WATER TURBINES OF THE WOODS POINT GOLDFIELD 1866-1867

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ABSTRACT

Water turbine technology was still relatively young when it was first introduced to the predominantly-dry continent of Australia. Some of the earliest examples of Australian water turbines were installed in Victoria during the mid-1860s in a relatively concentrated area of the remote Woods Point goldfield, situated on the upper reaches of the Goulburn River in the Great Dividing Range. This paper will outline of the development of water turbine technology up until its introduction at Woods Point and discuss the early history of that goldfield and initial choices of power technology. A short history of each of the mining sites at which the Woods Point water turbines were installed will follow, along with an explanation as to why mid nineteenth century transport difficulties over the recently-opened Yarra Track made water turbines the favoured technology. The majority of the Woods Point turbines were installed under the supervision of Richard Jenkin Polglase, a somewhat tragic, frequently insolvent, and almost-forgotten Cornish engineer. The paper will also discuss some of the reasons why the installation of turbines ceased after such a short period of operation. The paper will conclude with a comparative analysis of other early water turbine installations in Victoria and demonstrate that Woods Point pioneered the use of this technology in Victoria.

KEYWORDS: water turbines, gold mining Victoria, Yarra Track, Woods Point, Richard Jenkin Polglase.

1. A SHORT HISTORY OF THE REACTION WATER TURBINE UP TO 1870

The earliest form of reaction turbine powered by water was Dr. Robert Barker's mill of circa 1740 – a metal tube like an inverted letter 'T'. Water flowing under pressure from the lower arms turned the stem of the T (much like today's domestic lawn sprinkler), and this rotation could then be mechanically transmitted to power machinery. In 1747, Ján Andrej Segner of the University of Göttingen described a water turbine similar to Barker's mill, but with six jets instead of two. Swiss mathematician Leonhard Euler analyzed the fluid flow in the rotor passages of Segner's turbine and determined the torque and power that such a turbine provided – perhaps the first empirical work in turbine design. Little was done thereafter until 1775, when Monsieur Mathon de la Cour improved the turbine by introducing the water from below the arms. This reduced the need for the rotating shaft to carry the water and the upward pressure of the water relieved some of the weight of the shaft from the machinery above. However, it took nineteenth century improvements in working metals to turn the turbine into a practical device. In 1841, James Whitelaw and James Stirrat patented an improved version of de la Cour's bottom-fed turbine with curved arms tapering towards the jet, producing further improvements in efficiency. In 1843, a patent was taken out in America. This form of reaction turbine became known as the 'Scotch' turbine and was widely used up until the 1870s, when it was rendered obsolete by more efficient vane-based turbines.[1] The first glimmerings of what would become the modern water turbine were beginning to show just as Dr. Barker was demonstrating models of his mill. These primitive turbines had a vertical axis and outward flow, and were known as 'spoon' or 'tub' wheels from the shape of the buckets.

In 1823, Frenchman Jean Victor Poncelet introduced curved blades to a new design of undershot waterwheel (driven solely by water passing below it), more than doubling its efficiency. In 1826, Poncelet suggested turning his wheel on its side, permitting the water free egress from the wheel without having to reverse its flow. This influenced fellow Frenchman Benoit Fourneyron, who built the first successful outward flow radial water turbine in 1827. The turbine developed an efficiency of 80%, even when the wheel was completely flooded by water in the tail race. Over the following decades, Fourneyron further developed and improved the wheel. It was patented in 1832, the patent including for the first time the term 'hydraulic turbine'. Its high power, fast rotation and compact size revolutionised the water power industry. Fourneyron died in 1867 with the water turbine widely accepted and the technology spreading world-wide. By 1846, Irishman James Thomson, brother of the famous Lord Kelvin, had developed what he called his 'vortex' turbine which used adjustable guide vanes, the water flowing from the periphery of the wheel towards the centre. The first practical example was put into service in Ireland in 1852, and Thomson entered into an arrangement for Williamson Brothers to manufacture the turbine under licence. Williamson's successors, Gilbert Gilkes, still manufacture water turbines today.

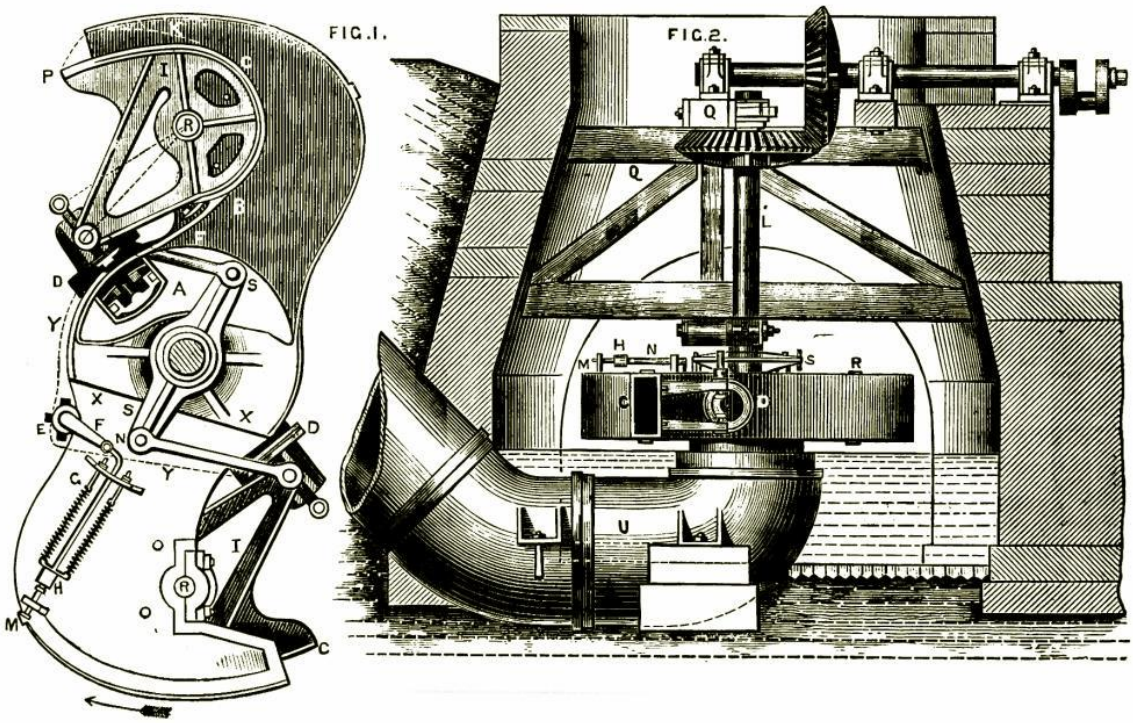

Figure 1: Whitelaw & Stirrat's hydraulic turbine. The Engineer, *7 April 1882, page 247.*

