

From Slitting Mill to Alloy Steel: the Development of Swalwell Ironworks

DAVID CRANSTONE

This reviews Men of Iron, M.W. Flinn's 1962 analysis of Swalwell Ironworks and the Crowley organisation of which it formed part, in the light of new information and a different approach. Ambrose Crowley III (1658–1713) developed a major mercantile iron business, supplied by his factories on Tyneside. The first major works, at Winlaton Mill, was started in the 1690s. Swalwell was set up by a separate company, but acquired by Crowley in 1707; he added a forge, Grand Warehouse, and workshops to the pre-existing slitting mill, and his son John (1689–1728) added steel furnaces and a foundry. Further workshop ranges were added until the mid-18th century. The works declined from the later 18th century under the Millington family; an increased emphasis on steel-making from the 1810s heralded conversion into a steelworks and specialist engineering works after buy-out by the final manager for the Millingtons. This works in turn was rebuilt in the 1880s, using gas furnaces and producing alloy steels. The processes of growth and decline were longer and more complex than believed by Flinn, and less completely centred on the achievements of Sir Ambrose Crowley.

BACKGROUND

The historical research reported here was undertaken in conjunction with the excavation by Pre-Construct Archaeology Ltd (PCA), reported separately by Jennifer Proctor in this issue. It therefore focused firmly on the physical development and technology of the main Swalwell site, with very little attention paid to the other Crowley works in the vicinity, to the remarkable social and managerial structure of the Crowley organisation, or to their wider context. The research is reported more fully in the Desk-based Assessment of the site held in the Tyne and Wear Historic Environment Record (HER).¹ Orientations within the works are given in relation to a 'site north' at right angles to the main (slitting mill) headrace (actually north-west by north).

The history of the Crowley organisation has been ably studied by Flinn in a pioneering and important study of both technology and managerial and social organisation. More recently, but relying primarily on Flinn's research and synthesis, Barraclough has shown the role of Swalwell and the other Crowley works in the development of British steel-making, and Evans and Rydén have placed the Crowley industrial empire in its context of developing mercantile capitalism and colonialism.² In these circumstances a new analysis effectively re-covering part of Flinn's work might appear superfluous. However, the range of documentation available, and its amenability to an organised search, has increased greatly since the 1950s. Also, the present author's project-driven focus has imparted a more rigidly chronological approach to the detailed report, in contrast to

Flinn's more synthetic but diachronic approach. This made it apparent that Flinn's approach had preconditioned as well as reflected his fundamental interpretation that the whole form of the Crowley industrial empire, and of the Swalwell works, had derived from the energy and genius of Sir Ambrose Crowley (Ambrose III in Flinn's terminology), had effectively been completed by 1709, and was followed by a century of stasis and then by half a century of decline (a further half-century is virtually ignored by Flinn).³ While Sir Ambrose's role remains pre-eminent, and one of towering achievement in the opening phases of the Industrial Revolution, a less synthetic and more chronological approach allows a more nuanced perspective. In this, the 18th-century *floruit* of both organisation and works can be seen as dynamic rather than static, and the period of decline as very much more complicated than perceived by Flinn.

It should be noted at the outset that, although generally referred to as Swalwell *Ironworks*, steel-making was an important facet of the works almost from the start. Many of the tools and other goods produced at the works were composites fabricated from both iron and steel.

SWALWELL BEFORE THE CROWLEYS, AND THE CROWLEYS BEFORE SWALWELL

Swalwell village (OS Grid Reference NZ 2072 6225) first developed as a hamlet in Whickham parish, on the tidal limit of the river Derwent and a mile from its confluence with the Tyne., (though the ironworks was located in Winlaton township/lordship and Ryton parish). By the late 17th century, coal

staites had been established on the Derwent at The Pingle (NZ 202 626, 500m north of the ironworks site) and at Derwenthaugh on both sides of the confluence of the Derwent with the Tyne, and were accessed both by coal roads and by waggonways.⁴

After a limited earlier history of iron-making in the Derwent valley, a blast furnace was constructed in the 1680s at Allensford by a partnership of Derbyshire and South Yorkshire ironmasters dominated by Dennis Hayford (or Heyford). The Hollow Blade Sword Company was separately set up at Shotley Bridge, employing German workmen from Solingen. From *c.* 1693 Hayford also had at least one steelworks, supplying the sword-makers among other customers and operated by William Bertram. Bertram was from Remscheid near Solingen, but had come to Tyneside from Sweden and may have introduced Swedish rather than German improvements in cementation steel-making and steel forging to make his 'German steel' and 'shear steel'. Bertram's first steelworks may have been at Allensford, at Blackhall Mill, and/or in Newcastle; the latter two were certainly operating in the 18th century, in association with Derwentcote steel furnace from its construction between *c.* 1720 and 1742. It is tempting to identify Bertram as the 'worker who had run off from Wira bruk [ironworks]' (which was associated with sword-making) and who was credited in Sweden with a great improvement in the quality and scale of English steel-making around 1700.⁵

The 17th-century English steel industry had developed, at least in part, from Sir Basil Brooke's cementation furnaces at Coalbrookdale.⁶ The West Midland region remained an important centre, and this was where the Crowley family originated. Ambrose Crowley I (160?–80) may have been merely a domestic hand-nailer.⁷ Either he or (more probably) his son Ambrose II (1635–1720) was the 'able Fire-man' who accompanied Andrew Yarranton to Saxony in 1667 in an attempt to discover the secrets of timplating.⁸ Ambrose II became a substantial ironmaster and steel-maker; he was a Stourbridge nailmaster, a partner in South Wales furnaces and a relative of Quaker ironmaster dynasties such as the Darbys and the Lloyds. From at least 1682, he held a steel furnace (at Amblecotes near Stourbridge) and a forge (Royal Forge, the scene of the earlier experiments with Yarranton on timplating after the trip to Saxony).⁹ Although on a smaller scale, this formed a substantial precursor to his son's business empire. Ambrose II was a leading Quaker. Ambrose III was an active Anglican in his adult life, though the remarkable (if authoritarian) welfare provision at his works may well reflect his Quaker upbringing.

Ambrose Crowley III started his business life as a London iron merchant around 1680. In 1682 he set up an ironworks in Sunderland to make chains, edge tools, files, hammers, locks, nails and other goods, and in 1685 he intended to add forges and a slitting mill.¹⁰ However, in 1691 he leased a corn and fulling mill in Winlton (the southern part of the later Winlton Mill site) with permission to convert it into an ironworks.¹¹ At around the same time, he also set up unpowered workshop 'squares' in Winlton village, and closed the Sunderland factory. By 1696 he was already a major supplier of ironwork to the Navy.¹² The lease of the remainder of the Winlton Mill site was acquired in the later 1690s, and by 1700 a major construction programme was underway, controlled by Crowley from Greenwich by numbered letters ('Council Instructions') to his management team (organised as a works council).¹³ A slitting mill and 'mill furnace' (for heating the iron bars during the slitting process) was completed in 1700, and in August 1701 Crowley gave instructions for the construction of a plating forge, iron-cutting shears, steel furnace, finery forge, and other workshops. The steel furnace was brought into production at the end of 1701; it had been built by Walter Parker (who had recently built or repaired Ambrose II's 'great furnace' at Stourbridge), and the blister steel from the furnace was to be worked up and forged by 'Job Coley's son'. Job Coley was living at Royal Forge when it was taken over by Ambrose Crowley II in February 1687/8,¹⁴ and may therefore have been involved in the 1667 experiments. It is interesting that his pay rates included no mention of German or shear steel, though they indicate an established steel forging trade. However, the actual steel-maker was to be Thomas Eckerhood; the German-sounding name suggests that he may have been recruited from Hayford and Bertram's furnaces. Crowley's major construction programme at Winlton Mill continued until at least 1711.

The Swalwell works was not founded by Crowley. During 1702–3, a partnership of Edward Harrison, William Bayliss and John Wood took on leases of Bishop's Mill (just south-west of the main ironworks site), Holm Mill and Holm Close (the main ironworks site), and High Mill (NZ 194 616, with crucial water rights on the Derwent); the complex proprietorship of these plots (dominated by members of the Clavering family, but increasingly divided over time) generated considerable legal paperwork and problems for the next two centuries.¹⁵ Harrison and Bayliss were described in the leases as merchants of Newcastle; in fact, Harrison was closely associated with Ambrose Crowley, acting as his Newcastle shipping agent and with

involvements outside the region.¹⁶ Bayliss' background is not known; he may simply have been an investor. However, John Wood of Masbrough held Masbrough slitting mill (near Rotherham, South Yorkshire) and was the son of William Wood, a close business associate of Dennis Hayford.¹⁷ The partnership therefore had links with both Crowley and Hayford; it is possible that they were acting at Crowley's instigation, perhaps putting up funds that he was unable to afford directly at the time. By 1707 a slitting mill had been constructed at the Swalwell site (implying that the main, 4 yard wide, headrace from the Derwent via High Mill had also been completed), and there is evidence for an office and nailers' and patten-ring makers' workshops.¹⁸ However, at this point Harrison and Wood assigned their leases and sold the tools to Sir Gregory Page of Greenwich, a wealthy merchant and close associate of Sir Ambrose (as he became in the same year). It is possible that Harrison and Wood had hit financial problems and that Page had the capital available to buy up the works at short notice, whereas Crowley did not. It is, however, strange that there is no known record of the transfer of title to Crowley, although he clearly controlled the Swalwell works by 1710 at the latest¹⁹ and his title was never subsequently questioned on these grounds.

