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WHITELAW TURBINES ON THE GOLDFIELDS

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Water wheels of various kinds were used extensively on the alluvial goldfields of Central Otago, mainly for driving the ubiquitous Californian pumps that kept the mining excavations clear of seepage water. Later, when gold reefs were discovered, large water wheels were used to provide power for the stampers that crushed the rock to release the gold (Petchey 1996).

Water wheels were built locally, and although smaller wheels could be transported in one piece, it was necessary to assemble larger wheels on the spot. They were cumbersome pieces of machinery and the difficulty of moving large wheels is dramatically recounted by Hannah (nd). She describes the removal of a large wheel from the head of the Fraser River, which became a major exercise even with the help of modern equipment such as tractors, trucks and a helicopter.

To derive much power from a water wheel a large supply of water was required and this was often not available in the winter when heavy frosts reduced the flow of mountain streams. The water turbine offered a solution to this problem. These machines depended on water pressure rather than on the weight of water which activated the conventional water wheel. They ran at much higher speed and developed more power with much less water than water wheels but the water supply had to be at a higher elevation than that needed for a water wheel. As they had to be manufactured in city foundries it was fortunate that they were more easily transported than water wheels.

Turbines of sorts had been known for a long time. Dr Barker's Mill, said to have been invented at the close of the 17th Century but not described until 100 years later, is regarded as the first *reaction* turbine. This is distinct from the *impulse* turbine where a high-pressure jet of water strikes a series of shaped cups around the circumference of a wheel and causes the wheel to revolve. The best-known impulse turbine is the Pelton wheel, which arrived in New Zealand in 1884.

Barker's reaction turbine consisted of a long upright tube with a hollow cross-arm at the lower end, like an inverted letter T. Water, fed down the vertical

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tube, emerged through outlets at each end but on opposite sides of the cross-arm. The resulting jets spun the entire T. An improvement saw the water brought down from the head race in a separate pipe and enter the cross-arm from below in a similar fashion to the common lawn sprinkler of today This meant that the vertical tube could be replaced by a solid drive shaft and at the same time the pressure of water from below helped to relieve the bottom bearing from the weight of the device.

Reaction turbines can operate when entirely immersed in water whereas the Pelton wheel operates in air (Johnson 1994).

James Whitelaw and James Stirrat patented the bottom-feed method in 1841. They also added curved arms which decreased in cross-section from the water intake at the centre and so increased the velocity of the water through the outlets. Their wheel became known as the 'Whitelaw' or 'Scotch' turbine and was manufactured from the 1840s, with various refinements added, until the 1870s when it was rendered obsolete by the introduction of more modern versions of turbines.

Apparently the remains of these machines are quite rare in America where only three examples are known. In New Zealand Whitelaw turbines were still in use up until about the turn of the century, driving stamper batteries for gold extraction.

A cross-section drawing (Figure 1) of the Globe battery on the Inangahua River 4.5 km southeast of Reefton, for example, shows clearly the reaction turbine installation that drove the 20-stamp battery (Mining Industry 1887). The head of water above the turbine is only 14 metres. The eventual fate of this turbine is unknown.

So far parts of three of these machines have been located and examined, in widely separated localities (Figure 2).

Bella Reef, Waipori

The most complete surviving Whitelaw turbine installation so far found in New Zealand is in the Waipori district about 40 km west of Dunedin. It lies on the side of a small gully leading down to Lake Mahinerangi. Here it drove the Bella battery which operated from 1891 until 1901.

So far as can be seen the machine is complete with even the supporting timbers in place, although some are partly decayed (Figure 3).

The machine has not been excavated so the underside of the rotor cannot be examined, owing to the presence of inwashed earth, and of the water-constraining steel shield which still partly surrounds it. For the same reasons the outlets cannot be seen clearly but their covers are visible along with the bolts used for adjusting the aperture of the outlets. Peter Petchey measured and