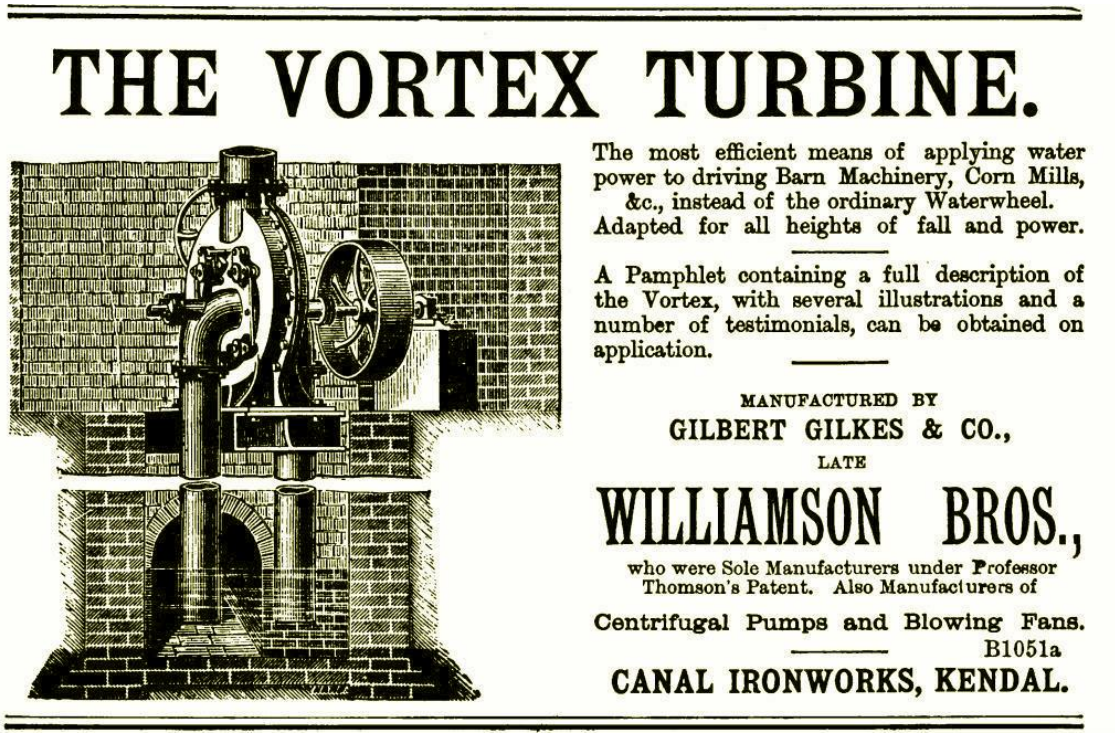

Figure 2: The Thomson Vortex Turbine. The Engineer *7 April 1882, page xxvii.*

Further turbine developments were made in North America. Samuel Howd introduced a successful inward flow turbine in 1838. A development of the Fourneyron turbine was introduced in Massachusetts in 1844 as the Kilburn turbine. In the same year, Uriah Boyden patented a variation of Fourneyron's turbine with a conical inflow passage, guiding the water into the turbine more efficiently. In 1849, James Francis was largely responsible for the introduction of accurate testing methods for determining the efficiency of water turbines, and further increased the efficiency of the inward-flow turbine to 88%, producing what would be regarded as the first modern turbine. In 1862, James Leffel patented a turbine that combined two wheels in one casing: the upper having inward-flow buckets while the lower had axial flow buckets directing the water out of the turbine and downward, increasing the efficiency to above 90%.[2]

Acceptance of water turbines in the United Kingdom was slow, with the first industrial example installed in 1840 and the first appearing at an industrial exhibition in 1862.[3] In contrast, by the 1850s, water turbines were displacing waterwheels all over North America. When the first batteries were being installed on the remote goldfields of Woods Point in the mountains of south-east Australia, the technology could be said to be maturing. Up until 1866, Woods Point batteries were powered either by overshot waterwheels or steam engines. With the realisation that water turbines met the unique requirements of the Woods Point goldfield, six turbines were installed in 1866-67 before mining operations collapsed due to a financial crash caused by prolonged and reckless speculation in mining shares. Before examining the reasons for the introduction of turbine technology to the Woods Point Goldfield, a brief history of the individual turbines is in order.