THE CROWLEY YEARS (1707–82): A WORLD-CLASS IRONWORKS

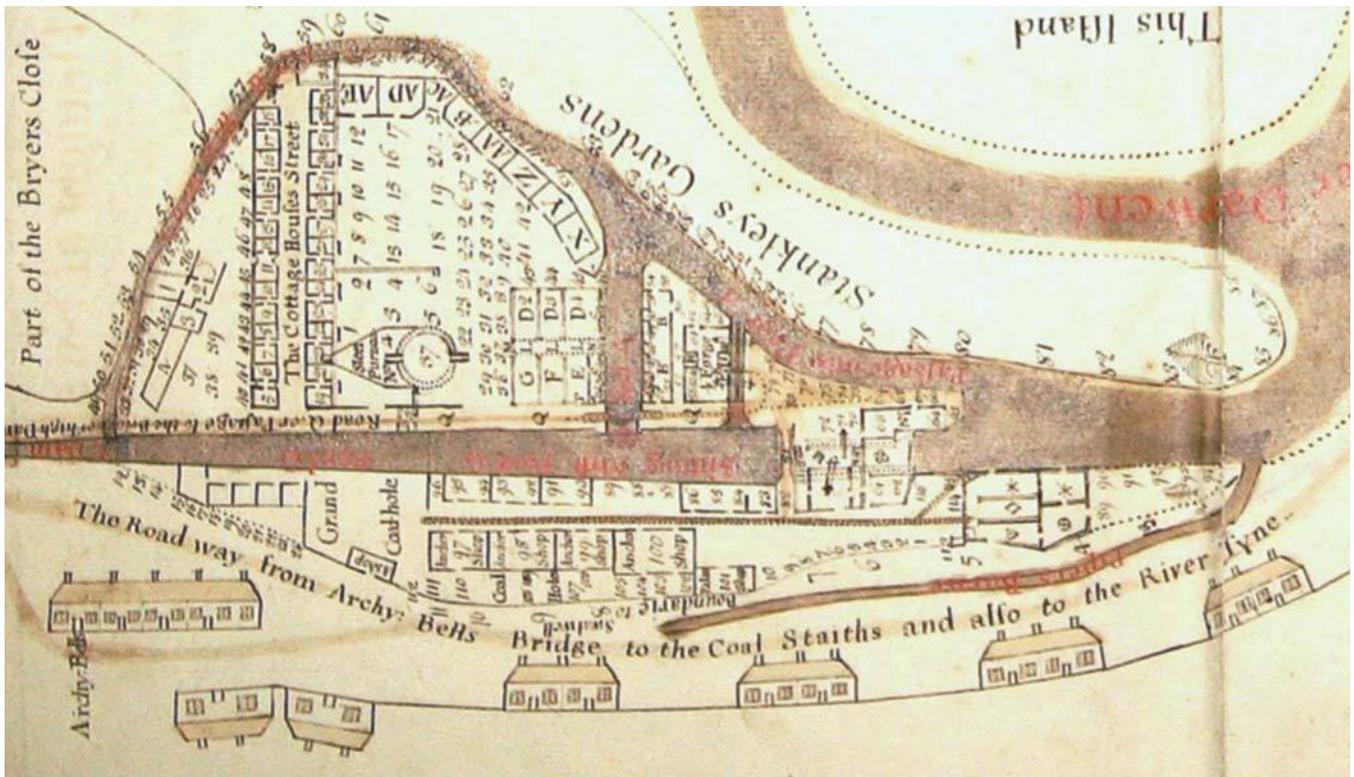
By 1711, for which a nine-month run of Crowley's detailed letters of instruction survives,²⁰ overall management of the Northern works had been transferred from Winlaton to Swalwell, and major building programmes were in progress at both Swalwell and Winlaton Mill. Unfortunately, the surviving volume of instructions is addressed to the Winlaton Mill management rather than Swalwell, which is only mentioned tangentially. Nevertheless, it is a superb source for early 18th-century ironworking and fabrication technology, and a fascinating window into Sir Ambrose's mature management system. Each Direction is numbered alphabetically (PA to SZ), sent at two- to three-day intervals, and consists of several pages of numbered 'verses' (9277 to 10476), with subject titles in the left margin for reference.

John Crowley (Ambrose's son and heir) was at Swalwell from June to October 1711, and was in overall charge of the Northern works during this period (probably either to supervise the building programme or as training for his inheritance). At least one anchor smithy had already been added to the works as acquired in 1707, and the 'Half-Forge' (so called because it only had a chafery, with no finery at this stage) was completed during the

year. In November 1711, ten tons of anchoneys (the part-worked iron product of a finery, finished into bars in a chafery) were sent from Winlaton Mill to the Half-Forge. The Winlaton Mill chafery was also converted from charcoal- to coal-fuelled; Sir Ambrose was being advised by 'Mr Norris',²¹ who was successfully working his chafery with coal, though he had had to bring in anchorsmiths to show his forgemen how to build and keep a 'hollow fire'. Problems were encountered with the new method, but seem to have been overcome, and it is likely that the Swalwell chafery also worked on coal fuel.

At Winlaton Mill, steel furnaces Nos 2 and 3 had just come into production, replacing the 1701 furnace ('No. 1'); there were teething problems due to melting of the firebrick inner linings. Thomas Kirkup was now the steel-maker, and under Sir Ambrose's close direction was developing Crowley's own 'mark' of bar steel, made from high-quality Swedish bar iron. In June and July Crowley decided to build two new furnaces (Nos 4 and 5) and a new warehouse (almost certainly the Grand Warehouse) at Swalwell, though in fact the Grand Warehouse was probably not completed until 1713,²² and the steel furnaces not until at least 1714 (see below). The delays may have been due to a cash-flow problem; in 1713, Sir Ambrose had to publicly deny rumours of his bankruptcy.²³ Passing references in the Directions confirm that the slitting mill and hoop-making shops were in operation at Swalwell, and mentions of 'the Square' may imply that the Cottage Rows (see below) had already been constructed, since they close in the west side of this. It is not clear how much more of the works as mapped in *c.* 1714 (below) was already in existence in 1711.

Sir Ambrose died in October 1713 and was succeeded by his son, John.²⁴ A map book of the Derwent valley from Winlaton Mill via Swalwell to the Tyne, prepared for Esq. [John] Crowley probably *c.* 1714, gives a detailed plan and schedule of the works soon after his accession (Figure 1).²⁵ Details in the numbering and schedule indicate that parts of the plan had been redrawn and updated from earlier originals. The works, at this stage confined to Holme Close, was bounded to the south by a road to the staithes, to the west and north by a curving watercourse (the 'northern channel' in this report), and divided east-west by the main headrace. The latter must have been embanked above at least some of the surrounding buildings and yards, perhaps by as much as *c.* 2m from the floors of the Forge and the basement of the Grand Warehouse. The slitting mill lay at the east end of the race, with a bar iron warehouse to its north-east and the Storekeeper's Warehouse or Old Warehouse to its south-east; these buildings



were probably the core of Harrison and Co.'s pre-1707 works. The remainder of the south side was occupied by anchor and grapnel, hoop-bundling and straightening, and nailers' workshops, with the main coal yard at the west end. The main access to the works was by a road along the north bank of the main headrace. This passed Holme Mill (now a corn mill and bakehouse for the works, with some nailers' workshops attached) and Cottage Rows (two terraces of workers' housing) on its north, before entering the factory compound through a gatelodge under the Warden's Office. Behind this, Steel Furnace No. 4 and its coalholes occupied the south-west corner of The Square, bounded to the west by the back wall of Cottage Rows and to the north-east by a row of workshops beside the northern channel. The steel furnace was depicted rather oddly, in bird's-eye view rising from a dashed circular 'footprint', and was described on the accompanying schedule as 'Steel Furnace alias ffurnaces N^o 4 & 5 with 3 Teasing houses'. A possible explanation is that Furnace No. 4 (only) was under construction at the time of the field survey, but that Furnace No. 5 and the teasing (ancillary) houses had been built or at least started by the time the schedule was added to the drawn-up map.

The south-east corner of the Square was occupied by the Grand Warehouse, planned at basement level with references to a 'grand floor' to the whole building at first-floor level. This was a sophisticated structure, with a keel (Tyne barge) dock beneath its east half flanked on both sides by under-cover wharves;

the eastern wharf formed the excavated 'Wharf Building', while the western wharf gave access to a series of storage bins and pits for various grades of iron, on either side of a central wagonway from the wharf to the steel furnace. It was intended to insert a pay office and a trial forge (for testing incoming batches of iron) into one of the bins. The building may well have been designed so that the 'grand floor' was on a level with the beds of carts on the road to its south, for easy loading and unloading.

To the east, the 'Half-Forge' was a rectangular building containing a chafery in its east side, and space for a finery on the west side. The chafery bellows and hammer were powered by separate wheels in a race along the east side. The areas north of the forge, between the forge and the slitting mill, and between the slitting mill and the storekeeper's warehouse, all formed open-air quays.

John Crowley died in January 1727/8, at the early age of 38. Documentation from within his period of ownership is limited, though a (damaged) wagonway plan of 1722 retains part of a bird's-eye view of a steel furnace (probably No. 4) with straight conical sides and buildings at each end,²⁶ confirming that this had been completed. A foundry had been constructed by 1719;²⁷ it is suggested that Isaac Wilkinson started his career as an ironfounder at Swalwell, before moving to Little Clifton furnace in Cumbria.²⁸ From later map evidence (below), the foundry was in the south-east corner of the works.

Figure 1. Swalwell ironworks, c. 1714 (TWAS: DX 10411, 13; reproduced by permission of Tyne and Wear Archives Service).

However, a detailed inventory prepared on John Crowley's death allows his contribution to the development of the works to be assessed.²⁹ The Swalwell works and its contents was valued at £25,005, of which buildings formed £2895 (including High Mill, outside the main works perimeter), and goods and stock £20,711. This compares to £5361 for Winlton Mill (of which buildings formed £1720) and £4105 for Winlton village. Swalwell was the second-most-valuable component of the Crowley empire, after the massive £111,110 of the main Greenwich warehouse and its contents; the whole industrial estate was valued at £157,928. Since some of the individually valued buildings were referenced to the *c.* 1714 plan, most can be located on the ground. Excluding a blade mill and a plating forge (both at High Mill) the main works consisted of: a lifting forge (the 'Half-Forge', probably now with a finery); two steel furnaces; air furnaces (the foundry itself was not valued, perhaps implying a timber open-sided building); three warehouses; nine 'shops for odd wares' (the nailers' workshops south of Holme Mill in *c.* 1714); two houses for straightening and bundling hoops (beside the main headrace, south-west of the slitting mill); nine 'double hand nailor and frying pann shops' (to the west of the hoop houses); four 'large shops for anchors' (as in *c.* 1714); and one 'large palm [anchor fluke] shop' (south-east of the anchor shops), all built or at least planned by Sir Ambrose. The main additions since *c.* 1714 were the completion of the steel furnaces, the foundry, five hoe-makers' shops (probably along the south-west boundary of the works), and four 'shops within the Square' (presumably one of the ranges first mapped in 1750, see below). John may also have been responsible for a northwards expansion of the works into the east end of Stankleys Garden (below). Other structures and locations mentioned, but not valued individually, included a 'Round House' containing Windsor bricks and Stourbridge clay, a house adjoining the Round House containing a fire engine (presumably in the modern sense, rather than a steam engine), 'shades' (sheds?) in the Back Square, a 'cooper's shade', and a 'brayhouse'. By 1750, the cooerage and charcoal store were within an area taken into the works from Stankleys Garden (to the north of the northern channel); this suggests that it was John Crowley who extended the physical perimeter of the works.