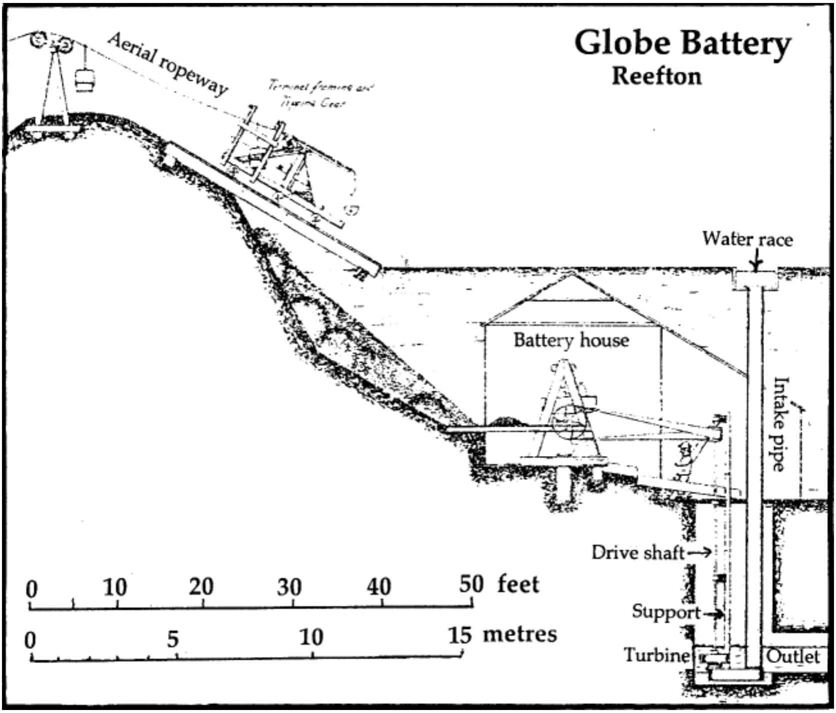

Figure 1. A cross-section of the Globe battery near Reefton shows the reaction turbine installation (after Report on the Mining Industry of New Zealand *1884: 124).*

sketched the machine ten years ago and has kindly made his data available. With some additions and minor modifications these are included in Figure 4.

The turbine was operated by water from a race on the ridge on the opposite side of the gully and about 15 metres higher than the turbine. The route of the pipeline can still be discerned.

White's Reef, Old Man Range

White's Reef lies on the slopes of the Old Man Range above Fruitlands at an altitude of 1000 metres. A turbine was installed in 1886 to drive a stamper battery but only the rotor and its base, which contains the inlet pipe, remain (Figure 5). Fortunately the rotor is now lying in such a way that the underside and the outlets are clearly exposed (Figure 7).

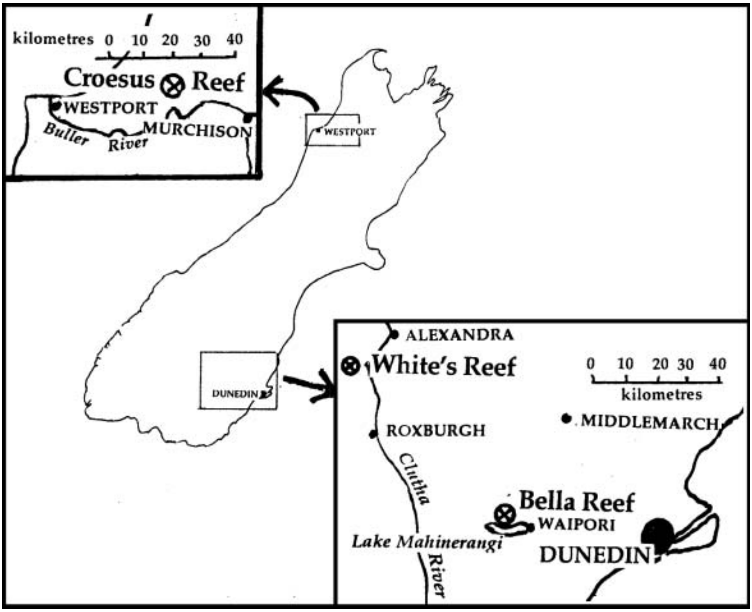

Figure 2. Locations where remains of reaction turbines have been found.

Figure 3. Turbine installation at Bella Reef, Waipori.

