Eric Edwards Collected Works

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Shedding Light in Dark Places: the story of the miner's lamp

George Stephenson (1781-1848).

Born Wylam. Northumberland.

1. Introduction

"There is blood on coal!"

Coal mining, as well as metal mining, was "…carried out for centuries in this country before any practicable form of safety lamp was produced in 1815." (Wedgewood, L. A. 1946). There are three examples of miners' safety lamps displayed in the Pitt Rivers Museum, Oxford.

In the Pitt Rivers Museum Oxford, in case 141.A in the Court are displayed three examples of miners' safety lamps. One lamp (1932.88.1152) was collected by Henry Balfour and donated by him in 1932. This lamp is of the type invented by Sir Humphry Davy in 1816 and is an example employing wire gauze to make a naked flame safe in a gaseous atmosphere. Another lamp is made of brass and has a glass safety surround with above it a metal gauze tube. Another example is a later safety lamp (post 1839) with linear wick possibly burning naphthalene (lighter fuel). The gauze does not go all the way to the top but ends in a gauze cap. The lamp is topped by a brass arch and hook for suspension. Situated in between these two is a later model (1930.22.2) that was once owned by Alfred Walter Francis Fuller and donated in 1930, and is the French Marsaut type made after 1882. The lower part has a glass surround with an upper gauze chimney completely enclosed in a metal bonnet. Most miners' safety lamps made after 1882 had gauzes protected by such bonnets. The miners' safety lamp was first and foremost a methane detector. Moreover "…you can still buy one, because even today every pit deputy must carry one, despite the universal use of electricity for lighting collieries." (Adams, 2005). Prior to the invention of the miners safety lamp it was in "…mining districts near the sea common for miners to work in dangerous places by the phosphorescent gleam of dried and usually putrid fish." (N.E.I.M.M.E. 8.12.2010). In some circumstances a water-soaked 'fireman', described as a 'penitent', went into a roadway with a candle on a long pole to ignite any gas accumulation. Skilled miners also 'tied the candle' in order to determine the amount of gas present. See **Figure 1** for examples of miner's safety lamps.

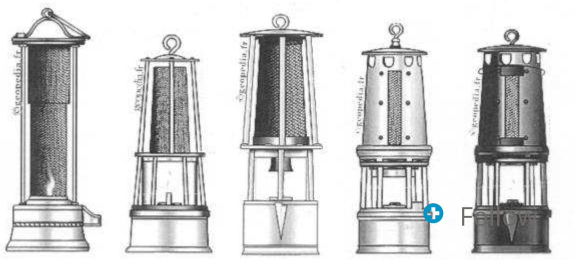


Figure 1. *Examples of Miners Lamps*: (1) Davy Lamp; (2) Clanny Lamp;

(3) Muesler Lamp; (4) Marsaut Lamp; (5) Marsaut Lamp II

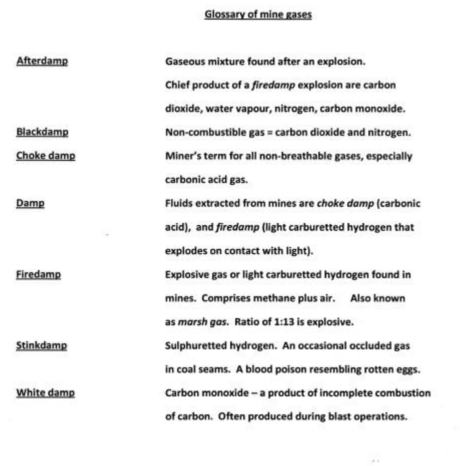
2. Mine explosions due to fire-damp

Towards the end of the 18th century explosions with increasing numbers of fatalities in coal mines occurred because seams were being dug at deeper levels. The use of steam engines for hoisting and water pumping enabled colliery deepening in England. At deeper levels fire-damp (methane) was more prevalent. At this time all explosions were attributed to fire-damp because the explosive nature of coal dust clouds was not recognised. Most explosions occurred at the point of a tallow candle flame. Developing ventilation technology, which meant the presence of large pumps and winding gear both below and above ground, pushed the danger of fire-damp explosion into the background. Consequently, in the early 1800's many pitmen died in northern England due to large colliery explosions. Indeed "…major incidents alone accounted for 558 deaths in Northumberland and Durham between 1786 and 1815…" (Adams, 2005). Indeed, from 1807 to 1812 estimates of casualties give 300 miners killed. See **Figure 2**.

Figure 2. *Aftermath of the Easington Colliery Mine Explosion.*

Fire-damp or methane (CH_4) is carburetted hydrogen. The gas is lighter than air and usually colourless and odourless. Fire-damp derives from bacteriological decay of the vegetable matter cellulose. Fire-damp in mines is really trapped marsh gas produced by chemical processes completed many millions of years previously. Fire-damp is able to combine with twice its volume of oxygen and after explosion leaves one volume of carbon dioxide (CO_2) and two of hydrogen. In order to become explosive fire-damp has to achieve critical mixtures. A mixture of 90.5% air and 9.5% fire-damp can cause a devastating explosion but a mixture of about 7 or 8% of fire-damp is easier to ignite. The range of explosive capability is approximately mixtures of 5 to 15%.

A devastating mine explosion will create havoc amongst the equipment situated below. Not only will the violence kill by blast and fire but wreck brattices (shaft partitions), destroy accumulated corves (baskets), tubs, rolleys (vehicles), ponies and horses. Moreover, the destruction of ventilation systems will lead to the asphyxiation of colliers by lethal *after-damp* resulting from combustion. This after-damp is a toxic gas mixture consisting of nitrogen, carbon monoxide, and carbon dioxide. Another lethal gas, *black damp* or *choke damp* (also known as *stythe*) is formed in mines when oxygen is removed from an enclosed atmosphere. This asphyxiant consists of argon, water vapour, nitrogen and carbon dioxide. The term *damp* is believed derived from the German *dampf* or vapours and similar mining terms are *white-damp* (carbon monoxide) and *stink- damp* (hydrogen sulphide). See **Figure 3**.



Glossary of mine gases

Afterdamp	Gaseous mixture found after an explosion. Chief product of a *firedamp* explosion are carbon dioxide, water vapour, nitrogen, carbon monoxide.
Blackdamp	Non-combustible gas = carbon dioxide and nitrogen.
Choke damp	Miner's term for all non-breathable gases, especially carbonic acid gas.
Damp	Fluids extracted from mines are *choke damp* (carbonic acid), and *firedamp* (light carburetted hydrogen that explodes on contact with light).
Firedamp	Explosive gas or light carburetted hydrogen found in mines. Comprises methane plus air. Also known as *marsh gas*. Ratio of 1:13 is explosive.
Stinkdamp	Sulphuretted hydrogen. An occasional occluded gas in coal seams. A blood poison resembling rotten eggs.
White damp	Carbon monoxide – a product of incomplete combustion of carbon. Often produced during blast operations.

Figure 3. *Glossary of Coal Mine Gases*

Initially an explosion is a violent out-rush of gas from the ignition source, but an inevitable and following in-rush (termed an *after-blast* by miners) fills the vacuum left by cooling gases and steam condensation. There are many causes of ignition of fire-damp in mine explosions. In the early days explosions resulted mainly from naked flame lamps and the accumulations of gas called *blowers*. Other reasons included the use of the early flint steel mill, defective safety lamps, flame from shot firing tunnel explosives, and sparks from faulty machinery, metal implements, and electrical equipment.

3. Historical background

The Felling mine explosion, on the 25th of May 1812, was one of the first major pit disasters in England, and claimed 92 lives out of 128 working in the pit, see **Figure 2.** This was the first great explosion that provided reasonably accurate records. Felling colliery, situated between Gateshead and Jarrow in County Durham (now South Tyneside), was extended in 1810 with a new deeper seam – Low Main. The pit had two shafts in use – William Pit and John Pit. The colliery was owned by John and William Brandling and their partners Grace and Henderson. See **Figure 4**.

Figure 4. *Memorial Plaque for those Lost at Felling, 1812.*

It was in the new seam that the engulfing explosion took place. An ignition of fire-damp triggered a coal dust explosion with devastating effect. The blast was heard up to 4 miles away and around the pit small coal, timber and wrecked corves (wagons or large baskets) rained down. Both headgears of the shafts were destroyed and a huge blanket of coal dust caused a dusk-like twilight in neighbouring Heworth where it descended like black snow. Tragically the blast produced a ghastly sight of miners "…some mutilated, some scorched like mummies', and some blown headless out of the mineshaft like bird shot." (Holmes, R. 2008). The resulting fire raged for 5 days. It took nearly seven weeks to remove the dead after putting out fires and waiting for the after-damp to disperse. Ninety-two men and boys (more than 20 were 14 or younger) lost their lives and the eventual funeral procession comprised ninety coffins when it finally reached the church. Of the boys three were brothers – one of 15, one of 13 and one younger. The names of those lost are collected under the heading "In Memoriam" in the archives of the Durham Mining Museum. In addition their "…places of burial are also given where known: a tribute to the lasting loyalties and strength of feeling among the mining communities to this day." (Holmes, R. 2008). A further explosion at Felling (which is just one and a half miles ESE of Newcastle) on Christmas Eve 1813 killed 12 men and 9 boys aged 8 to 15 years.

The aftermath of the tragedy was first effort to establish a properly co-ordinated movement of public opinion in favour of mine safety. This movement not only aroused scientific interest and endeavour in the cause of accident prevention. It also drew attention to the need for a flame lamp that would not ignite fire-damp, and to devise a means of lighting safe in a gaseous atmosphere. See **Figure 5** for an engraving of the aftermath of a pit explosion.

Figure 5. *Victorian Engraving Depicting the Rush to the pit after and Explosion.*

A major protagonist in the campaign was one Reverend John Hodgeson (1779-1845), ministrant to the bereaved and he who buried their dead as incumbent of the parish of Jarrow and Heworth. Hodgeson was instrumental in establishing the accident prevention society which came to fruition in Sunderland on 1.10.1813. A Safety Committee under the auspices of the Duke of Northumberland and the Bishop of Durham was thus established but dithered until the second explosion at Felling in 1813 spurred them to action.