On John Crowley's death his estate passed to his widow Theodosia in trust for his nine-year-old son Ambrose (IV). Ambrose IV came of age in 1739, but died without issue in 1754; the estate passed to his younger brother John (II), but he died in 1755 and the estate reverted to Theodosia, who retained control

until her death, at the age of 88, in 1782.³⁰ Flinn believed that Theodosia Crowley depended on the Greenwich-based managers (John Hanmer till 1730, and John Bannister from 1730 to 1740); this may reflect mid-20th-century sexist assumptions as much as 18th-century reality, but Hanmer and Bannister do appear more prominently in the surviving records than previous (and indeed most subsequent) general managers. It is unclear how active Ambrose IV or John II were in personal management of the business after 1739 (there are hints that they acted as a duumvirate, with John running the Northern manufacturing end of the business and Ambrose running the sales side and maintaining overall control from Greenwich). From 1738 until *c.* 1750, the business was also embroiled in complex legal proceedings with the Claverings over the Swalwell leasehold. The uncertainty over tenure may have discouraged Ambrose and John from major investment in the works, as may the lack of an heir (applying also to Theodosia in her second term of ownership after their early deaths).

Strategic development of the business empire certainly continued through the 1730s. In 1735 Crowleys took over the High and Low Teams works, two miles east of Swalwell and just above the confluence of the River Team with the Tyne, from its builders William and Richard Thomlinson (who had also held Derwentcote forge until 1733, though it is not certain whether the steel furnace was built during their tenure).³¹ The combined Teams works as taken over by Crowleys comprised at least one slitting mill, steel furnace, forge, other mill(s) and workshops.³² The Teams steel furnace was then operated by the Swalwell steelmaster and worked in close conjunction with Swalwell; this appears to have led to confusion between the Teams and Swalwell furnaces by some of the 18th-century overseas visitors to the works. The two Winlton Mill furnaces (Nos 2 and 3), active in 1728 but closed by 1754, may have been closed down at this point; this may be the reason for a riot by the Winlton workmen.³³ In 1739 John Bannister, presumably acting on behalf of the Crowleys, leased a keelroom and adjacent plots at the then Dunston staithe³⁴ (NZ 224 626, not the modern location), presumably as a wharf for Teams; the adjacent plots were developed as 'Dunston Square'. A further development from *c.* 1739, though outside the region, was the leasing of Ashburnham and Darvel furnaces in Sussex; probably taken primarily to supply pig iron to the Tyneside works.³⁵

A revised lease of 1750 for Swalwell (perhaps marking the final resolution of the dispute with the Claverings) includes a plan and schedule of the works (Figure 2).³⁶ This is decidedly crude, and seems to be based on the *c.* 1714 plan with eyed-in rather



Figure 2.
The works in 1750
(DRO: DICG
7/1578).

than accurately-surveyed additions. Working broadly clockwise from the west end, alterations since *c.* 1714 included:

- 3 Shops for different sorts of Iron Work (within The Square; a long row backing onto the eastern terrace of Cottage Rows, two shorter back-to-back ranges at right angles to this, and two short north-south ranges – one of the latter was presumably the ‘4 shops within the Square’ constructed between *c.* 1714 and 1728, the remainder being post-1728 constructions)
- 5 Steel Furnace No. 5 (shown as an east-west range to the north of Furnace No. 4, and running east from the south end of the range of workshops backing onto Cottage Rows)
The foundry (labelled but not planned or numbered)
- 11 Scrap Houses (an implausibly narrow feature along the south boundary)
- 12 How [hoe] Shop (the palm shop in *c.* 1714 and 1728)
- 13 Anchor and How Shops (the anchor and grapnel shops in *c.* 1714)
- 15 Slitters’ House (the hoop-bundling and straightening shops in *c.* 1714 and 1728)
- 16 Spade and Grapnel Shops (nailers’ shops in *c.* 1714, and nailers’ and frying pan shops in 1728)

- 17 Odd Ware Shops (two ranges in the south-west corner of the works, one probably being the five hoemakers’ shops built between *c.* 1714 and 1728, the other a post-1728 addition)
- 21–3 Charcoal Yard, Cooperage, and Raff Yard (in the post-1714 Stankleys Garden expansion of the works)

The location of Furnace No. 5 to the north of No. 4 is totally at variance with the 1802 and subsequent plans (see below), which show a short range of workshops in this location with Furnace No. 5 to the west of No. 4; while it is possible that this reflects a genuine rebuilding and relocation between 1750 and 1802, it seems as likely that the 1750 surveyor was confused by the *c.* 1714 depiction of this area and mislabelled his field draft.

The site had been considerably infilled with workshops since 1728, most notably within the Square but also along its southern boundary. The most likely context for this investment would seem to be Theodosia Crowley and John Bannister’s management in the 1730s, before the insecurity of the Clavinging litigation, and forming a pattern with the acquisition of Teams and Dunston. If the new workshops do represent a single horizon of construction in the 1730s, this would be a very active period of growth. The extent to which the internal fittings and working methods of the various forges, furnaces, mills and workshops were updated after their construction (apart from the changes of use listed above)

can rarely be determined. Flinn's assumption of technological stasis (whereby descriptions dating mainly from the 1750s and 1760s are assumed to apply to the whole of the 18th century) may be overstated. One upgrade which can be identified is the replacement of the conventional bellows serving one of the forge hearths by cast iron cylinder bellows, probably in 1747.³⁷ Cylinder bellows for forge hearths were introduced by Isaac Wilkinson in 1736,³⁸ but did not become widely used until the 1750s or 1760s; the Swalwell blowing cylinders were the only ones seen by Angerstein. They may well have been supplied by Wilkinson (who moved from the foundry at Backbarrow to Low Wood furnace at this time).

The period from the late 1740s to *c.* 1770 was the heyday of overseas visitors to Swalwell, mainly from Sweden; the best known of these is Angerstein, who visited Swalwell in 1754.³⁹ The Swalwell works included a plating forge and grinding mill (both at High Mill); a bar-iron forge; a slitting mill; two steel furnaces; a foundry; 22 hoe forges; three anchor forges; three screw shops; one shop for bolt iron; three harpoon shops; one shop for balances and lifting jacks; two shops for sugar-cane machetes; two for fire-irons; three for sugar mill equipment; one for braziers; two for ship nails; ten for smaller nails; and 'many' for hammers and blacksmiths' tools. The forge had a finery using charcoal, a chafery using pit coal, and a hammer. The Swalwell and Winlaton Mill forges between them produced 400 tons of bar iron annually, whereas the combined consumption at all the Crowley works was 2350 tons; the remainder was supplied by imported Swedish and Russian bar iron. The slitting mill was rolling heavy sheets as well as slitting nailrod.

There were three steel furnaces (presumably including Teams), one holding 14 tons (Swalwell No. 4?) and the others 10–12 tons (Swalwell No. 5 and Teams?), and consuming nearly 400 tons/year of the best Oreground and Russian iron. Some of the steel was forged and re-cemented at Teams to produce the highest-quality 'German steel'. The iron foundry had two furnaces (presumably the 1728 air furnaces), and still produced small castings. The anchor forges worked entirely by hand and normally produced anchors weighing one to 74cwt (though they could produce anchors of up to 5 tons). The hoe shops each had three workers, and used an anvil 'former' to shape the necks of the hoes. The hoes, along with many of the other implements produced, were steeled, and the steel pieces were forged to size and shape in separate workshops; this may contrast with practice in *c.* 1714 and 1728, when all the workshops seem to have been producing end-products.

Angerstein does not mention chain-making at Swalwell, but by Robsahm's visit in 1761 the anchor forges were largely used for forging heavy chain-links.⁴⁰ Robsahm also provides a detailed description of steel-making, mentioning a brick furnace; Andersson, another Swedish visitor in 1766–7, adds that the furnaces had heavily stayed chimneys with cylindrical tops.⁴¹ Jars (who visited in 1767), by contrast, describes a rectangular masonry furnace, with a brick chimney 'in the form of a sugar loaf';⁴² this does not fit with any description or mapping of the Swalwell furnaces, and was probably in fact Teams; it is strikingly similar to Derwentcote, also perhaps built by the Thomlinsons.⁴³

By Arthur Young's visit in 1770, Swalwell was also producing artillery and gun-carriages; the addition of cannon-founding to the repertoire of the foundry suggests a substantial upgrading since 1754, perhaps with new furnaces (air and/or cupola) to replace the pre-1728 air furnaces.⁴⁴ However, Young also provided the first hint of decline when he noted that a falling-off business and criticised the lack of mechanisation. Theodosia Crowley's second period of control had maintained the status of her works in the short term, with sufficient dynamism to adopt chain-making and cannon-founding, but was not engaging with the incipient late 18th-century revolution in the iron industry.⁴⁵

CROWLEY MILLINGTON AND OFFSHOOTS (1782–1862): DECLINE, REJUVENATION, AND FALL

After the death of Theodosia Crowley in 1782, practical management of the business passed to Isaiah Millington, the Greenwich-based overall manager. Although occasionally referred to as Theodosia Crowley & Co. as late as 1802,⁴⁶ the business was generally known as Crowley, Millington & Co., and between 1782 and 1824 Millington partners progressively replaced Crowley descendants.⁴⁷ Isaiah Millington died in 1806, and his son Thomas in 1808; his son Crowley Millington was a minor until 1816, running the business from then until he died without male issue in 1849. The years from 1849 to the final demise of Crowley Millington & Co. in 1862 were complex; the picture presented below from primary evidence differs substantially from that of Flinn.⁴⁸

