Water Power in Mining: Papers presented at the National Association of Mining History Organisations' Conference at Aberystwyth, 5-8 July 2002.
Mining History: The Bulletin of the Peak District Mines Historical Society. Volume 15, Nos. 4/5, 2004.

SIR FRANCIS LEVEL: DRIVEN BY WATER

Martin Roe

Abstract: Sir Francis Level in Swaledale, Yorkshire, is well known for its surviving hydraulic pumping and winding engines, but it was also the first mine in Yorkshire to introduce compressed air drilling. Like most mines in the Pennines water was the source of power for everything from compressed air production to pumping and winding as well as ore dressing. What complicates this story is that the mine was developed as a joint project by two separate companies. This paper will focus on how the archaeology of the site and its surroundings, can help to explain how the site functioned and why some aspects of the site have been misunderstood in the past.

Introduction

Gunnerside Gill runs north from the village of Gunnerside in Swaledale North Yorkshire (Fig.1). It is a steep sided valley crossed by a number of major mineral veins, which have been worked by shafts, levels and hushes since at least the 16th century. In the 19th century the valley which formed part of the AD mineral royalty was divided into three mining grounds. These were the Old Gang Mine to the east of the Gill centred round the Friarfold and Old Rake Veins, Lownathwaite Mine on the West side and the Blakethwaite Mine at the head of the valley. From 1836 the Blakethwaite and Lownathwaite mines together with the nearby Swinnergill Mine were leased together (Gill 2001).

The driving of Sir Francis Level in Swaledale was the idea of Sir George Denys, the main owner of the AD mineral royalty, who had realised that the mines were heading for a crisis. Even if the market price remained static the main bearing beds were becoming exhausted and the cost of raising ore would increase once it had to be followed below adit level. He therefore promoted this project both verbally, and later financially, and work started in 1864.

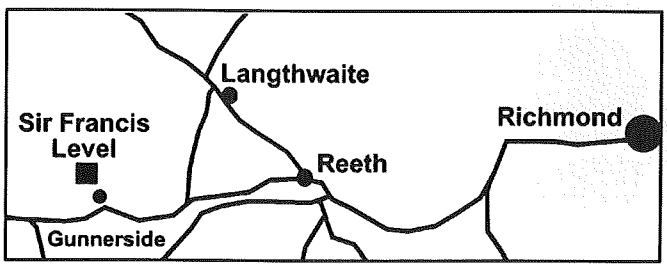


Fig. 1. Location of the Sir Francis Level, Yorkshire.

The level was driven as a joint project by the Blakethwaite Company who were working the west side of the valley and the Old Gang Company who were working the east, and was to be just over a mile long to cut the rich Friarfold vein 35 fathoms below the lowest level. As a sweetener the Old Gang Company was issued a new 21 year lease at the start of the project with a promise of further renewal. In return they were obliged to pay 4/5th of the cost of driving the level. Disaster nearly struck when the Blakethwaite Company was wound up in 1867. The Old Gang Company continued driving the level on their own until 1870. As with the driving of earlier levels, progress was painfully slow, and only 404yds had been completed in the first 5 years. At that rate it was calculated that it would take 25 years to reach the vein.

Sir George had been to Cornwall where he had been impressed by a demonstration of General Haupts compressed air rock borer, which had been improved by Messrs J.A. Mckeen and Taylor. He later went to Greenock in Scotland where he saw the same equipment being used to bore a tunnel to bring water to the town. On his return Sir George suggested that the use of rock borers at Sir Francis would be a good idea. The Old Gang Company were reluctant to take on the cost of introducing compressed air drilling as it was still an unproved technology and the set up costs would be much more than the traditional methods. Sir George therefore took on the role of contractor. He agreed to take over the Blakethwaite Company's obligation to pay 1/5 of the cost of driving the level and would pay for the air compressor and borers. The Old Gang Company were to build the engine house, watercourses, and provide rails, pipes, timber, sleepers and pay Sir George £8.10.0 per fathom to drive the level to the Friarfold Vein (Denys 1877).