Sir Humphry Davy (who was on the continent with his wife at the time) was enlisted by the Society in Sunderland to investigate the phenomenon of fire-damp (Davy, J. in Davy, H. 1839). In July 1815 Davy was on holiday in the Highlands. It was correspondence between Hodgeson and Dr Robert Gray of the Coal Mines Safety Committee that requested assistance from Davy. They earnestly stressed that the "…situation in the mines was becoming critical (another fifty-seven men had dies at Success Colliery, Newcastle, in June)." (Holmes, R. 2008). Davy replies on August 18th and proposes to visit Walls End

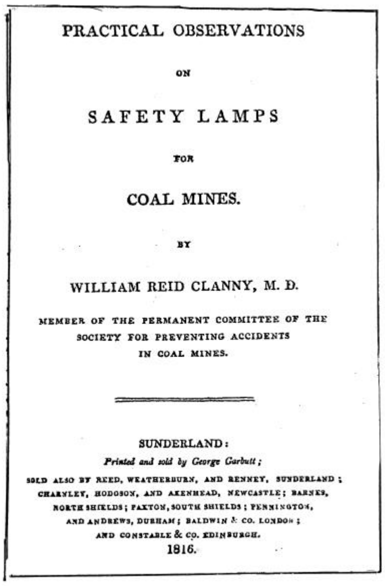
Colliery outside Newcastle to observe fire-damp. Thus travelling "…as a bachelor, he rode down to Walls End (from the Yarrow Valley) and on the 24th of August had a long discussion with John Buddle, the Chief Mining Engineer." (Paris, J. A. 1831). After visiting some mines in County Durham he returned to London where he took over the Royal Institution laboratory on the 9th of October, 1815. In August of that year he had examined some fire-damp in wine bottles despatched from Hebburn Colliery. Davy thereupon recruited the Institutions' instrument-maker (John Newman) and summoned Michael Faraday to assist him.

Meanwhile, inspired by the Felling disaster "…an almost untutored genius at Killingworth Colliery, see **Figure 6**, on the north bank of the Tyne, was trying independently to discover the means to produce a reliable lamp." (Duckham, 1973). This was George Stephenson, a then unknown engineer, who was backed by a Nicholas Wood, a Richard Lambert, and the Bramblings' as owners of Felling Colliery.

Figure 6. *An Early Victorian Engraving of Killingworth Pit*

Spedding devised the flint and steel mill in 1740 as the first serious attempt to provide pit lighting, but it proved to be of dubious safety as well as cumbersome and clumsy, requiring constant working by a boy. A famous medical member of the Society was a certain Dr William Reid Clanny (1776-1850) who himself since late 1811 had been attempting to devise a safety lamp. His efforts eventually had him awarded gold and silver medals by the Society of Arts. William Martin (1772-1851) also invented a safety lamp, accepted by pitmen but not by the mine-owners and it was suppressed. Martin, who lectured on Davy's "murder" lamp tested his lamp at Willington Colliery, near Walls End 1n 1818 (Adams, 2005).

William Reid Clanny was an Irish inventor born in Bangor, County Down, in 1770, and who died in Sunderland (after practising as a physician for 45 years) in 1850. Clanny invented the Clanny Safety Lamp in 1813 and published his observations in 1816. This lamp was first used Herringham Mill pit where Clanny had experimented in person. Northern coal owners and other contemporaries noted the value of his lamp which was emphasised in his obituary in the Sunderland Herald. After his first "blast lamp" of 1813 he maintained his interest in lighting in gaseous environments and created six other lamps. The last two are regarded as true Clanny lamps, between 1839 and 1842. See **Figure 7**.



PRACTICAL OBSERVATIONS

ON

SAFETY LAMPS

FOR

COAL MINES.

BY

WILLIAM REID CLANNY, M. D.

MEMBER OF THE PERMANENT COMMITTEE OF THE SOCIETY FOR PREVENTING ACCIDENTS IN COAL MINES.

SUNDERLAND:

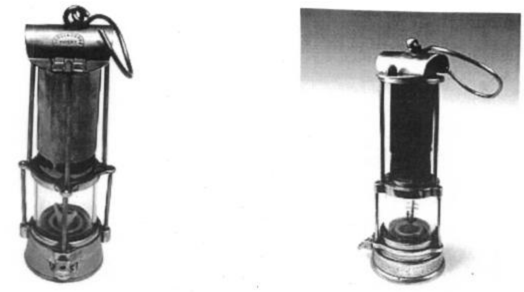
Printed and sold by George Garbutt;

SOLD ALSO BY REED, WEATHERBURN, AND RENNEY, SUNDERLAND; CHARNLEY, HODGSON, AND AKENHEAD, NEWCASTLE; BARNES, NORTH SHIELDS; PAXTON, SOUTH SHIELDS; PENNINGTON, AND ANDREWS, DURHAM; BALDWIN & CO. LONDON; AND CONSTABLE & CO. EDINBURGH.

1816.

Figure 7. *William Reid Clanny's Publication of his Work on Miner's Safety Lamps*.

The 1813 lamp, which was an oil lamp, was operated by a bellows with the flame isolated behind glass by water reservoirs. It was seen as clumsy and, as it went out in the presence of gas, it had little practicality in a coal mine. On Clanny's lamp George Stephenson considered "…it as constructed upon a principle entirely different from mine, that of separating the external and internal hydrogen by means of *water*." (Stephenson, 1817 a). See **Figure 8**.



Clanny lamp (Routledge & Johnson Patent). Made by J. Abbott & Co, Newcastle, c. 1870.

A Clanny miners safety lamp. Made by J. Mills, Newcastle, c. 1880.

Figure 8. *Two examples of Clanny's lamps made in Newcastle in 1870 and 1880.*

4. George Stephenson's 'Geordie' lamp

George Stephenson was born in Wylam (as was William Hedley the inventor of the locomotive "Puffing Billy") nine miles west of Newcastle on 9.6.1781 and died 12.8.1848. He was the second son of Robert Stephenson, foreman of the Wylam Colliery pumping engine. Aged 14 he was an assistant fireman to his father at Dewley Colliery, then at Duke's Winning Pit at Newburn. Aged 17 he was engineman at Water Row Pit west of Newburn and in 1801 began working at Dolly pit at Black Callerton Colliery as a "brakeman" (controlling pit winding gear). Married in 1802 he moved to Wilkington Quay east of Newcastle working as a brakeman. He moved again, as a brakeman, in 1804 to West Moor working at Killingworth Pit and the adjacent Mid Hill Winning Pit. The pumping engine at High Pit, Killingworth, had to be repaired by him in 1811. As a result he was elevated to an enginewright for the surrounding collieries of Killingworth. Yet it was not until 1799 that he began, in his spare time, to learn to read and write.

After the Felling disaster Stephenson began, in 1813, experimenting with a safety lamp that could employ a naked flame without igniting an explosion. It was his conclusion that "…if a lamp could be made to contain the burnt air above the flame, and permit the firedamp to come in below in small quantity to be burnt as it came in, the burnt air would prevent the passing of the explosion upwards and the velocity of the current from below would also prevent its passing downwards." (Encyclopaedia Britannica, 1962). It was after 1811, to Stephenson's credit, that he started to apply his inventive capacities to design a miners' safety lamp. His design was one which used small tubes to allow the entry of air to support combustion and passage of gases. This lamp design was arrived at by trial and error and the prototype was tested at Killingworth on 21.10.1815. An improved version was tested again on the 4.11.1815 and 30.11.1815, and shown to R. W. Brambling and a Mr Murray on the 24th of November, when he "…had just built his first locomotive at Killingworth Colliery." (Adams, 2005). The test was at a fire-damp issuing fissure underground in Killingworth pit a month before Sir Humphry Davy presented his design to the Royal Society in London. Stephenson showed his successful safety lamp design to the Newcastle Literary and Philosophical Society on 5.12.1815. See **Figure 9**.

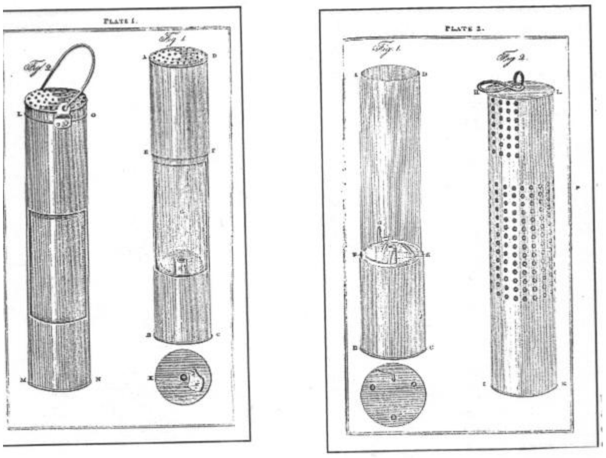


Figure 9. *Stephenson's Lamp*

Stephenson's lamp became known as the 'Geordie Lamp'. Unlike the Davy lamp it had no gauze but glass around the flame, gave a brighter light and was popular with miners. Glass breakage was a problem with the Geordie lamp but, with the invention of safety glass, this was later resolved. The Geordie lamp, unlike the Davy lamp, was employed exclusively in the north east pits. Stephenson was unaware that Sir Humphry Davy was working on the same problem. Sir Humphry applied scientific methods and analysis whereas Stephenson relied on practical empiricism and, lacking Davy's laboratory facilities, worked in his own home and was obviously "…blessed with a fertile mind and considerable mechanical ingenuity." (Barnard, 1936).

