributory cause is a proportionally larger gun head weight being sold off at a much lower scrap metal cost compared with smelted liquid metal cost. Gun heads sales made no real contribution to margins.

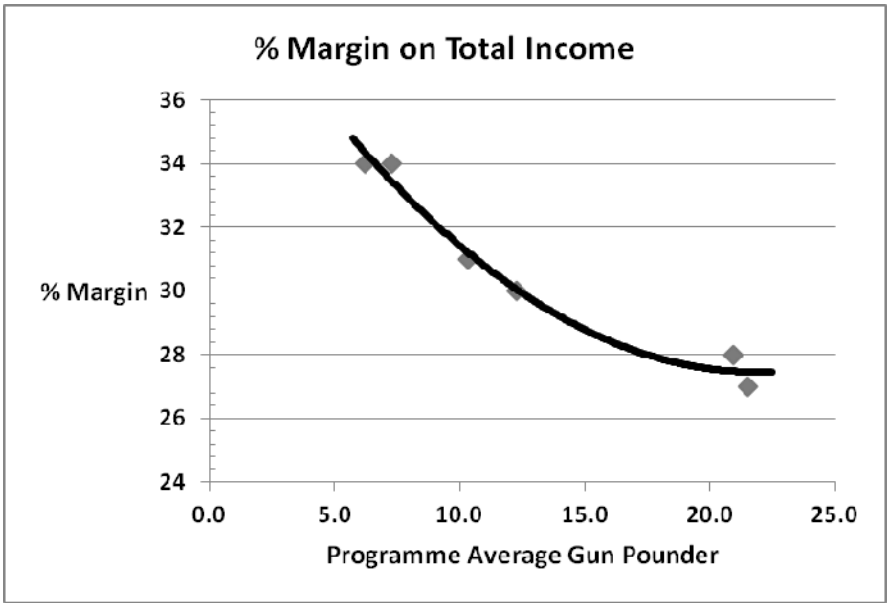


Figure 5 – Percentage Margin on Total Income – No Refused Guns

The model shows Fuller achieved his aim of more great guns in programmes giving his business a much higher income earning rate. However it was achieved at progressively lower trading margins or 'profitability' and less effective use of furnace metal.

Scenario 2 - Financial Effects of Proofing Failures

Model results presented in Scenario 1 assume all manufactured guns were successfully received by Office of Ordnance. This second scenario examines the practical effects of proofing refusals on financial performance. Data was extracted from Fuller's letters for a sample of 391 guns of different calibres in batches across a number of proof tests. Whilst calculated overall average refusal rate is about 17% the model uses the rate for the given gun calibre. Even with limited data for great guns they do show a disproportionate higher refusal rate of possibly up to 50%. This

Fuller Letter No.>	164	302	386	589	594	724
Year	**1732**	**1739**	**1741**	**1744**	**1745**	**1750**
Nos. of Guns	169	82	161	72	136	64
Weighted Avg. Pounder	7.3	6.2	12.3	10.4	21.5	20.9
Tons Metal Cast	237	100	269	100	336	157
Received £	2363	971	2628	942	3239	1531
Total £	2860	1202	3151	1171	3836	1813
£ Margin on Total	883	365	733	275	574	301
% Margin on Total	31	30	23	23	15	17
Avg. Total £ Income/gun	16.9	14.7	19.6	16.3	28.2	28.3
Avg. £ Margin/gun	5.2	4.5	4.6	3.8	4.2	4.7
£ Margin/gun metal cast	3.7	3.7	2.7	2.8	1.7	1.9

Table 3 – Effects of Refusal Rates by Calibre on Gun Campaigns

level represents a significant loss of income of around £9-£10 per ton over debenture price.