Sir George bought the compressor he had seen in action at Greenock for £180 excluding the receiver and additional driving gear in April 1869. (NYRO ZLB10/1/10) This was a Lowes double air compressor manufactured by E.R. and W. Turner of Ipswich powered by a 28 x 4 ft water wheel and supplied up to 60lb per square inch pressure (Denys 1877).

The borers were supplied by December 1869 and in use by January 1870, but their introduction was not with out incident. The compressor failed to supply enough pressure, parts of the borers broke, and the sockets which attached them to their columns were too big, but this was still the dawn of compressed air drilling. At the time there were only two mines in Cornwall and one in Flintshire using compressed air rock drills. In 1873 new borers and an air compressor were supplied. This was also the year when the AD Mining Company was put together to take over the ground previously worked by the Blakethwaite Company. Sir George took 300 of the 500 shares and became the Managing Director. Around the same time dynamite was introduced for blasting and together with the borers this increased the driving rate from 10ft per month to 68ft per month. Dynamite was not the only alternative to the traditional black powder that was tried. As Sir George recounted in Robert Hunts British Mining (Hunt 1887):

We have of course tried various kinds of guncotton, powder and Tonite but prefer No2 Dynamite to anything . . . It is safer than powder or cotton and in favourable places we can bore with a machine and charge it accordingly bringing enormous burdens. In orey places if not cautiously used it smashes the rock I think over much.

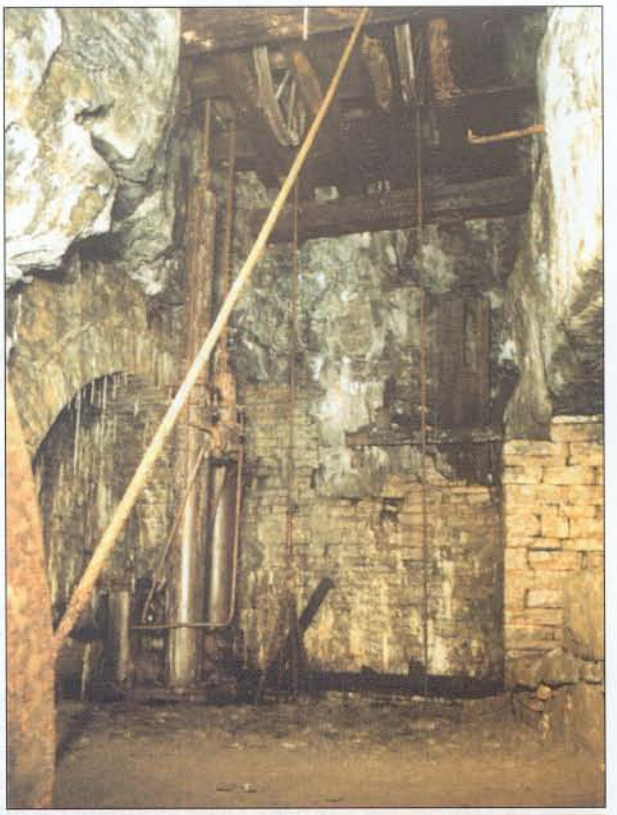


Plate 1 (top left). Pump Spear - Old Gang Engine Chamber.

Plate 2. (top right). AD Engine Room.

Plate 3. (right). Cage above the AD Sump.

Plate 4. Site of the Sir Francis Level and the AD and Old Gang Dressing Floors.

The dynamite was stored in a magazine within the mine, which did cause some conflict with the mines inspector (NYCRO ZLB 8/10/3).

The Friarfold Vein was cut in March 1877 and the level was turned east and west on the vein. Sir George noted optimistically in his diary "Friarfold Vein Cut in Sir Francis, great jubilation thereon 13 years labour finished triumphantly without loss but also without profit. The profit will be in the future for the men who will find employment for generations" (NYCRO ZLB, Sir George Denys Notebook). Once the vein was reached the AD Company has a further 25 fathoms to drive before reaching the boundary of their ground.