5. Sir Humphrey Davy's lamp

The Davy lamp of 1815 contained a candle, even though he is recognised as the inventor of the safer oil burning lamp, and some of the ideas of Clanny and Stephenson. The Sunderland Society for the Prevention of Accidents in Mines charged Sir Humphry Davy with investigation of the problem of mine explosions. It was at the end of October, 1815, that Davy had three prototypes of his "Safe

Lantern" which were sealed lamps using metal tubes or "fire sieves" as air inlets. He read a paper about these tube lamps the Royal Society on 9.11.1815.

It was Davy who surmised that a flame cannot ignite fire-damp or mine-damp if contained within a wire mesh. He showed this using a metal mesh of 28 openings to the inch gauze. This mesh screen, using two concentric mesh tubes to increase safety, cooled combustion products so that flame heat was too low to ignite the gases outside the gauze. This gauze contraption functioned therefore as a *flame arrestor*. The fine mesh permitted methane to pass through but stopped the passage of the flame itself. The first trial was carried out at Hebburn Colliery on 9.1.1816. As we can see Davy's lamp was developed towards the end of 1815 but not tested until January 1816 in the collieries at Wallsend and Hebburn. Davy spent two hours down G-pit with the result that "…the state of the flame indicated the presence and even the strength, of the fire-damp in a shaft! His lamp not only caged the flame, it transformed it into a canary." (Holmes, R. 2008; also Davy, J. Vol 6, 116-117). It became obvious that tubular lamps were only relatively safe but Davy in "…late December or early January…made a further technical breakthrough…" (Holmes, R. 2008) which he reported to the Royal Society on November 9th, 1815. Davy discovered he could replace the need for an airtight glass lamp chimney with a "…fine-gauge mesh (that) would work even better than thin metal tubes in preventing an explosion." (Holmes, R. 2008). It was this gauze-enclosed prototype lamp that became known as 'the Davy' that was presented to the Royal Society on the 25th of January, 1816, and successfully tested at Hebburn and Walls End pits later that month (James, F. 2005). See **Figure 10.** Stephenson's lamp "…represents the lamp at present in Killingworth Colliery. One…was in the hands of the

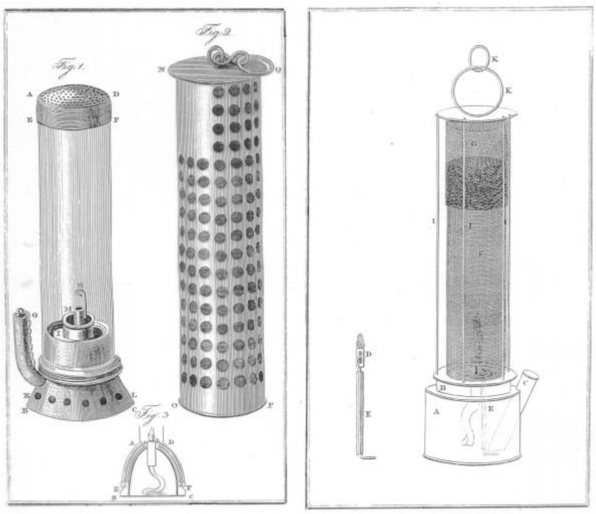


Figure 10. ***Stephenson's lamp compared to that of Davy.***

manufacturer at the time I exhibited my former one to Mr R. W. Brandling and Mr Murray…on the 24th of November, and was tried in the same mine on the 30th, and on the 5th December was exhibited before the Literary and Philosophical Society of Newcastle." The Davy lamp represents a wire gauze safe-lamp as constructed according to the specifications of Sir Humphrey Davy. It shows the wire gauze cylinder, which should not have less than 625 apertures to the square inch.

Flammable gases were noted to burn with a blue tinged flame and when placed on the ground the flame went out due to accumulations of the asphyxiant gas (CO_2) known as *black-damp* or *choke-damp*. Davy was performing experiments with fire-damp at the same time as others. In 1815 he realised that the holes of fine metal gauze acted the same as narrow tubes (viz Stephenson's lamp), thus mine air passed through small orifices fed a flame that would not ignite the outside gas. Davy's original experiments with fire-damp "…discovered its 'lag' on ignition." (Barnard, 1936). Davy's lamp [see 1932.88.1152] was eventually surrounded by metal mesh and thus differed from Stephenson's lamp with its glass surround. Thus Davy wrote, in a communication of 1816 that his "…invention consists in covering or surrounding the flame of a lamp or candle by a wire sieve…", and further that his object "…at present is only to point out their application to the use of the collier." (Davy, 1816 b.)

6. The controversy over priority

Davy was in France and Italy 1813 to 1815 but on his return started experiments with lamps for colliery use. H. R. Clanny and the then unknown George Stephenson had already shown the idea of a safety lamp.

In 1813 the Society for Preventing Accidents in Coal Mines was formed in Sunderland (TWAS 1589 cited Smith, J. 2001) and which was directed by Reverend John Hodgeson who invited Davy in 1815 to research fire-damp (Northumberland Record Office, cited in Smith. 2001). George Stephenson was directly involved as a mining engineer and already experimenting with fire-damp and a safety lamp (Stephenson, 1817 a). In his own time Stephenson's research led to "…the consequent formation of a Safety Lamp, which has been, and is still, used in that concern…" which his friends considered "…as precisely the same in principle with that subsequently presented to their notice by Sir Humphry Davy." (Stephenson, 1817 b).

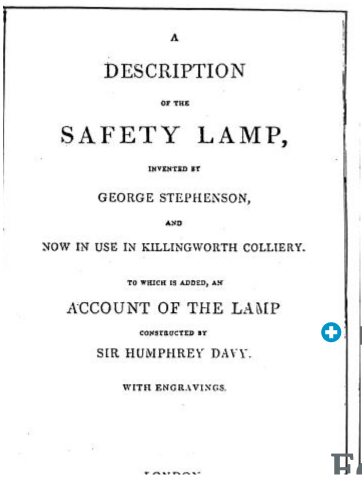
It was to Stephenson that we were "…indebted for the discovery of the Principle of Safety…" that hydrogen will not explode down narrow tubes and "…will hereafter recognise as the Stephenson Principle." (Charnley, 1817). The Principle was pointed out to several persons long before Davy came into the County, and Stephenson's lamp was in the hands of the manufacturer during Davy's visit. (Stephenson, 1817 b.). Stephenson made "…three lamps, *all perfectly safe*: and by following precisely the same steps, Sir Humphry Davy was enabled subsequently to construct one…" (Charnley, 1817). The Northumberland Record Office possesses 37 unpublished letters signed by Davy dated September 1815 to March 10th, 1818, and known as the Hodgeson Bequest. Within this context Davy made "…complete acknowledgement of the priority of Mr Stephenson's claims", and moreover "…acknowledges the same principle of safety which Mr Stephenson had previously established and proceeded with his experiments in the same way." (Charnley, 1817). Admitting that "…my habits, as a practical mechanic, make me afraid of publishing theories…" Stephenson avowed that the principle "…has been successfully applied in the construction of a lamp that may be carried with perfect safety into the most explosive atmosphere" (Stephenson, 1817 a). Davy's response described the dispute as an "…indirect attack on my scientific fame, my honour, and veracity." (Davy, cited in Smith, J. 2001). It seemed to many that "…the invention of a miners' lamp, similar in design to Davy's, with a measure of evidence to suggest priority, by a largely uneducated colliery engineer, stuck in Davy's craw." (Smith, J. 2001). Especially as Stephenson had previously announced to many associates the principles of his lamp and begun its manufacture (Newcastle Chronicle, 1815, November 2nd). Davy only announced the results of his fire-damp experiments on 19th October.

In 1816 Davy was awarded £2000 as a public testimonial for his lamp whereas Stephenson received a miserly 100 guineas. The following furore at such a snub resulted in a local subscription that raised £1000 from local dignitaries, colliery owners and managers. A Resolution of the Coal Trade, August 31st, 1816, considered the award to Davy for *his* safety lamp, but an adjourned coal owners meeting, 11.10.1816, credited Davy with inventing *the* safety lamp. At this point Stephenson joined the fray with letters, with supporting correspondents, in the Newcastle Chronicle. A supporter opined "Mr Geo

Stephenson, of Killingworth Colliery, was the person who first discovered and applied the principle upon which lamps may be constructed." (Brandling, 1816, Newcastle Chronicle, August 29th).

Davy among many derided Stephenson and poured scorn on his invention and the priority dispute became "…characterised by local patriotism on the one hand and academic sneers on the other…" (Duckham. 1973). There was attempt made by Davy to contact Stephenson.The experience with Davy made Stephenson distrust theoretical and scientific experts based in London for the remainder of his life. Davy has been described as "…less than fair to the man who was to father Britain's railways" (Duckham, 1973), especially for others as the evidence awards conclusively "…the priority to Stephenson in the invention of the miners lamp." (Smith, 2001). In token of gratitude Davy was awarded £2000 at the same time as Stephenson was accused of stealing Davy's idea, and it is regrettable that "…Davy regarded Stephenson as no more than a pirate…" (Knight, 1996). It is noteworthy that Davy received his award "…at a banquet presided over by his old friend John Lambton, afterwards Earl of Durham, who had been with him at Bristol under the care of Dr Beddoes." (Hartley, 1971). It was the high-minded attitude of Davy over precedence that initiated the bitter dispute. In the spring of 1816 the normally publically reticent Stephenson challenged Davy over the issue of priority and accused Davy of plagiarism in respect to his own 'Geordie Lamp' the model which employed solid glass and metal using tubes and perforations. This was the lamp that had its final working version tested in Killingworth pit on the 21.10.1815. The Stephenson and Davy lamps did look similar but at this juncture Davy's "…gauze lamp had not yet been published – or indeed invented." (Holmes, R. 2008). It is worth noting that Davy left no original laboratory notes concerning his work on the lamps. Davy responded by complaining about Stephenson's alleged pilfering and miserable lying and in this way Davy "…showed no professional generosity towards Stephenson." (Holmes, R. 2008).

