

THE FIRTH AND CLARK BATTERY AT WAIORONGOMAI

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THE UNIVERSITY OF  
**WAIKATO**  
*Te Whare Wānanga o Waikato*

## THE FIRTH AND CLARK BATTERY AT WAIORONGOMAI

**Abstract:** *A Thames battery was reconditioned at greater cost than anticipated because of adding the latest improvements. To power it, two water races were constructed through difficult country, and because so much gold was lost in the process then used, a tailings plant was soon added. Throughout the 1880s more improvements were made, but the fineness of the gold and the presence of base metals required a better process. After making a brief inspection of the latest American techniques, the first reverberatory furnace to be used in New Zealand was installed.*

*For battery hands, the work could be dangerous, but the only fatality was not inside the building and nor was it the fault of the employers.*

### ACQUIRING A BATTERY

The first battery was commonly referred to as Firth and Clark's because its principal owners were Josiah Clifton Firth and James McCosh Clark, who floated the private Battery Company to finance its erection and operation.<sup>1</sup> As on many goldfields, it was reconditioned. Originally the Bright Smile, or Piako, battery, which had been erected on the Waiokaraka Flat at Thames,<sup>2</sup> in February 1882 Firth purchased it for £2,100; its steam engine went to his Matamata estate and the crushing machinery to Waiorongomai.<sup>3</sup> One month later, one newspaper foolishly prophesied that 'in a couple of months we may expect to see the mill busily employed'.<sup>4</sup> Two months later, it was still being dismantled and taken up-river to where foundations were being prepared.<sup>5</sup> Its re-erection was then delayed when a gale blew down the framework in July.<sup>6</sup>

### DESCRIPTIONS OF THE PLANT

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<sup>1</sup> See paper on the Battery Company.

<sup>2</sup> *AJHR*, 1882, H-19, p. 11; Own Correspondent, 'Te Aroha Goldfield', *New Zealand Herald*, 5 February 1883, p. 6.

<sup>3</sup> *Thames Advertiser*, 21 February 1882, p. 2, 22 February 1882, p. 3.

<sup>4</sup> *Thames Advertiser*, 31 March 1882, p. 3.

<sup>5</sup> *Thames Advertiser*, 16 May 1882, p. 3, 27 May 1882, p. 3; *Waikato Times*, 23 May 1882, p. 2, 20 June 1882, p. 2.

<sup>6</sup> *Waikato Times*, 4 July 1882, p. 2.

By November, a visitor from Thames reported that ‘everything’ in the nearly erected plant was ‘being finished in the most complete manner, no labour or expense being spared to render the machinery and apparatus for gold-saving of the very best order’.<sup>7</sup> William Thornton Firth,<sup>8</sup> son of Josiah, had visited Nevada and California during August and September and ‘picked up a great many improvements in mining and milling machinery, some of which’ he added to it.<sup>9</sup>

A very detailed description was published in the *Waikato Times*:

The large building in which the battery is erected is situated on the western side of the Waiorongomai creek, near where the stream emerges from between high ranges, and from thence winds through the flat to the Waihou River. The building is 85ft by 82ft, and the walls 18ft high. The roof is covered with corrugated iron. Twenty-four sky-lights and 12 windows will give sufficient light during the day, and at night 12 large kerosene lamps are to [be] used. The stamps are 40 in number, five stampers to one box, and are geared in four different batteries, ten stampers to each battery. The bed log on which the boxes are fixed is of solid kauri, three feet square, and 62 feet in length, laid on cross logs 12 inches square, and the whole bolted down on a solid concrete foundation. Each battery of stamps is supported by cast iron columns and brackets stayed with inch and eighth and inch and quarter round iron diagonal stays. The length of each stamper and shank complete is 12ft, and the weight 10cwt; the shanks are three inches in diameter, and fitted with screw disks and jam nuts. The stamps are to be wrought, with a nine-inch drop which can be increased to 11 inches, but the latter is seldom used.

The driving shaft, which is 5in and the cam shaft 4 1/2in in diameter, are fixed in front of the columns. Each battery has a separate cam shaft, geared from the driving shaft with a set of two-to-one cog-wheel gearing, and provided with a disconnecting clutch attached to the driving-shaft pinion. The stamps are driven by two Furneyron Turbines of 60 horse-power each; one fixed at either end, and geared to the driving shaft. The belting from the 20in wheel on the turbine shaft to a five-foot driving-wheel, is of the best ten-inch rubber. This five-foot wheel is geared to the

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<sup>7</sup> *Thames Advertiser*, 7 November 1882, p. 3.

<sup>8</sup> See Mona Gordon, *The Golden Age of Josiah Clifton Firth* (Christchurch, 1963), pp. 161-162, 170; *Te Aroha News*, 26 July 1935, p. 4.