2. THE WOODS POINT GOLDFIELD

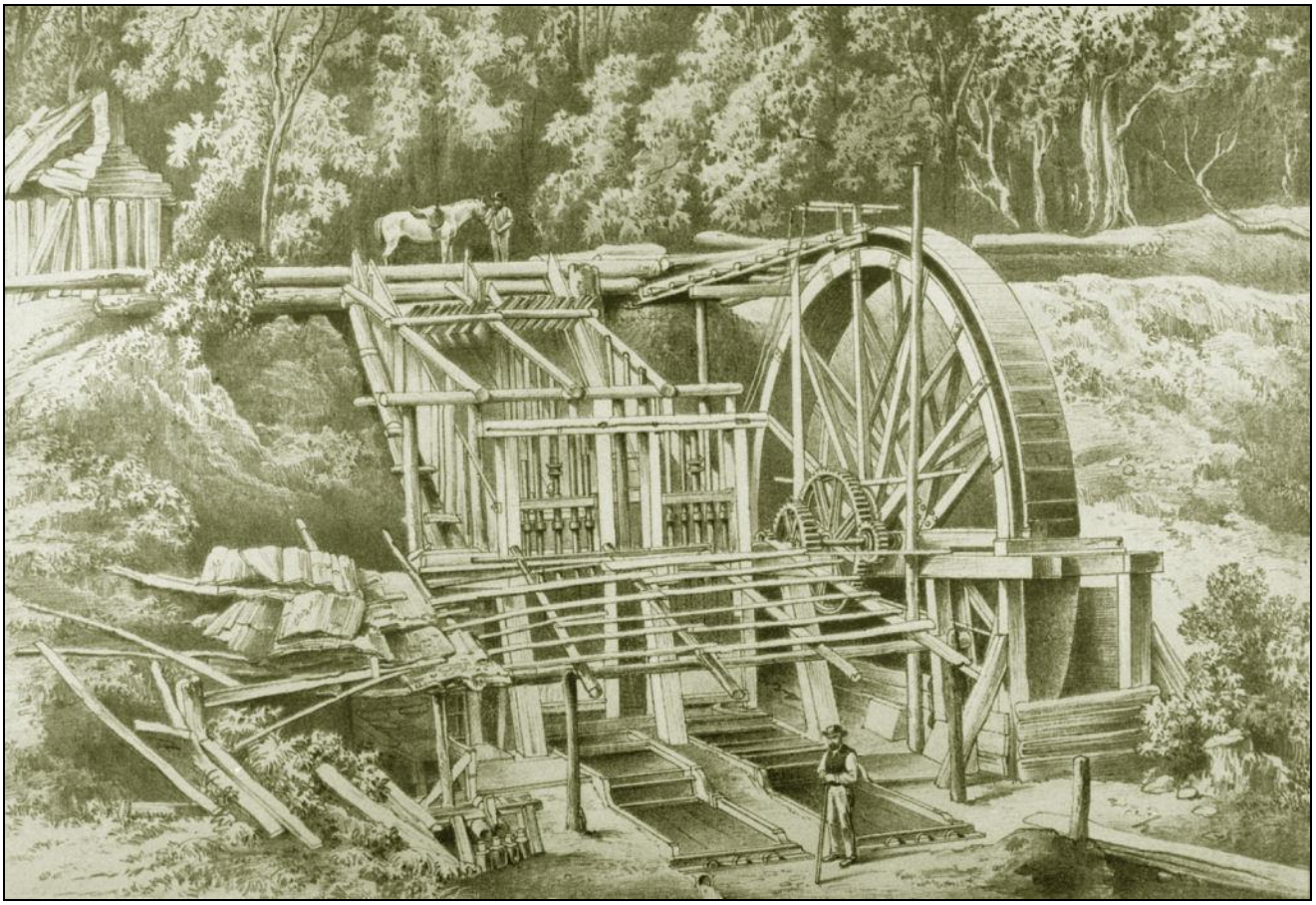

Figure 3: A typical mountain goldfield battery powered by an overshot waterwheel. Peter Evans collection.

The Woods Point goldfield was discovered by prospector William Gooley around May 1861 when he found alluvial gold in what is now Gooleys Creek, a tributary of the Upper Goulburn.[4] The narrowness of the river valley meant that the amount of alluvial ground that could be taken up was limited, and it was not long before miners started to turn their attention to the quartz reefs outcropping on the steep slopes above the Goulburn River. Stamp milling of quartz was firmly established by the Port Phillip & Colonial Company at Clunes, which started its battery in May 1857.[5] By the time the short-lived alluvial rush at Woods Point had died away in 1862, stamp milling had become well-established, and a number of Victorian manufacturers offered suitable appliances, mostly powered by steam engines.

These manufacturers were largely based in Ballarat and Bendigo, and machines could be made heavy and robust since they only had to be hauled relatively short distances. The long and difficult haulage to Woods Point, the last stage entirely by pack-horse, imposed tough new conditions on the design of machinery until the Yarra Track was opened in late 1864, at last providing a route for wheeled traffic to Woods Point. Components for waterwheels could be more easily transported than steam engines, since only the main axle, gearing and requisite fasteners were required; timber to construct the wheel being sawn on site. Even when iron buckets were used, these could still be transported relatively easily in comparison to steam engines. For this reason, the majority of early Woods Point batteries were powered by overshot waterwheels. The problem with water power was that it was a seasonal resource, being widely available only in the winter. Waterwheels were also not the most efficient use of water, having an efficiency at best approaching 80% and a maximum delivery of between 10 to 30 horsepower.[6] Turbines were becoming widely used in America at the time the Woods Point mines were being opened up, and the technology quickly made its way onto the new goldfield.