In 1817 George Stephenson published two pamphlets pointing out that his lamp was the result of 'mechanical principles' whereas the lamp of Davy was one based on 'chemical principles'. In these pamphlets Stephenson signed himself "The Inventor of the Capillary Tube Lamp". Davy's announcement of his prototype lamp in November 1815 was somewhat premature because Stephenson's lamps "…had been introduced before Davy's, worked safely, were cheap and robust… legally adopted by many Newcastle miners who fondly referred to them as home-grown 'Geordies'. " Holmes, R. 2008). Prior to this the Newcastle Literary and Philosophical Society adopted an objective position and showed examples of both Clanny's *bellows lamp* and Stephenson's *conical lamp* on the 5th of December, 1815. When The Society compared "…examples of the true gauze lamp, as used by Buddle at Walls End, at its meeting of 6 February, 1816." (Holmes, R. 2008), it became obvious that the two lamps were different instruments. See **Figure 11**.


A

DESCRIPTION

OF THE

SAFETY LAMP,

INVENTED BY

GEORGE STEPHENSON,

AND

NOW IN USE IN KILLINGWORTH COLLIERY.

TO WHICH IS ADDED, AN

ACCOUNT OF THE LAMP

CONSTRUCTED BY

SIR HUMPHREY DAVY.

WITH ENGRAVINGS.

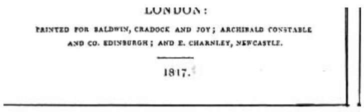

LONDON:
PRINTED FOR BALDWIN, CRADOCK AND JOY; ARCHIBALD CONSTABLE AND CO. EDINBURGH; AND E. CHARNLEY, NEWCASTLE.
1817.

Figure 11. *Publication describing the safety lamp invented by George Stephenson* (1817).

Considering the derisory comments from Davy and his supporters it is worth considering Stephenson's own words in his defence as recorded in 1817 (Stephenson, G. 1817 a). Stephenson pointed out that his lamp was "…the same in principle with that subsequently presented to their notice by Sir Humphry Davy." Furthermore the gauze of Davy's lamp was "…a variation in construction." Stephenson goes on to say that "…it might be considered a want of candour were I not to take notice of the lamp constructed by Dr Clanny, but my reason for not inserting it is, that I considered it as constructed upon a principle entirely different from mine, that of separating the external and the internal hydrogen by means of water." Stephenson then proceeds to vindicate himself chronologically by saying "…the following dates I have extracted from Mr Hodgeson's letter, and the Newcastle Chronicle." Therefore, the 15.10.1815 Sir Humphrey Davy receives fire-damp; on the 19.10.1815 Davy informs Hodgeson he has discovered that explosion will not pass through small *tubes*. On the 25.10.1815 announces his discovery to the Chemical Society of London. On the 30.10.1815 Davy describes a lamp on the principle of *tubes* above and below. Following this Davy announces his *Tube Lamp* to the Royal Society on the 9.11.1815 which was duly reported in the Newcastle Chronicle on the 23.12.1815. The Morning Chronicle announces Davy's application of wire gauze and which is also reported in the Newcastle Chronicle on 23.12.1815. Stephenson points out that Davy writes in Newcastle on the 9th of November, 1816 that "…whenever workmen etc are exposed to such highly explosive mixtures, double gauze lamps should be used, or a lamp in which the circulation of air is diminished, by a tin plate reflector placed in the inside, or a cylinder of glass reaching as high as the double wire, with an aperture in the inside. Such lamps, likewise, may be more easily cleaned than the simple wire gauze lamp, for the smoke may be wiped off in an instant from the tin plate or glass." Stephenson stresses that "…he first embraced the idea, the principle upon which the Tube Lamp is constructed was published, and a plan of it shown in early September…" and furthermore "…that it was actually burning in the mine on the 21st of October." Then he goes on to affirm that Sir Humphry Davy "…does not announce his discovery of the fact that explosion will not pass down tubes, till the 19th of October." Rising to his sense of just cause Stephenson continues by saying "…my double perforated plate lamp was certainly ordered some time before the 24th of November, and tried in the mine on the 30th of the same month…" He then points out that "…the earliest notice I had of Sir H. Davy having applied wire gauze for the same purpose was, from the Newcastle Chronicle of the 23rd of December." Stephenson then goes on to say that, in refutation of the criticisms directed against him, "…I have been actuated solely by a justifiable attention to my own reputation, and a sincere desire to have the truth investigated, and not by any disgraceful feeling of envy at the rewards and honours which have been bestowed upon a gentleman who has directed his talents to the same object…". After such magnanimity Stephenson then writes of the "…refusal of two subsequent meetings summoned for the purpose of bestowing some mark of approbation of Sir H Davy, to enter upon an investigation of dates and facts, was justified by many gentlemen…". He refers pointedly to the claim of Davy's supporters thus "…when at the second meeting, the expression of 'the invention of his Safety Lamp' was altered to 'his invention of the Safety Lamp', I felt myself called upon to assert my claims." George Stephenson thus vindicated himself and demonstrated that he was right to complain about the unfair way he had been treated.

Stephenson was eventually exonerated by a local enquiry committee, termed *Stephensonians*, who awarded him £1000 but this proved unacceptable to Davy's supporters. They refused to recognise how an uneducated man had arrived at the solution he had. It was only in 1833 that Stephenson was given equal claim to priority by a House of Commons Committee. In the meantime Davy had been awarded the Rumford Medal for his efforts by The Royal Society in 1817

7. Pit disasters

The earliest reference to gas explosions in mines dates from 1621 and was blamed on 'Auld Nick' known otherwise as the devil. Across Durham and Northumberland between 1800 and 1899 there were around 300 major colliery disasters that claimed the lives of more than 1500 men and boys. The major cause was due to fire-damp explosions as well as some mine collapses. See **Figure 12,** for a Victorian engraving of a pit disaster funeral.

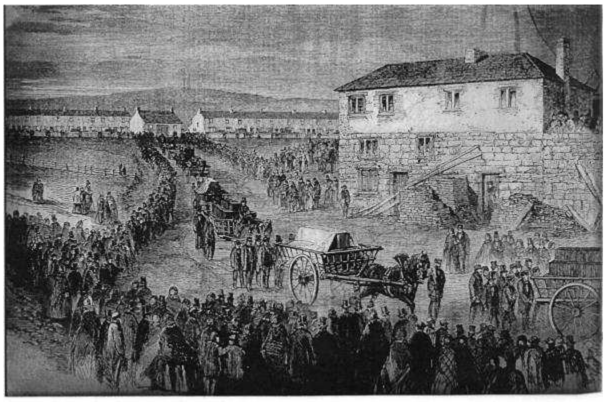


Figure 12. *Funeral procession following the New Hartley Pit disaster.*

On 16.1.1862 in Northumberland 199 miners died.

Killingworth Pit (where George Stephenson was an engineer) is about 5 miles from Newcastle where 10 were killed on March 28th, 1806, with a further 12 lost on September 14th, 1809. Haswell Pit near Sunderland in October 1844 had 95 killed by gas explosion and New Hartley in Northumberland had no survivors from 204 men and boys. This disaster at Hartley in 1862 had 199 men entombed in a one shaft pit which led to the end of the practice of one shaft workings. See **Figure 13.**

Figure 13. *A group of children orphaned by a pit disaster in England.*

Between 1708 and 1951 there were 2106 colliery fatalities of men and boys in the north-east. These losses due to explosion include 52 at Wallsend in 1821; 102 at Wallsend in 1835; 164 at Seaham in 1880; 168 at West Stanley in 1909; and 81 at Easington (County Durham) in 1951. See **Figure 14.**

The Six Worst Mining Disasters in North-East England – 1812 to 1882.

1812	Felling	County Durham	91 killed
1833	Wallsend	Newcastle	102 killed
1841	Haswell	County Durham	95 killed
1860	Burradon	North Tyneside	76 killed
1862	Hartley	near Blyth	204 killed
1880	Seaham	County Durham	164 killed
1882	Trimdon	County Durham	75 killed

Source: "Introduction to Coal Mining and Railways in the North-East".

Englandsnortheast.co.uk. (11.12.2011).

Figure 14. *Record of major mining disasters in the north east of England.*

8. Pit diseases

There can be a negative impact on the public health of mining communities due to coal mining operations. A study in West Virginia, USA (Hendryck, M. 2006) pointed out that residents "…of coal mining communities have long complained of impaired health." and these "…residents are at an increased risk of developing chronic heart, lung and kidney diseases." Therefore coal production has a bearing on the incidence of cardiovascular, lung and kidney disease in mining communities.

Mines, especially coal mines, are the "…most difficult lighting environment in the world." (I.E.S.N.A. 1993). For mining engineers the coal face "…is one of the most difficult environments to illuminate, due to the low reflectivity of the coal roof, walls and floor…and the need for flameproof equipment." (Pardoe, D. R. G. 1994). The most used and probably most important of all human senses is that of sight. At the coal face it becomes paramount that adequate illumination is needed for reasons of health, safety, and productivity. A common disorder in regard to miners' eyesight is called 'miner's nystagmus' which means the eye is unable to maintain visual fixation in certain conditions or circumstances. This form of nystagmus can result from long periods of constrained viewing in poorly illuminated mining working areas, and the effort made to see small objects. It is found to be more common in miners who have worked below ground for more than 20 years. Attributed to such poorly illuminated spaces this eye disorder presents with impaired dark vision, dizziness, headaches, eye pain, lachrymation, excessive sensitivity to glare, and peri-corneal congestion. Dim light or the partial gloom or darkness of a coal mine can have acute and chronic effects on health. Such high visual demands on coal miners can cause eye strain and fatigue, especially over a period of 8 hours.

Occupational respiratory disease in mining presents as lung disease commonly in the form of CWP (or coal workers pneumoconiosis), asbestos related diseases, lung cancer and other lung conditions. Many of these respiratory diseases in the mining industry have a long latency and may only become apparent after some time. Such latency therefore in both individual and community terms "…remains of considerable importance after mining operations cease." (Ross, M. H. 2004). Historically, since the 1500's, a relationship between lung disease and mining has been recognised and documented.