By 1794 (perhaps on slightly earlier information), the Swalwell forge was listed as having two fineries, a chafery, and a balling furnace;⁴⁹ the second 'finery' may have been a 'refinery' or 'running-out fire' (for desiliconising coke pig before fining or puddling), and the 'balling furnace' was probably for preparing scrap iron for the finery. If so, this was a limited response to changing technology; by

contrast, the Hawks ironworks in Gateshead was installing steam power by *c.* 1790 and obtaining many Government contracts formerly held by Crowleys'.⁵⁰

In 1802 the plan attached to a new lease⁵¹ (Figure 3) was clearly updated from the 1750 plan; it attempted to distinguish between pre-1750 buildings and post-1750 additions, but unfortunately the latter were identified from a very literal reading of the 1750 map without regard to its schedule or rather diagrammatic nature. In fact, the only building within the Holme Close area which can be confidently accepted as new is the 'large anchor shop' ('k' on plan) immediately north of the Grand Warehouse (certainly new since *c.* 1714, probably since 1750). A water channel along the west side of the Forge is also shown for the first time; this can be accepted as new since *c.* 1714, but was probably merely omitted in 1750, and was probably the race for the finery waterwheel(s). However, the Stankleys Garden area had been substantially remodelled, with a new range of workshops along its south-west side beside the northern channel, and a cooperage and timber store in the north-west end (replacing the former charcoal store); the 1750 cooperage further east was now a carpenters' shop, adjoined by new cartwright's and spade tree-maker's workshops. Goods from, and iron for, Winlton Mill were now carried by waggonway to a warehouse on the other side of the Derwent at Derwenthaugh; a sailed keel is shown here, whereas several (beautifully drawn) keels shown further upstream are depicted as oared but not sailed.

The case of Steel Furnace No. 5 and its attached buildings (identified as new since 1750) is more difficult; a case can certainly be made for taking the evidence literally, in which case the furnace had been relocated and was a new build. However, given the cartographic problems of this area in both *c.* 1714 and 1750, and the consistency of Angerstein's description of one furnace being slightly larger than the other with the 19th-century evidence (assuming his second smaller furnace was at Teams), it seems more likely on balance that Furnace No. 5 as mapped in 1802 and described in 1834 (below) was in fact the original as built in 1714 or soon after.

The end of the Napoleonic Wars in 1815 precipitated a crisis in the increasingly old-fashioned Crowley works; the coming-of-age of Crowley Millington in 1816 may also have facilitated overdue changes. In 1816 the works at Winlton village was largely closed, and soup kitchens were opened in Winlton and Swalwell to feed laid-off workers.⁵² High Forge and Bishop's Mill may well have been given up at this time, and within the main works the foundry was probably closed and many workshops became derelict. The iron-working community became radicalised, and were believed to have made arms at the works for use during the protests against the Peterloo Massacre in 1819; if this was true, either the tight Crowley works discipline had broken down, or the local management were quietly sympathetic.⁵³ This active and sometimes violent radical tradition continued until at least the Chartist movement of 1839–42.

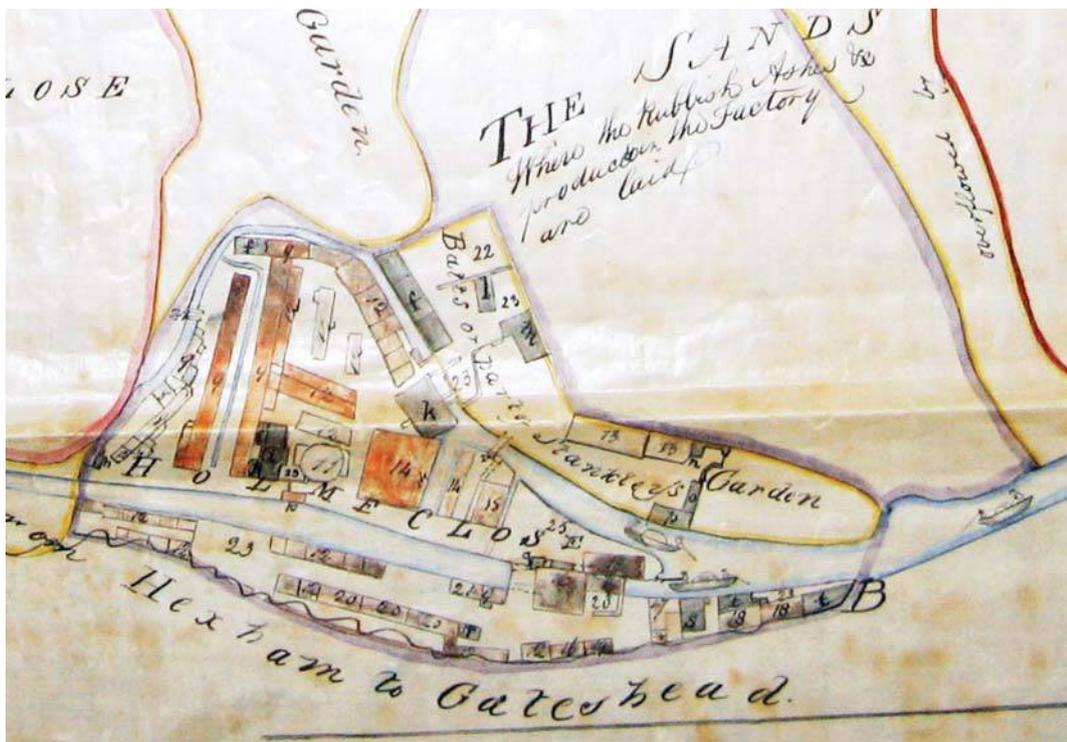


Figure 3. The works in 1802. Pre-1750 buildings in red on original and numbered; post-1750 buildings (as interpreted by the surveyor) in black and lettered. Note the oared keels in the northern channel (TWAS: DT. BEL/2/22; reproduced by permission of Tyne and Wear Archives Service).

One new development among what seems to have been a massive retrenchment was the invention of the 'dolly' ('a contrivance attached to a chain maker's anvil for pressing the link after it is welded') for chain-making by a Swalwell workman; perhaps followed by the erection of 'new works' for chain-making in 1819.⁵⁴ Another introduction around this time, though almost certainly *not* at Swalwell⁵⁵ was crucible steel-making, first mentioned (but not located) in 1834.⁵⁶ There is no evidence for a crucible melting shop at Swalwell until *c.* 1860 (see below). The most likely location is Dunston; Fulthorp & Co. had six crucible melting furnaces at Dunston in 1864, and since George Fulthorp had been Crowley Millington & Co.'s last manager at Teams (which probably included Dunston), he may well have taken over a former Crowley Millington plant when Teams closed in 1860.⁵⁷

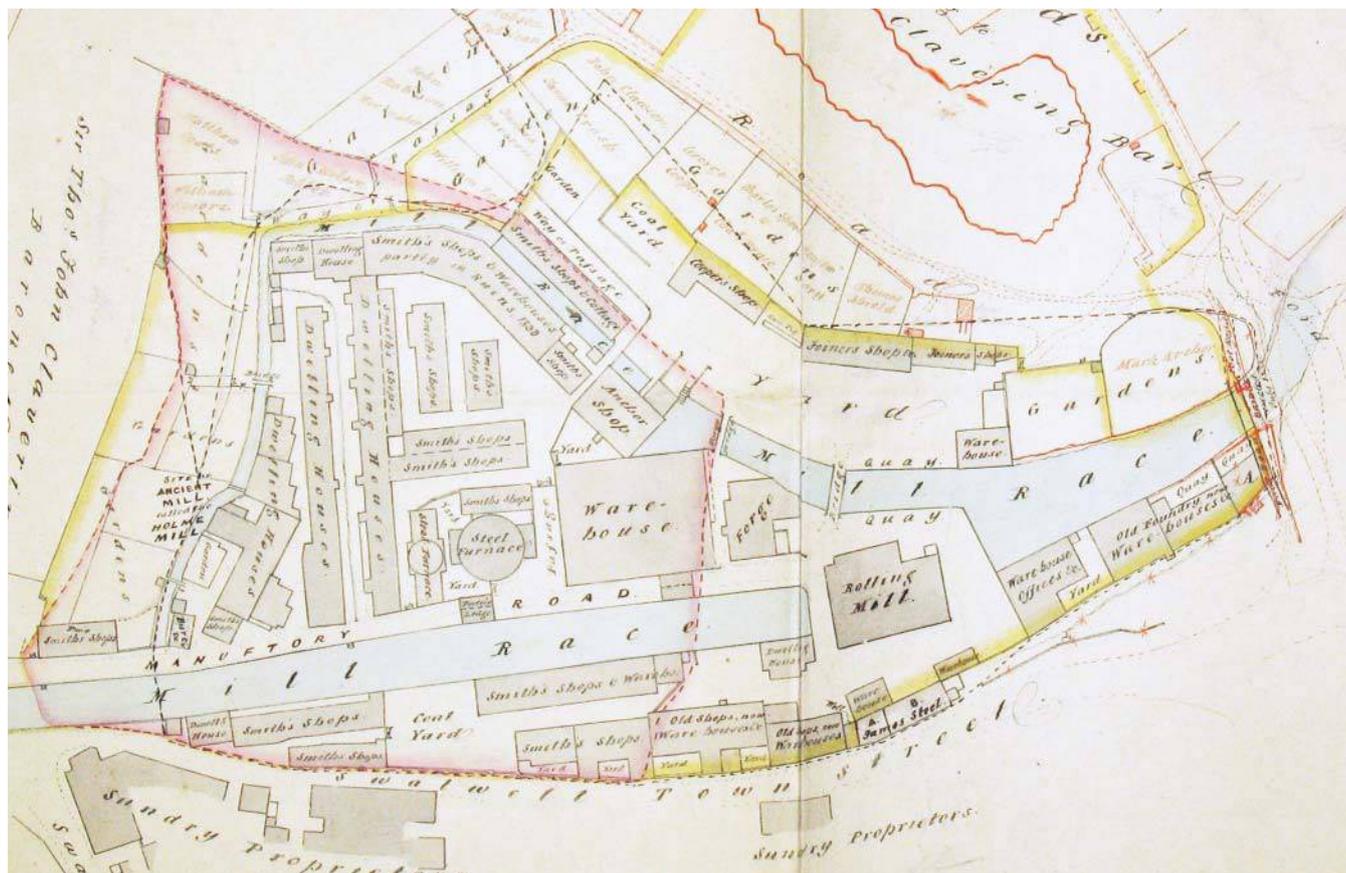
In 1830, Crowley Millington & Co. were one of only thirteen companies in Britain approved to purchase Hoop-L iron (the premium grade of Swedish iron for cementation steel-making),⁵⁸ and in 1834 cementation and steel-casting were 'one of the greatest props, if not the greatest, that remains to us in these ruinous times'.⁵⁹ One factor in the revival of the steel business was action against counterfeiters of the Crowley brand mark on shear steel, especially in the American market.⁶⁰ This indicates that the company were still

making high-quality shear and bar steel (as well as the new cast steel products), and that it had a reputation worth considerable legal expense to maintain.