In 1878 the Old Gang lease was surrendered and a new company was put together. Ore was proving to be patchy and better below the level sole so the AD company began sinking a sump and tried to persuade the Old Gang Company to contribute to the project which included the installation of water pressure pumping and winding engines. At this point the AD Company was in a precarious financial state with its bankers refusing to pay a wage bill (Gill 2001). The Old Gang Co declined to join the scheme and instead began to sink their own sump draining it with a small donkey engine ironically borrowed from the AD Co. The AD Co with the support of the bank completed the project between 1879 and 1881. Hathorn Davey and Co of Leeds supplied hydraulic pumping and winding engines suitable for working to a depth of 360ft, however the sump only ever reached a depth of 127ft.

Between September and November 1880 Hathorn Davey's engineers worked at the mine fixing pipes, installing beams for the headgear, and laying concrete for foundation beds (WYA, Hathorn Davey Order Book). By December 1881 the hydraulics as they were known were working although the mine was almost stopped due to lack of funds. The engines worked until the summer of 1882 and then sat unused for nearly 8 years. Sir George Denys died in February 1881 so never saw the engines at work.

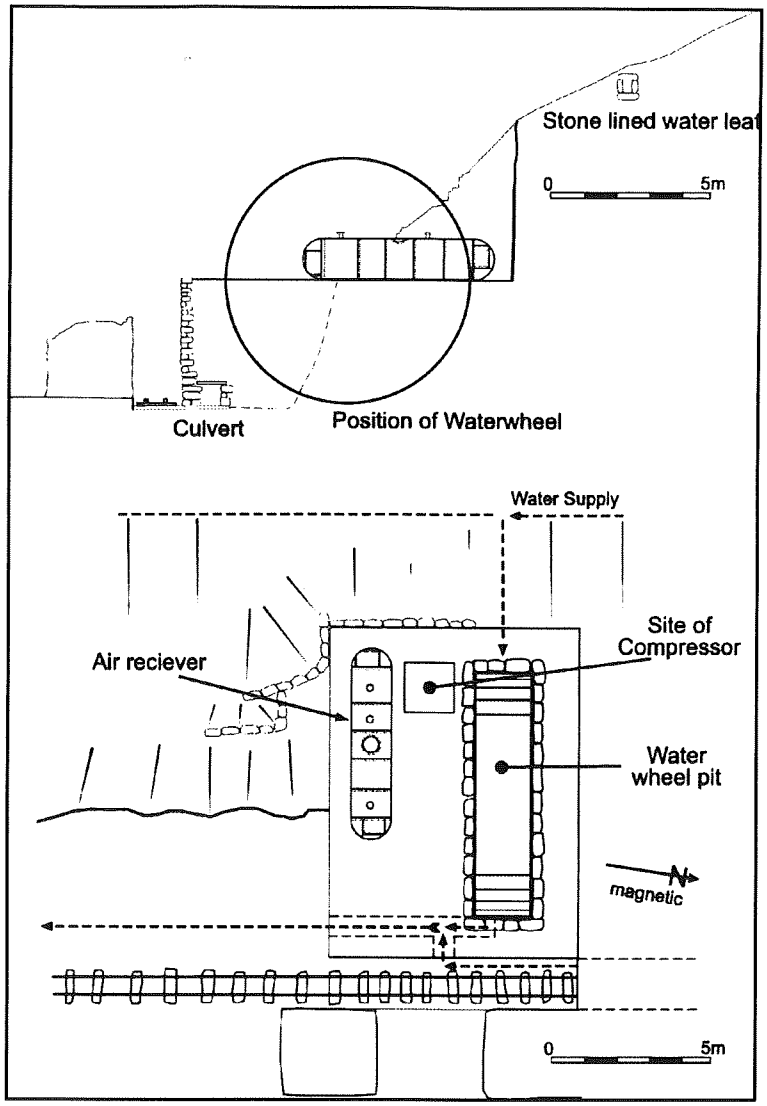
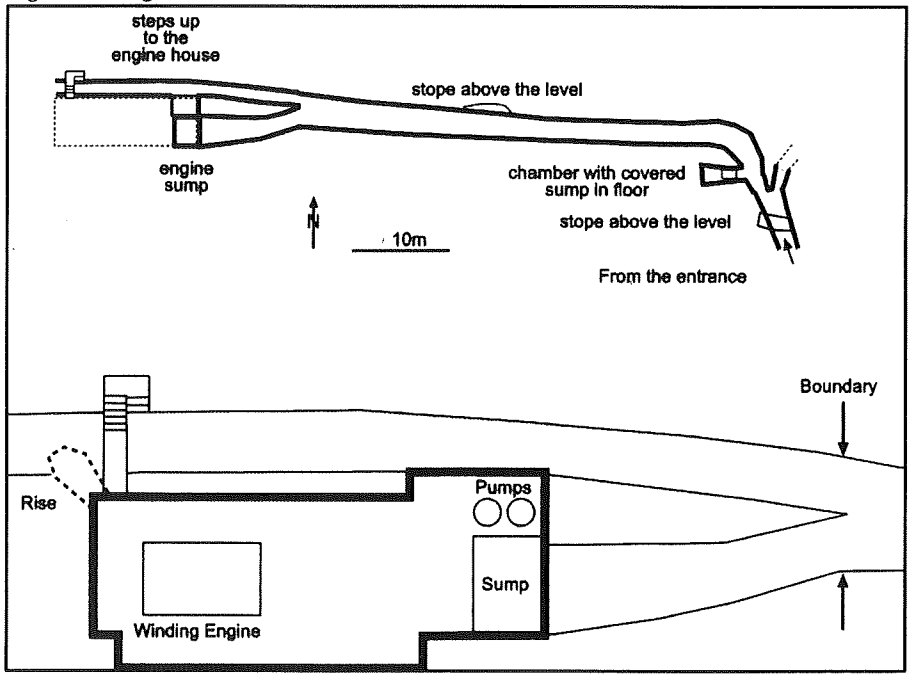