Coal workers pneumoconiosis (CWP) is also called 'black lung disease' and is caused by long term inhalation of coal dust. An intitial or preceding and milder form is known as 'anthracosis'. Coal dust inhalation builds up progressively in the lungs from where the body cannot remove it. Coal miners exposed to the dust develop industrial bronchitis. This eventually leads to inflammation, pulmonary fibrosis, and in worst case scenarios to actual lung necrosis. Black lung represents and arises in a specific set of conditions with coal miners having an occurrence of 16 to 17%. In the late 1990's some 10,000 coal miners in America died of CWP. Another occupational respiratory disease associated with mining is 'silicosis' – a major disease with world-wide distribution affecting other occupations as well as mining, and which has long been recognised as having a connection with tuberculosis. The condition presents as chronic obstructive airways disease (emphysema) with chronic bronchitis – both of which are "…common manifestations of long term occupational exposure to silica dust…" (Ross, M. H. 2004). See **Figure 15.**

Medical conditions associated with mining

Ankylostomiasis	Miner's anaemia. Aka Egyptian chlorosis. Intestinal nematode parasitic worm or *Ankylostoma duodenale* in miners and tunnel workers.
Anthracosis	Chronic lung disease of coal miners. Inhalation of coal dust
A form of pneumoconiosis. Results in coal nodules, coal macules and massive fibrosis A severe bronchitic disease	Colliers Lung and Miner's phthisis Aka Black Lung Disease Aka Black Spittle and Coal Lung Aka Miner's asthma; Silicosis; Collier's asthma; Miner's consumption; Siderosis (deposition of iron in tissue).
Labrador Lung	Mixed dust and pneumoconiosis in iron miners in West Labrador (iron, silica, asbestos).
Mesothelioma	Malignant lung tumour of lining of pleura and abdominal cavities. Asbestos associated.
Miner's Elbow	Enlargement of the olecranon bursa in those leaning in low roofed mines.
Miner's Nystagmus	A rapid, involuntary, oscillatory motion of the eyeball.
Siderosis	Deposition of iron in tissues due to iron oxide in iron ore mining. Similar pathology to asbestosis.
Silicosis	Fibroid phthsis due to inhalation of silicaceous materials. Aka Rand miner's phthisis.

Figure 15. *Glossary of mine diseases*

A connection between metalliferous mining and lung disease has long been known, with a particular association between the lung condition known as 'pthisis' with mining for copper, tin, gold, and mica. Stone cutters, millers and miners were particularly susceptible liable to tuberculosis in metal mining (Beddoes, T. 1799). Again, it was surmised early that in miners pulmonary diseases were possibly connected with certain types of dust produced in mines and pits.(Thackrah, C. 1832).

An example of metal mining and associated disease can be found in the Cornish mining industry. Moreover, unlike coal mines, Cornish mines had no artificial ventilation systems so temperatures often rose in excess of 100 degrees Fahrenheit. The Royal Commission of 1842's report "…showed for the first time the abundance of lung disease amongst Cornish miners…the reason for the excessive mortality…" was due to miner's pthisis (Proctor, E. S. 1999). In 1904 a Royal Commission into the Health of Cornish Miners despatched Dr J. B. S. Haldane to look into several instances of illness characterised by rashes and anaemia. Haldane "…discovered that most of the current disease was due to an infection by the ankylostoma hookworm that had been brought to the mines by men who had worked in the tropics." (Proctor, E. S. 1999). Some 90% of all foreign white miners working in the gold fields of Witwatersrand in Transvaal between 1902 and 1903 were from Cornwall. The worm could only survive in hot conditions as provided by the excessive temperatures of Cornish tin mines. Migratory Cornish miners were particularly associated with mining hard rock formations. Miner's worm was a parasitic nematode worm commonly called a 'hookworm' due to its predeliction for attaching itself to the lining of small intestine of its host. Its name is Ankylostoma duodenale and causes the condition termed ankylostomiasis. It is now known that symptoms attributed to ankylostoma were recorded in Egyptian papyri circa 1500 BCE. In the 11th century the Persian physician Avicenna found the worm in a number of his patients and associated it with their condition. Much later the parasitic disease was found in a number of mining communities in England, Germany, Belgium, France, northern Queensland and elsewhere. In 1877 during the construction of the Cotthard Rail Tunnel it was found that Italian tunnelers had an anaemia and diarheoa. In 1880 the hookworm transmission was due to fact that the workers defecated in the tunnel's 15 km workings. It was not until 1897 that it was deduced that the infection route was through the skin. The disease which was known as miners worm, tunnel disease, or cachexia of miners by 1906 "…is definitely known to be caused by the nematode worm Ankylostoma duodenale." (Hickson, S. J. 1906). In Europe there was a serious spread of the parasite through the mines of France, Germany, Belgium and some mines in England. Eradication of the hookworm still left excess mortality due to dust inhalation and secondary tuberculous infection. Cornish miners resorted to their own folk remedies in time of affliction – blaming piskies, pelloes, spriggans, and white witches, as well as a repertoire of local and traditional herbal remedies.

9. Women in mines

Earliest records from the 17th and 18th centuries report that women were used to dress and wash down ores in the lead mining areas of the Yorkshire Dales, County Durham, and the Peak District. Copper mines also employed women in Angelsey and Staffordshire, as did the iron mines of Blaenavon and Shropshire. Women and girls worked in the mining industry across Britain. The Cornish metal mines used many women and girls but most were employed in the coal mining industry. In the coal industry of Cumbria, Scotland, Shropshire, Yorkshire, Lancashire, and Northumberland, women were certainly employed underground. Referring to women miners it was said that "…indeed, the mother and her daughters – they work among men rough as Hottentots, and almost, sometimes quite as naked." (Eddy, T. M. 1854). See **Figure 16**.

Figure 16. *Engraving of Victorian women miners.*

Parliamentary Papers from 1842 (volumes XVI, p.24-196, and Volumes XV and XVII) pointed out that in England, but exclusive of Wales, only in some parts of Lancashire and Yorkshire were young children regularly allowed to go down and work in coal mines. In the West Riding men worked naked in great numbers being assisted by females aged 6 to 21 years who laboured stripped to the waist. In 1841 some 2350 women were working in mines in the United Kingdom – about a third of these in Lancashire.

The Coal Mines Regulation Act of 1842 made it illegal for women and children in mining communities to work underground. For the first time women in Scotland were excluded on the basis of gender from following an occupation. This resulted in pit ponies replacing women as underground bearers. However, dressed in the garb of male miners, some women continued working below illegally. Gradually women moved into over-ground jobs at the pits. Of the 2400 women originally estimated to work in the mines only 200 had found employment by 1845. As a source of lower paid labour the pit-owners preferred women to work at the 'picking tables' as the men replaced women underground. Some 90% of women employed 'screening' at coal mines were sorting coal by the early 1900's. Screening was the process whereby women, known as screen lassies, and children separated different sizes of coal on a conveyer belt using large sieves called 'riddles'. Basket women hooked on the tubs and were usually chosen from widows of colliers or men who had met with mine accidents. The "coal bearers" were women or children who were used to carry the coal on their belts (weighing between 0.75 to 3 cwt) down the steep braes and up the non-railed roadways. See **Figure 17.**

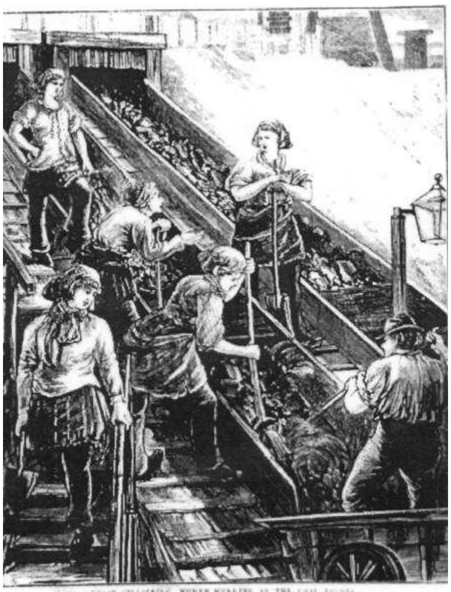


Figure 17. *Women pit head sorters at a Victorian South Wales Colliery.*

In 1887 another Coal Mines Regulation Act raised the minimum working age to 12 years. Women, called 'pit brow lassies', some 99% of whom married miners, were young and usually in the 20's. A family affair these women worked alongside their fathers, mothers, husbands, as well as siblings, at or down the mine. They worked a 6 day week with shifts of 12 to 18 hours. As such these 'pit brow lassies' formed a very tight knit group. The report of the Royal Commission of 1842 pointed out that miners were perceived as wild and hard drinking uneducated immoral men with a godless outlook. Their women and children also did hard and back-breaking jobs down the pit for long hours in dangerous and cramped situations. The report stirred the conscience of the general public and inspired Victorian philanthropists to pressurise Parliament for reform.

Pressure was exerted by the miners' trade union throughout the 19th century to have women cease employment in the mines. Parliament witnessed concerted efforts to have this put into effect in 1887 and again in 1911. This was met by organised female protests in 1887 with the result that the Mines and Collieries Acts only banned women from pushing heavy wagons. Over time the employment of women at coal mines was reduced from between 5000 and 6000 in 1841 to less than 1000 in the 1950's. In 1972 the last two women employed in the British coal industry retired. It has to be recognised that these women mine workers struggled and worked together in common left behind them a trail of tears and sweat. Like the men they also suffered the losses of frequent mining disasters. For example, the Silkstone Disaster (1805) near Barnsley was where many women and girls died in an explosion. Again, in 1838 a serious flooding of the Moorside Pit drowned 7 girls aged 9 to 17 years. See **Figure 18**.

