

Thoughts on Saws

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(With some additional notes by Graham Isherwood, 2008)

One of the most interesting aspects of Hafodlas mill is the variety of saws with which it has been equipped and hence the varied evidence of same to be found on site. Four types of saws have been used there, if reports of a diamond saw late in its career are correct; conventional, sand, Hunter and diamond. All four types could towards the end of its life be seen working together more or less under the same roof and some blocks might be sawn on three different types in the course of manufacture – offcuts showing conventional, Hunter and sand saw lays have been found.

The conventional saw needs no introduction as it was the usual method of cutting in most Welsh slate quarries. The reciprocating sand saw was less widely used in the slate industry but common where hard slate was processed for block manufacture. Still employed in the stone industry today, it employed simple metal blades working backwards and forwards under a fairly heavy load lubricated with sand and water. Such a saw wears its way through rather than cutting; it is slower than a toothed saw but produces a much smoother lay, so that blocks can be finished in the saw. Also, having a much gentler cutting action, it can make multiple cuts close together without danger of shattering the thin sections thus produced. AT Hafodlas sand saws appear to have formed an essential part of the equipment throughout its career.

Probably the greatest interest attached to the Hunter saw, introduced by W.F.Cooke in the early 1860's. Developed by James Hunter and his son George, of Leysmill, Arbroath, it was an early application of renewable tip tooling. The Hunters may indeed have invented this principle, which is now widely applied in the engineering industry. The basic tool, and so far as can be discovered the only one used at Hafodlas, was basically a tapered steel pin with an enlarged head, the latter turned hollow to produce a cutting edge and then hardened. Coincidentally, perhaps, the tool resembled a golf tee. It was held in a tapered socket in a holder slotted into the periphery of the saw blade. As in a normal saw blade the teeth (in this case holders) were set so that it cut a kerf wide enough to clear the blade and ensure that each tool cut over no more than about a quarter of its periphery. Besides ensuring that the tools did not jam, this permitted them to be turned to present a fresh cutting edge so that four lives were obtained before sharpening or re-profiling.

James Hunter was the Manager of the freestone quarry at Leysmill, from which came high quality paving stone that was sent all over Europe. In 1833 he became interested in mechanised stone dressing and after two years work obtained his first patent for a planning machine in 1835. Twenty years later came the big saw embodying renewable tip tooling, a principle (and a common design of tool) applied also to planers, milling machines and reciprocating saws. Patents were obtained in the joint names of James Hunter and his son George, but contemporary accounts suggest that George was largely responsible. Hunter's machinery was made by Archibald Munro & Co. of the Arbroath Foundry and was considered by many to have been a major factor in the expansion of the Scottish granite industry:

“But important as the planning machine proved to be, it has been eclipsed by the stone-cutting and dressing machines invented by Mr. Hunter's son, Mr. George Hunter, and now of the Welsh quarries, in conjunction with Messrs. Munro and Company of the Arbroath Foundry. The machines, which are sent to all parts of the country where there are quarries, form a considerable article of manufacture at Arbroath” (D.Bremner; The Industries of Scotland 1869; p.416)

“There is no doubt that the Hunters' inventions greatly improved the sandstone and slate industries, not only locally, but also throughout Britain” (Alexander Mackie: Sandstone Quarrying in Angus, The Edinburgh Geologist; No.8 1980)

In the latter quotation, slate refers more to stone slates than to the material familiar in North Wales.

The Hunters left Leysmill in 1860, possibly on James' retirement and moved to Coleford in the Forest of Dean. James may have died shortly afterwards (Bremner refers to the late Mr. James Hunter), because George Hunter moved to Maentwrog to try his hand at slate quarry management. [The 1861 census shows George at Bakers Hill, Coleford, gives his year of birth as 1831 and gives his position as head of household.GI] Here he was a near neighbour of W.F.Cooke, though whether his association with Cooke was the cause or the result of his move to North Wales is not at present clear. William Fothergill Cooke became an important promoter of the Hunter saw and Hafodlas may have been laid out as a showcase for it. [Maenofferen may well have been the showcase for the tunnelling machines, and there was certainly a Hunter saw installed in the leased mill at the "Lower Works" as well. GI] Despite this, Alexander Mackie says that "*George Hunter died comparatively poor, but other men reaped the benefits of his efforts*" – an all too common epitaph for the British inventor. [W.F.Cooke also died in penury, having lost all the money he had gained from the telegraph patent and its subsequent sale in his investments in North Wales quarries.GI]

