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## GEORGE GREEN, ENGINEER & ENTREPRENEUR, 1824 - 1895

S.J.S. Hughes

### SYNOPSIS

*Mining districts such as Devon, Cornwall and North Wales have called into being manufacturing industries which, as part of the mining infrastructure, supplied commodities and services. The supply of foundry products was an integral part of this, and names like Perran, Haveys, Sandicroft and others are well known to the mining historian. To many, however, the name of George Green, whose Cambrian Foundry supplied mining equipment to mines in the hinterland of Aberystwyth and subsequently throughout the world, has been largely – and undeservedly – forgotten. This neglect is possibly due to an almost complete absence of records on the man, his business and family. The former were destroyed by fire in 1908. A clever and innovative engineer, Green was responsible for many interesting items of machinery which he manufactured at his works, and was also an adventurer in some of the mines which used them. From the scant references which do remain, the author has managed to assemble a fascinating cameo of this remarkable engineer and entrepreneur.*



*George Green in later life. c1886*

George Green was born in Codsall, near Wolverhampton, on the 11th of January 1824. Both his father and grandfather were engineers and originated from the Black Country, but by the very nature of their work, Codsall can have represented little more than a base.

His grandfather was described as a contemporary of Boulton and Watt in the manufacture of steam boilers. He may very well be the son of the W. Green recorded as having purchased the boiler and Newcomen engine from the Griff Colliery in 1731-2. Further reference is made to Green in 1732 as the engineer of an engine with a 34½ cwt. cylinder and 8 cwt. base cast at Coalbrookdale. The engine was destined for use at a place called Wyken, no doubt a

contemporary spelling of Wigan 18 miles north west of the city of Manchester. It is recorded that George Green's grandfather was engineer to the Salford and Manchester Waterworks Company and whilst he held this post, advocated the use of cast iron for the manufacture of water pipes. The idea was found acceptable to his employers and found universal acceptance amongst the nineteenth century water boards. It is further claimed that he was the original inventor of the circular saw.

George Green's father also followed the family profession of engineer and supervised the manufacture and erection of all the ironwork for the Salford and Manchester Waterworks. He was one of the original advocates of iron ships some ten years before the transitory period of iron cladding of wooden vessels begun.

The infant George was moved from Codsall to Manchester in 1826, where he learned the traditional skills of the family and became apprenticed to the Atlas Engineering Works about the year 1840.

By 1848 he had finished his apprenticeship and was employed by his father in Manchester. It was from here that he first visited Aberystwyth in order to erect a small steam engine at Ellis's Eagle Foundry. Whilst in the town he became aware that there was sufficient trade to support another foundry. By 1850 he had made his move to Aberystwyth and was producing engines, boilers and other such ironwork. Agricultural machinery, church railings, railway fittings and civil engineering requisites were all produced at The Cambrian Foundry in Alexander Road almost opposite the site chosen to build the railway station some fifteen years later. It is of interest to note that in 1864, Green supplied the ironwork for the canopy covering the station and also cast, in 1865, the canopy which covers Aberystwyth pier.

After his move to Aberystwyth, one of his first contracts was for the Llwynmalus Mine who wanted to erect a steam engine as they had insufficient water power on site. Matthew Francis was mine captain, J. Maitland - purser, and several eminent persons were involved in the management and directorship of the company. In 1849-50 a conflict developed between the directors, Maitland and Francis, which resulted in several insalubrious comments being published in the *Mining Journal* which suggested that Francis was practising a mixture of puffing and insider trading to the advantage of a few individuals and not the company generally. The *Mining Journal* reports also cite the fact that an engine had been commissioned from Green, at a cost of £800, and that it was in the process of being erected. In June 1850 it was declared that the engine was completed,

*"It is a beautiful piece of work, and does Mr. Green, of Aberystwith (sic), much credit. The boiler having been sent to Chester in error, has been lying there for want of a vessel to convey it to Aberystwith, causing further delay. The walls of the engine and boiler house are now upwards of 12 feet high and most likely in my next report I shall be able to say that the walls are up to the height specified."*

Two months later the boiler arrived on site and the engine ran on the 16th of August attaining 12 strokes per minute with a pressure of 10 p.s.i.

In September the *Mining Journal* quoted

*"The engine works uncommonly well forking the water at the rate of 9 feet per 24 hours, a result never obtained with the water wheel. We are at present using*

*very little steam, and doing good duty; the pressure of steam on the piston is not more than 4 p.s.i.”*

December was a foul month and torrential rain fell ceaselessly for 36 hours at one stage. The water was slightly more than the engine could cope with but not sufficient to seriously effect the production.