<sup>9</sup> W.T. Firth to R.R. La Valline, 23 March 1883, William Thornton Firth Letterbook 1883-1900, MSC 19, Hamilton Public Library.

main driving shaft with a set of heavy 1 to 5 pinion wheels. The turbines are powerful enough singly to drive the whole of the stamps, but both will be used as there will be less strain on the driving shaft. The tables, which are 6ft 4in in width, are provided with No. 20 gauge copper plates; there are three drops to each, five inches between the plates, seven inches from lower plate into trough, and five inches from trough to the blanket streaks, which are 22 feet in length. The berdans are 12 in number, arranged in one row in frames of 6in x 6in heart of kauri timber, and are driven by a turbine of 20 horse-power, the driving shaft is 70 feet long, 2 3/4 inch iron, and each berdan is provided with separate clutch gear. The berdans are 4 feet in diameter, and are so set that when water is up to the brim in front there will only be three-quarters of an inch on the bottom behind the boss. The berdans are situated to admit of trucks on a small tramway running between the blanket troughs at the foot of the tables and the feeding boxes at the back of each berdan. The hoppers into which the quartz is to be tipped from the tramway waggons are situated immediately behind the building, so that the self-feeding hoppers placed near the stamp boxes are filled by means of an iron shoot from each door. In order to ensure that the quartz falling into the main hoppers shall not exceed a certain size a large iron grating is placed over each where the waggons are to be emptied, the large rocks will roll down the grating to a platform, where they are to be broken by hand labour in the meantime, but eventually stone-breaking machines, driven by water-power, are to be substituted. There is one self-feeding hopper to each stamper-box, and the quartz is discharged into the stamper-box in the following manner:- The bottom and lift of a self-feeding hopper is a cast iron circular plate or disc, 20 inches in diameter, provided with a circle of levelled teeth on the side, under this is set with a slight incline, the lower edge being about six inches above the opening to the stamper-box, a spindle from the under side of the plate resting in a socket supports it, and leaves it free to revolve. Alongside of the second stamp from the outside of each battery a bumping rod with rubber spring top is so arranged that when the stamp drops to 3/4 of an inch from the bottom, the bumping rod receives a blow from the disc on the stamper shank each time it descends. The bumping rod is attached to the end of a lever with a spring return, which works a ratchet; on the axle of which is a small bevel wheel with teeth fitting those on the under side of the plate, which forms the bottom of the hopper. When quartz gets low in the stamp-box, the disc strikes the bumping-rod; this, by the aid of the spring return, works the ratchet, and the plate is caused to revolve by the bevelled pinion. The quartz resting on the plate is thus carried to the edge; immediately over the opening a guide plate is here fixed which sweeps it off into the stamp-box. A gangway is built along the whole length of the 40

stamps, on the top of the self-feeding hoppers, and the levers attached to the doors of the main hoppers can be worked by any one walking on it. The person in charge of the feeding is thus enabled to attend to the whole of the stamps, and do all the work necessary from this gangway. There are eight pots outside the building to which the tailings are conveyed in a flume from the end of the blanket streaks. The level floor near the berdans is laid with concrete, the remaining portions being laid where necessary with timber. A retorting house with two furnaces and concrete floor is erected in front of the main building near the tailing pits. The whole of the building, the hoppers and tramway are erected in the most substantial manner, the battery being one of the most complete of its kind, and provision is made to adopt such suitable labour-saving appliances as may enable the proprietors to crush quartz at a much less cost than is required in connection with most batteries in this part of New Zealand. A great deal more might be said, in order to give a just description of the battery.<sup>10</sup>

Others provided more details. One correspondent noted that no expense had been spared 'to make it as complete as possible'. Beneath the stamper boxes concrete was 'laid several feet deep, making a firm and solid bed' for the very heavy stampers, and one set of these had quick-silvered plates

instead of the ordinary copper ones. These plates extend for a distance of twelve feet, dispensing with a considerable amount of blanketing, and it is fully expected a much larger percentage of gold will be saved through this means. Another and no less important alteration will be in the gratings. These will be pierced to the number of 1400 to the inch, and when it is remembered that those commonly in use at the Thames are under 200, it will readily be perceived how much finer the quartz must be crushed before it will pass through the former. From this fact we apprehend that the charge for crushing will be relatively higher.<sup>11</sup>

No one else warned of higher costs. The hoppers erected at the end of the tramway could hold 520 tons, 'somewhat less than a week's crushing';<sup>12</sup> 'over 50,000 feet of solid heart of Kauai timber' were used to construct

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<sup>10</sup> 'A Visit to the Battery at Waiorongomai', *Waikato Times*, 15 May 1883, p. 2.

<sup>11</sup> Own Correspondent, 'Te Aroha Goldfield', *New Zealand Herald*, 5 February 1883, p. 6.