Fig. 2. The engine room (compressor house).

The installation of the AD Co plant took away the water supply for the Old Gang donkey engine and by February 1881 it had been removed and they had to abandon work beneath the level. The AD Co was liquidated in 1884 and although the Old Gang Co was also having financial problems they managed to continue until 1887 when they surrendered their lease. A new company the Old Gang Lead Mining Company Limited was formed in 1889 to work the combined ground of both companies. Sir Francis level was cleared out and the hydraulics were repaired and set to work. The air compressor and borers were also put back to work at the beginning of 1890 being used to drive forwards the horse level. The bucket covers on the pumps were replaced in August 1890 and work started sinking in what was referred to as the North Vein. In January 1891 one of the clack valves failed and this, combined with a lack of water, stopped the engine and any further work below Sir Francis Level (Barker MSS, lessors letter book).

Over the next few years the borers continued in use but, like the hydraulics, water supply was often a problem with water-courses freezing in winter and drying up in summer. Work was now confined to the beds above Sir Francis. The level had been

Fig. 3. The engine houses.



connected to Pricilla Level via various rises and allowed access to ore below Pricilla. Further work also occurred between Pricilla Level and the higher Blind Gill Level. Mining finally came to an end in 1906 (NYCRO, ZLB 2/276).

The Physical Remains

Compressed Air Generation

The compressor house was built adjacent to the level entrance and remains as a platform 8m x 10m, 4m above the floor of the level, and is partly cut into the hillside (Fig. 2). The most obvious feature is the cast iron air receiver, which measures 6m x 1.2m. On the opposite side of the platform is the rubble filled wheel pit and towards the back between the wheel pit and air receiver are several bolts, which mark the location of the air compressor. A stone lined water leat cut into the hillside supplied water to the wheel. The height of the leat suggests that the wheel was either overshot or high back shot. The water for the compressor house is taken from Gunnerside Gill several hundred metres upstream and although originally built for the generation of compressed air the leat was extended down the valley for use on the dressing floors. The exhaust water ran away into a culvert where it was joined by the water flowing from the level. Although there is currently little physical evidence, documentary evidence indicates that the compressor was contained in a building with windows (NYCRO, ZLB 2/276 Dilapidation Survey October 1906). The lack of structural evidence might suggest that this was a wooden building.

Underground Features

The present entrance to the mine is via a ladder pitch down an airshaft. Access cannot be made directly because of falls in the level, which has caused water to back up for a considerable distance to a depth of 1-1.5m. A cast iron compressed air supply pipe runs along the left or west side of the level for its full length. This is approximately 3 inches in diameter and in some places is accompanied by a smaller pipe of approximately 1 inch diameter.