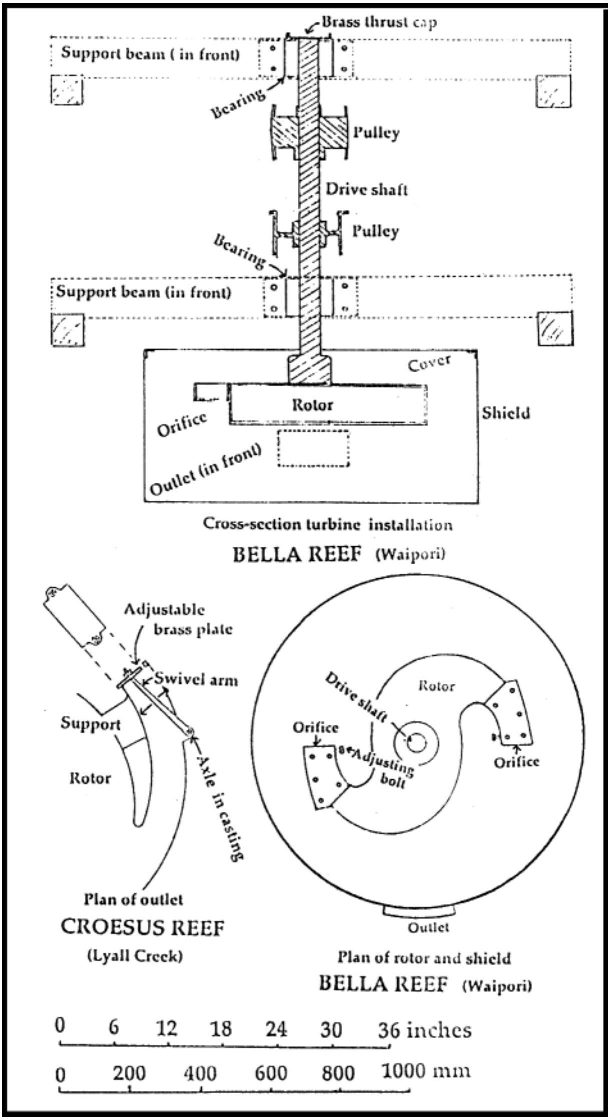

Figure 4. Diagram of Turbine Installation at Bella Reef, Waipori. with diagram of the Rotor at lower right. At lower left is a diagram of the mechanism for adjusting the width of the outlet on the rotor at Croesus Battery, Lyall Creek.

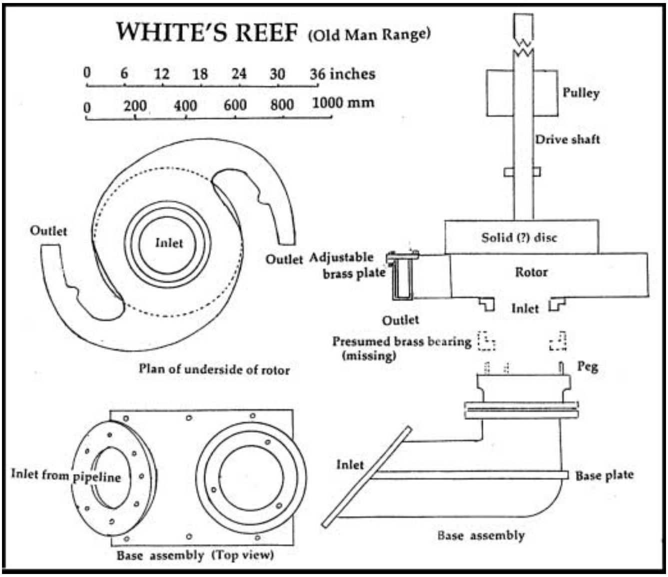

Figure 5. Diagrams of the rotor and its base at White's Reef.

A feature not present on the other two rotors examined is a disc 24 inches (610 mm) in diameter and 6 inches (150 mm) thick which, as far as could be determined, is comprised of solid iron, cast as an integral part of the upper surface of the rotor (Figure 6). It is possible that this was to provide extra weight to keep the turbine in its seat in the base assembly in the face of the high water pressure which had been provided in the first place for hydraulic sluicing.

It is evident that that there must have been a large brass disc which acted as a bearing between the base assembly and the bottom of the rotor. This disc was kept in place by three pegs still protruding from the base. Unfortunately this bearing has, presumably, fallen victim to scrap metal collectors as did the stamper battery and remainder of the turbine.