<sup>12</sup> Own Correspondent, 'From Christchurch to Te Aroha', *Lyttleton Times*, 24 October 1883, p. 5; Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

them.<sup>13</sup> Two turbines drove 20 head of stampers each, and the third drove the berdans, but the first two were each ‘capable of doing double work, in the event of an accident to the other. The third turbine delivers its waste water on to the tables, and thus economises water’.<sup>14</sup> The two turbines for the stamps were each of 60-horse power, while the one for the berdans had half that power.<sup>15</sup> Each stamp could reduce one ton in 24 hours.<sup>16</sup> It was expected the self-feeders connected to each stamper box would cause ‘a regular and continuous supply of quartz to pass into the boxes without the aid of manual labor for feeding; thereby causing an enormous saving in expenses’.<sup>17</sup> Once crushing started, a visitor was informed that this cheaper method ‘worked admirably’, for ‘one boy can superintend the feeding of the whole battery with ease’. The concrete floor, combined with the way the machines had been ‘fitted up so firmly’, meant vibrations were ‘scarcely noticeable’. Four stone breakers at the hoppers worked one shift each day manually reducing lumps too large to go through the screen.<sup>18</sup> One mining correspondent believed it to be ‘perhaps the most complete mill of its kind in the colony, certainly in the North Island’.<sup>19</sup>

## COSTS

The cost was originally estimated as £10,000, but £15,000 had been spent on both battery and water races by March 1883, and Henry Andrew Gordon, the Inspecting Engineer of the Mines Department, correctly anticipated that the final cost of both would be more than £20,000.<sup>20</sup> The total spent by 1884 was £22,000.<sup>21</sup> As the warden, Harry Kenrick,<sup>22</sup>

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<sup>13</sup> Own Correspondent, ‘Te Aroha Goldfield’, *New Zealand Herald*, 5 February 1883, p. 6.

<sup>14</sup> *Te Aroha Mail*, 10 February 1883, reprinted in *Thames Star*, 24 February 1883, p. 3.

<sup>15</sup> Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

<sup>16</sup> *Te Aroha News*, 10 November 1883, p. 2.

<sup>17</sup> *Thames Star*, 14 May 1883, p. 3.

<sup>18</sup> Special Reporter, ‘A Trip to Te Aroha Goldfield’, *Thames Star*, 10 December 1883, p. 2.

<sup>19</sup> Own Correspondent, ‘Te Aroha Goldfield’, *New Zealand Herald*, 5 February 1883, p. 6.

<sup>20</sup> *Thames Advertiser*, 10 June 1882, p. 3; Henry A. Gordon to Under-Secretary, Mines Department, 25 May 1883, *AJHR*, 1883, H-5, p. 1; *Thames Star*, 14 February 1883, p. 2.

<sup>21</sup> *AJHR*, 1884, H-9, p. 54.

<sup>22</sup> See paper on his life.

commented, this was ‘a most substantial guarantee’ of Firth and Clark having faith in ‘the future of the district’.<sup>23</sup>

## WATER RACES

While the building was being erected and the machinery overhauled and modified, a water race to provide water to drive the machinery was being constructed by the contractor, Henry Hopper Adams,<sup>24</sup> to his own specifications. By September 1882, he was working day and night to complete it on time.<sup>25</sup> Commencing slightly downstream from the foot of Butler’s Spur and running along the eastern side of the Waiorongomai Stream for three quarters of a mile, it had six ditches three feet wide and two feet deep, totalling 1,798 feet, six flumes totalling 761 feet, and three tunnels totalling 1,073 feet;<sup>26</sup> the fall was 1 in 400.<sup>27</sup> A dam stored water at the head of the race; in the twentieth century, and presumably originally, it was a large kauri log.<sup>28</sup> The *Thames Advertiser* considered the race was ‘constructed in a manner which would do credit to a Government as a colonial undertaking’. Most of it was ‘carried through the solid earth, the gullies crossed being spanned by substantial trestle-work carrying wrought-iron open fluming’.<sup>29</sup> One tunnel 600 feet in length was ‘driven from both ends simultaneously, and notwithstanding that the country driven through was of a very rough character, so well were the levels taken that the drives met almost in a direct line with each other’.<sup>30</sup> All joints in the tunnels were ‘carefully cemented’.<sup>31</sup>

To ensure a sufficient supply of water, in November 1882 the company applied for another race two and a half miles long and originating at the

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<sup>23</sup> Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

<sup>24</sup> See paper on his life.

<sup>25</sup> *Thames Advertiser*, 27 September 1882, p. 3; *Auckland Weekly News*, 10 February 1883, p. 20.

<sup>26</sup> F.C. Brown, Report on Hardy’s Mines, 1 March 1906, Mines Department, MD 1, 23/4/54, ANZ-W.

<sup>27</sup> *Thames Star*, 24 February 1883, p. 6.

<sup>28</sup> *Thames Star*, 24 February 1883, p. 6; Les and Russ Hill, interviewed by David Bettison on 13 June 1975.

<sup>29</sup> *Thames Advertiser*, 7 November 1882, p. 3.

<sup>30</sup> Own Correspondent, ‘Te Aroha Goldfield’, *New Zealand Herald*, 5 February 1883, p. 6.

<sup>31</sup> *Thames Star*, 24 February 1883, p. 6.