The first features encountered are two recessed areas on the left of the level approximately 100m from the airshaft and a short distance apart. Each is about 3m wide by 3m deep. The second retains evidence of a wooden frame and door, which suggests that it was a store. This is probably the dynamite store previously mentioned.

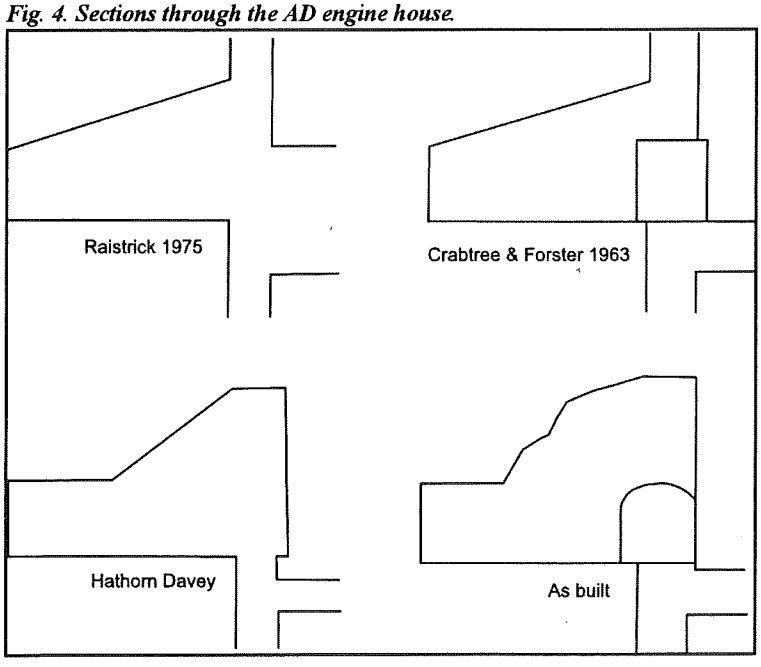
After approximately a mile the level forks, and the right branch is immediately blocked by a major fall (Fig. 3). Within the fall- debris there is a large diameter iron pipe with a valve. To the left the level continues and passes a small chamber on the left. The entrance to the chamber is narrow but opens out to 2m wide and runs back about 5m. The main part of the floor appears to be boarded over and water can be seen welling up from the floor. An iron rod with a mortised end protrudes from the floor and appears to extend some distance below the floor. It appears that this is the sump sunk by the Old Gang Company and the iron rod is a pump spear, which was once connected to the donkey engine borrowed from the AD Company (Plate 1).

Continuing along the level it forks again and the left branch opens out to double level proportions and runs to a flooded sump. This sump is lined with timber and partitioned. A cage is suspended above the sump and a wire rope disappearing into the water indicates that a further cage is at the bottom of the sump (Plate 3). The right branch from the junction continues as an arched haulage level. A wide arch on the left connects with the sump previously described. Pump rods pass through the roof of this opening and through a wooden cistern, which fills the floor. In the centre of the cistern is the top of the rising main.

A few metres further on a set of stairs lead up to a large chamber measuring approximately 11m x 5m and containing winding and pumping engines. The full specification of these engines has been previously published (*The Engineer*, XLIV, 30 April 1880; Davey 1900; Crabtree and Foster 1963; Lodge 1966) and it is not intended to discuss the detail of the engines here but it is worth discussing the various published representations of the engine room (Fig. 4). The first two both date from the 1880s with the version from *The Engineer* being the better known as it was reproduced in Raistrick (1975, 54) where the outline of the engine house was enhanced. As with the drawing from the *Hathorn Davey Ltd Catalogue* (WYAS) it depicts a shaft directly above the sump, which appears to be for the water supply pipe. In reality the water supply enters via the rise at the opposite end of the chamber and there is no shaft above the sump. Both plans also show the roof sloping upwards from the rear of the chamber to reach its maximum height above the sump. A similar profile was later published by Crabtree and Foster (Crabtree and Foster 1963) but this correctly shows the section of roof over the winding engine, which although arched appears flat as this is a section. They also show the remainder of the roof sloping upwards to the flat roof above the sump. In reality this part of the roof is in solid rock and much more irregular as shown in the last section and this serves as a reminder that both contemporary illustrations need to be used cautiously and later published sources may contain inaccuracies.