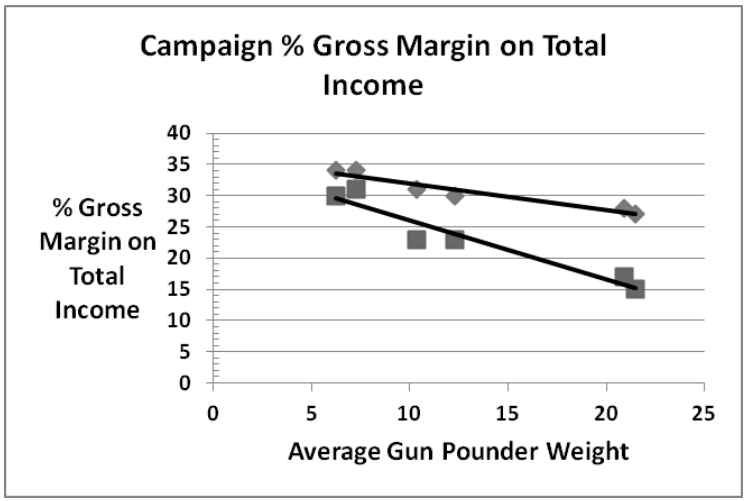


Figure 6 – Comparative Effects of Refusals on Campaign Gross Margin

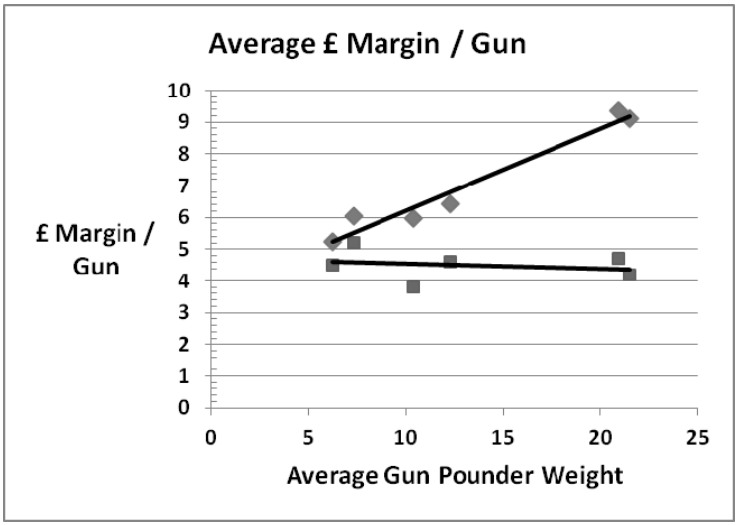


Figure 7 – Comparative Effects on Average £ Margin per Gun

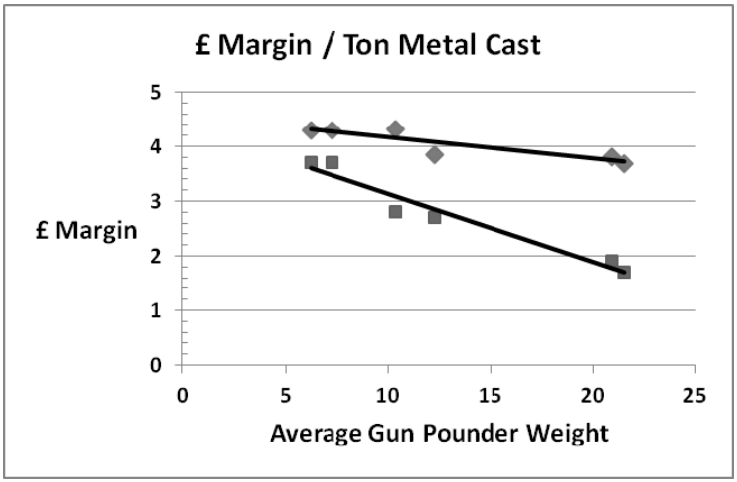


Figure 8 – Comparative Effects on £ Margin per Ton Metal Cast

Table 3 shows model outputs and calculations after applying gun refusal rates by calibre to gun mix in each of the six example campaign programmes.

Figures 6-8 show comparative effects on three key performance measures. Upper trend line represents 'No Refusals' and 'Refusals' by the lower trend line.

A general conclusion is this model scenario shows clearly the trends and levels of progressively adverse financial effects of refused guns, compared with 'No Refusals', on overall campaign incomes, margins and lower effectiveness of metal use in programmes with higher proportions of larger calibre guns.