Wairakau Stream, upstream from Waiorongomai. Four feet deep and two feet three inches wide, it could carry eight sluice-heads of water.<sup>32</sup> In 1884, the company was granted approval to tap six creeks over which the Wairakau race was carried.<sup>33</sup> Three years later, a new race was constructed to take an additional five sluiceheads from the first creek at Wairakau, but this extra section was never used because of landslips.<sup>34</sup>

*Brett's Auckland Almanac* lauded the construction of the races as a 'formidable task' because nine tunnels pierced the 'mountains of rock' and 'precipitous defiles' were skirted and gorges requiring 2,000 feet of fluming and tall trestling.<sup>35</sup> The combined length of the original races was two and a quarter miles.<sup>36</sup> The race tapping the Waiorongomai Stream was 62 chains in length and in 1883 the Wairakau one was 111 chains. They met at 'a self-acting sluice 225ft vertically over the battery', giving a pressure of 90 pounds to the inch.<sup>37</sup> Their combined capacity was 13 sluice-heads, and whilst either would supply sufficient water both had been constructed 'to provide against accident or emergency'.<sup>38</sup> From the penstock to the turbines was 500 feet, the water being carried in a 20-inch pipe; in winter the water pressure provided 100 horsepower, in summer from 20 to 25.<sup>39</sup> (Six years later the pipes were stated to be 21-inch ones.)<sup>40</sup> The tank erected on the

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<sup>32</sup> *Waikato Times*, 25 November 1882, p. 3; *Thames Star*, 24 February 1883, p. 6.

<sup>33</sup> Te Aroha Warden's Court, Register of Applications 1883-1900, 24/1884, BBAV 11505/1a, ANZ-A.

<sup>34</sup> *Te Aroha News*, 5 March 1887, p. 2, 26 March 1887, p. 2; Waiorongomai Correspondent, *Te Aroha News*, 6 February 1889, p. 2.

<sup>35</sup> *Brett's Auckland Almanac, Provincial Handbook, and Strangers' Vade Mecum for 1884*, ed. Thomas W. Leys (Auckland, 1884), p. 120.

<sup>36</sup> Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

<sup>37</sup> *Auckland Weekly News*, 10 February 1883, p. 20; *Waikato Times*, 27 February 1883, p. 3; note that *Thames Star*, 24 February 1883, p. 6, gave the combined length of the water races as 176 chains.

<sup>38</sup> *Waikato Times*, 27 February 1883, p. 3; Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

<sup>39</sup> F.C. Brown, Report on Hardy's Mines, 1 March 1906, Mines Department, MD 1, 23/4/54, ANZ-W.

<sup>40</sup> Director's Report to 30 June 1912, Waitawheta Gold Prospecting Company, Company Files, BADZ 5181, box 222 no. 1314, ANZ-A.



kauri stand at the junction of the two races had ‘a bullet hole towards the top of it used for a long time as an indication of when it was full’.<sup>41</sup>

### TESTING AND PRAISING

When water first ran down the races on 1 February 1883, after nearly six months’ work and the spending of £7,000, the local newspaper applauded ‘a most creditable piece of work’.<sup>42</sup> A ‘most successful’ trial of the battery held early in April proved everything worked satisfactorily.<sup>43</sup> ‘Amid the enthusiasm of those assembled to witness its opening operations, it was found that a speed of from 55 to 60 blows per minute could easily be attained’.<sup>44</sup> Expectations were high, as illustrated by Kenrick’s April report. ‘All the latest improvements in gold-saving apparatus have been erected ... at a very considerable expense. The entire plant and buildings are finished in the most thorough and complete manner, and will compare favourably with any similar plant elsewhere’.<sup>45</sup> Writing in the following month, Gordon agreed that it was ‘one of the largest and most complete crushing plants’ in New Zealand and featured several improvements. The automatic self-feeders were ‘now largely used in Colorado’ and the gratings were the norm in California. Both turbine water wheels were constructed by Price Bros of Thames, but ‘the proprietors have on the ground two additional turbine wheels’ as ‘largely used in America’ should they be needed.<sup>46</sup> Providing electric light was being considered, there being ‘splendid water power to drive the dynamo’.<sup>47</sup>

### THE TAILINGS PLANT

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<sup>41</sup> Les and Russ Hill, interviewed by David Bettison in July 1975.

<sup>42</sup> *Te Aroha Mail*, n.d., reprinted in *Thames Advertiser*, 5 February 1883, p. 2.

<sup>43</sup> *Waikato Times*, 10 April 1883, p. 2, 17 April 1883, p. 2; see also *Te Aroha Mail*, n.d., reprinted in *Thames Star*, 11 December 1882, p. 3; *Thames Advertiser*, 16 December 1882, p. 3.

<sup>44</sup> *Thames Star*, 13 April 1883, p. 2.

<sup>45</sup> Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1883, *AJHR*, 1883, H-5, p. 15.

<sup>46</sup> H.A. Gordon to Under-Secretary, Mines Department, 25 May 1883, *AJHR*, 1883, H-5, p. 1.

<sup>47</sup> *Waikato Times*, 27 November 1883, p. 2.