The main reason for adopting this design was almost certainly metallurgical. Before the advent of mass-produced steel, the only material available for making large circular saw blades was wrought iron, which is virtually useless for cutting slate or stone. Crucible steel suitable for saw teeth was available only in small casts and very expensive. By using separate teeth, therefore, one could make large blades at a realistic price without compromising mechanical properties. Blades were made as large as 13ft. diameter, these being used to cut the giant blocks needed to build breakwaters.

The saw was an early application of the "low speed, heavy feed" principle later exploited by Frederick Beaumont's diamond drill and Moses Kellow's hydraulic drill. The basic idea behind this is to maintain a continuous and aggressive cutting action so that the cutting edge of the tool is always submerged. Worked thus it has adequate leverage to carve away material and is prevented from backing off to bounce or skid over the surface, creating the best conditions for maximum life of the cutting edge. On the debit side, heavy cuts require suitably robust tools and machinery to withstand the forces involved, and there is always a danger of overheating the tools.

The original Hunter saw had an enormous blade mounted beneath and protruding through the moving table, similar to a timber saw and of course the layout used in the traditional slate saw. The over-table version of the Hunter saw with which we are here concerned was developed by George Hunter and Archibald Munro shortly before his departure from Leysmill, this being the form in which it was used at Hafodlas and elsewhere in North Wales. [Munro also patented a similar machine in 1868, but with a different form of tool and table drive GI]

The main shaft was mounted over the table and carried up to four blades of 4ft. overall diameter which rotated just clear of the table. The position of each blade on the shaft could be adjusted to enable blocks of different widths to be cut. The ability to make two or more parallel cuts simultaneously meant that blocks could in theory be finished by two passes through the saw, being turned through 90 degrees intermediately. Many saws appear to have been "double," which by deduction from the patent drawings meant that they had two table side by side and driven separately, two blades over each table. This enabled one side to be cutting while a block was set up ready on the other table.

Cooke claimed that the saw was much quicker than any other type and quoted some figures which to present-day eyes are somewhat incredible. A feed of one foot per minute though a block one foot thick, for example, involved the removal of about 2250 cubic centimetres of slate per minute, per blade. This alone would require something like 21hp/blade and may be compared with the best of today's diamond saws which can achieve 3000 cu.cm. per minute. In practice it is suspected that a much lower figure was achieved, if for no other reason than that Hafodlas possessed insufficient power for more than one saw of this potential, even if they were available, which it frequently was not.

The reasons for moving the saw blade from beneath the table to overhead were to reduce as far as possible the shock loads imposed by a coarse pitch saw cutting at low speed under heavy feed, which could easily shatter the edge of the block being sawn, if not the block itself, and to avoid the complexities of a divided table. [Somebody, one suspects DeWintons, later devised a way of using a "Hunter" saw blade in a conventional split table, regrettably no photograph has survived GI] The definitive Hunter saw had 4ft blades carrying twenty eight teeth and running at a peripheral speed of 45ft/min. Under these conditions one hundred teeth passed through the kerf every minute and the normal feed was between three and six inches per minute depending on the thickness of the block. The advance per tooth was therefore at least 0.03in and could be considerably more. For teeth to pick up a cut at such a depth right away would result in shock loads both on the block and on the teeth, for this reason the saw cut downwards.

The principle of cutting upwards is shown in the accompanying diagram, from which it is seen that the cut began at the bottom of the kerf with the blade moving in the opposite direction to the block. "Upwards" is relative to the kerf and not to gravity. Run thus, each tooth cut progressively into the curved path left by its predecessor, the load coming on gradually with a minimum of shock. To achieve this, the blade did not cut all the way through the block, the bottom of the kerf being $\frac{1}{2}$ in or so from the uncut face and it was for this reason that the overhung form of the saw was adopted. In a conventional table, the bottom of the kerf would be at the top of the block and its height above the table dependent upon the thickness of block being cut, so achievement of ideal conditions involves adjustment of the blade and/or table height to suit each block. With the blades over the table, however, the bottom of the kerf is always in the same place, and no provision for vertical adjustment is necessary. The machine is further simplified by elimination of the split table necessary with the underhung blade, and it can of course cut blocks of different thicknesses in the same load.