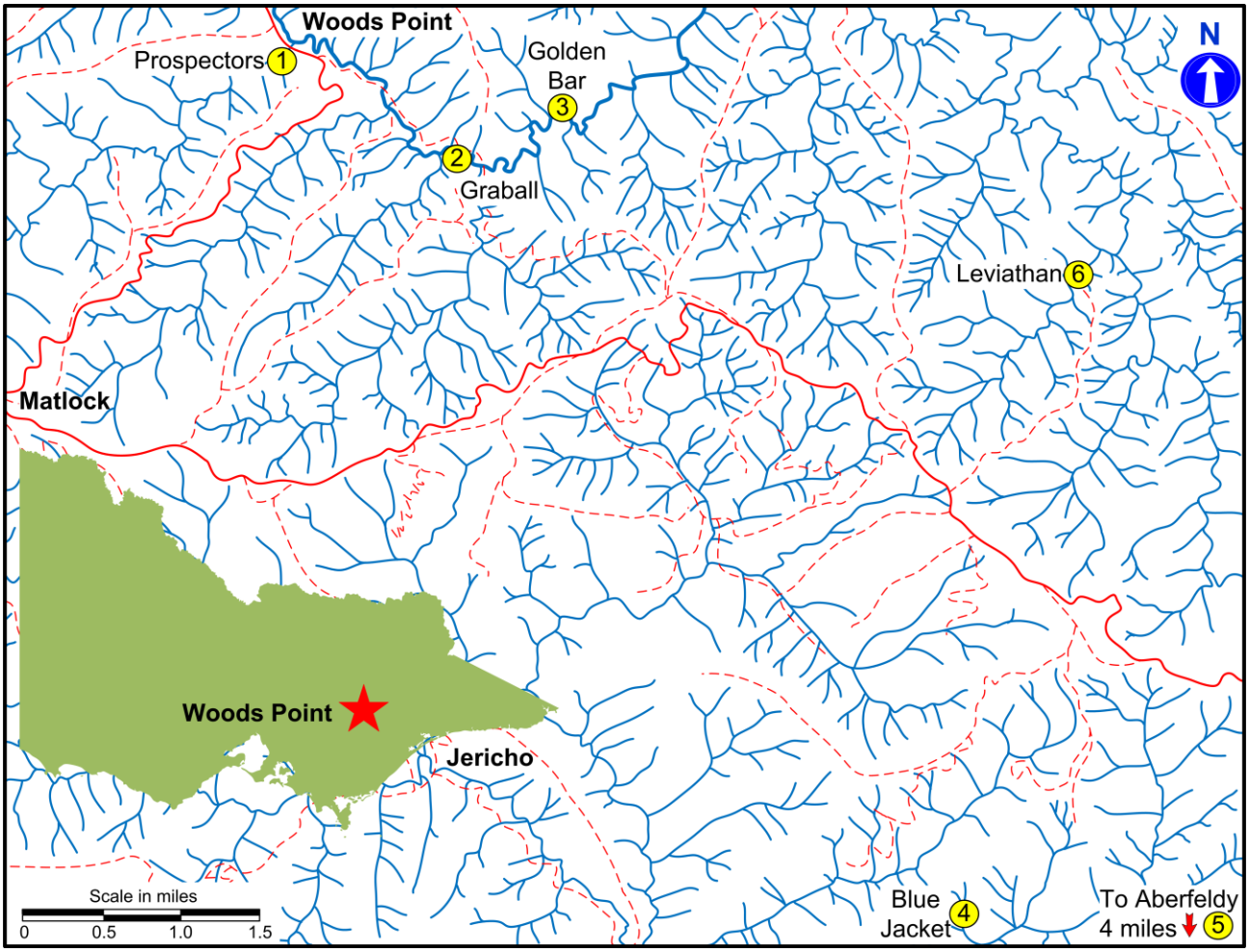

Figure 4: Hydraulic turbine locations, Woods Point goldfield. Map by Peter Evans.

3. THE WOODS POINT TURBINES

3.1 The Prospectors' claim, Morning Star Hill

The fabulously rich gold-bearing dyke concealed below what became known as Morning Star Hill was discovered in mid-1861. The gold trapped within the quartz could be seen with the naked eye. A large claim was marked out which was to produce gold for over a century, providing the foundation for the town of Woods Point, which grew up around a store erected by Canadian Harry Woods. A trial crushing of 15 cwt of quartz dollied by hand produced 33 oz of gold, proving the richness of the find. Little could be done to exploit the quartz deposit until machinery was available, so discoverers 'Reedy' Joe Corry and Dittmar Behrens, now joined by Colin and Duncan McDougall (their former partners at Gaffneys Creek), worked the Morning Star alluvial prospecting claim at the junction of the creeks to raise some capital. Colin McDougall was sent to Melbourne to buy machinery that could be dismantled into small enough sections to allow it to be packed to the site. By August 1862, the machinery was in place.[7] The battery was powered by an overshot waterwheel fed by two races, one from the Right Hand Branch of the Goulburn River, and the other from the Left Hand Branch [Morning Star Creek]. The waterwheel was 20 ft in diameter and drove two boxes of four stamps.[8]

By early 1865, a second mill had been erected just below the first. This used the water coming from the first mill to drive a second waterwheel 25 ft in diameter. This wheel drove twelve stamps identical to those used in the first mill, and both mills crushed exclusively for the Prospectors' claim.[9] The pair of waterwheels required two million gallons of water daily and, despite the large investment in water races, it was not possible to operate all of the heads of the batteries simultaneously during the summer months.[10]

In late 1865, Mining Surveyor A. B. Ainsworth noted:

> … a matter of greatest import to the district, the introduction into this subdivision by the Morning Star prospectors of the turbine as motive power. The value of this introduction is very great, its success certain.[11]

The turbine was built by Douglas of Kirkcaldy, Scotland and was introduced as a speculative venture by Mr. Alexander Binnie, engineer for the Prospectors' claim. The turbine cost £1200 installed but resulted in a great increase in efficiency, and provided sufficient power to drive three times the number of stamps presently connected, as well as leaving enough water to enable the original waterwheel to continue in use.[12] Its success perhaps encouraged the introduction of other turbines to the Woods Point Goldfield.

3.2 The Pride of Graball battery

The discovery of rich reefs at Gooleys Creek led to almost every outcrop of quartz in the area being intensely worked. In January 1866, storekeepers James Holt and Edwin Sabine invited

> … parties in the vicinity of Gooleys Creek to inspect proposals now lying with us to lay down tramways and erect machinery to crush for the public.[13]

Holt & Sabine were acting as agents for Melbourne businessmen Henry Cook and Richard Hodgson. The battery was to be the first of several erected by the two 'Melbourne capitalists' in the Woods Point district, and would initially crush for the Shamrock, Atlantic and Evening Star companies.[14] By the end of June the machine was almost complete.[15] It was driven by a water turbine and consisted of twenty-eight stamps housed in a substantial building measuring 45 ft by 30 ft. Cook & Hodgson had purchased the machinery from Wright & Edwards of Little Bourke Street, and it was erected under the supervision of engineer Richard Jenkin Polglase.[16] The *Woods Point Times & Mountaineer* reported that the new turbine was constructed to the patent of 'Whitelaw & Stodart'.[17] It is assumed that the newspaper's reporter misheard the name of the owners of the patent for the newly-installed water turbine, which was almost certainly that of 'Whitelaw & Stirrat'.