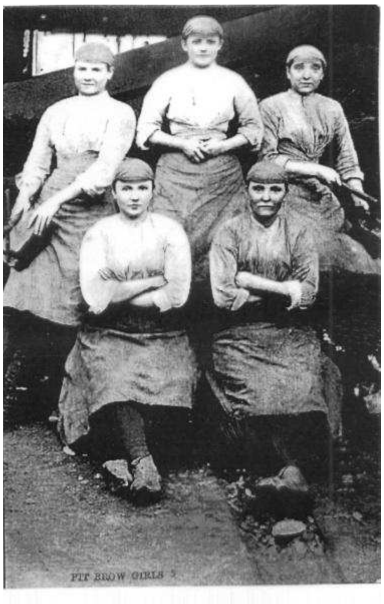


Figure 18. *Pit brow lassies in England.*

In Cornwall and Devon women and girls have most likely been working at or in tin mines since antiquity. Medieval written records are the earliest evidence of this working. From around 1770 to 1860 large numbers of women were working in the industry with the last laid off during the 1920's. In the West country these women mining workers were called 'Bal Maidens' and worked with copper, tin, zinc, lead, manganese, antimony and lead, throughout the industry. The term 'bal' is old Cornish and means 'mining place'. In 1880 the female mining contingent had increased to 2000 and 6000 by 1851 which means that in the two centuries between 1770 and 1870 more than 80,000 women and girls laboured in the Cornish and Devon mining industries (balmaiden.co.uk).

Women have worked in mines worldwide since antiquity. In the 2nd century BC women worked in Egyptian gold mines having arrived as slaves and captives and worked above and below ground. Women and children across the world were routinely recruited to mining industries from the early 18th century. Women are listed for pay in the Mexican and Peruvian silver mines, in Swedish iron mines, as well as the Indian diamond fields. For example, women mined for diamonds in Hyderabad mines that employed nearly 60,000 people. The tin mines of Bolivia in 1884 employed women alongside their husbands and by 1933 were employed in the deeper pits. Women sluiced the Malaysian tin mines in 1935 which employed some 7,800 women. Even in the early 20th century large numbers of women and older girls laboured in coal mines in China, Belgium, France, Malaysia, the Ukraine, and the mica mines of India. See **Figure 19**.

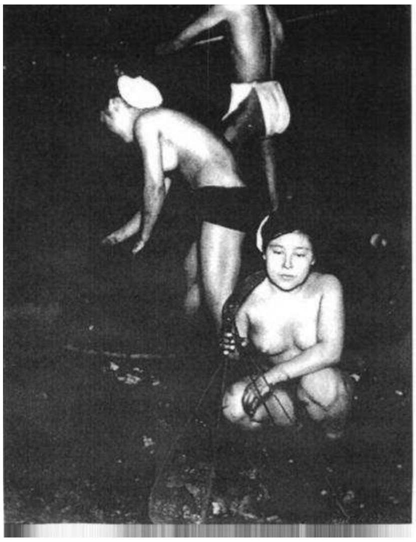


Figure 19. *Photograph of modern women miners working in a Japanese colliery.*

Stripped to the waist as did the Victorian women miners in England.

10. Children in mines

Prior to industrialisation children of working class and poor families worked for centuries as child labour. Child labour is defined as the employment of children as sustained and regular employment. Child labour implies in the main children used to make a commodity or service saleable in the market place at a profit regardless whether or not their labour is remunerated. As anybody aware of the writings of Charles Dickens (who referred to 'Dark Satanic Mills') and Charles Kingsley (of 'The Water Babies' fame) are aware the Victorians were notorious for employing young children. Children laboured in factories, coal and other mines, as well as in quarries and as chimney sweeps. See **Figure 20**.

Figure 20. *A Victorian child chimney sweep.*

Such places of exploitation, including mines, have been referred to as "places of sexual licence, foul language, cruelty, violent accidents, and alien manners." (Thompson, E. P. 1966). The practice of putting children to work, as ancillaries to the work done by their parents, was documented first during the medieval period. Estimates of child labour in the work force in metal and coal mining comprised a large number of children in the Victorian mining industry. In the Swedish iron mines girls worked underground in the 1830's. In the 1840's boys and girls worked for a while in the copper mines of Glen Osmond, Australia. See **Figure 21.**

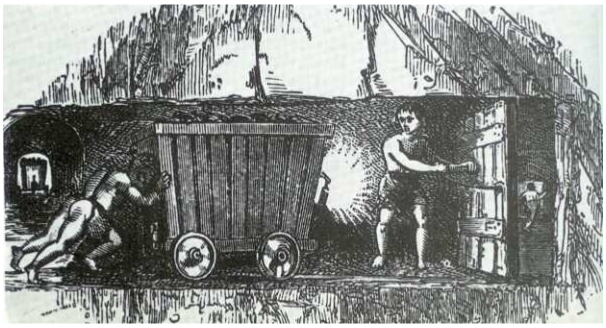


Figure 21. *A Victorian 'thruster' pushing a coal tub, and a trapper opening a ventilation door.*

From: Report of the 1842 Royal Commission into Children's Employment (Mines).

Before 1842 it was commonplace for entire families to employed together, working underground, in order to earn enough money to survive. Most children who worked in collieries started at age 8, some as early as 5 years, and were often dead by 25 years of age. Many were carried to the mine still half asleep in the arms of their parents. They laboured long from 4am until 5pm and had to crawl though narrow tunnels too small for adults. These children were directed to transport coal, or ore, along to the horse-path or the main pit shaft. The conditions they worked in were dangerous with many killed by explosions, others in pit collapses, some in flooding, some who fell asleep and were crushed by oncoming carts. In addition many children because of their developmentally young age contracted lung cancer and other respiratory afflictions. An example of the ever present danger was the Huskar Pit Disaster in Yorkshire in July 1838. A total of 26 children were drowned aged 7 to 17 years. The youngest was James Burkinshaw who was 7 along with his 10 year old brother George. The loss included 3 girls aged 8 out of 11 girls between 8 to 17 and 15 boys aged 7 to 17 years.

The youngest child of a family employed underground was usually had the simple job of a "trapper". Usually sitting alone in total darkness for 12 hours they had to watch and open and close wooden doors known as "traps" that permitted fresh air to circulate through the mine. Trappers were the smallest children in the pit who thus regulated mine ventilation by means of the division doors.

Older children, half-grown girls and women were employed as "hurriers" and "thrusters" (putters) who worked in conditions where they had to crawl on their hands and knees. The large coal tubs were pushed by thrusters and pulled by hurriers along the roadways from the coal face to the pit bottom. A "putter" therefore was a boy or youth or woman who pushed or dragged the coal along the tunnels from the workings to passages where ponies could be used. See **Figure 22**

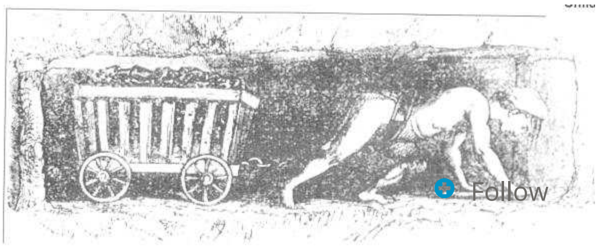


Figure 22. *A Victorian 'hurrier' pulling a tub of coal.*

Report of the 1842 Royal Commission into Children's Employment (Mines).

These workers were classified into "trams", "headsmen", "foals and "half-marrows". In these occupations younger children worked in pairs whereas older ones, as did women, worked alone. A "foal" was a boy not yet strong enough to "put" or push from behind on his own but able to do so with the help of another boy. A young "putter" or foal was also known as a "half-marrow". The coal tubs weighed as much or more than 600 kgm (11.8 cwt) and the roadways were often only between 60 to 120 cm high (24 to 48 inches). The oldest and strongest miners were the grown men and strong youths who worked at the coal face as "hewers" or "getters" and were the only ones who worked continually with a lamp or candle.

A "driver" was a lad used for driving the ponies on the main underground roadway and was aged 14 to 15 years old. A "gin-driver" drove the horses in the engine or "gin" that hoisted the coal from moderately deep pits. Youths aged 16 to 18 were often used as "flat-lads" or crane operators who hoisted the corves of coal – a corf was a wicker basket for pulling the coal and contained some 4 to 7 cwt. The "greasers" were boys who greased the axles of the coal tubs. Girls or boys called "pumpers" were made to descend to the deepest part of the pit to pump rising water to the pump-engine to maintain dry work spaces for the coal face hewers. A first for a boy underground was that of a "wood boy" or "supply boy". They carried materials to various parts of the mine using ropes or a mono-rail. See **Figure 23.**

Figure 23. *Children who worked were subject to appalling conditions.*

Many who worked in the mines were dead before they reached 25.

Other occupations of children in the coal mining industry included "wailers" who picked out slate, pyrites and other admixtures from the coal. A "water leader" took away water from the horse-ways and helped the deputies with their duties. Finally a "way cleaner" was a lad aged 11 to 15 who cleaned the pit rails using hay or rope. They also removed coal dust accumulations. See **Figure 24**.

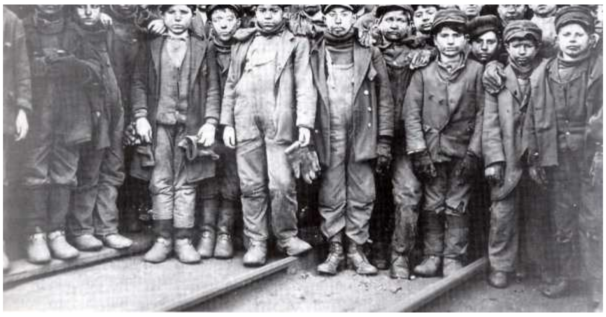


Figure 24. *Real life Oliver Twists: Child miners were often beaten, abused, hungry and tired. Their childhood was often over before it began.*

Estimates of child labour in Britain's coal and metal mines are revealing. In 1842 children employed in coal and metal mines ranged from 19 to 42% and by 1851 children totalled 30% of the coal mining population. Similarly in 1838 an estimated 5000 chuldren were employed in the Cornish metal mines which, according to an 1842 report, had risen to 5,378. In 1838 also 85% of the 124 tin and copper mines in Cornwall employed children. Of the 105 mines surveyed for the 1838 report children comprised between 2 and 50% of the mining populations with an average of 20% per pit. After the 1870's the use of children in Cornish mines began to decline.