One area that has received very little attention is the layout and organisation of the engine chamber. One basic and fundamental question to ask is how was the engine house lit? The operation and maintenance of machinery requires good lighting but how and where. It is known that an underground engine room at the Blakethwaite Mine was lit by a "large chandelier" (Gill 2001). This was probably an arrangement with multiple lighting sources such as candles or oil lamps hung from the roof. The only evidence present in the AD engine house is an iron pin fixed into the wall in the middle of the room about 3m off the floor (Plate 2). This would be a good place to hang a light to provide a general lighting to the room but key areas such as the winding engine controls would have been in shadow, so perhaps a main light was supplemented with more localised lights which have left no trace. In the 1960s a workbench and anvil stood in the engine room indicating that at some point it had also doubled up as a workshop (Crabtree and Foster 1963).

Fig. 4. Sections through the AD engine house.



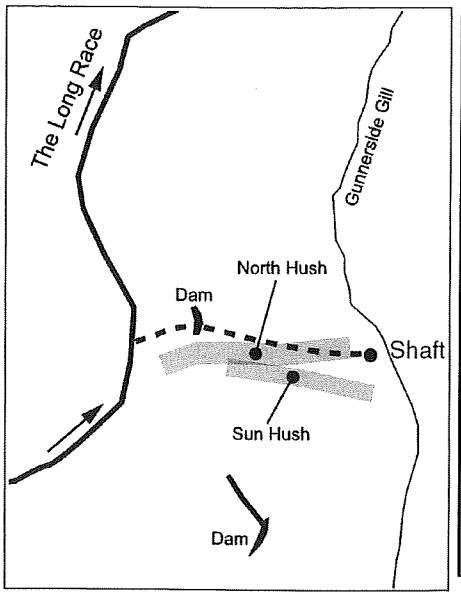


Fig. 5. Water supply features.

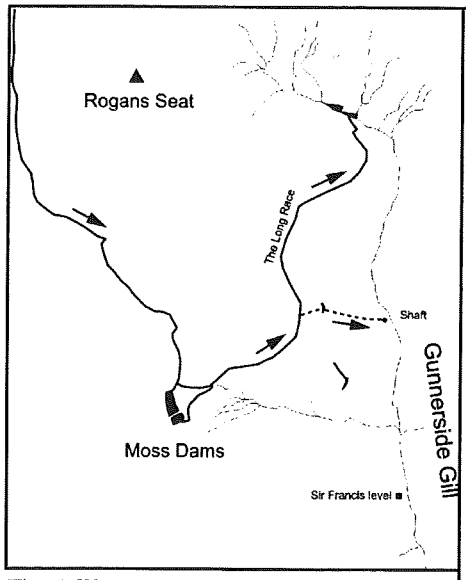


Fig. 6. Water sources.