The year 1834 also saw a new plan of the works (Figure 4),⁶¹ seemingly drawn up to regularise the tenure of various gardens and to establish the boundaries of the various leasehold plots for the increasingly divided ground-tenure. The latter was done incorrectly, with the eastern boundary of Holme Close thought to follow the keel dock beneath the Grand Warehouse; the boundaries were corrected by annotations in 1857. Within the works, the broad building locations and outlines were virtually unchanged from 1802, though the 'footprints' were more detailed, and various yards and sub-divisions were mapped for the first time, allowing the internal connections and access routes of the works to be seen. The range of 'smith's shops and warehouses' along the north-east side of The Square were partly in ruins except for a single narrower smith's shop at the SE end; they appear to have been rebuilt in wider format at some point after *c.* 1714. The large anchor shop to their south-east now had an extension over the northern channel (possibly the 1819 chain-making works).

The Forge had been extended to the north-east, its original eastern wheelrace replaced by a single wider wheelpit, and the western race infilled or covered-in; a small projection on

Figure 4. The works in 1834, with (incorrect) boundaries of Holme Close (DRO: D/Bo/G 37 (vii)).



the west wall (feature [93] in the excavation) may have given access to a water supply in the former wheelrace. The excavation showed that the west wall had been rebuilt, supporting the evidence from the loss of the wheelrace that the finery had been removed. It seems likely that the building was now a hammer forge for heavy fabrication; the hammer may well have been the 'lift hammer' (a heavy belly-helve), of which a model allegedly made in 1840 at the works is recorded in a later photograph.⁶²

In the southern part of the works, the slitting mill was now a rolling mill and had probably been substantially rebuilt. The former foundry was now warehouses. The 1802 hoop house had become a dwelling, the eastern part of the former anchor shops was now warehouses, the western part of the old anchor shop range was 'smith's shops', and the row of workshops north of this beside the main headrace now included another warehouse. Overall, there had been a fairly substantial reorganisation since 1802 (probably in or just after 1816), with the conversion of the slitting mill to rolling, alterations to the forge, an extension to the large anchor shop, closure of the foundry, and conversion of some smiths' shops into warehouses. How many of the various buildings were in active use, and how many were derelict (apart from the labelled ruins), cannot be determined.

The report of the 1842 Children's Employment Commission gives some information on working conditions at this time, at least for the unskilled labouring jobs done by children.⁶³ Crowley's employed 395 adults, 145 young persons, and 23 children (presumably at all their works). At Swalwell, staff worked a 12-hour day (including 1½ hours for meals), and the forges and rolling mills worked 24 hours per day on two shifts. Most of the youths worked on 'open' smiths' shops, producing chains and iron hardware (steel-making is not mentioned, perhaps because it did not employ any children). The workforce were notorious for their ignorance and illiteracy (a sad deterioration from Sir Ambrose Crowley's emphasis on education).

In 1844, a detailed written survey and valuation of Holme Close (as incorrectly defined in 1834) provides considerable detail of this part of the works.⁶⁴ The large steel furnace (No. 4) was 15 yards diameter externally with entrance *porches* and valued at £15 p.a., whereas the smaller furnace (No. 5) was 8 yards diameter with entrance *chambers* and valued at £10. The Grand Warehouse (with an Ambrose Crowley 1713 datestone) had 'several spacious ware rooms' on the upper floor, and iron cellars, some sunk into the ground to accommodate long bars stacked upright. The forge and rolling mill were outside the area of the survey, but the various

workshops and dwellings, both north and south of the main headrace, were enumerated in detail. Many were in poor repair, and the ruinous states of the Holme Mill building (now a dwelling) and the anchor shops south of the main race were particularly singled out (though the workshops on the north-east side of The Square were not, perhaps implying that they had been repaired since 1834).

The steel furnaces were among the few buildings whose condition was not criticised. The 1844 survey confirms the massive difference in 'footprint' between the two furnaces, far greater than the difference in value, or the differences in capacity noted in 1754 by Angerstein (10–12 tons and 14 tons). Although the 18th-century history of Furnace No. 5 is ambiguous, the huge circular footprint of No. 4 is consistent on all maps from c. 1714 onwards; Barraclough⁶⁵ estimates that this should have had a capacity of c. 25 tons. The 1844 survey also describes the smaller furnace as having entrance chambers, whereas the large furnace had only porches. Although cementation furnaces were normally a single structure, with a conical chimney rising from the top of the cementation chamber, exceptions are known. It seems likely that Furnace No. 4 had a separate, much larger, cone *enclosing* the actual furnace and its working areas in the manner of a glass cone (this form is occasionally documented for cementation furnaces, and an example has recently been excavated at Brightside in Sheffield).⁶⁶ This would fit with the relatively slight differences in value and capacity relative to the difference in footprint, with the 1844 identification of only 'porches' on the large furnace, and also with the 'Round House' large enough to contain stores of Windsor bricks and Stourbridge clay in the 1728 inventory (since Furnace No. 4 is consistently the only circular footprint on plans of the works), the space between the outer structure and the actual furnace forming an annular internal 'teasing house'.

Following the death of Mr Crowley Millington in 1849, the partners in Crowley Millington & Co. included his daughters Mary Ann (until 1853) and Jean Ann; Jean Ann married the eminent scientist Lyon Playfair in 1857, but there is no evidence to support (or refute) Flinn's claim that he controlled the partnership in its final years.⁶⁷ They also gave up their Greenwich headquarters in 1853, moving their London base to The Doublet on Upper Thames Street and disposing of large amounts of old stock.⁶⁸ However, a new lease of Swalwell in 1858 was to 'Thomas Fergus Graham and Robert Graham both of Upper Thames Street, London, iron and steel manufacturers *trading as Crowley, Millington and Company*' (my italics); Fergus Graham had been Crowley

boiler, and steam and blast pipes across the race suggest that this and the foundry engines were also serving the machine shop in the former Grand Warehouse.

POW & FAWCUS (1863–78): INTERREGNUM

The Swalwell works were bought by Pow & Fawcus, established chain, cable, and anchor manufacturers of North Shields. They also acquired Winlaton Mill, sold separately by the bankruptcy trustees at the same time as Swalwell and now mainly a rolling mill (Teams was also sold in 1863, but on behalf of the Millington family⁸¹). Their Directory entries suggest that they remained primarily nautical ironwork and equipment suppliers, though with an iron founding and steel-making side based on Swalwell.⁸² They appear to have made little or no alterations to the works; the notice and plan for an abortive sale in 1870 list nothing that was clearly new since 1863, and the rolling mill remained uncompleted.⁸³

Henry William Fawcus and Charles William Scorer, trading as Pow and Fawcus, filed for bankruptcy in 1878.⁸⁴ However, they were presumably able to pay off their creditors, as they continued in operation at North Shields until at least 1885. At Swalwell, Common and Fawcus (about whom nothing else is known) were listed in *Ward's Directory* for 1879–80, but the *Directory* for 1881–2, probably compiled at the end of 1880, already listed Ridley & Co. as steel manufacturers at Swalwell.⁸⁵

RIDLEY & CO. (c. 1880–1912):
A NEW AND FINAL STEELWORKS

James Cartmell Ridley (1844–1914)⁸⁶ was a mechanical engineer of Newcastle upon Tyne by 1865, when he took out the first of three patents relating to iron- and steel-making.⁸⁷ The first and third of these (for decarburising molten pig iron by a blast of carbon dioxide, and for decarburising pig iron or scrap by the addition of lead in a puddling furnace) are unlikely to have worked; the second (for ‘box-piling’ scrap Bessemer steel with wrought iron and fluxes) may have been workable. From 1877 to 1877 he was managing partner of the Walker Malleable Iron Company (also known as Bell, Ridley & Bell), with Joshua Henry Bell and John Lowthian Bell of the Newcastle and Cleveland ironmaster dynasty.⁸⁸ John Lowthian Bell was initially a partner in Ridley & Co. (with others), but from 1884 onwards Ridley was the sole proprietor.⁸⁹

Ridley & Co. probably entered Swalwell as sub-tenants of Common & Fawcus, since there is no evidence that they ever held a direct lease. In 1883 the landlords issued a new lease to William Grace and Co. of

Scotswood, paper-makers. It appears that the intention was always for Ridley’s to retain their sub-lease of the south side of the site, while Grace’s took over direct occupation of the remainder to build a new paper mill, and this was formalised in 1891;⁹⁰ Riddleys’ plot included the rolling mill and the excavated Forge Building, while the shell of the Grand Warehouse (which was retained) and everything to its west and north (which was demolished, including the two cementation furnaces) passed to Grace’s. Ridley & Co. proceeded to remodel their holding into a more compact modern steel and engineering works; this was at least partly in operation by 1890.⁹¹

By 1887, Ridley’s were producing high-quality tool steels, including ‘self-hardening steel, high-class machine steel for planing, tap and die steel, shear steel, chisel, cup, drill steel, cutter steel, mining and jumper steel, drift steel, &ca.’⁹² Self-hard steel was the first commercially important alloy steel; although it was introduced in 1868 by Robert Mushet, its production does not seem to have become widespread until the 1890s,⁹³ and Ridley & Co. was therefore a relatively early manufacturer. Their other steels may have been either alloy or carbon; apart from the shear steel, most were forged from cast ingots. Large forgings and cast steel products were also being made. Shortly afterwards, the works comprised

steel foundries of large dimensions, forges for steel and iron, tilting-hammers for tool-steel, smithies, and machine-shops for the manipulation of heavy castings and other work [. . .]. The products of the establishment consist in crucible steel castings of a high-class character for all purposes, tool-steel of every description, and steel and iron forgings, together with general smithwork. A large amount of locomotive and marine engine steel castings are turned out in excellent quality [. . .].⁹⁴