The rectangular outlets at the end of the tapering spiral arms of the rotor are well preserved and the method of adjusting the outlet slot is clear. By unbolting a small iron plate on the upper surface of the rotor arm a moveable curved brass plate is exposed. By moving this the width of the outlet slot could be adjusted. Replacing the cover and tightening its bolts ensured that the brass water guide was clamped in place (Figure 7).

Figure 6. Upper side of White's Reef rotor.

Croesus Reef, Lyall Creek Nelson

A few kilometres up Lyall Creek from the main highway through the Buller Gorge are the remains of the Croesus battery. The stamper battery itself has been restored and nearby are a couple of bedans and the very large rotor from a reaction turbine. Apart from its size (52 inches [1.3 m] in diameter, 16 inches [405 mm] in width) the main feature of interest is the mechanism for adjusting the width of the outlet slot. A moveable brass plate is fastened by nuts to two arms that are keyed to an axle which turns in bearings cast on to the rotor. By slackening the two nuts the device can be swivelled to form outlet slots of different widths. When the nuts are tightened the brass plate is clamped in place at the selected width (Figure 4).

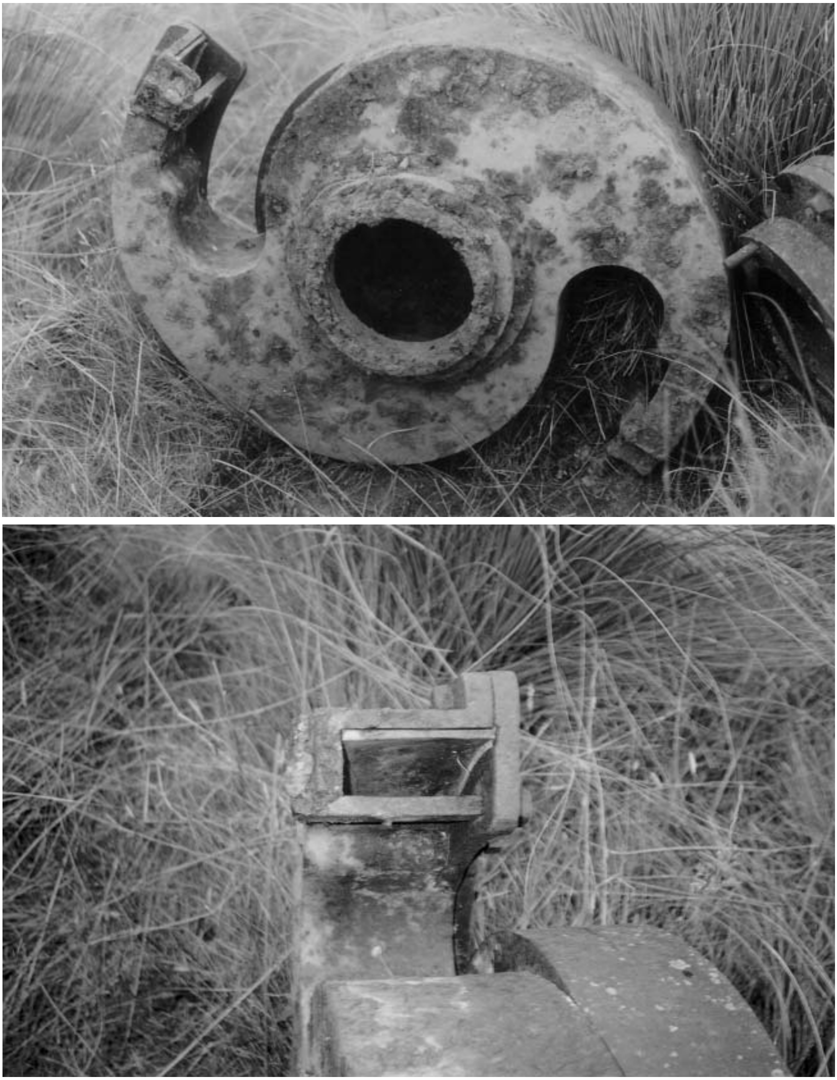

Figure 7. Top: Under side of White's reef rotor with inlet. Bottom: Close up of an outlet of White's Reef rotor with moveable plate for adjusting the aperture

Acknowledgements

I am grateful to Peter Petchey for drawing my attention to the turbines at Waipori and Lyall Creek and providing locations and details of them.

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