The Hunter saws used at Hafodlas exemplified this technique of sawing. The blades rotated two or three inches clear of the table and blocks for sawing were placed on sleepers – wooden packing about $\frac{1}{2}$ in thinner than the gap between blade and table. The sleepers were placed immediately inboard of the blades on either side of the block, so that the offcuts were unsupported. Stout iron dogs inserted into holes in the table restrained both the block and the sleepers. The blade being overhead there was little likelihood of an upward cut lifting the block because the resultant cutting force was inclined forwards and thus resisted by the dogs; the thinner and lighter the block the nearer this force came to the horizontal. On completion of the cut, the overhanging weight of the offcuts would in most cases cause them to break off, leaving the characteristic incompletely cut edge seen in several blocks used to build the walls of the mill extension. If the offcuts did not break off automatically, a blow from the rhy would have sufficed to complete the job.

This type of sawing was hard on the tools, which in those days were inferior to a modern tool steel, and replacement was almost a continuous process. According to Cooke a tool could be turned or replaced without stopping the saw, due to the low speed. There was, of course, no Health & Safety legislation in Cooke's day! Evidence suggests that a small smith's hearth and sharpening facility was situated by each saw table, with which worn tools were first softened, re-turned to present a new edge (if too worn they were upset to restore head size) and then hardened again. Each saw was thus a self-contained unit, in size and general concept anticipating the multi-axis machine tools of our own age.

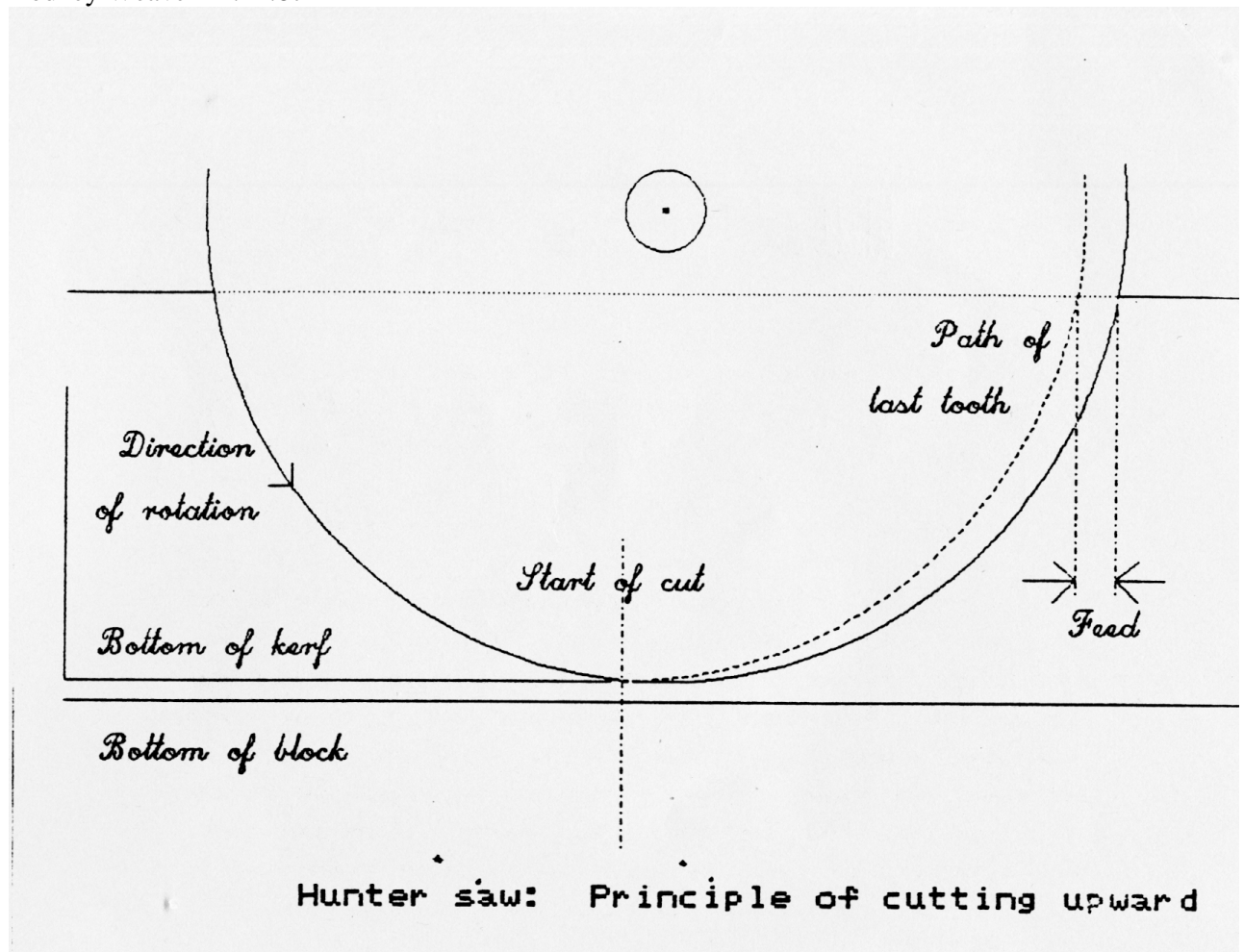
The main drawback to the Hunter saw, apart from the points just made, were the high cutting forces involved which precluded the processing of thin slab. Again, the staggered teeth produced a pronounced lay recognisable from several feet away. This was too rough a face for splitting to the thickness necessary for slate production, and too rough for jointing. The Hunter saw was thus of little use for roofing slate production and of but limited use for blocks beyond initial breaking down of the rough slab. Despite Cooke's enthusiastic claims, therefore, it is considered unlikely that the saws were much better than conventional saws except for handling really thick slab. That so many were installed at Hafodlas may indicate that their availability was poor compared with conventional and sand saws fewer in number yet apparently doing much more work.