Scenario 3 - Break Even Analysis

The previous two scenarios looked at individual programmes and effects of trends in gun mix on performance measures. This third scenario applies the broader business view of Break Even Analysis to identify campaign metal tons production at which, as sales increase, the business moves from loss into a surplus margin or 'profit' – the campaign 'Break Even

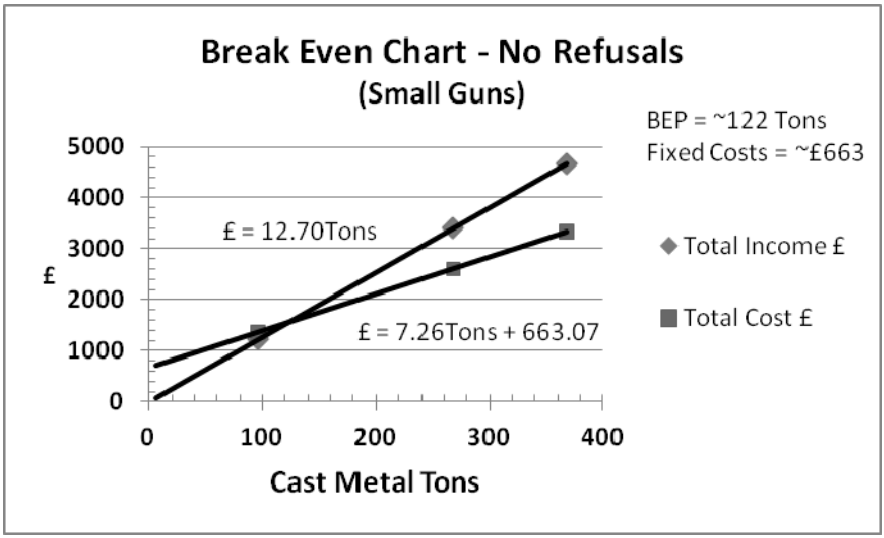


Figure 9 – Break Even Chart – Small Guns Programme – No Refusals

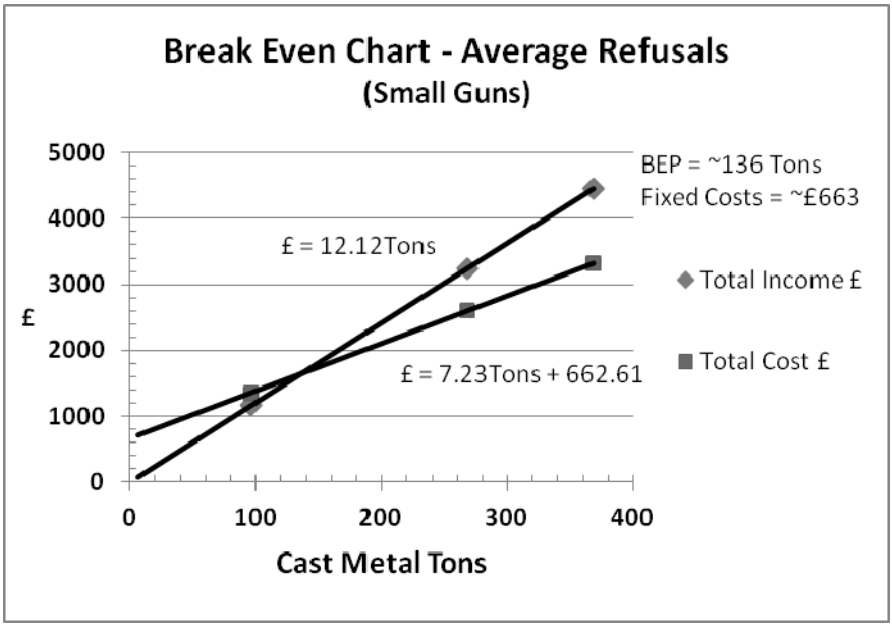


Figure 10 - Break Even Chart – Small Guns Programme – Average Refusals

Point' (BEP). This scenario compares also the effects of either No Refusals or Average Refusals by gun calibre on BEPs.

Five created campaign programmes, comprising small (7.7 & 12 average pounder), medium (15 average pounder) and large (18 & 20.6 average pounder) gun sizes, had numbers of guns adjusted to require furnace output capacities of 100% (370 tons), about 75% and about 25% in turn. Model results for the small guns programme are shown in Figures 9 & 10.

At 122 tons Figure 8 shows a BEP at 33% of furnace campaign capacity for producing a small guns programme with an average pounder of 7.7. However the impact of average refusals by calibre for the guns in the programme raises the BEP to 136 tons or about 37% of furnace capacity (Figure 9) – a relatively modest increase.