By the early 1890s,

The main offices, which front the thoroughfare already mentioned [Swalwell main street], are a substantial two storey block of buildings. In the same block is the testing-room, efficiently equipped with hydraulic appliances capable of fulfilling all requirements for testing. Passing into the yard, we first note the large gas producers, used for supplying the furnaces. A little further on we find numerous hands engaged in dressing castings for marine and locomotive engines, ships’ machinery, &ca. In the foundry — a spacious quadrangular structure with an area of about 15,000 square feet — steel castings of all descriptions and for all purposes are turned out. A powerful steam locomotive crane travels the entire length of this building; further noticeable items of the equipment being stationary cranes and a series of drying stoves, annealing furnaces, &ca. The melting-houses proper contain a capacious gas-furnace, and

also ordinary furnaces, in which latter is manufactured the familiar brand of tool steel, for which Messrs. Ridley and Co. have gained such a reputation all over the world ['mark' shown — R & C^o set vertically in a diamond]. We noticed that after the tool and mining steel is tilted, sample pieces are broken off each end of the bar so as to ensure reliability — a number of samples shown us exhibiting remarkably fine texture and beauty of fracture. Proceeding from the foundry to the crucible-shop we find a complete plant of crucible-making machinery. We next visited the fitting and machinery-shops, which had the usual complement of machinery for cutting, turning, planing, slotting, drilling, and sawing, and finishing castings. Close at hand we have the forges for the production of steel or iron forgings. We next visit the pattern-shop, where we are shown, amongst other numerous patterns in course of construction, a newly-finished model of a heavy anchor, made to fulfil Lloyd's requirements, ready for placing in the sand. This department practically concludes our tour of the main work-shops, but we have still to visit the smith's-shop, containing 20 fires, and also the tool steel warehouse, where heavy reserves of the well-known brand are maintained.⁹⁵

Since this last description is geographical, it should be relatable to the 2nd edition OS survey of 1895⁹⁶ (Figure 7), and a plan accompanying a new lease of 1901⁹⁷ (Figure 8). Both show the rebuilt works, with slight differences between the two, though some aspects of the relationship to the description are problematic.

Although the former Holme Mill and the west terrace of Cottage Rows survived, the remainder of the northern part of the works had been demolished, the northern channel infilled, and the new paper mill constructed across the area. The west end of the Grand Warehouse (including the 1860s crucible steel-works) had been demolished, but the remainder survived as two storehouses separated by the keel dock (now a reservoir closed-off from the surviving part of the northern channel), all within the paper mill plot.

Within Ridley's works, the Forge Building survived and the excavated chimney was shown in 1901. The rolling mill building survived but had become a steel forge, with an extension westwards in 1895 that had been removed by 1901. The south-east corner of the works had been consolidated into a single block of offices, smiths' shop, and stores (probably the 20-fire smiths' shop and tool steel warehouse), though this may have incorporated much earlier elements. To the west of the main entrance, another office (probably the 'main offices' in the description) occupied part of the buildings along the southern boundary, the circular features behind this being the gas producers. Beyond this the western part of the works had been almost completely rebuilt, with a large steel foundry

(substantially altered between 1895 and 1901, and visible as a large steel-framed corrugated-iron clad building with a tall thin metal chimney rising from within its south side on early photographs⁹⁸), and a narrower range of 'coke holes' to its west; the locomotive crane presumably ran on the railway track through the foundry building, but from here on correlation to the early 1890s description becomes more difficult. The 'capacious gas furnace' was probably a gas-fired Siemens multiple-crucible furnace⁹⁹ within the main building, and the 'ordinary furnaces' traditional coke-fuelled 'melting holes' in the range to the west.

However, the reference to a crucible shop, separate from the melting-houses with their ordinary furnaces, is confusing. The association of crucible shop with a seemingly adjacent machine shops fits the layout of the Grand Warehouse area on the 1870 plan, rather than anything visible on the 1901 plans, and on careful reading the early 1890s description refers only to crucible-making at this point. It therefore seems likely that when the description was written the Grand Warehouse (or rather its shell) was still occupied by Ridley & Co.; a new crucible melting shop had been constructed next to the foundry, but the old crucible-making and machine shops were still in use. This would also fit with the geographical progression of the description. The 'forges' in the description were presumably the excavated Forge Building, the rolling mill building ('steel forge' in 1901) and the building on the north side of this. The pattern shop cannot be located; geographical logic would put it in or near the rolling mill building, though the excavated Wharf Building (not otherwise mentioned in the description)

Figure 7.
OS 2nd edition survey
(OS 1:2500 sheet Co.
Durham Sheet 6.2:
revised 1895,
published 1897).

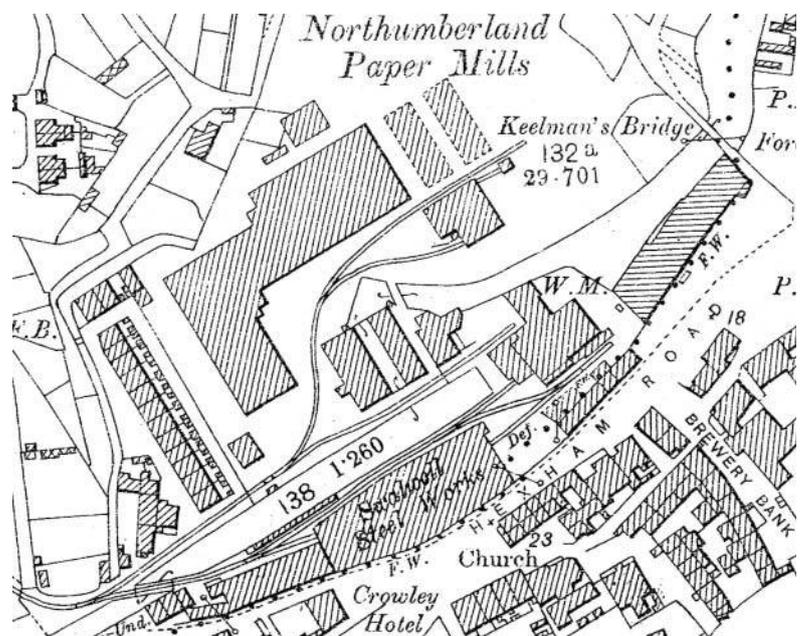




Figure 8. Ridley & Co.'s steelworks and Grace & Co.'s paper mills, 1901 (DRO: DICG 711664).

is an alternative possibility. Neither would be very convenient for the foundry.

The 1914 OS survey¹⁰⁰ (not reproduced) indicates some further alterations to the steelworks in its final years; the main foundry building had been extended east to adjoin the rolling mill building, and an open yard-like area had appeared within its footprint. The paper mill had probably closed by the end of 1908;¹⁰¹ in June 1909 the Graces sold the lease to David and Thomas Gallon Adams (metal merchants, probably primarily scrap merchants). However, Ridley and Co. remained in operation as sub-tenants until 1912, when James Cartmell Ridley surrendered the lease to the Adams's; there is no evidence that Adams & Co. or anyone else ever used the steelworks site, which was disused on the 1914 OS survey and partially demolished by 1923.¹⁰²

CONCLUSIONS

As noted in the Introduction, this paper originated from a project-focused historical study of the physical development and technology of the Swanley works, rather than from more academic research. However, some broader points can be made.

The first of these is the sheer richness of the historical record for the Crowley organisation in general and for Swanley and Winlaton Mill in particular, especially in combination

and dialogue with the archaeological and archaeo-metallurgical record (again at Swanley and Winlaton Mill in particular); the limited pre-development excavation at Swanley has shown the site's potential despite the rather unpromising surface appearance, and the quality of below-ground survival at Winlaton Mill may be exceptional.¹⁰³ This applies as much to the remarkable managerial, economic, and social organisation of the early Crowley empire,¹⁰⁴ barely mentioned in this report, as to the physical nature of the works and the processes.

The second is the range of sources and interconnections for the technology of the Crowley works in their setting-up phases, and the potential for technology transfer and innovation (at least at the detailed level — Crowley's policy appears to have been to use and improve the best of existing technology, and there is no evidence for major innovation or breakthroughs). In the early years at Winlaton Mill, Ambrose III clearly drew heavily from the West Midlands workforce and expertise of his father, though by the 1710s he appears also to have accessed the 'shear steel' technology introduced or developed by Bertram. Ambrose II may also have been the source of what seem close similarities in both terminology between steel- and glass-making; Stourbridge was a centre of both industries, and Stourbridge clay a vital refractory. As the 1711 Mill Directions makes clear,

craftsmen for the expanding workshops were also recruited widely (the Sheffield area figuring particularly heavily). At a broader level, Ambrose III with his direct personal interest in ironworking and his broad contacts at his Greenwich headquarters may also have formed a channel for innovation, both from within Britain (as witnessed by Mr Norris and the coal-fuelled chafery) and potentially internationally; he clearly had substantial Swedish contacts, and also with the East India Company.¹⁰⁵

Moving to the other end of Swalwell's history, the field evidence for the late furnace in the Forge Building, and the difficulties over its interpretation (Proctor and Mackenzie, this volume) highlight how little we yet know about the archaeology and archaeometallurgy of 19th-century iron-making; a vital element in the later stages of industrialisation and in the development of modern society, yet one where we are still forced to rely on a limited range of contemporary metallurgical texts. If the excavated flue and its slags were indeed from a reheating furnace (as this author thinks probable), they are probably the first (at least in Britain) to have been identified and analysed; how far they are typical, or the reverse, and how we can distinguish the full range of furnaces and their residues used in 19th-century iron-making, and use this knowledge to augment (and no doubt at times challenge) the narrative derived from the historical sources, remains a work in the early stages of progress.