In June 1882, Firth requested approval for a water race to convey ‘tailings from my battery to one of the swamps on the flat which I intend to purchase’.<sup>48</sup> Eight months later, Adams recommended adding another 40 stamps to enable the battery to treat all the ore.<sup>49</sup> Instead, in December Firth announced he would build a tailings plant 200 yards below the mill, to be powered by its waste water.<sup>50</sup> At first it was intended to have 80 berdans, driven by a ‘horizontal undershot wheel’.<sup>51</sup> In mid-April 1884, when 34 out of the revised total of 64 berdans had been erected, the machinery was tested and shown to be capable of treating nearly all the tailings when all the berdans were working. The ‘arrangements’ were described as ‘very complete’, everything being done ‘to make the plant as effective as possible’. As the gold was very fine, the plant was expected to increase the yield greatly.<sup>52</sup> The first two days spent grinding tailings for the New Find suggested these hopes would be fulfilled, for 74 ounces of amalgam was produced, expected to be one-sixth gold, ‘a return of 12 ounces for two days work ... at the rate of 36 ounces per week’.<sup>53</sup>

The local newspaper published ‘a brief description’:

The building in which the machinery is erected is a spacious structure 80ft in length by 40ft in width, with 14ft walls and a double roof covered with iron. The interior is well lit up by windows in both ends and sides. On the floor there is ample working space for 64 berdans.... When all are placed there will be four rows of 16 each. Two of these rows dipping towards each other with a space of about 4ft between the basins are placed on each side of the building. Along this space, and sunk into the floor, are a series of pits lined with timber, and intended for the reception of the tailings from the battery. These pits are connected with the main tailings shoot outside ... by smaller box-shoots, which are so arranged that the tailings belonging to the different companies that may be crushing at the battery flow directly into the pits adjoining the berdans used by the respective companies. The sludge on leaving the basins will be conveyed through shoots to a large pit outside the building. At the tail of

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<sup>48</sup> J.C. Firth to Harry Kenrick, 7 June 1882, Te Aroha Warden’s Court, Applications to form a Water Race 1882, BBAV 11289/9a, ANZ-A.

<sup>49</sup> *Thames Star*, 14 February 1883, p. 2.

<sup>50</sup> *Thames Star*, 6 December 1883, p. 2, 7 December 1883, p. 2.

<sup>51</sup> *Te Aroha News*, 8 December 1883, p. 2.

<sup>52</sup> Te Aroha Correspondent, *Waikato Times*, 19 April 1884, p. 2.

<sup>53</sup> *Waikato Times*, 3 May 1884, p. 2.

the shoot an electro-plate 8ft x 4ft will be placed, over which everything will flow before falling into the pit. In connection with the plate there will be an electric battery by means of which the quick-silver will be kept constantly active, and any sickening from the baser minerals will thus be guarded against. The berdans have each the usual clutch-gear, by means of which they can be separated, stopped, or started at will. The basins are of the shell and liner pattern, and are 3 feet 6 inches in diameter. The motive power is obtained by a series of belts and pulleys from a hurdy-gurdy wheel constructed on Pelton's principle,<sup>54</sup> and of the kind now in use at several places on the Thames. This wheel is 6 feet in diameter, is of cast-iron, and weighs about half a ton. It is placed outside the building in a pit, the bottom of which is 16 feet below the level of the floor on which the berdans stand. As the water is let on to the wheel it flows from the flume into a bell-mouthed penstock, 4 feet 6 inches in diameter, below which is the pipe, 2 feet 6 inches in diameter, with a 3 3/8 inch nozzle at the lower extremity. The head is 37ft 5in, which, with the ample supply of water always at command, will give more than sufficient power to work the full number of berdans. A covered tail race has been brought up from the creek to the bottom of the wheel pit, and through this the water escapes on leaving the wheel. The same water that supplies the motive power for the battery is utilised for working the tailings plant. It is conveyed from site to site along a flume 10 chains in length, constructed of cast-iron plates and supported on trestling, the fall in the entire distance being 9 inches. Attached to the trestle-work is the shoot for the conveyance of the tailings from the battery to the berdan house. It is 2ft in width, and is partitioned off into four divisions, so there are in fact as many separate shoots. The fall from end to end is 22ft. The timber is smoothly planed inside so that there may be no obstruction to the flow of the tailings. These are led directly from the tables at the battery into the shoot, and are carried by the water to their destination without being once handled. Each company crushing has a separate compartment of the shoot, at the lower end of which are the box pipes previously referred to, through which the tailings flow into the pits by the berdans. As has been stated, a commencement will be made with the thirty-four now in position. The others will have to be erected very shortly, for, doubtless, they will be at once required, seeing that the whole 64 will not be more than sufficient to keep pace with the regular supply of tailings from the battery, without taking into account the large heap containing some thousands of tons now stacked there. The whole of the arrangements are of the most complete description. Everything that money can procure or ingenuity devise has been done to render the place effective for

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<sup>54</sup> Printed as Fulton's; for correct spelling, see *Auckland Weekly News*, 19 April 1884, p. 17.

gold-saving purposes, and great credit is due to Mr Adams for the admirable manner in which the work has been planned and carried out.<sup>55</sup>

Another newspaper reported that no expense had been spared, 'everything having been done on almost an elaborate scale'. Adding the tailings plant put the company 'in the proud position of having the most complete if not the largest gold saving plant in the Australasian colonies'. It would save wages by employing 'one or more boys' to charge the berdans from the pits.<sup>56</sup>

In December 1885, when Professor James Black of Otago University College visited,<sup>57</sup> Adams took him

through what is undoubtedly the best quartz-crushing battery and tailings plant I have seen in the colony. It is a splendidly-housed forty-head stamper battery furnished, in all its details, with the most approved appliances for quartz-crushing and gold-saving of the present day. It is a self-feeding battery.... The machinery is driven by a splendid supply of water, and the stampers are, by special mechanical contrivances, which I have not seen elsewhere, kept under easy and perfect control throughout their whole extent. There are about twenty berdans at work in the battery itself, besides thirty-two others at a lower level in the tailings plant, situated about five chains from the battery.