Double saw tables were huge affairs and the remains excavated so far confirm the impression given by both patent drawings and by Cooke himself. These remains, and any yet to be discovered, are an important feature of the site and worthy of full excavation. There is photographic evidence that Munro supplied at least one Hunter saw to North Wales in 1863, but those at Hafodlas were supplied by Vulcan Foundry Co. Ltd. of Newton-le-Willows in 1867. It is believed that this famous locomotive builder had supplied machinery for laying the first transatlantic telegraph cable, a project in which W.F.Cooke and Sir Daniel Gooch had been involved before their entry into the Hafodlas story.

There is some evidence that a diamond saw was installed in the 1920's which would be the first such saw in North Wales. Personal reminiscence in this instance supported by saw waste uncovered on one of the Hunter bases. Much finer than anything produced by Hunter or conventional saws, it is also free of the small chips characteristic of normal slate saw waste. The firm is known to have been seeking some new and presumably more modern sawing machinery in 1914; the possibility being that early diamond saws were derived directly from the Hunter design, enabling conversions to be carried out, has yet to be investigated.

Investigations are proceeding in Sheffield and Arbroath. So far some interesting information on the Arbroath end of the story has been provided by Matthew Kerr, Alisdair Sutherland (Librarian) and Mrs Margaret King (Assistant Curator, Signal Tower Museum). An innocent enquiry seems to have awakened interest, it now being realised that Munro and the Hunters deserve greater recognition locally for their contribution to the commercial development of Arbroath.

Rodney Weaver 14.11.87



Additional Notes by GI

George Hunter was manager at Braichdu Slate & Slab Quarry near Trawsfynydd. He was also probably involved at the same time in the Cae'n y Coed Quarry. Michael Lewis kindly provided the following snippets:

Caernarfon & Denbigh Herald 25th July 1863

Letter on the subject of Braichdu Slate & Slab Quarry near Trawsfynydd, by "A visitor"

The quarry is worked by the Liverpool & Birkenhead Slate & Slab Co. Ltd. They used to saw by circular and sand saws – very tedious as slabs very hard. Recently the company erected one of Mr Hunter's improved cutting, sawing and planing machines. A Great Success – can now cut any thickness. A block 7'3" long by 6" thick sawn easily in 40 minutes. Water driven, if more water had been available, would have been faster. Also new planing machine. Much to be commended. Quarry Manager G Hunter.