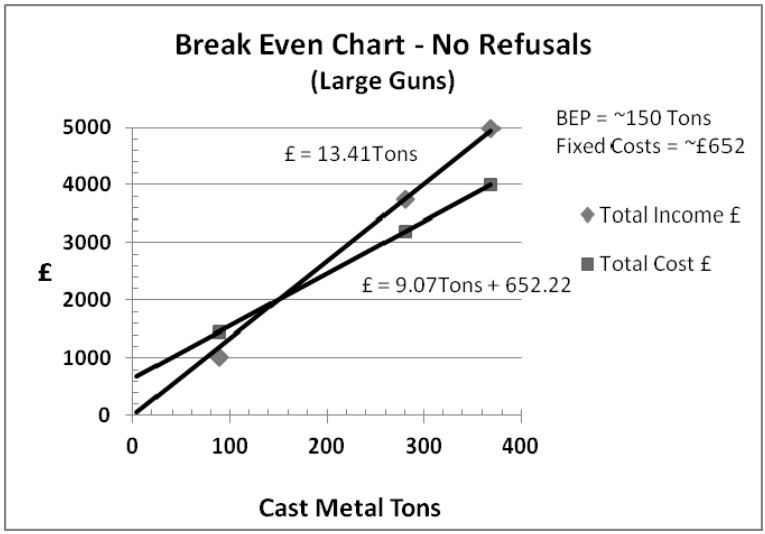


Figure 11 - Break Even Chart – Large Guns Programme – No Refusals

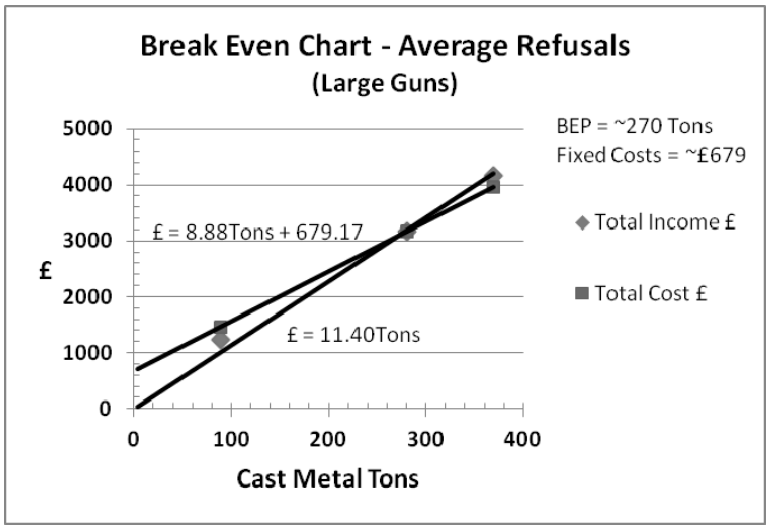


Figure 12 - Break Even Chart – Large Guns Programme – Average Refusals

However and in contrast for great guns with an average pounder of 20.6 Figures 10 and 11 show the corresponding break-even charts.

The shift in BEP from 150 tons (about 41% capacity) to 270 tons (about 73% capacity) is quite significant and shows how effects of disproportionate refusal rates raise BEP to very high production output values.

These charts show the significant effect of refusals on change in BEP furnace campaign tonnage to achieve a Campaign Surplus. For no refusals there is only a relatively small increase from around 120 to around 150 tons in BEP as programme average weight increases. However average refusals on heavier programmes give significant increases in BEP to around 270 tons making Campaign Surplus more difficult to achieve with larger gun programmes.

A low BEP was of concern to Fuller when in 1748 he expresses concern to Office of Ordnance (Letter 698) seeking their help for more warrants to add to his existing commitment of only 168 tons for 24-pounder guns. Unless they could oblige he could not "*make um with any Profitt to myself or Service to the Government"*. The model indicates 168 tons represents about 46% of ideal furnace capacity and without refusals a small Campaign Surplus of about £200 could be made. However anticipated refusals could incur a potential campaign loss of around £140.

Scenario 4 - Effects of 1750 change in Gun Selling Price

Pre-1750 pricing structure shows an increasing BEP especially for medium and larger guns with higher refusal rates. Strategic trend is that of falling profitable incomes impacting long term business sustainability. In 1750 Office of Ordnance increased debenture prices per ton of gun. Small and medium guns price up to and including 9 pounder calibre now became £16 per ton and for larger guns the increase was from £15 to £20 per ton.