The tailings plant being conveniently situated at a level lower than that of the battery, there is no difficulty in conveying the tailings by water down an open sluice to the lower berdans.

The self-feeding contrivances ... were such that one boy could manage the whole of this part of the work, which otherwise would require the constant attention of several men.<sup>58</sup>

#### FURTHER IMPROVEMENTS

At first, the treated tailings were allowed to run to waste, but when it was decided in 1884 that they would be 'raised by hydraulic pressure and stacked', a 'very large area' was acquired on the eastern side of the stream.

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<sup>55</sup> *Te Aroha News*, 12 April 1884, p. 2; similar details in *Auckland Weekly News*, 19 April 1884, p. 17.

<sup>56</sup> *Auckland Weekly News*, 19 April 1884, p. 17.

<sup>57</sup> James Black to Minister of Mines, 24 May 1886, *AJHR*, 1886, C-4B, p. 1.

<sup>58</sup> James Black to Minister of Mines, 24 May 1886, *AJHR*, 1886, C-4B, p. 8.

In February 1885, Adams erected ‘an ejector for raising and stacking’ them, the first on any Hauraki goldfield. The tailings were left ‘to await the time when a more scientific method of extracting the gold will be available’.<sup>59</sup>

Other additions and improvements were made over time. Within days of crushing starting, it was decided to add 12 additional berdans, and Adams did ‘an excellent job’ adding 13 at the beginning of 1884.<sup>60</sup> At the end of that year, changes were made to cope with the water shortage that handicapped it during summer, Adams replacing one turbine with a five-foot hurdy-gurdy wheel, thereby producing the same amount of power from one-third of the water. He intended to replace the other turbine with another hurdy-gurdy so that he could crush throughout summer.<sup>61</sup> In his 1885 inspection, Gordon recommended using a stone breaker in place of the manual reduction of quartz to the size needed to go through the mesh of the stamper boxes.<sup>62</sup>

#### A BETTER PROCESS NEEDED

James Black confirmed that the battery was admirably suited for extracting gold from clean-milling quartz comparatively free from complex metallic sulphides’, but as it could not extract ‘all the gold or much of the silver’ it was necessary to import processes used in other countries to deal with the Waiorongomai ore.<sup>63</sup> Three months after crushing started, William Thornton Firth described the ore as being ‘of such a rebellious nature that the ordinary battery process wastes both gold and silver’, and sent a sample to at least one overseas firm in the hope that their process could treat it.<sup>64</sup> Kenrick’s report of April 1884 stated that,

in consequence of the fineness of the gold and, possibly, the presence of base metals, an unusually large percentage passes away in the tailings: these are being saved, and a careful test of

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<sup>59</sup> *Te Aroha News*, 14 February 1885, p. 32; George Wilson to Harry Kenrick, 8 April 1884, *AJHR*, 1884, H-9, p. 21; Harry Kenrick to Under-Secretary, Gold Fields, 20 April 1885, *AJHR*, 1885, C-2, p. 29.

<sup>60</sup> *Te Aroha News*, 10 November 1883, p. 2, 5 January 1884, p. 2, 9 February 1884, p. 7.

<sup>61</sup> *Te Aroha News*, 15 November 1884, p. 2; see also *Waikato Times*, 28 February 1884, p. 2.

<sup>62</sup> *Te Aroha News*, 29 August 1885, p. 2.

<sup>63</sup> James Black to Minister of Mines, 24 May 1886, *AJHR*, 1886, C-4B, p. 8.

<sup>64</sup> W.T. Firth to Hugh Craig, 1 February 1884, William Thornton Firth Letterbook 1883-1900, MSC 19, Hamilton Public Library.

some tons shows that from 1oz to 1 1/2oz of gold may be saved from the ton of tailings, even then leaving a large quantity of gold to be accounted for: this, with the gold-saving appliances at present in use at the Aroha, it is to be feared must be considered as lost.<sup>65</sup>

The following month, Gordon noted that ‘the fine character of the gold, and the way in which it is diffused through the stone, requires special manipulation to extract it’. There was ‘something still wanting’ to extract more gold before it went to the tailings plant, and until this was done ‘the crushing machinery cannot be said to be anything like perfect’.<sup>66</sup> In 1885, Kenrick provided more details:

The extreme fineness of the gold, coupled with the difficulty experienced in separating it from the silver and baser minerals, ensures a loss of from 40 to 60 per cent of the gold by the present treatment. I have no hesitation in saying that at Te Aroha, as also in many parts of the Thames Goldfield, not more than one-third of the gold is saved. This has been demonstrated by careful and numerous tests of the stone taken from different portions of the reef, as also from the stone passing through the battery. The tests have been made at the banks, both in New Zealand and Sydney, and privately, by experts. Stone that at the battery was giving, after the tailings had been passed through the berdans, an average of 1oz to the ton, was found to contain from 3oz to 5oz. Stone that would not give more than 1/2oz to the ton was found to contain from 1 1/2oz to 3oz.