The first of the quartz from the Star of the East was delivered to the battery on 6 August 1866. The following day, the battery was duly christened in front of a large crowd. Ten of the twenty stampers were set to work in front of the spectators, who raised three cheers for the 'Pride of Graball'.[18] During the winter, debris brought down by the creek damaged the turbine, and a screen was erected at the head of the race.[19] New parts were ordered from Melbourne, following which it was reported that 'the turbine wheel, after a series of disasters, has been at length induced to run well'.[20] The turbine settled down to regular work in July 1867. With plenty of water, the turbine was keeping ten heads going with 'only about half the power on'.[21] By the end of August 1867 the machine was hard at work crushing for a number of local reefs.[22]

3.3 Golden Bar Prospecting Gold Mining Company

The Golden Bar reef was discovered in the first half of 1864. The reef traversed the spurs on the north side of the Goulburn River east of Gooleys Creek and showed coarse gold, but work was abandoned due to lack of machinery.[23] In May 1866, the Golden Bar Prospecting Gold Mining Company was incorporated[24] with Richard Jenkin Polglase appointed manager.[25] A trial crushing of four tons of stone packed to another battery in early 1866 yielded amalgam equivalent to one ounce of gold to the ton.[26] In February 1866, it was reported that a group of 'Melbourne capitalists' were to fund the erection of a battery for the Golden Bar. For the first twelve months the machine owners would claim half the gold won. At the end of twelve months, the machine would be offered to the mine at valuation, or an extension of the same arrangement could continue.[27] The 'Melbourne capitalists' were Cook & Hodgson and their engineer was Richard Jenkin Polglase. Ten heads of stamps and a water turbine rated at 30 hp were ordered.[28] Inclement weather delayed the machinery and it was not until 29 October 1866 that it had all arrived on site.[29] The wheel installed was 'one of Smith's turbines'.[30] Very likely, the reference is to A. K. Smith, engineer of Carlton, a northern suburb of Melbourne, who had already supplied mining equipment to Polglase at Woods Point and who had been advertising the availability of water turbines from late 1864.[31]

By the end of November 1866, Polglase had completed all of the other machines he had contracted for and expected to have the Golden Bar machine finished within a fortnight.[32] On 9 January 1867 the water was turned on to the turbine 'and around went the wheel with great velocity'.[33] Crushing commenced on 28 January. Since gold was clearly visible in the stone being brought from the mine, good results were expected.[34] The first crushing produced only 25 oz but, apparently, some gold was being lost and, once this was rectified, better results were hoped for.[35] It was not to be. The next nine day's crushing produced a mere 12 oz of gold. The shareholders were very disappointed, and it seemed that work was likely to come to a standstill if the claim could not be let on tribute (assigned to others to work for a percentage of the gold won).[36] By this time the Golden Bar Company was already defending cases of unpaid debts in the local court.[37] By the end of May 1867, it was clear the mine was not a payable proposition,[38] and the Company's lease was declared void in September 1867.[39] However, the Golden Bar machine was fortunately situated when the Sir John Franklin claim was opened upon the opposite bank of the river in the same year.[40]

3.4 Blue Jacket QMC proposed turbine-driven pump

The Blue Jacket Quartz Mining Company was registered in November 1864 to work the Blue Jacket prospecting claim in the Jordan Valley.[41] In June 1865, two tons of stone were packed fifteen miles to the Loch Fyne machine and crushed for a yield of 14 oz to the ton.[42] By the middle of August, about 100 tons of quartz had been raised and stacked, and it was decided to erect a crushing plant immediately.[43] The first of the machinery was due on the ground at the beginning of November[44] and, by the end of the month, the din of the riveting hammer resounded from the nearby hills as the boiler was put together.[45] Only a few weeks later, the boiler and the heavy timber foundations for the steam engine were completed. The battery was ready to work by the end of February 1866.[46] For a time returns were reasonable[47] and, during August 1866, a contract was let for the installation of a 'turbine wheel' and pumps.[48] It is not known if the work was actually carried out and, in July of 1867, it was announced that the claim had been let on tribute for two years.[49] The mine subsequently saw little development until the 1880s. We cannot be certain that this proposed turbine-powered pump was to be a Cook/Hodgson/Polglase installation, but we know from the Mining Registrars' *Quarterly Reports* that at least Hodgson and Polglase's names were associated with a battery on Dry Creek nearby.[50]

3.5 Aberfeldy Gold Mining Company

The Aberfeldy lease was situated on the Aberfeldy Creek near Mount Misery. The reef was initially followed down to a depth of 60 ft,[51] and the Aberfeldy Gold Mining Company was registered in June 1865.[52] The Company's 23-acre lease contained 480 yards of the line of the reef. Two hundred yards were opened up on the surface and found to be gold-bearing over the whole of that distance, so it was decided to erect a battery.[53] The battery was to be provided by 'Melbourne capitalists' and would consist of ten heads driven by a turbine. For the first twelve months the machine owners would claim half the gold won. At the end of twelve months, the machine would be offered to the mine at valuation, or an extension of the same arrangement could continue.[54] Cook & Hodgson had most of the machinery on the ground by the end of March 1866 and the battery was in the course of erection under the supervision of Richard Jenkin Polglase.[55] The machine started work in mid-December

1866[56] but ceased only weeks later because of a shortage of water.[57] The results from the short crushing season must have been poor, as the Aberfeldy Gold Mining Company was wound up in November 1867.[58]

3.6 The Leviathan Amalgamated Gold Mining Company

The Leviathan reef was situated on a tributary of Standers Creek.[59] The reef projected well above the surface of the ground and was 20 ft wide, with gold in the stone visible to the naked eye.[60] The Leviathan was initially worked by open cut, with ore was taken out the side of the cut via a short tunnel. Partnership disputes and mismanagement resulted in very little progress until the No.1 North and No.1 South prospecting claims were amalgamated as the Leviathan Amalgamated Gold Mining Company,[61] registered in March 1865.[62] A share increase was made to raise money to purchase machinery[63] and, by the end of April 1866, offers had been received for the supply of plant.[64] Richard Jenkin Polglase was contracted to supply ten head of stamps powered by a water turbine. The contract included all the necessary water races, tramways and shoots required for the works.[65] The battery was to be financed by Cook & Hodgson and the turbine was manufactured by Wright & Edwards of Little Collins Street.[66] In September 1866, Polglase arrived with the final installment of plant, which had been brought up from Sale on four drays.[67] Water for the new battery was supplied by two races from the Leviathan Creek each capable of carrying 1.5 million gallons of water a day with a head of 50 ft to the turbine.[68]