Mining Journal January 1864 p51

Letter from George Hunter, Maentwrog. 18th January

Last week mention made of apparatus for cutting thick slabs by Mr Huddart, Brynkir. No problem in such work; my machinery in operation 8 months; movable teeth. Two discs each 2ft 6in diameter over tools. Each has separate spindle, driving wheel and pinions, but driven by same strap, over pulley 2ft 4in diameter, revolving 16 times to one turn of disc. Making a larger version for cutting 14ft blocks, with 4 discs.

Mining Journal April 1864 Page 316

The improved slate-cutting machinery invented by Mr George Hunter of Arbroath, is about to be set to work at the Braich Ddu Quarries, Tanybwllch.; the machine has been manufactured by Messrs Munro & Co. of Arbroath Foundry, and is the largest machine of its kind yet made; on its axle are fixed four discs 4ft in diameter, and into each of which are inserted 28 cutters. The principal improvement in this machine is that the tools are made to cut up the stone instead of down, that being found to produce better work. When pure slate has to be operated upon the machine will, it is estimated, cut a block 14ft long, 3ft wide and 1ft thick, and divide it into five slices in three minutes. At Braich Ddu the capabilities of the machine will be thoroughly tested, as it will be put to cut very hard slate rock, having veins of granite through it from ¼ in to 1in thick. The rock is very stiff to cut; and before Mr Hunter's machines were invented the task was impossible, the granite veins having been thrown away as useless. It is now cut up into pavement flags, the steps of stairs, and for other building purposes. This fact is not without importance to other quarries producing low-quality slate.

Caernarfon & Denbigh Herald 30th March 1867

Advertisement for slate of Plant at Cae yn Coed Quarry, including Hunter's disc patent sawing machine, 4 blades, bed 14ft x 10ft; and Hunter's planing machine, bed 10ft 3in x 5ft 3 in. "The whole of the above costly machinery, &c, having only recently been fitted up.

n.b. Cae'n y Coed appears in Porthmadog slate shipments only in 1864 (94 tons) and 1865 (168 tons), 1864 is therefore the most likely date for the installation of Hunter saw. No limited company is known to have operated Cae'n y Coed, so proprietors unknown; but highly likely Hunter himself, as a Maentwrog resident, was involved.

W.F.Cooke was at Aber-ia (Present day Porthmeirion) by 1861, and probably moved there with the creation of Maentwrog Slate Company in 1861.

G.Hunter was at Braich Ddu, living at Maentwrog in 1862 or 1863 to at least 1867, but was not in the census for 1861 or 1871.

Sir William Fothergill Cooke and George Hunter

In 1862 WFC is described as “Tenant” of the Bettws-y-Coed Quarry, and by 1867 was a Director of the Bettws-y-Coed Slab and Slate Co.Ltd.

In 1867 WFC and GH offered to waive all claim for licences and royalties on tunnelling machines employed at the Llanberis Slate Co. in consideration of 1800 shares being allotted to them, £4 10s per share being considered as paid, leaving C & H with a liability of £1000, which they agreed to pay as £100 down and £900 in June 1869.

By January 1868 the first machine ordered was at work at the quarry , and WFC consented to join the board of the company.

In 1871 both WFC and GH described as “tenants” of Abercwmeiddaw.

Llanberis Slate Co. incorporated 1863, closed 1873. Appears to have worked Cefn Du?

Alexander Munro & Co. appear to have been taken over by the company of George Anderson, as the Munro Foundry in Arbroath and that of Anderson are the same.

“Anderson-Grice Co. Ltd was founded by George Anderson of Arbroath. Anderson had previously operated from the Arbroath Foundry in Dickfield Street, Arbroath. He was an excellent engineer and familiar with the needs of the quarry industry. His foundry specialised in cranes, stone cutting and planing machinery. “

“By 1886 the foundry had out grown the Dickfield Street premises and larger ones were sought. In around 1886, Anderson began to relocate the business to the neighbouring town of Carnoustie where the former Taymouth Linen Works was vacant. The move was completed by 1898.”

“Arthur Grice became a partner in the company in 1902 to assist the ageing George Anderson. Four years later he introduced the company to a new venture - car manufacturing. Between 1906 and 1910 they built a small number of cars. The Dalhousie cars never achieved fullscale production. “

“The main products of the company continued to be cutting machinery. They earned a worldwide reputation for their skills.”