Consequently, tens of thousands of tons of ore were not being broken out because treatment did not meet the costs. He estimated that during the past year between 10,000 to 15,000 ounces of gold had been lost.<sup>67</sup> In 1886, a visiting American mining engineer, John D. LaMonte,<sup>68</sup> condemned the crudity of the methods, prompting one Waiorongomai correspondent to report that the gold-saving appliances had been ‘more or less condemned

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<sup>65</sup> Harry Kenrick to Under-Secretary, Gold Fields, 19 April 1884, *AJHR*, 1884, H-9, p. 19.

<sup>66</sup> H.A. Gordon to Under-Secretary, Mines Department, 20 May 1884, *AJHR*, 1884, H-9, p. 1.

<sup>67</sup> Harry Kenrick to Under-Secretary for Gold Fields, 20 April 1885, *AJHR*, 1885, C-2, p. 29.

<sup>68</sup> See paper on the Tui district.

and ridiculed' by visiting experts.<sup>69</sup> LaMonte claimed that, for a mere £1,200, he could make the battery save 80 per cent more of the gold,<sup>70</sup> but his offer was ignored, wisely, for when tried at Karangahake his process proved a failure.<sup>71</sup>

Loss of gold was not confined to Waiorongomai: Gordon believed 'that on the average not more than 33 per cent of the gold contained in the ores on the Thames, Coromandel, and Te Aroha goldfields was saved'.<sup>72</sup> Joseph Campbell, a self-proclaimed saviour of mining at Te Aroha,<sup>73</sup> in 1896 estimating that only about 40 per cent was extracted because 'the appliances' were 'so crude'.<sup>74</sup> (His process also failed.) Two years later, the *Thames Advertiser* estimated that only about 30 per cent of New Find ore had been saved, which meant that when free-milling ore in this and other mines was exhausted, they had to be abandoned.<sup>75</sup>

As well as the low rate of extraction, other difficulties were soon discovered. Firth stated in August 1884 that, when the battery was purchased, they told it 'would crush an average of 500 tons a week but found its capacity not to exceed 300 tons' because the quartz was much harder than at Thames. 'This was a source of considerable disappointment'.<sup>76</sup> In 1886, Gordon reported that working expenses and wear and tear were 'so costly that low-grade quartz cannot be worked to pay with the present appliances'; any yielding less than 15dwt per ton was not payable.<sup>77</sup>

According to *The Handbook of New Zealand Mines* of 1887, after treatment the 'residue' contained 'about as much gold, if not more', than had been extracted. The gold was 'extremely fine', requiring 'a different system

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<sup>69</sup> *Thames Advertiser*, Te Aroha Correspondent, 26 May 1885, p. 3, 30 May 1885, p. 3, 7 June 1885, p. 2, Waiorongomai Correspondent, 23 June 1885, p. 3.

<sup>70</sup> *Waikato Times*, 28 May 1885, p. 2.

<sup>71</sup> See *Auckland Weekly News*, 30 May 1885, p. 20, 5 December 1885, pp. 18-19, 24 April 1886, p. 20; *Te Aroha News*, 9 January 1889, p. 2.

<sup>72</sup> *Auckland Weekly News*, 5 May 1888, p. 21.

<sup>73</sup> See paper on Joseph Campbell and his Hyperphoric Process.

<sup>74</sup> Joseph Campbell, 'The Gold-Fields of the Hauraki Peninsula, New Zealand', *Transactions of the Federated Institution of Mining Engineers*, vol. 12 (1896), p. 473.

<sup>75</sup> *Thames Advertiser*, 2 March 1898, p. 2.

<sup>76</sup> *Waikato Times*, 2 August 1884, p. 3.

<sup>77</sup> H.A. Gordon to Minister of Mines, 4 May 1886, *AJHR*, 1886, C-4, p. 37.