[10]



*Group photograph of the staff at the foundry. c1890.  
George Green is the bearded figure, with bowler hat, just right of centre*

Later, Green was in conflict with Matthew Francis at Bwlch Mine, near Goginan, in 1858, but was reluctant to obtain satisfaction through the courts for non payment of the account for various castings. Eventually Green's bank took the matter up with Francis and threatened to act on their client's behalf as he seemed reticent to do so. Details of this incident are expanded upon in *The Goginan Mines*, B.M. No.35, by the same writer, to be published in 1988.

A lesser known product of the foundry was an early drilling machine of 1862 and is well described in the Kinnaird Report. It was merely a "Crease" drill which was produced in Aberystwyth under licence. It was reported that this machine was then working in the Clogau Mine near Dolgellau and contemporary with a major refit above and below grass.

It could operate on either compressed air or steam provided that the pressure was above 15 p.s.i. but a major disadvantage was that its weight was 15 cwt (750 kg). To overcome this, the whole of the machine with its mounting pillar and stretcher bar was mounted on a flat bed bogie. With a bore of 4½ inches and a stroke of 4 inches, the drill ran at between 400 and 500 blows per minute at 20 p.s.i. "with ample in reserve". Air, or steam, was conveyed from the iron main

by a flexible gutta percha tube, no doubt reinforced with canvas and wound with wire. George Green was of the opinion that the drill would work with 3 or 400 fathoms of this pipe provided that it was of sufficient bore to overcome the friction. The examiners were informed that the machine could be built to drive whatever size heading was required, 7 feet high by 5 wide being a suitable size; it could operate in levels as narrow as 3 feet wide, but for a level only 2 feet wide the machine and its supporting column had to be dismantled and carried to the face! Green added that levels of this width were not in favour at the time. For the machine only, Green quoted a price of £90; 1/3d to 2/- per foot for iron piping, the gutta percha pipe was "more expensive". A suitable compressor was quoted at £75, and there was still the need to find appropriate motive power to turn it.

The rate of penetration was two inches per minute or about 30 inches per hour which compares very poorly with "hand jacking", particularly in view of the capital costs.

In association with Robert Girdwood, a fellow engineer and mining entrepreneur from Edinburgh, Green supervised the driving of the cross cut deep adit at the Bodcoll Mine near Devil's Bridge. The adit measured 10 feet by 8 feet, and had a particularly fine masonry portal but was destroyed in the reclamation of the development rock for roadstone by the Forestry Commission in the late 1950s and early 1960s. This was reputedly driven using an improved rock drill, designed and patented in 1864, but its performance was poor and it was held up to ridicule by the Welsh miners.

By the time that rock drills were becoming reliable, it appears that Green had ceased to manufacture such machines; no doubt he considered that two disasters for a single machine was more than enough.

At the age of 35 he was appointed agent to the Aberffrd Mine in Cwm Rheidol. However, due to the fact that no ore was produced, the company ceased to trade in 1860. His next such appointment came in 1868 as agent to the Allt y Crib Mining Co. in Talybont, a company in which he probably held shares. The mine had been previously owned by the Francis Bros., and in true tradition the value of the orebody had been less than initially anticipated. Green departed from this post in 1871 but was later to return as a consultant to compliment reports on the property prepared by Captains James Clint and Thomas Glanville. Clint, in his report, states that:

*Mr. Green, the engineer from Aberystwyth, fully inspected the mine, and expressed himself very freely in favour of our mine.*

There is little doubt that the promoter of the mine, Joseph Fell, intended to raise excessive capital against these reports, as in fact he accomplished a few years later. Naturally, the company was doomed from the very start and when they folded, Green's old associate Robert Girdwood purchased the site and had Green

install a small steam engine of his own manufacture in the engine shaft about 120 feet below the collar.

The association of Green and Girdwood appears to have started about 1870 with the driving of the Bodcoll Deep Adit and Green's appointment as agent. By 1874 he had become Girdwood's partner in mining ventures at Darren, Hendre and Bodcoll. Later he purchased several mines near Bow Street named Elgar, Pen y Cefn and Mynydd Gorddu. It is reputed that at these mines he tested the experimental machinery which was then produced in Aberystwyth. It is also worth noting that from 1876/77 his son James G. Green acted as agent to all three mines. James was also a competent surveyor and an example of his work is epitomised in the plan of Mynydd Gorddu Mine [11] preserved at the National Library of Wales. As a family, the Greens were also involved with Nant y Creiau Mine as owners, co-owners and agents from 1883 to 1913 and also the Ystumtuen Mines from 1882 to 1894 as owners, agents or secretaries.