The machinery was tested on 19 November and crushing commenced without ceremony the following day.[69] The first result was better than 2 oz to the ton, but a shortage of water was already causing a reduction of the number of heads that could be driven.[70] By the end of January, the battery had been stopped for some weeks, and the mining manager was authorised to purchase a steam engine. The delay was especially frustrating since the claim was now producing stone superior to that yet seen in the mine.[71] By the end of February 1867, with the season well advanced and the return of the rains imminent, it was decided not to proceed with the installation of steam power just yet.[72] Cook, Hodgson and Polglase must have been awaiting the return of the rains with some anticipation - of the four claims on which they had erected machines, only the Leviathan appeared to be payable.[73] It was not until June 1867 that there was sufficient water to work the turbine.[74] With winter rains supplying plenty of water, a series of rich crushings followed, and the first dividend of £1 per share was declared in September 1867 with a further dividend of £1 per share in November.[75] The mine was clearly progressing well, but summer again led to a shortage of water. By the middle of December crushing had ceased altogether. To work the battery in summer and continue the flow of dividends, a portable steam engine was purchased from the nearby Robert Burns Company,[76] an engine which survives on site today. The Leviathan site is one of the few turbine sites at Woods Point not affected by later sluicing, and this raises that prospect that the turbine may still be in-situ somewhere at this location.[77]

4. SUMMARY

For the purposes of this discussion, we will ignore the steam batteries installed high up in the heads of creeks or on minor watercourses where there was little water available (All Nations, Loch Fyne, Alabama and Edwards) and those large batteries employing steam power in conjunction with a waterwheel (Alps Great Central, Scott & Cherry), and concentrate on those batteries employing water power alone for the purposes of comparing the waterwheel with the water turbine in the context of Woods Point. Why, after the installation of eight successful overshot waterwheels in a period of four years between 1862 and 1865, were five (and possibly six) water turbines installed in the two years from 1866 to 1867, before investment in Woods Point mining collapsed for a little over a quarter of a century? The answer lies in the distinct advantages provided by the turbine in a mountain goldfield context.

Even at Woods Point with its abundant rain and snow fall, water power was a seasonal affair. In summer batteries either operated with a reduced number of heads or were stopped altogether. In winter, flooding often filled the tail races rendering the water wheel either inefficient, or stopping it altogether. Full operation of an overshot waterwheel required between one million and four million gallons per day (depending on the diameter and width of the wheel and the depth of the buckets), a considerable volume of water. Any power source that could make more efficient use of the water would be welcomed. The first turbine installed at Woods Point was reported in the local press as giving great increase in efficiency, provided sufficient power to drive three times the number of stamps presently connected, and left enough water to enable the original waterwheel to continue in use. In addition, a turbine could still operate when fully flooded, avoiding unnecessary stoppages due to excess water in the tail race.

An overshot waterwheel can utilise a head only a little greater than the diameter of the wheel, which is limited by the strength of the materials available to construct it. At Woods Point, with one exception, waterwheels were largely constructed of timber, which had limited strength and a short life. None of the waterwheels used at Woods Point exceeded 35-ft in diameter, which limited the head (and hence the power) that could be utilised. Due to the steep slopes at Woods Point, heads much greater than this were commonly available. The second turbine-powered battery at Woods Point operated with a head double that which could have been utilised with an overshot waterwheel. A turbine has a much smaller footprint than an overshot waterwheel. At Woods Point, where battery sites were limited by the steep-walled valleys, spacious battery sites were rare. While the battery itself remained the same size per head as batteries powered by waterwheels, the compact power source was another advantage.

The major advantage provided by a water turbine is probably the least obvious and the most directly applicable to the Woods Point goldfield. It relates to the cost of transport. From its discovery in 1861 until December 1864, Woods Point could only be reached by a circuitous route, the last part of which was by packhorse alone, limiting the largest item to be carried to 200 lbs. From December 1864, a new road, the Yarra Track, was available which cut the distance from Melbourne to Woods Point to 100 miles, and allowed wheeled vehicles to reach the town. Despite this, the cost of cartage remained a particular problem of the Woods Point goldfield for decades to come. Even after the opening of the Yarra Track, the cost of cartage could reach £50 per ton. By the time improvements to the road were effected in late 1867, which reduced the cost to £15 per ton[78], five or six turbines had already been installed around Woods Point. Even given that the cost of transporting battery components would be constant for a particular installation, any cost reduction in transporting the power source would constitute a major saving.

The iron components of a waterwheel could be quite heavy: waterwheel shafts in the Woods Point batteries averaged 5½-inches in diameter with maximum of 7¼-inches for a wheel 3-ft-6in wide, and boasted cast-iron spur wheels up to 6-ft in diameter.[79] When the bearings and all of the hardware for wooden wheel struts and buckets were added to this, the iron components of a large waterwheel were relatively heavy. Wooden waterwheels required a lot of maintenance and were prone to lose water through leakage. In addition, there was only one sawmill at Woods Point, so if timber was not available from this source, the timber components of the water wheel had to be pit-sawn at great expense. If iron was used for the buckets, the mass of metal to be transported from Melbourne was considerable. The local press recorded that at least four wagon loads of components were required for the Fermoy waterwheel, which was all iron. In his intensive study of the vertical waterwheel, Terry Reynolds produces figures comparing the weights of the two power sources per horsepower produced. He concludes that a vertical waterwheel outweighs a comparative-power turbine by the order of 20 to 40 times,[80] with a similar disparity in transport costs. While we do not have accurate historical or archaeological evidence for the weight and size of the turbines used at Woods Point, it is unlikely that the turbine component constituted much more than a single dray load compared to at least four wagons for a vertical waterwheel. At Woods Point, hampered by both distance and poor roads, this transport cost saving was critical to the success of mines both proven and untried.

Finally, there is the human factor. We have two partners who have chosen as a method of speculating on mining not shares, but machinery. An application for a mining lease near Gooleys Creek in July 1867 made in the name of Henry Cook of 5 Bond Street Melbourne; Richard Hodgson of 123 Lonsdale Street Melbourne, and Edwin Sabine of Gooleys Creek[81] seems to support that these are the Cook & Hodgson who were financing the turbine-powered batteries. Examination of Sands' & MacDougall's Directories for Melbourne from 1862 to1868 raises as many questions as it provides clues to the identity of these men. The directories list a 'Henry Cook & John H. Dodgson', importers and paper merchants of 5 Bond Street Melbourne. There was one reference to the turbine financiers in the Woods Point newspapers under the name of 'Cook & Dodgson' but, thereafter, they appeared as 'Cook & Hodgson'. Richard Hodgson of 123 Lonsdale Street is listed as a merchant in the business of R. Hyde & Company (he was married to Margaret Hyde[82]) and Richard Jenkin Polglase refers to him as Richard Hodgson in legal documents, so the similarity of the names seems little more than coincidental.