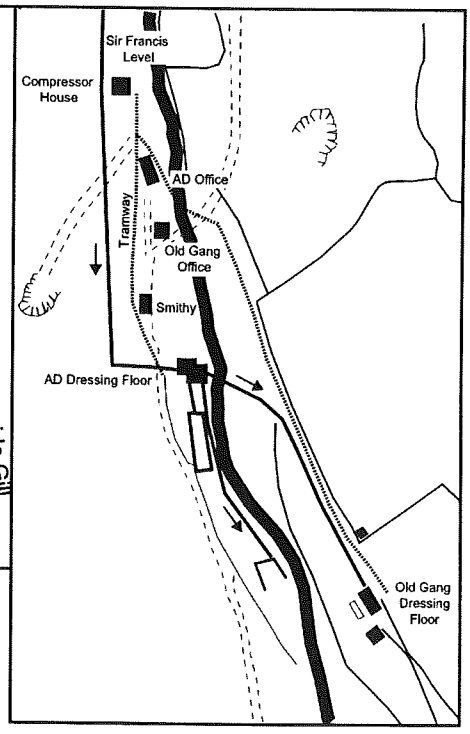


Fig 7 (right). Dressing floors

This would also suggest that good lighting was present. Underground engine rooms and workshops are often whitewashed to maximise the available light but there is nothing to suggest that that happened here. Another point to briefly mention is the apparent lack of a safety rail or chain at the top of the sump. Without a rail and chain it would be all too easy to accidentally step off and fall down the sump. Similarly there is no evidence of gates in the level below where the cages would be loaded and unloaded. Were there arrangements to stop accidental falls down the sump, which have now decayed or have been removed? These questions show how important it is to remember that archaeology never tells a full story: there are always elements of the picture missing.

Water Supply to the Underground Engines

Having stated that the Old Gang engine had its water supply cut off when the AD engines came on line there is some conflicting evidence which suggests that the Old Gang engine might have had its own water supply. Firstly there is a reference to water pipes belonging to the Old Gang Co in May 1878 (NYCRO, ZLB 3/27) which predates the installation of the AD water supply pipes. Secondly there is the pipe and valve seen in the right hand branch of the level where it strikes the vein. Where does it come from and where does it go? This is an area where further research may show that a parallel supply system was installed.

The supply to the AD "hydraulics" is better understood and well documented (*The Engineer*, XLIV, 30 Apr. 1880). The descriptions tell us that the water was supplied from a dam 500ft above the adit level running 1800ft down the hillside in pipes before entering the mine down a 240ft shaft. Raistrick (1975) and others have referred to this dam as Sun Hush Dam. This is erroneous as there is no obvious dam associated with Sun Hush and, even if there were, the top of Sun Hush is less than 1800ft from the shaft. There is however a large hush dam just to the north of North Hush, which is around 1800ft from Woodward Shaft where the remains of the water supply pipe enter the mine (Fig. 5). Because the water was carried in pipes it is very difficult to trace its course but this dam is also in an ideal position to be fed by the Long Race a large water leat, which runs from Moss Dams on Ivelet Moor to the Blakethwaite dams at the head of Gunnerside Gill. The Moss dams are in turn fed by a catchwater leat which runs around the western flanks of Rogans Seat (Fig. 6). The origins of the Long Race and Moss Dam system are difficult to track down but probably postdate 1836 when the combined grounds of Blakethwaite and Lownathwaite were worked together with the ground to the west. The system would certainly have been used to supply the Withams water pressure engine that began pumping the west end of the Blakethwaite mine in 1842 (Gill 2001). Surviving maps offer little information on its construction date although the catch-water around the western flank of Rogans Seat is described as "new" on a map of 1855 (NYCRO, ZLB 41/13). The water supply pipes on the surface survived until 1927 when they were sold to Geoffrey Hesletine of Gunnerside for scrap (NYCRO, ZLB 2/276) and there is now very little evidence of their course.

Dressing Floors

As the level was driven by two companies it should be no surprise that there are two separate dressing floors at Sir Francis. At this point the valley is quite narrow and space is limited so the Old Gang floor is sited downstream of the AD dressing floor (Plate 4). Traditionally it has been considered that the companies confined all their activities to the separate sides of the gill but that was not quite true. Most of the buildings are on the west bank upstream of the AD dressing floor and a survey of the mine indicates that one of the buildings was an office for the Old Gang Company (NYCRO, ZLB 2/276).

The relationship between the Old Gang and AD companies was never harmonious and surviving correspondence paints a picture of continuous petty squabbles. It is therefore a surprise to see that the Old Gang Company appear to have relied on waste water from the AD floor to run their dressing operatio: the two floors are shown on Fig. 7. The water leat, which supplies the compressor house, continues along the hillside between the two floors. From this it is clear that a set of stone piers supported a launder where it crossed the stream. This has been previously discussed by Shayler et al. (1979), however they failed to recognise that a flat area protected by a retaining wall was also part of the AD dressing floor. An inventory of 1887 (NYCRO, ZLB 3/27/15 Valuation of the AD mine "Outside Plant") gives a full list of the AD plant and the following extract shows how many water wheels were employed on this side of the gill

.