Two other mines with which the family were involved were firstly the Crown or Tan y Ffordd Mine near Ponterwyd, where George acted as secretary from 1888 to 1889 and also the abortive trial in the Myherin valley – near Nant y Creiau known as Nant Syddion which William, his youngest son, worked as a joint venture with F.E. Boycott, of whom no details are known.

Jigs, classifiers and other patent dressing machinery were all made at Greens Cambrian Foundry and whilst many thought very little of the expensive and new fangled machinery, there is little doubt that it did work effectively and it must be presumed that on occasions when a mine failed, either the management of the mine had developed greater expectations than could be fulfilled, or it was a simple case of poor grades showing their colours. Green was then held as a scapegoat by unscrupulous promoters. At Penyrallt near Llanidloes an "expert" informed the proprietors that they had "one of the best, if not the very best mines in the Principality" and in consequence of the expected riches to come, £3,000 was spent on erecting a new mill and plant. Ten tons of ore were sold in 1871 valued at about £130. It is unlikely that as a manufacturer of mining machinery his reputation suffered much from being associated with mines which were "puffed" by such unscrupulous promoters as the Francis brothers, Matthew and Absalom, or Joseph Fell.

Similarly, at Rhoswydol, in 1870, Green and Girdwood were involved with a Glasgow based company and sold them a considerable amount of self-acting dressing machinery which they had designed. These included roll crushers, jiggers, buddles and classifiers, these being driven by a 45 foot diameter waterwheel with a breast of 4 feet. Three steam engines provided auxiliary power when water was scarce. The mill was constructed in such a classic style that it took the attention of D.C. Davies who chose to illustrate and describe the workings thereof in his *Metalliferous Minerals and Mining* in 1881. Initially the "revolutionary" machinery failed to satisfy the shareholders, as a previously rich

mine it had not produced any ore since the new, expensive, machinery had been installed by Green and Girdwood. (see page 4)

The press published a series of scathing comments blaming Green and his new machinery. He was vindicated; the following five years yielding about ten thousand pounds worth of ore and whilst not a resounding success it was far from being the failure that occurred at Penyrallt.

There are many accounts of self acting jiggers in contemporary literature but the writer has not found such an explicit description as that given by Martin Eissler, a mining engineer and metallurgical chemist based in San Francisco in the last half of the nineteenth century.

*“Green’s jigger consists of a series of sieves which receive a reciprocating movement up and down in water by means of eccentric or revolving cranks. The space below is portioned off, so that each sieve discharges into a separate compartment. Not alone does this apparatus effect a concentration of the ore, but by making the sieves of different degrees of fineness a sizing can be effected. The accompanying engineering plans and sections show the apparatus as fitted with three sieves (21), (22), and (23). These are fixed in a rectangular frame, (24), fitted to work up and down in a fixed rectangular frame, (25), forming the upper part of a tank or hutch, which is supplied with clean water from a pipe, (26). The bottom of the tank is formed by three inverted pyramidal cast-iron shells, (27), (28), and (29), forming separate compartments respectively under the sieves, the whole is supported by cast iron standards, (30). These standards are fitted with bearings, (31), for a horizontal shaft, (32), running along above the middle of the tank, and driven by a belt acting on a pulley, (33). The shaft is formed with three cranks, (34), of a small throw, to which are adapted brass bushes fitted to the heads of three connecting rods, (35), fixed to the supporting bars, (36), of the sieve frame, (24). The sieves, (21), (22), and (23), are fixed within this frame at successively lower levels, and there are also transverse division pieces, (37) & (38), between the sieves, with their upper edges cut down to the proper overflow level for each sieve. The orestuff to be acted upon is fed with water, in a pulp, from a launder, (39), upon the highest sieve, (21), and what is not separated by this sieve then overflows to the middle one, (22), and successively this middle sieve overflows to the third sieve, (23). The waste from the apparatus then overflows by a discharge duct, (40), at the end of the third sieve. The materials which pass through the sieves are discharged at intervals from the compartments below them formed from the pyramidal shells, (27), (28) and (29), by opening valves or sluices. Alternatively a continuous discharge may be effected into the launders (42), (43), and (44), these launders being manufactured with overflow ducts, (45), to carry the water off.”*

*Green’s jigger. Plan.*

*Longitudinal section of Green’s jigger.*

*Section of Green’s Jigger.*

The foundry displayed its complete range of self acting dressing machinery at the London Mining Exhibition in 1876, with resounding praises from the technical press.