Unfortunately, as an investment, all of the turbine-powered batteries installed by Cook & Hodgson turned out to be 'duffers'. The Woods Point gold rush occurred at a time when mining in Victoria had almost completed an important transition. What had started out in 1851 as a free-wheeling, democratically-inspired celebration of the rights and aspirations of individual miners working, at most, in small cooperative parties, had become a marriage

of labour and capital in mechanised company-based mining. The Woods Point alluvial phase had been short-lived due to the restricted nature of the alluvial deposit, and deep quartz mining was dominant almost from the birth of the new goldfield. The alluvial phase had been so short-lived that only a few parties accumulated enough capital for their quartz ventures to be self-financing. The majority of the mines had to rely on outside capital, either from Melbourne or one of the larger regional mining centres such as Ballarat. This reliance on outside capital, new legislation on company formation, a spate of fresh discoveries of quartz reefs, and one of those periodic epidemics of human greed combined to produce the phenomenon that became known as the 'Woods Point Mania'. Sadly, it turned out that there were plenty of mining leases that contained no reefs, and plenty of reefs that contained no gold.[83] Apart from the short-lived success of the Golden Bar battery in crushing for the nascent Sir John Franklin mine, none of the turbine-powered batteries would have been a financial success for its owners.

The man who supervised the work of installing these turbines (and seems to have been a partner in the speculation as he bore some of the financial pain) was engineer Richard Jenkin Polglase. He was born in Gwinear, Cornwall, England, to farmer Ralph Polglase and Eleanor Polglase (née Jenkin) in early 1817. He may be the same Richard Jenkin Polglase, 'Engineer' of Middlesex, England, mentioned as having received provisional protection of a patent for improvements to boiler plates in March 1854[84] or the Richard Polglase, 'Millwright, Engineer and Boilermaker' in charge of the Atlas Works, 80 Borough Road Southwark, in 1856.[85] Whatever the case he was no financial success, as Richard Jenkin Polglase, 'Millwright' of Middlesex, was declared insolvent on 29 February 1856.[86]

Perhaps looking for a fresh start, he arrived in Australia around 1858 and became manager of the Crown Iron Works (in partnership with Henry Tregellas) from January 1859 at 274 Elizabeth Street. The Crown Iron Works specialised in cast iron stoves. Richard Polglase also offered to sharpen millpicks [a tool used to dress millstones] 'superior to any other man in the country', citing many years of experience in London.[87] An early interest in gold mining was indicated by the application for a patent for 'improvement in machinery for breaking stones',[88] and by the trial at the Crown Iron Works of 'Mr Manuel's' patent amalgamator 'as used at Tarrengower'.[89] Polglase was also involved with W. Williams in the Victoria Tin Smelting Works, but abandoned the venture in April 1860.[90] Another partnership with Francis Hocking, blacksmith, was dissolved in September of the same year.[91] The partnership between Polglase and Tregellas in the Crown Iron Works was dissolved in February 1862 with accounts to be paid by Polglase[92] and the business was put up for sale on 24 June 1862.[93] Richard Jenkin Polglase appears in the Melbourne Post Office directories from 1860-62 as a 'Smith & Engineer' of 271 Elizabeth Street, but is absent from the directories from 1863 onwards.

He is next recorded at Gordon(s) as a sawyer at the Green Hill Sawmills (probably that owned by Robert Hall).[94] Here he became insolvent on 27 February 1864,[95] with liabilities of £1,464 and assets of £1,407, with a certificate of discharge being granted 27 March 1865. He paid a dividend to his creditors. He was described as 'elderly' [49] when he moved from Blackwood to Woods Point in 1866.[96] The earliest newspaper reference to him at Woods Point is in March 1866, and he then appears regularly both in connection with the installation of the turbines and at least one steam-powered battery, but also in connection with speculation in mining shares and leases. By August 1867 he was again in financial difficulty.[97] Bailliere's Post Office Directories list him as an engineer residing at Gooleys Creek with his wife Eleanor from 1868 until he was again declared insolvent in Melbourne on 17 January 1871. Since 1866 he had been accumulating debts, mostly small amounts for stores and labour, but also for some money advanced as loans. In 1869 he had offered his creditors six shillings in the pound, which some of them had accepted. In an effort to earn some money, he hired Richard Hodgson's battery on Dry Creek above Red Jacket to crush for the Commercial Reef Gold Mining Company, for which he would take a share of the gold produced. However, little gold was won and, in October 1870, floods washed away the dam feeding the machine. Polglase lost what gold he had obtained and a valuable watch. By this time, the debt of a little over £200 to A. K. Smith's Carlton Foundry was too large to be left any longer, and it was Smith who enforced the insolvency. There was also a debt of £140 due to Wright & Edwards for the supply of machinery. Both of these debts were probably due to the purchase of turbines and associated crushing machinery. Polglase's liabilities totaled £1430 and his assets a mere £28, and he surrendered his estate for sequestration. A certificate of discharge was granted on 26 May 1871.[98]

Richard Jenkin Polglase passed away at his residence at the corner of Raglan Street and Skipton Road Ballarat on 1 March 1878 at the age of 61, having battled a bowel complaint for five months. A heat wave in Ballarat may have hastened his demise. He was buried in Ballarat the following day, his death unremarked in the local press

save for a single funeral notice.[99] The lack of any probate documents (and his repeated insolvencies) indicate that his estate was probably negligible. Whatever his abilities as an engineer, he was clearly no businessman.