Air compressor, pipes, wheel, & all complete
Crushing mill wheel, rollers & all complete
Chat mill wheel, rollers & all complete
Water wheel, circle buddle & all complete

Water wheel, 2 circle buddles, 1 dressing tub, flooring, bingstead & all complete.

This gives a total of five water wheels. Taking away the compressor wheel that has already been discussed that leaves four located on the dressing floor. Although a substantial proportion of the AD dressing floor has been eroded away by the gill there is enough field evidence which when combined with an early 20th century photograph of the site suggests that it housed the first three wheels and that the water used on the Old Gang dressing floor was the waste water from the crushing mill and chat mill (the local name for a secondary or fine crusher). A portion of the supply was taken to power the first circular buddle, which was also at the AD site, and then the remainder continues down the valley to the Old Gang floor where the final two circular buddles were housed.

There is very little information about the Old Gang dressing floor other than some derogatory comments made by the AD Company who claimed it was inefficient and old fashioned, and so its interpretation has to be based on the surviving archaeology. They appear to have had a fairly standard double-sided ore crusher driven by a water wheel. One side would have acted as a course or primary crusher and the other a fine crusher or chat mill. In front and beside the crusher are terraces covered in varying grades of spoil marking the probable position of manually operated hotching tubs. There are no obvious sign of buddles downstream of this point but the abundance of fine dressing waste would suggest that there was probably some kind of buddle employed.

Further research may discover that the Old Gang Company had access an alternate supply of water and so was not totally dependent on water coming from the AD Company floor. It is unclear what happens to the water, which flowed out of the level and was joined by the waste water from the compressor house. It is unlikely that the water was simply turned into the gill and a careful study of the relative heights of the site components may show that it could have been utilised on the Old Gang dressing floor.

Conclusion

Water played a very important part in the development and working of Sir Francis Level, a mine that deserves to be remembered for more than its surviving hydraulic engines. Exactly how the water was used is a story that has not yet been fully told but further fieldwork coupled with documentary research should be able to add a considerable amount of detail.

Mss References and Acknowledgement

Barker MSS: private collection. Copies held in Northern Mine Research Society records.
NYCRO: North Yorkshire County Record Office.
WYAS: West Yorkshire Archive Service, Sheepscar, Leeds.
The Engineer (London)

References

Davey, H. 1900 *The Principles, Construction and Application of Pumping Machinery (Steam and Water Pressure)*. London.

Denys, S.G. 1877 *Machine versus Hand Labour in Mining*. Richmond.

Crabtree, P.W. and R. Foster 1963 Sir Francis Mine. *Cave Science*, 5, 33, 1-24.

Gill, M.C. 2001 *Swaledale: its Mines and Smelt Mills*, Landmark, Ashbourne.

Hunt, B.M. 1887 *British Mining*. 1887. London.

Lodge, P.D. 1966 Hydraulic Pumping and Winding Machinery, Sir Francis Level, Swaledale. *Memoirs of the Northern Cavern and Mine Research Society*, 21-26.

Raistrick, A. 1975 *The Lead Industry of Wensleydale and Swaledale: Volume 1 The Mines*. (Moorland Hartington).

Shayler, A. E., Almond, J. K. and Beadle, H. L. 1979 *A Guide to the Past Lead Industry in Swaledale and Teesdale: Mining and Smelting in Swaledale and Teesdale*, (Redcar: Cleveland Industrial Archaeology Society).

The Engineer 1880 XLIV, 30 April 1880.

Martin Roe has had an interest in mining history for over 20 years. In July 2000 he graduated from the University of Leicester with a first class degree in archaeology. His dissertation on the surface and underground archaeology of Cononley Lead Mine won Leicester University's Garner Prize, an Association for Industrial Archaeology Fieldwork Award and the Society for Post Medieval Archaeology dissertation award. After completing an MSc in Archaeological Prospection and a PhD study of the components of lead mining landscapes in the Yorkshire Dales he is now working as a freelance archaeologist. Martin sits on the committee of the Northern Mine Research Society, is the Conservation Officer for NAMHO and sits on several archaeology panels.