R.J. Prichard (British Mining No.27) notes that fittings for the New Skip road for the Allt Ddu Mine were supplied by Green's Foundry in December 1873. The same author also notes that on 30th August 1890, Green purchased considerable equipment from the bankrupt Rheidol United Mines.

The home market for mining machinery was ailing in the last quarter of the nineteenth century but there was still an expanding overseas market and also refits at such large mines as Greenside, near Glenridding in the Lake District. Export orders had been despatched to Rio Tinto and other Spanish mines, Italy, France, Sweden, Ceylon, South Africa, North America, Columbia and Asia Minor.

For Green, the first twenty five years in Aberystwyth were busy ones and business took place over politics. However, in 1875 he was elected to the town council. In 1879 he became an Aberystwyth Town Commissioner and was elected mayor in 1886 and again in 1887. By 1891 he had been elected a County Councillor and also leader of the Liberal Club. His ailing health prevented any further political activity. His ailment was simply described as "a recurring fever" which was caught at Batum (near the Caspian Sea) whilst inspecting a mine in 1893, and he succumbed to its effects on the 3rd March 1895 and was interred at Llanbadarn Road Cemetery, Aberystwyth, with much pomp and formality in what was traditionally one of the biggest funerals ever to take place in the town.

George Green, as well as being a businessman, had held strong political views throughout his life and was a staunch Liberal. He was also "a lifelong advocate of the Temperance movement" and whilst still in Manchester became a Custodian of the Chartist Movement for social reform. Whilst in Manchester it is probable that he became acquainted with Cobden and Bright, who purchased the Dylife Mines in 1858, as they were active Chartists and later both became Members of Parliament. Whether Green ever sold machinery and fittings to the Dylife company has not been ascertained, but it must be commented upon that the mine used some magnificent machinery which included a 63 foot diameter waterwheel; one of 50 feet and another of 40 feet and many much smaller ones; a 60 inch pumping engine; a 20 inch auxiliary engine, and a 12 inch engine for the dressing mill as well as two small high pressure "puffers", the first two having double boilers and the remainder being equipped with single boilers.

In the years before his death, George Green delegated the home trade to his son William whilst the export trade was entrusted to his elder son James. In turn, James was unable to personally supervise all the administration, design work, specification, delivery, erection and training of personnel, and so retained the services of competent local engineers. After his death, the business passed to his sons who continued this system. We therefore find many local engineers at sites like Batum; Chihuahua in Mexico, and several in Colombia, from about 1885 until 1908. It is also worth noting that several employees continued to work



overseas until about 1920. The route to the Colombian Mines for both staff and machinery was by ship from Aberystwyth to Barranquilla on the Caribbean Coast and then by river steamer up the Magdalena River, 600 miles, to Honda. From Honda a railway followed an unnavigable part of the river as far as an inland port and the road to Frias; mules were then used to get to the mine.

Recalling that George Green first came to Aberystwyth in 1848 to erect an engine at the Eagle Foundry for the Ellis family, it is ironic that when the Eagle Foundry ceased trading (or the Ellis's were bought out by Green) the Ellis's found employment at the Cambrian Foundry. Today, one can hardly imagine that there was ever a need for a foundry in Aberystwyth, but in the 1870s, when the local mines were at their most active, the demand for foundry work was sufficient to support half a dozen such concerns of various magnitude:- Ellis's Eagle Foundry in Northgate Street, Green's Cambrian Foundry in Alexandra Road, William's Central Foundry, Williams & Metcalfe's Foundry, Manchester & Milford Engineering works, all in Park Avenue, Phoenix Foundry in South Road and the Providence Foundry in Trefechan, who both specialised in Brass founding. Initially, the Central Foundry specialised in Marine Engineering but later turned to the manufacture of mining machinery and jiggers. An example of one of their self acting jigs may be seen on display at the Llywernog Mining Museum.

Very little is known about the construction of steam engines at Aberystwyth. The Llwynmalus engine was built in 1850, three puffers for Rhoswydol, an underground engine for pumping at Allt y Crib in the 1879s. Maybe there were others [13] such as Dylife and Bronfloyd. It was a descendant of Owen Ellis of the Eagle Foundry who saw fit to preserve some photographs of the machinery sent to Colombia by Green's. Amongst these is a beautiful photograph of a twin cylinder double acting winding engine on a bed plate with cylinders of about 10 x 18 inches and a 6:1 reduction from the crank to a double winding drum of four feet in diameter. The whole apparatus was controlled by a simple steam cock, independent strap brakes, independent clutches, and a Stephenson reversing linkage. There is nothing unorthodox in its construction; slide valves were used as opposed to piston valves and they were housed in a sectional steam chest. Drip feed cylinder lubricators were mounted at mid stroke, but no drain cocks appear to have been fitted to draw off condensate. Nothing more is known about this engine apart from that its destination was the Tolima Mines in Colombia.