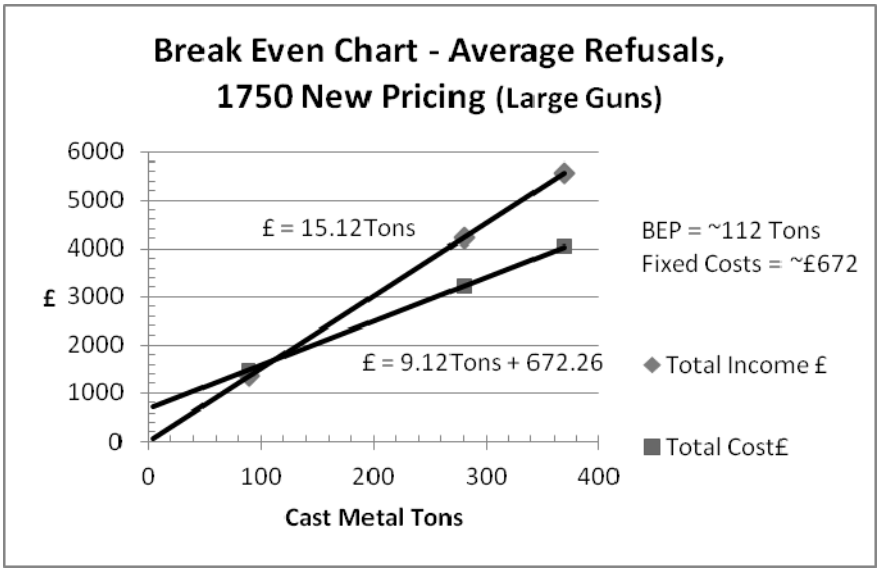


Figure 12 - Break Even Chart – Average Refusals, 1750 New Pricing

Comparing Figure 12 with Figure 11 shows significant improvement, even with refusals, from a much lower BEP of about 112 tons (about 30% of capacity) compared with previous BEP of 270 tons (about 73% of capacity). Income lines comparison shows an effective Achieved Income increase of £3.72 per ton for large guns.

For this scenario the model indicates a potential ideal maximum campaign income now of around £5,600 compared with around £4,200 at pre-1750 pricing.

Conclusions

An important achievement has been using mid 18th-century cannon manufacturer's historical records to create a computer business model to explore and quantify how changes in operating factors influence financial performance. The model provides a research tool to assess annual performance through trialling different combinations of manufacturing gun programmes, operating conditions and management decisions.

Moreover even though built using Fuller's information model content and flexibility are relevant for other similar businesses (the Fullers produced at times other products for sale. Whilst providing additional sources of income, these were subsidiary to the main business of cannon making and were not included in this model).

Achieving Profit as a key objective was hardly mentioned in *Letters*. Focus was much more on income generation and cash flow management – especially to address the usually delayed issue of debentures by the Office of Ordnance. (However other products sales and/or other estate incomes may have helped to mitigate this problem). Profit amounted to achieving excess income over costs, 'making a turn' and not being 'out of pocket'. Importantly, cash held above current needs could be invested to give an income stream (e.g. Letter 703).

Using examples of actual gun programmes the model shows how incomes increased significantly after 1740 from Fuller's policy insistence on higher proportions of larger calibre guns in warrants and post-1750, from higher selling prices to the Office of Ordnance. However the model shows clearly the strategic effect of this policy through progressively decreasing margins as the proportions of larger guns increased (at constant prices and costs). Whether this effect was fully recognised and considered important by Fuller is speculation for the moment. Whilst higher selling prices to the Office of Ordnance gave further income improvements it was unlikely to rectify the underlying strategic problem.

Tomlinson referred to "*profitable cannon making business meant Profit on Sales could be more than 25%*".[8] Model average Profit on Sales (model Gross Margin on Achieved Income) for six representative actual programmes with no refusals is 31% (range 27-34%). However the model shows gun refusals reduces this value to around 23% across all calibres and to around 27% for just small and medium calibre guns together. Model results support Tomlinson's assertion at this level of measuring business performance. However model outputs show how allocation of fixed and semi-variable costs against Gross Margin make Campaign Surplus more representative of business profitability. Unfortunately the

letters do not give useful information about capital employed in the business to provide a more meaningful campaign profit to capital employed measure.