However, the main theme of this project has been a challenge (though a revision, not a total rebuttal) to Flinn's conception of the Crowley organisation as entirely the creation of one man, Ambrose Crowley III, between the 1680s and 1713 (and in the case of Swalwell, largely between 1707 and 1709¹⁰⁶), followed by stasis then inexorable decline, with the possible lurking assumption that this trajectory was and is inevitable. The nature and circumstances of innovation and success, and their opposites, must form an important theme in any understanding of 'industrial archaeology'; the more nuanced trajectory for Swalwell presented here may have wider relevance. To summarise: Ambrose Crowley III's vision and achievement, though remarkable, built on a model already part-developed by his father, and on his father's technology and workforce. They were also well short of completion at the time of his death. While John Crowley's substantial additions at Swalwell may largely have been carrying out his father's plans, development both of the Swalwell works and of the wider organisation clearly continued at least through Theodosia Crowley and John Bannister's period of

control in the 1730s, with some innovation continuing until at least the 1760s. And (remaining within Flinn's model of top-down agency, which this author would support in this case) the role of contingency might be examined: what if Sir Ambrose had gone bankrupt in 1713 or before? What if John I, Ambrose IV and John II had not all died without issue? What if the Clavering landlords had not been so relentlessly litigious in the 1730s and 1740s?

Turning to the later periods, Flinn's model of stasis in the later 18th century, merging into first relative then absolute decline, remains intact. But Mr Crowley Millington's tenure can be seen as an attempted rally, unsuccessful for the manual workshop side of the business but much more successful for steel-making. And (to this author's considerable surprise) the 1860s remodelling into a specialist steel-making and engineering business, centred solely on Swalwell, emanated firmly from Graham & Graham — the last of the lineage of Greenwich managers of the Crowley organisation — rather than from the 'new broom' of Pow & Fawcus. In its 1860s form this was a very qualified success, but the move was repeated in the 1880s by Ridley & Co., in which form it was (so far as we can tell) successful for a generation. While a degree of underlying process and inevitability may well be present, the actual picture is much more complicated.

ACKNOWLEDGEMENTS

This paper derives from research for Pre-Construct Archaeology; I am grateful to Jennifer Proctor and Robin Taylor-Wilson for commissioning it, and for their patience during its preparation. My thanks to the staff of the various Record Offices and Libraries consulted during the research for their friendly assistance. I am grateful to Hazel Fleming, Jeremy Hodgkinson, Jenny Morrison and John Nolan, among others, for help on various points, to Peter Barber (British Library) for information about John Warner and the context of the 1718 map, and especially to Paul Belford, Professor Chris Evans (Glamorgan University), Dr Peter King and Dr Rod Mackenzie for repeated help with information and various informative and enjoyable discussions. Responsibility for any errors, omissions, and misinterpretations remains, of course, my own. My debt to Flinn's *Men of Iron* is greater than may appear from the references, since I have cited primary documents where possible. All photographs are by David Cranstone. Figures 1 and 3 are reproduced by permission of Tyne and Wear Archives Service, figs 2, 4, and 8 by permission of Durham Record Office, and fig 8 by permission of Durham University Library Special Collections.

NOTES AND REFERENCES

Record Offices within North-east England (DRO, DULSC, NCL, NRO, TWAS) and East Suffolk Record Office (ESRO) were visited in person for research. Remaining repositories cited below were catalogue-searched via Access2Archives (<http://www.nationalarchives.gov.uk/a2a/> [consulted February 2010]), supplemented by correspondence where appropriate; since a2a is limited to catalogues and is estimated to contain c. 30% of catalogued records nationally, this is recognised as being a very incomplete coverage.

The *London Gazette* was consulted on <http://www.london-gazette.co.uk/>, *The Times* on http://infotrac.galegroup.com/itw/infomark/0/1/1/purl=rc6_TTDA?sw_aep=newcit, and the *Newcastle Courant* (1800–1900) on <http://find.galegroup.com/bncn/start.do?prodId=BNCN&userGroupName=newcit>, the latter two via Newcastle City Libraries.

¹ Cranstone, D., 'Swalwell Ironworks, Gateshead: Detailed Historical Report' (unpublished report to PCA Ltd and Tyne and Wear HER, 2010).

² Flinn, M.W., *The Law Book of the Crowley Ironworks*, 167 (Durham: Surtees Society, 1957); Flinn, M.W., *Men of Iron* (Edinburgh, 1962); Barraclough, K.C., *Blister Steel: the Birth of an Industry* (The Metals Society, 1984a); Barraclough, K.C., *Crucible Steel: the Growth of Technology* (The Metals Society, 1984b); Evans, C. and Rydén, G., *Baltic Iron in the Atlantic World in the Eighteenth Century* (Leiden and Boston: Brill, 2007); Evans, C., 'The Plantation Hoe: the Rise and Fall of an Atlantic Commodity', <http://glam.academia.edu/ChrisEvans/Papers/184512/The-Plantation-Hoe--The-Rise-and-Fall-of-an-Atlantic-Commodity-1650-1850> (formal publication forthcoming).

³ Flinn, 1962, ref. 2, 54.

⁴ Bennett, G., Clavering, E., and Rounding, A. *A Fighting Trade: Rail Transport in Tyne Coal 1600–1800*, 1 (Gateshead: Portcullis Press, 1990), 85–106; vol. 2, Plans 23–7.

⁵ Barraclough, 1984a, ref. 2, 63–70; Cranstone, D., *Derwentcote Steel Furnace; an Industrial Monument in County Durham* (Lancaster, 1997), 17–18; Cranstone, D., 'Steel in the Derwent Valley: but Enlightenment?', *Historical Metallurgy*, 42.2 (2008), 100–11; Evans and Rydén, ref. 2, 53; Linsley, S. and Hetherington, R., 'A Seventeenth Century Blast Furnace at Allensford, Northumberland', *Historical Metallurgy*, 12.1 (1978) 1–11.

⁶ Belford, P. and Ross, R.A., 'English Steelmaking in the Seventeenth Century: the Excavation of Two Cementation Steelworks at Coalbrookdale', *Historical Metallurgy*, 41.2 (2007), 105–23; Belford, P., 'Steel at the Dawn of Capitalism: Reformation, Technology and Enlightenment', *Historical Metallurgy*, 42.2 (2008), 89–99.

⁷ Flinn, 1962, ref. 2, 8–9.

⁸ Brown, P.J., 'Andrew Yarranton and the British Tinplate Industry', *Historical Metallurgy*, 22.1 (1988), 42–3; King, P.W., 'Wolverley Lower Mill and the Beginnings of the Tinplate Industry', *Historical Metallurgy*, 22.2 (1988), 104–13. Both Brown and King (pers. comm., September 2010) now believe this was Ambrose II rather than Ambrose I.

⁹ Flinn, 1962, ref. 2, 10–15; King, 1988, ref. 8.

¹⁰ Meikle, M.M. and Newman, C.M., *Sunderland and its Origins: Monks to Mariners* (Chichester: Phillimore & Co., 2007), 162; Flinn, 1962, ref. 2, 31–41.

¹¹ Durham Record Office (DRO): D/CG 19/34.

¹² The National Archives (TNA): Navy Board: Records ADM 106/1, various.

¹³ Northumberland Record Office (NRO): SANT/GEN/IND/3/1.

¹⁴ Shakespeare Centre Library and Archive (SCLA): ER 3/185.

¹⁵ Flinn, 1962, 52–4; DRO: D/CG 7/1577; DRO: D/X 196/2; ESRO: HA1/GC/1/5.

¹⁶ NRO: SANT/GEN/IND/3/1; Hertfordshire Archives and Local Studies (HALS): DE/L/4529.

¹⁷ Sheffield Archives (SA): SpSt/64713/6, /64713/4–5, /64713/7–8, /64713/10–11, /158/5, /64713/12.

¹⁸ DRO: D/Bo/G 91/37, D/CG 19/35; ESRO: HA1/GC/1/19.

¹⁹ Flinn, 1962, ref. 2, 51–2.

²⁰ Newcastle City Library (NCL): SL669.1Crowley, Ambrose. Mill Directions 1712 9277–10476 28 April 1711–3 January 1712 (microfilm from unlocated original bound volume).

²¹ Probably William Norris, anchor supplier to Sheerness naval dockyard from 1696 to 1718 (Peter King, pers. comm.).

²² DRO: D/Bo/G 91/104; NRO: SANT/BEQ/2/1/15/16.

²³ *London Gazette*, 13 June 1713, 5; 7 July 1713, 2.

²⁴ Flinn, 1962, ref. 2, 62.

²⁵ Tyne and Wear Archives Service (TWAS): DX 104/1, 13. The mapbook is dated by TWAS to 1718 from a glued-in letter, but this in fact relates to its replacement by a new survey, not known to survive; the mapbook must therefore be several years earlier, and a date of c. 1714 is probable.

²⁶ DRO: D/ST/P13/1.

²⁷ Flinn, 1962, ref. 2, 54, 186.

²⁸ *Dictionary of National Biography*, 'Isaac Wilkinson' (oxforddnb.com [consulted 22 January 2010]).

²⁹ ESRO: HA1/GD/5/15.

³⁰ Flinn, 1962, ref. 2, 76–90. Most of the documentation in ESRO, and of the 18th-century material in DRO, relates to the legal settlements and disputes of the 1730s to 1750s.

³¹ Cranstone, 1997, ref. 5, 18–19; Evans and Ryden, 2007, ref. 2, 195–6.

³² Flinn, 1962, ref. 2, 79–80, 184–7.

³³ DRO: D/St/C1/3/198; Flinn, 1962, ref. 2, 79–80.

³⁴ Durham University Library, Special Collections (DULSC): DHC1/III/22, /23, /26, /27 (notes kindly supplied by Dr Peter King).

³⁵ King, P.W., 'Ashburnham Furnace in the Early 18th Century', *Sussex Archaeological Collections*, 133 (1995), 260.

³⁶ DRO: D/CG 7/1578.

³⁷ Berg, T. and Berg, P. (trans.), *R R Angerstein's Illustrated Travel Diary, 1753–1755* (Science Museum, 2001), 260; Flinn, 1962, ref. 2, 185.

³⁸ Cranstone, D., 'Isaac Wilkinson at Backbarrow', *Historical Metallurgy*, 25.2 (1991a), 87–91.

³⁹ Berg and Berg, 2001, ref. 37, 260–3 for Swalwell, 258–66 for the other Crowley works.

⁴⁰ Barraclough, 1984a, ref. 2, 185–6.

⁴¹ Barraclough, 1984a, ref. 2, 202–4, 62–3.