Also illustrated (although too poor to reproduce), in Owen Ellis's collection is a photograph of an air compressor, also bound for Tolima. Very few details are visible; it was driven by a belt, clutching was effected by fast and loose pulleys. The dimensions of the two cylinders are unknown but they appear to be double acting and were enclosed in box section water jackets, the pistons have a rigid rod through a stuffing box onto a slider held in a crosshead and operated by connecting rods attached to a 900 crankshaft with about a 5:1 reduction effected by straight cut gears from the input shaft. Although a nicely constructed machine, it was not in the same class as the winding engine.

His main contribution to steam engineering must, however, be regarded as the "Green's Economiser". This was one of the more successful devices for aiding thermal efficiency in boilers by using waste heat to increase the temperature of the feed water, thus effecting a more economical use of the coal consumed.

As stated, his sons inherited the foundry and ran it for thirteen years on a mixture of home and export trade. However on the night of 20th June 1908, a fire broke out in the pattern maker's shop after the staff had left; the wooden patterns provided the fire with a firm hold and in a short time the whole building was well alight. Such was the ferocity of the fire that many of the fishing boats returned to port thinking that the town was burning. By dawn the foundry was gutted. William placed advertisements in the usual journals and papers stating that the company would resume trading within a short time, and also sent for his brother James who was in Colombia at the time. However, not one piece of ironwork was to be produced by Cambrian Foundry ever again. Williams's Central Foundry thrived for a while on the trade which was passed to them after the disaster but as the ailing mines closed it was inevitable that so too would iron founding in Aberystwyth.

It is interesting to postulate that James Green felt that his business future lay in the overseas market of engine and plant erection, and that after the foundry burned down there was no need to rebuild it to allow him to continue with his side of the business.

Although the Greens moved away from the town, the Ellis family stayed and we are fortunate that they preserved a few papers and photographs recalling their employment at Cambrian Foundry. These papers are now preserved at the Ceredigion Museum in Aberystwyth.

Local tradition recalls that the foundry produced certain parts for the Sydney Harbour Bridge but this is absolute fallacy as this construction was not commenced until some thirty years after the Cambrian Foundry burned down.

Sadly, there are virtually no records known to exist regarding George Green, his family or the foundry. All the information available can only be found by ploughing through such sources as the *Mining Journal*, *The Cambrian News*, Francis' papers and other difficult sources.

*Twin cylinder double acting winding engine sent to Colombia by Greens.*

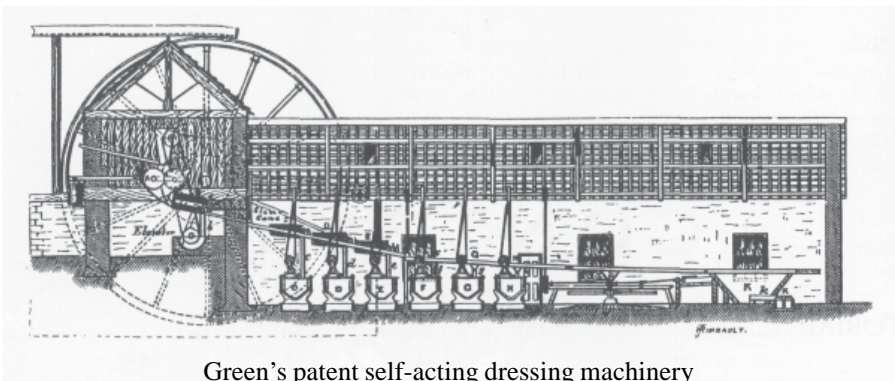
The fire of 1908 also destroyed the whole of the company's records; had these been preserved there would have been the most incredible collection of papers for the mining historian. As the situation stands, there are only passing or secondary references upon which to draw to illustrate the business enterprise which the Greens ran for nearly two centuries and, at "its zenith, under George Green. Throughout the world there are still rusting iron plaques that bear the words "Green's Foundry. Aberystwith"., though few know where Aberystwyth is and fewer know who George Green was.

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[14]



Green's patent self-acting dressing machinery