Child labour in the mining industries is still common in the modern world. Tens of thousands of children are used above and below ground in small-scale gold mining operations in Africa, Asia, and South America. Like their historical Victorian counterparts they risk death and maiming from explosions, rock falls, and tunnel collapses, as well as inhaling air contaminated with noxious fumes and dust. Children, just like adults, can suffer the deleterious effects of vibration, noise, poor lighting and bad air, as well as over-exertion and exhaustion. Moreover, serious conditions affecting the respiratory system include silicosis and pneumoconiosis. Other ailments include hearing and sight problems, joint disorders and other orthopaedic conditions, constant headaches, deafness, dermatological problems, fractures and wounds.

In Africa in the Sahel region, Burkina Faso, and the Niger, children are working in the gold mines – an occupation called "orpaillage". Some 30 to 50% of the orpaillar workers are under 18 years of age. That is a total of 200,000 to 500,000 across both countries with approximately 70% of them aged less than 15 years. Small-scale mining in Ghana is called "galamsey" (to gather and sell) with an estimated 10,000 children working in mainly gold extraction. In the Cote d'Ivoire children are trafficked in from Mali, Guinea, and Burkina Faso and made to work in mining in slavery-like conditions. See **Figure 25.**

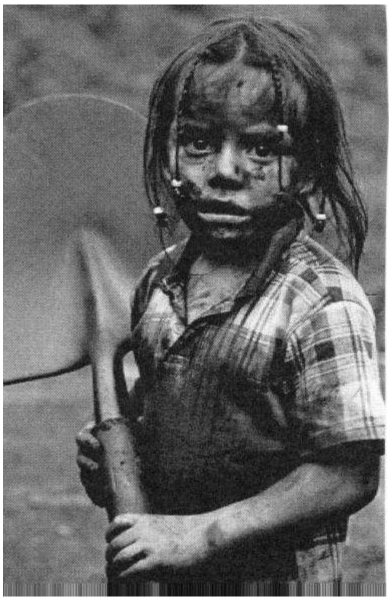


Figure 25. *A girl working in a modern African mine.*

There are also rich gold deposits in Mongolia where the average age of a child miner is only 14. Below the age of 13 there are more girls employed at mines than boys. There are gold deposits in the Philippines where a child miner is usually between 15 and 17 years old. They have a particularly risky task of diving into muddy wells some 2 metres wide and 7 metres deep to retrieve the gold bearing soil. In the region of the Andes, Bolivia, Peru and Equador gold mining employs as many as 65,000 children. See **Figure 26.**

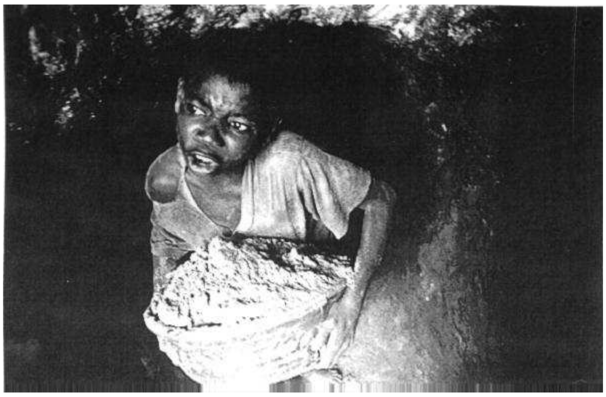


Figure 26. *A boy working underground in a modern African mine.*

11. An anthropological perspective on mining

During the last 6000 years mining has employed millions of people throughout the Old and New Worlds. During that time mining has transformed vast regions of the surface of the earth. Mining is an important feature of production and social reproduction and thus it is important to become aware "… of the social, spatial and ideological dimensions of technology and of past or present industrial communities…" (Knapp, A. B. 1998), as well as the environmental impact (including pollution) that resulted from mining. In this context archaeology, anthropology, and ethnographic studies have a contribution to make to the study of mining communities.

From antiquity to medieval times most mining was conducted on an individual basis. The work was carried out by people living in agriculturally based communities. An anthropology and archaeology of mining can be seen as a study of social life taking place in a set of material conditions. This can be described as a social archaeology that necessitates investigating a number of factors that include technical, physical, social and cultural (see: Wylie, A. 1993). The study of historical mining communities demands the recognition of a number of demographic factors that encompass ethnicity, the technological, social class, and ecology. Evidence may be found in the material record or surviving material culture of the mining community concerned (see: Raber, P. 1987). In addition mining can be seen as a form of social organisation that "…is partially conditioned by the physical and or socio-cultural isolation of mining communities, and partially by the harsh working conditions and labour requirements of the extractive and productive phases in mining." (Roberts, 1996). All too often in the history of mining and mining cultures "…social historians, archaeologists and archaeometallurgists tend to focus on the history and technology of mining." (Knapp, A. B. 1998). However, mining in modern times is very often labour intensive and therefore requires an inexhaustible and dependable supply of workers.

12. Mining communities

The harsh working conditions of mining combined with the physical isolation and social organisation of mining communities inspires the view that miners are "…best known for their accidents and strikes, that are the inherent part of their daily life…" (Matosevic, A. 2008). It follows that, from an anthropological and ethnographical point of view, mining cultures "…give rise to recurrent patterns of population dynamics, labour recruitment practices, and political organisation." (Godoy, R. 1985). The combination of teamwork and team spirit, so essential to safety at collieries, with the traditions and pressures associated with underground working created the coal culture of mining communities. In addition mining communities even though "…often socially and spatially remote, they are linked into broader social, communications, transport and economic networks." (Knapp, A. B. 1998). During the miners strike of 1984-1985 the pit of Maerdy in South Wales, see **Figure 27**, was adopted for support by Oxford. During the dispute they were supplied from Oxford with donations of cash, food parcels and Christmas presents for miners children.

Figure 27. *Assembly of striking miners from Maerdy Colliery, South Wales.*

In Victorian times coal miners, together with their wives and children, were "…subjected to measures of social ostracism, partly on account of the spirit of the times – which in a much greater degree than now regarded all labour as material…" (Barrowman, J. 1897). In other words miners and their dependents were perceived as lacking humanity, as some form of troglodytes. For example in mid-19th century Northumberland miners lived in a long rows ("raas") of single storey cottages which had neither toilets, mains water supply or lighting. In such circumstances the colliery, where everybody had to work, dominated the lives of the miners and their families. In the 1920's there developed the concept that mining communities should be recognised as richly deserving. A coal levy singled out pit villages for the provision of welfare. This levy provided much needed baths, sports facilities, libraries, welfare halls, and community facilities. Nonetheless, due to the dangerous and solitary nature of their work miners forged a sense of separateness due to "…dirty and unattractive work, in darkness and alone, and dissociated from the activities of the outer world, the collier settled into that condition of separateness which is characteristic of the class to the present day." (Barrowman, J. 1897). An analysis of gender in consideration of the androcentric myths about mining shows that "…both women and men were fully integrated into the socio-cultural mainstream of the mining community." (Knapp, A. B. 1998). It was the role of women that determined the structural dynamics of mining communities – which made itself apparent during the miner's strike of 1983 to 1984. See **Figure 28**.

Figure 28. *Community support and solidarity during the aftermath of the Easington Colliery explosion. Waiting at the pit head for news.*

Around 700 miners were working in coal mines in the north-east of England in 1787 which rose to about 1,000 1n 1810. By 1919 the region had 223,000 coal miners employed of whom 154,000 were in County Durham. In Durham County this number had increased to 170,000 in 1923. Many of these colliery workers had migrated into the region from Wales, Scotland, Ireland and other parts of England. The majority were local.

The exploitation of coal began in the Forest of Dean in the early 1800's with large collieries developing after 1830. The mining community of the Forest of Dean had unique mining traditions going back to the 1700's with rights awarded to "Free Miners". (Pope, I. 2006). The origin of the free-miners dates back to the middle ages. For example miners "…who were born in the Hundred of St Briavels, and worked for a year and a day in a Forest mine could apply for the right to work a 'gale' of coal or iron. A gale being an area of a coal seam or iron ore vein." (Beard, R. 2011). As with other pits the Forest of Dean coal mines suffered tragedies and disasters with 600 recorded fatalities between 1797 and the present day.

The exploitation of tin and copper mines in early 19th century Cornwall made up an established mining community. Indeed, surrounding the metal mines of Cornwall in the 19th century was in fact the longest established metal mining community in the world. Working conditions in Cornish tin mines were dangerous, hard and dirty. It was an industry that employed women and boys (who started at age 12) on a large scale. Unlike coal mines women did not work underground but processed the ore at the surface. The work levels were reached by ladders because mechanical lifts were not installed. Men and boys laboured in total darkness their only illumination that of candles often attached to their hats. The candles had to be purchased by the miners themselves. Conditions were improved eventually by the introduction of safety lamps.

Unlike coal mines elsewhere disasters in Cornish mines were not large scale but nonetheless "…the toll of men, both young men through accident and older men through lung disease, was extreme." (Rule, J. 1998). Moreover, unlike coal mines, Cornish mines did not suffer explosions due to fire-damp. Even so the annual average death rate per 1000 miners in Cornish mines between 1849 and 1853 was greater than the losses of northern coal miners in each age cohort. The presence of women in Cornish mining has to be stressed and tragically "…the proportion of widows to total female population in Cornwall in 1851 was higher than in any other country." (Rule, 1998). See **Figure 29.**

Figure 29. *Cornish tin miners in 1886.*

One example of how a terrible disaster can come to an entire mining community was the waste tip slide at Aberfan, near Merthyr Tydvil on Friday the 21st of October, 1966. At 9.15 am a colliery waste tip slid down a mountainside and engulfed Pantglas Junior School and 20 houses in the pit village. The slip destroyed a farm cottage on the way down killing all inside. A total of 144 people lost their lives of which 116 were school children. See **Figure 30**.