Proofing failure was the bane of gun manufacturing. Poor proofs, especially for large guns, but averaging at about one in six gun failures overall, reduced and delayed significantly expected campaign debenture incomes and margins. Moreover replacements for failed guns had to be remade in a later campaign (or procured via other manufacturers). This was a fundamental strategic loss to the business. Some lost income relief was afforded from scrap value sales of refused guns and usual gun head sales. Even so, small guns campaigns could suffer 4-5% total margin loss whilst great gun campaigns could lose easily 10-12% income so reducing campaign profitability significantly. The model shows also the knock-on aspect of failures causing lower furnace metal productivity and margin reduction of up to 54% when making larger guns. This modelling finding is upheld In Letter 674 where Fuller makes the comment about higher metal use efficiency when producing medium guns than great guns.

Break Even Point (BEP) for a 'no refusals' campaign metal output would probably be in the range of 150-160 tons (around 42% of furnace capacity) across all gun calibres. However effects of refusals are shown again to be increasingly significant especially for medium and great guns. For great guns the model shows break-even metal tons production could rise to around 270 tons. This damaging effect was reduced by the 1750 price rise restoring great guns BEP to around 30% of capacity.

Whether Fuller's aim was to maximise incomes or margins is probably answered by an underlying theme of income and cash flow management expressed in many letters. Avoiding 'out of pocket' expenditures can probably be taken safely as meaning operating at no loss although *Letters* are incomplete in identifying all direct expenditures and capital employed. A conclusion from modelling is that cannon income was paramount for Fuller. However quality issues within variable operating conditions caused significant lost income opportunity and made profit achievement much less controllable. Profit seemed more of a beneficial

outcome than a business objective to be attained.

Future Developments and Uses for the Model

The model is being upgraded to reflect more completely the diversity of historical iron business manufacturing. Firstly to enable modelling of cannon and/or other product types giving product mix analyses, secondly holding campaign financing, cash flows and working capital needs as a basis for business sustainability and thirdly providing additional business performance and efficiency reporting.

Modelling, under conditions of historically evolving economic forces along with business and technology change, enables strategic assessments for a variety of iron business organisations. This may include the same or different time periods or even different geographic locations. Whichever scenarios are chosen model parameters for product mix, raw materials, 'local' costs, pricing, terms and technical efficiencies of the time and location can be applied and evaluated.

References

1. Lapsley, G. T., 'The account roll of a fifteenth-century iron master', *English Historical Review*, **14** (1899), 509-529.
2. Crossley, D. W., 'The management of a sixteenth-century Ironworks', *Economic History Review*, 2nd Series, **19** (1966), 273-288.
3. Johnson, B. L. C., 'The Foley partnerships: the iron industry at the end of the charcoal era', *Economic History Review*, 2nd Series, **4** (1952), 322-340.
4. Guiseppi, M. S., 'The accounts of the ironworks at Sheffield and Worth in Sussex, 1546-1549', *Archaeological Journal*, **69** (1912), 276-311.
5. Grassby, R., 'The rate of profit in seventeenth-century England', *English Historical Review*, **84**, (Oct. 1969), 721 -751.
6. Edwards, J. D., 'Early bookkeeping and its development into accounting', *Business History Review*, **34** (1960), 446-458.
7. Crossley, D. & Saville, R., *The Fuller Letters: guns, slaves and finance, 1728-1755* (Lewes, Sussex Record Society, 1991).

8. Tomlinson, H. C., 'Wealden gunfounding: an analysis of its demise in the eighteenth century', *Economic History Review*, 2nd Series, **29** (1976), 383-400.

CORRIGENDA

WIRG *Wealden Iron*, 2nd series, **23** (2003) p. 4 – Ifield Brook bloomery

The grid reference for this site was incorrectly printed. It should read TQ 246378, not as printed.

WIRG Wealden Iron, 2nd series, **31** (2011) p. 23 – Witley Park Furnace

There is an error in the grid reference given for this site, which should read SU 2975 3740, not as printed.

Index to *Wealden Iron*, 2nd Series, 32 (2012)
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