Figure 5: The headstone of Richard Jenkin Polglase in the Ballarat Old Cemetery. Photo: Peter Evans

5. COMPARATIVE ANALYSIS

The Woods Point goldfield almost certainly pioneered the use of water turbines in Victoria (first suggested for mining purposes in 1858) and perhaps even in Australia, because they did not appear in that other well-watered State, Tasmania, until 1879, and did not become popular until the 1880s.[100] Until the introduction of the Pelton wheel, few water turbines received mention in the quarterly reports of the Victorian Mining Registrars. The earliest was a turbine of 32 hp to drive twelve stamps at the New American mine in the Crooked River subdivision in late 1865,[101] at the same time as the first turbine was being installed at Woods Point. In June 1872, after all the Woods Point turbines were in place, the New North Clunes Company took delivery of a Fourneyron turbine with a diameter of 23 inches designed and built by Hunt's Victoria Foundry in Ballarat to develop 30hp and drive twenty stamps. It replaced an existing steam engine.[102] The turbine consumed two and a half million gallons of water per day and rotated at 500 rpm.[103] In late 1880 a wheel 'built on what is known as the reaction principle … looked upon by many as quite an experiment' was erected by a Mr. Turner almost within the township of Bright.[104] In 1881 a turbine was ordered from America by the Simmons Reef Amalgamated Mining Company in the Blackwood and Blue Mountains Mining Division to drive twenty heads (their neighbours the Koh-i-noor Company may have been using a similar turbine to drive ten heads).[105] Despite its fall of 60 ft, the Simmons Reef turbine was not a success – it was continually out of order and assessed by the local Mining Registrar to have been less efficient than a conventional overshot waterwheel of 45 ft diameter, which would have done the same job.[106] In 1885, an imported English-made Vortex turbine was noted out of use at the Murrindal silver-lead mine on the Buchan River.[107] A ten head battery and 'turbine' were installed at the Glen Albion mine at Doctors Creek, Jamieson in early 1894.[108] In 1896 the Alpine battery at Mount Wills consisting of ten heads and a turbine was shifted to the Anaconda mine.[109] (An American Francis turbine survives at the site). In the same year a Melbourne-built Smith & Ballantyne turbine was supplied to the Mount Orient mine in Bright.[110] Finally, a 'New American' 64 hp turbine with a head of 59-ft was installed at the Pioneer mine near Bright in the early years of the twentieth century.[111]

The only other reaction turbines of which the writer is aware were installed in nineteenth century Victorian flour and paper mills. Around 1875, two 200 hp Francis American-type turbines were installed at the Bridgewater flour mill on the Loddon River. A third turbine was added in 1877. At any one time, two turbines were capable of directly driving the mill while the third was used at low water levels and for driving an auxiliary generator. In 1954, the original turbines were replaced by a Gilkes turbine developing 321 hp. The mill was still operating largely using water power in 1990. Less successful was the water powered flour mill that commenced work at Dights Falls on the Yarra River in 1843. After a rather chequered and unsuccessful career, the mill was reconstructed in 1887 for Gillespie, Aitkin & Scott. The use of an undershot waterwheel was abandoned and a water turbine supplied by Austral Otis of South Melbourne was installed. A later description of the mill indicates that this was two turbines with a combined output of 350 hp. The mill was destroyed by fire on 22 May 1909. Today, the two turbines survive in situ at this, Melbourne's oldest extant industrial site. The only other known use of a nineteenth century water turbine in Victoria was at the Barwon paper mill in Geelong, constructed near Buckleys Falls on the site of a former flour mill in 1877. The mill operated using both steam and its Macadam of Belfast Fourneyron turbine until 1923,[112] and the turbine survived in situ until 1962. The final installation at a flour mill is believed to be in mid-1898 at Anderson's flour mill at Smeaton, where a Leffel turbine was used to produce electricity independently of the mill's overshot waterwheel. This turbine survives on-site.[113]

Water turbine technology only came into widespread use in Victoria in the twentieth century for the generation of electricity. Small turbine-powered plants were installed on Rocky Creek at Warburton for the Seventh Day Adventist community in 1905; on the Victoria River in Gippsland for the Cassilis Gold Mining Company in 1908, on the Toorongo River at Noojee for the Goodwood Timber Company in the 1920s, and a small plant on the Agnes River to supply Toora and Foster with electricity. The first large-scale water turbine installations in Victoria were for the State Electricity Commission of Victoria Sugarloaf hydroelectric scheme completed in 1928, and for the Kiewa hydro-electric scheme constructed between 1938 and 1961[114]. Practically all of the non-SEC turbines were of the Pelton type.

Given their relative rarity in the Victorian mining industry and their pioneering nature, any discovery of substantial remains of any of the Woods Point reaction turbines would be of State heritage significance. Perhaps Richard Jenkin Polglase's headstone could be restored in recognition of the pioneering nature of his work at Woods Point.

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[8] *Woods Point Times & Mountaineer*, 16 August 1865.

[9] *Woods Point Times & Mountaineer*, 16 August 1865, 5 January 1866.

[10] *Dickers Mining Record*, 3 February 1866, page 106; *The Mountaineer*, 24 February 1865.

[11] *Quarterly Reports of the Mining Registrars and Surveyors* (afterwards *Quarterly Reports*) for quarter ended 31 December 1865.

[12] *Dickers Mining Record*, 29 May 1866, page 354; 19 June 1866, page 398; 10 July 1866, page 14; *Woods Point Times & Mountaineer*, 14 July 1866. An intriguing possibility is that this turbine was the one imported for a planned upgrade of the Dights Falls mill at Abbotsford, Melbourne, consisting of papermaking plant imported on the *Black Prince* in mid-October 1865 and including a Thomson patent 'Vortex' turbine manufactured by Douglas of Kirkcaldy. (Presumably Robert Douglas of the Dunnikier Foundry, Kirkcaldy, manufacturer of paper making machines and general engineer). The Dights Falls mill upgrade was cancelled because of the death of the mill leaseholder Thomas Kenny after a short illness in July 1866, and the paper-making machinery was moved further down the Yarra where a suitable fall to utilise water power would not have been available. Around this time a Douglas of Kirkaldy water turbine appears at Woods Point. See also *Launceston Examiner*, Tuesday 21 November 1865; http://home.vicnet.net.au/~paper/paperbio.html accessed on 9 April 2008.

[13] *Woods Point Times & Mountaineer*, 5 January 1866.

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[16] *Woods Point Times & Mountaineer*, 4 July 1866.

[17] *Woods Point Times & Mountaineer*, 5 September 1866.

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[25] *The Argus* 17 July 1866, page 8.

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[46] *Woods Point Times & Mountaineer*, 20 February 1866, 16 December 1865.

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