Figure 30. *Miners and rescuers attempting to save trapped children and teachers at Abefran.*

Five teachers and half of the pupils of Pantglas Junior were killed. Trained mine rescue teams arrived but no survivors were found after 11 am and it was nearly a week before all the bodies were recovered (McLean, I. 1997). See **Figure 31**.

Figure 31. *Graves and memorial for those who died in the Aberfan Disaster.*

Most collieries in Britain are now gone but the former mining areas still possess their individuality and embedded community spirit that has long been a feature of mining communities. Pit villages and mining towns have their own hard earned identity that is often reflected in their names – such as Stony Heap, Deaf Hill, Quaking Houses, Pity me, and No Place. See **Figure 32.**

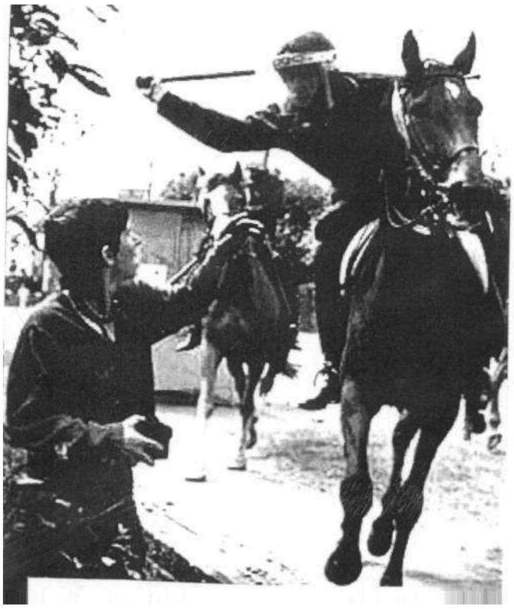


Figure 32. *Iconic media image of the conflicts between miners and police during the strike of 1984-85.*

13. Conclusion

The period 1880 to 1890 proved to be the most important in the development of miners' safety lamps. That history shows on examination "…that imperfections and prejudice influenced the popularity of lamps." (Wedgewood, L. A. 1946). The miners' safety lamp was an "…icon of the industrial revolution every bit as powerful as Stephenson's 'Rocket' or the Iron Bridge at Coalbrookdale." (Adams, 2005). The miners' lamp, to whomever its invention may be credited "…should be regarded as a landmark in the history of civilisation." (Barnard, 1936). With regard to his lamp Stephenson said it "…might be considered a want of candour were I not to take notice of the lamp constructed my Dr Clanny…" (Stephenson, 1817 b). Whereas it seems "…less than justice to Stephenson, that history seems to accept Davy's right to priority, when the evidence suggests otherwise." (Smith, 2001).

After the introduction of the Davy lamp there was an increase in mine explosions for a number of reasons. According to the North of England Institute of Mining and Mechanical Engineers and the

Davy lamp lack of instruction "…on its limitations did not lead to an immediate reduction in the number of explosions." (2011). Firstly mine-owners delayed in installing gas extractors: secondly it encouraged re-opening dangerous pits, and working in methane rich seams was not curtailed. Also lamps were purchased by the miners, as well as the expensive candles from the company store, and not provided by the owners. Stephenson's lamp became popular in the north east coalfields but Davy's lamp was introduced elsewhere. In August 1816 144 of Davy's lamp were in use every day at Walls End Colliery (Paris, J. A. 1831). It is fair to say that there was "…no doubting the advantages of Davy's gauze over Stephenson's perforated plate, and the substitution of gauze for the perforated plate led to what we know as Stephenson's lamp." (N.E.I.M.M.E. 2010).

The priority controversy continues to reverberate to the present day as it has come to be recognised that "…Davy was not the inventor of the safety lamp…" and that "…his lamp was not really safe." (Adams, 2005). In the 1830's the issue grumbled on with a Parliamentary Select Committee on Mining Accidents of 1835 opining "The principle of its construction appears to have been *practically* known to the witnesses, Clanny and Stephenson [sic], previously to the period when Davy brought his powerful mind to bear upon the subject, and produced an instrument which will hand down his name to the latest ages." (Papers. 1835). It was this Committee that led eventually to the Victorian movement that banned child labour in the mines. Davy's lamp was cheaper and thus preferred by the mine-owners. The attitude may mean the "…liberty of laissez-faire might imply the coal-owner was master in his own house; for the collier it merely secured *his* freedom to die violently by earth, fire or water." (Duckham, 1973). Also Davy's lamp, in wet conditions, deteriorated rapidly and rusting metal gauze made it even more unsafe. Both the Davy Lamp and Stephenson's lamp became "…unsafe in rapidly moving air-currents." (Barnard, 1936). In effect – fire-damp explosions increased. Nonetheless the wire gauze of Davy's lamp was eventually used in every subsequent safety lamp, with modifications, for nearly 200 years. It is noteworthy that Stephenson later adopted the principle of Davy's gauze instead of tubes – it is this revised design that became known in the 19th century as the "Geordie Lamp".

Regardless of who first invented the 'first' safety flame lamp for mines there is an important point to note. Its success was the culmination of principles discovered by three men – William R. Clanny, George Stephenson, and Sir Humphry Davy. Neither Davy or Stephenson patented their lamp designs. All three inventors worked independently, all around the same time, and each had some knowledge at least of each others work. It was Clanny who separated the flame from the firedamp atmosphere of the mine. It was Davy who first enclosed the flame in wire gauze. It was Stephenson who first left a space above the flame for burnt air. And indeed the lamps of the three were all eventually fitted with wire gauze. The lamps were thus the fruits of work representing an "…untypical conjuncture of requirements of growing industrialism and the resources of scientific enquiry." (Duckham, 1973). The modified lamps have remained an integral part of the mining industry up to and beyond the demise of most of the coal industry after the colliery closures following the miners' strike of 1984. Davy's safety lamp was his finest public achievement and his creation was soon in use in Britain and Europe (Holmes, R. 2008). In tribute see **Figure 33.**

I remember well, those scars of blue,
That covered my Granddad's hands.
Hands that were gnarled and wrinkled,
The hands of a working man.
Many a man bears the scars,
From the work they had to do,
But only the working miner's hands,
Have the scars forever blue.

Figure 33. *Poem by a north-east miner with the name of Winstanley recalling the coal dust scarring of a collier's hands.*

Appendix: Chronology of the Stephenson and Davy Lamps.

Sept 1815.	Stephenson publishes principle of lamp.
15.10.1815	Davy receives fire-damp
19.10.1815	Davy realises explosion will not pass through small tubes
21.10.1815	Stephenson tests his tube lamp in Killingworth Colliery
25.10.1815	Davy announces discovery to Chemical Society, London
30.10.1815	Davy describes his principle on tubes in lamps
4.11.1815	Stephenson tests improved lamp in Killingworth Colliery
9.11.1815	Davy announces Tube Lamp to Royal Society, London. Report in Newcastle Chronicle, 23.12.1815.
24.11.1815	Stephenson orders double perforated plate lamp. Lamp shown to Mr Brambling and Mr Murray.
30.11.1815	Stephenson tries modified lamp in Killingworth Colliery
5.12.1815	Stephenson shows his successful lamp to the Newcastle Literary and Philosophical Society
23.12.1815	Davy announces principle of gauze lamp. Date of Newcastle Chronicle report of Davy's gauze lamp.
9.1.1816.	First trial of Davy's gauze lamp at Hebburn Colliery.
9.11.1816.	Davy writes in Newcastle that double gauze in preferable.

Postscript

The 14th of October 2013 was the 100th anniversary of the worst ever coal mining disaster in Britain, at the Universal Colliery at Senghenydd in the Aber Valley, south Wales. The cause of the explosion was never technically established. The explosion killed 439 men and boys eight of whom were just 14 years old. The disaster simultaneously created 205 widows and 542 orphans. As the result of findings "…the company and its local manager were charged with 17 breaches of the 1911 Act." Further the "… magistrates dismissed all charges against the former, fining the manager a total of £24 for five offences. On appeal, fines plus costs were extended to the company and increased to a total of £39 and five shillings. Today's equivalent would be around £3,300, or £7.50 per life." [Information from Robert Griffiths, *Remember the miners, their families, the lesson*. The Morning Star, 14.10.2013].

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Dedicated to my great grand uncle, and mining engineer, Frederic Henry Edwards (1852-1919), of Forth House, Newcastle upon Tyne and Bath Street, Newcastle. Member of the Institute of Mining Engineers (from 1867), and local explosives agent for Alfred Nobel.

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23/01/2014 at 10:02 am

Thank you so much friend for posting the such a nice and informative post. Really it was very useful for us. Flameproof tube light

Reply

uccindia
11/02/2014 at 9:30 am

Please share more! Good research.
Flameproof tube light

Reply

Eric W Edwards

14/02/2014 at 12:44 pm

Thank you for your welcome comment. For your interest I am sending the following information. It seems that your company specialises in compressors. My second great-grandfather Frederick Howorth Edwards (1821-1876) patented a compressor (called an air-engine) in 1860. It reads thus: Frederick Howorth Edwards (Number 2,999) patented an air-engine for obtaining power, by a differential pressure obtained by heating successive particles of air. See "Examples of steam, air, and gas engines". by Bourne, J. "Technology and Engineering", Longman's, Green & Co. (1878). Letters Patent List, 12.12.1863. 2999. Frederick Howorth Edwards of the town and county of Newcastle upon Tyne, civil engineer, for the invention of "improvements in air-engines." Dated 7.12.1860. Noted in the London Gazette, 18.12.1863.

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