⁴² Barraclough, 1984a, ref. 2, 205–8.

⁴³ Cranstone, 2008, ref. 5, 105–6.

⁴⁴ Young, A., *A Six Months' Tour through the North of England*, III (1771), 11, quoted by Bourn, W., *Whickham Parish: its History, Antiquities and Industries* (Carlisle, 1893), 97–8.

⁴⁵ Hayman, R., *Ironmaking: the History and Archaeology of the Iron Industry* (Stroud: Tempus, 2005), 39–66.

⁴⁶ DRO: D/CG 7/1583.

⁴⁷ Flinn, 1962, ref. 2, 87–91; *London Gazette*, 12 July 1817, 1548; *London Gazette*, 20 November 1824, 1919.

⁴⁸ Flinn, 1962, ref. 2, 93–5, derived largely from Bourn, 1893, ref. 44. Bourn, W., *History of the Parish of Ryton* (Carlisle, 1896); Bourn, W., *Annals of the Parish of Whickham* (Consett, 1902).

⁴⁹ Birmingham City Archives: Boulton & Watt MII/5/10; information and comments kindly supplied by Peter King.

⁵⁰ Manders., F.W.D., *A History of Gateshead* (Gateshead: Gateshead Corporation, 1973), 66–70.

⁵¹ DRO: D/CG 7/1583; copy of map (with slight discrepancies) TWAS: DT.BEL.2/22.

- ⁵² Bourn, ref. 44, 100.
- ⁵³ Flinn, 1962, ref. 2, 250–1.
- ⁵⁴ Bourn, 1893, ref. 44, 96; Flinn, 1962, ref. 2, 191–2; Haldane, H. *Northumberland Words*, 28 (Paul, Trench Trubner & Co. for English Dialect Society, 1892), 242.
- ⁵⁵ *Contra* Barraclough, 1984a, ref. 2, 111; 1984b, ref. 2, 175.
- ⁵⁶ *Newcastle Weekly Chronicle*, 14 June 1873, quoting letter of March 1834 from Crowley Millington to T.F. Bennett.
- ⁵⁷ Spencer, T., 'On the Manufacture of Steel in the Northern District', in Armstrong, W.G., Bell, I.L., Taylor, J., and Richardson, Dr T (eds), *The Industrial Resources of the District of the Three Northern Rivers, the Tyne, Wear, and Tees* (London and Newcastle upon Tyne: Longman Green, Longman, Roberts and Green and A. Reid, 1864), 120–5 (122, 125); *Newcastle Courant*, 15 August 1855, 2 January 1863, 26 August 1864, 29 March 1867; *London Gazette*, 30 December 1862, 6600; 1 May 1863, 2358; 6 August 1867, 4395.
- ⁵⁸ *Newcastle Courant*, 14 August 1830.
- ⁵⁹ *Newcastle Weekly Chronicle*, 14 June 1873, quoting letter of March 1834 from Crowley Millington to T.F. Bennett.
- ⁶⁰ *Newcastle Courant*, 24 May 1834; *The Times*, 27 October 1835, 4, col. B; 19 March 1838, 6, col. E; 26 March 1838, 6, col. F; *Gateshead Observer*, 14 March 1840, 3, col. 3; 22 November 1856, 1, col. 5; 26 May 1860, 1, col. 4.
- ⁶¹ DRO: D/Bo/G 37 (vii) (with 1857 annotations); schedule DRO: D/Bo/G91/73 (dated September 1834); DULSC: Gibson Volumes: Maps and Plans 47, 48 are probably working drawings.
- ⁶² Gateshead Library (GL): GL002219.
- ⁶³ Leifchild, J.R., *Report by John Roby Leifchild on the employment of children and young persons in the collieries, lead mines and iron works of Northumberland and the North of Durham, and on the condition, treatment and education of such children and young persons* (Parliamentary Papers, 1842, Vol.16), 686–7.
- ⁶⁴ DRO: D/Bo/G 91/103 [final valuation], /104 ['field' notes]; DULSC: Gibson Volumes: Maps and Plans 69 was probably drawn to accompany this survey.
- ⁶⁵ Barraclough 1984a, ref. 2, 203.
- ⁶⁶ Barraclough 1984a, ref. 2, pl. 7, no. 27; R Mackenzie, pers. comm., June 2010.
- ⁶⁷ *London Gazette*, 28 July 1882, 3541; Flinn, 1962, ref. 2, 91, 93.
- ⁶⁸ *The Times*, 22 June 1853, 3 August 1853.
- ⁶⁹ DRO: D/CG 7/1612; Flinn, 1962, ref. 2, 91, 93–4.
- ⁷⁰ *Gateshead Observer*, 24 January 1863, 8, col. 1; *London Gazette*, 28 November 1862, 6104; 17 March 1863, 1539; 27 March 1863, 1809; 29 May 1863, 2825; 17 July 1863, 3609; 14 August 1863, 4077.
- ⁷¹ DRO: D/CG 7/527; DRO: D/Bo/G 37 (vii) 1857 annotations; D/Bo/G 91/36; D/Bo/G 91/183–5; D/Bo/G 91/213, /216, /217; DULSC: Gibson Volumes: Maps and Plans 3; TWAS: DT/BEL/2/30.
- ⁷² *Gateshead Observer*, 6 September 1851, 1, col. 5; 13 September 1851, 1, col. 4; 13 March 1852, 1, col. 4; 20 March 1852, 1, col. 3; 31 December 1852, 6, col. 6; 15 January 1853, 1, col. 4.
- ⁷³ *Ward's Directory*, 1855 and 1857 editions; *Ward's Directory* entries from 1850 onwards, both for Crowley Millington & Co. and for later owners of Swalwell, broadly confirm the primary documentary evidence but with some time-lags and other discrepancies.
- ⁷⁴ DRO: D/St/E6/3/1.
- ⁷⁵ DRO: D/CG 7/3083; DRO: D/CG 7/1612.
- ⁷⁶ OS 1:2500 Co Durham Sheet 6.2; surveyed 1856, published 1858.
- ⁷⁷ *Wards Directory*, 1861–2, Advertisements, 156.
- ⁷⁸ *Newcastle Courant*, 23 January 1863 (repeated 30 January, 6 February); *The Times*, 24 January 1863, 12.
- ⁷⁹ *Gateshead Observer*, 28 February 1863, 1, col. 6; 7 March 1863, 1, col. 6; 16 May 1863, 1, col. 6; 16 May 1863, 5, col. 1; *The Times*, 28 February 1863, 15 (repeated 7 March).
- ⁸⁰ DULSC: Gibson Volumes: Maps and Plans 1.
- ⁸¹ *Newcastle Courant*, 8 May 1863; *Gateshead Observer*, 16 May 1863.
- ⁸² *Ward's Directory*, 1865–6 to 1877–8.
- ⁸³ *Newcastle Courant*, 22 April 1870; DULSC: Gibson Volumes: Maps and Plans 1.
- ⁸⁴ *London Gazette*, 29 January 1878, 502.
- ⁸⁵ *Ward's Directory*, 1879–80 to 1885–6.
- ⁸⁶ [*Newcastle*] *Evening Chronicle*, 28 December 1914, 3, col. 4.
- ⁸⁷ 1865, No. 2657; 1869, No. 1240; 1871, No. 160.
- ⁸⁸ North Yorkshire County Record Office (NYCRO): ZKF, deed of co-partnership, Bell Ridley & Bell; *London Gazette*, 22 February 1878, 898.
- ⁸⁹ *London Gazette*, 19 June 1883, 3176; 26 February 1884, 994; 30 December 1884, 6035.
- ⁹⁰ DRO: CC/X 13/14, D/CG 7/1639, D/CG 7/1664, D/CG 7/1689. William Grace & Co. probably brought the Northumberland Paper Mill into production in 1887, and by 1894 it was making manillas, rope and other browns, glazed and unglazed, casings, and tips (Stirk, *The Lost Mills: a history of papermaking in County Durham* (Sunderland: University of Sunderland Press, 2006), 179–80).
- ⁹¹ *Newcastle Weekly Chronicle*, 25 October 1890.
- ⁹² *Newcastle Weekly Courant*, 20 May 1887.
- ⁹³ Barraclough, 1884b, ref. 2, 131–3.
- ⁹⁴ Anon. [c. 1888], 200 (held at TWAS).
- ⁹⁵ Anon. [c. 1894], 107 (NCL hold four copies, not all containing the Swalwell entry and perhaps from successive years; the Swalwell entry has an internal *terminus post quem* of 1891).
- ⁹⁶ OS 1:2500 sheet Co. Durham Sheet 6.2: 2nd edition (revised 1895, published 1897).
- ⁹⁷ DRO: CC/X 13/14, D/CG 7/1664.
- ⁹⁸ Brazendale, A., *Images of England: Whickham, Swalwell and Dunston* (Stroud: Tempus, 1998), 53 lower, 60 lower; GL photograph collection: GL000830. Surprisingly, these are almost the only known early photographs of the works.
- ⁹⁹ Barraclough, 1984b, ref. 2, 76–82.
- ¹⁰⁰ OS 1:2500 sheet Co. Durham Sheet 6.2: 3rd edition (revised 1914, published 1919).
- ¹⁰¹ Since Grace's were not listed in *Ward's Directory* for 1909–10.
- ¹⁰² DRO: CC/X 13/14.
- ¹⁰³ Cranstone, D., 'Winlaton Mill Ironworks — an Interim Report', *Archaeology North*, 2 (1991b), 22–4.
- ¹⁰⁴ Flinn, 1962, ref. 2, throughout.
- ¹⁰⁵ Flinn, 1962, ref. 2, 139–40. See also Evans and Ryden, 2007, for a superb exposition of the linkages of 17th- and 18th-century mercantile capitalism more broadly.
- ¹⁰⁶ Flinn, 1962, ref. 2, 54.

David Cranstone, FSA, is a freelance consultant archaeologist working mainly on the archaeology of industry and technology; his main research interests centre on historical archaeology, the iron industry from the medieval period to the 19th century, and on coastal salt making. He is currently Secretary of the Historical Metallurgy Society, and is a former Secretary of the Society for Post-Medieval Archaeology. Address for correspondence: 267 Kells Lane, Low Fell, Gateshead NE9 5HU, UK. Email: cranconsult@btinternet.com