of treatment from that adopted in any of the Australasian Colonies'.<sup>78</sup> Two years later, Gordon noted that the battery 'was only suitable for free-gold ores' and could not properly treat ore containing gold, silver, copper, zinc-blende, and galena. 'The combination of sulphur, arsenic, galena, and zinc-blende with the gold sickened the mercury used in the battery treatment to such an extent that even a fair percentage of the gold could not be obtained'. Adams had struggled 'for about three years in trying experiments with this class of ore' before inspecting processes used in America.<sup>79</sup> In September 1886, after Firth had gone there to investigate possible improvements, he asked Adams to join him and bring samples from several mines for testing.<sup>80</sup> They 'visited the principal mining centres in California, Nevada, and other parts of the United States', and inspected 'a great many processes of quartz treating and gold-saving'.<sup>81</sup> Judging by his comment made after hearing a lecture by Professor Brown of Auckland University College, it seems Firth was selectively impressed with the advice. 'He agreed with the Professor on the matter of concentration, and thought no process could be at all successful without its aid. During his visit to America he had heard sufficient about experts to quite agree with the lecturer's opinion of them'.<sup>82</sup> As a result of their visit, Firth and Adams were convinced that 'the most economical and practical method of treating' their ore was by calcining, whereby the ores were roasted in a furnace after crushing and then 'ground with suitable chemicals in pans for the purpose of amalgamation. A much greater percentage of the assay-value of the ore is thus saved - more than sufficient to compensate for extra cost of treatment'.<sup>83</sup>

By late November 1886, Adams was supervising the erection of 'a new testing furnace and assaying laboratory of the most approved style' to treat small quantities of ore 'on the principles held in highest favour in

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<sup>78</sup> *The Handbook of New Zealand Mines* (Wellington, 1887), p. 373.

<sup>79</sup> H.A. Gordon to Under-Secretary, Mines Department, 27 June 1889, *AJHR*, 1889, C-2, p. 44.

<sup>80</sup> *Thames Advertiser*, 15 September 1886, p. 2; *Te Aroha News*, 18 September 1886, p. 2.

<sup>81</sup> H.A. Stratford (Warden) to Under-Secretary, Mines Department, 7 April 1887, *AJHR*, 1887, C-6, p. 9; *Te Aroha News*, 20 November 1886, Supplement, p. 2.

<sup>82</sup> *Auckland Weekly News*, 7 May 1887, p. 19.

<sup>83</sup> H.A. Stratford to Under-Secretary, Mines Department, 7 April 1887, *AJHR*, 1887, C-6, p. 9.



California'.<sup>84</sup> It was capable of roasting 15cwt of crushed ore 'at one charge'.<sup>85</sup> Adams believed it would be possible to save 85 per cent of the bullion,<sup>86</sup> and from January to March 1887 tested ore from Tui, Karangahake, and Waihi. As results were 'up to expectations', it was decided to erect a larger furnace.<sup>87</sup> Gordon was delighted:

A small reverberatory furnace has been erected to treat samples of the ore by roasting. The experiments made with this furnace prove conclusively that in order to treat the different ores successfully a roasting-furnace is indispensable, as any ores containing tellurides, sulphides, and arsenicides carry away gold and silver unless they are got clear off before commencing to collect the metals the ore contains. I have been trying to impress this on the miners for several years, and now look forward with pleasure to the time when a better system of treating ores is likely to be adopted.<sup>88</sup>

One prominent mine manager, John Watson Walker,<sup>89</sup> suspected Adams' enquiries had been 'confined to the methods of treating auriferous rock, and did not include the manipulation of the various classes of silver-bearing ores'. He did not believe much 'detailed and complex data could have been collected in the short time' Adams was in America.<sup>90</sup> His comment raised the question of whether sufficient research had been done to prove whether the new process would succeed, but all other published comments anticipated an improved result. In April the *Te Aroha News* detailed developments that might end the depressed state of mining:

The building about to be erected to contain the furnace and other machinery will adjoin the existing tailings plant, on the western side. The structure will be built of wood, all covered with corrugated iron, and be 55ft in length by 40ft wide, with 16ft

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<sup>84</sup> *Te Aroha News*, 27 November 1886, p. 2; *Te Aroha Correspondent*, *Waikato Times*, 4 December 1886, p. 2.

<sup>85</sup> H.A. Stratford to Under-Secretary, Mines Department, 7 April 1887, *AJHR*, 1887, C-6, p. 9.

<sup>86</sup> *Te Aroha News*, 4 December 1886, p. 2, 18 December 1886, p. 2.

<sup>87</sup> *Te Aroha News*, 22 January 1887, p. 2, 12 February 1887, p. 2; *Thames Advertiser*, 10 March 1887, p. 2.

<sup>88</sup> H.A. Gordon to Minister of Mines, 5 May 1887, *AJHR*, 1887, C-5, p. 30.

<sup>89</sup> See paper on his life.

<sup>90</sup> *New Zealand Herald*, 24 January 1887, p. 3.

studs, lighted by means of side windows, and with a ventilating louvre the whole length of the gable. It is the intention to erect one of the White Owl Revolving Furnaces, a class of furnace very extensively used in America, from whence it is being imported. The furnace will be 27ft long, 53in in diameter, and will revolve at a slight angle, whereby the ore as it enters at the upper end will, by natural gravitation, pass slowly through the furnace and out at the lower end, and by means of this arrangement the ore gradually becomes heated to the highest point, as it approaches the fires. The furnace will be automatic in its working, self-feeding and self-discharging. The building will be large enough to receive a second of these furnaces later if found necessary. The furnace will be driven by the present Pelton water-wheel which works the tailings plant, by the extension of the existing main driving shaft. The chimney stack will be octagon shaped, 54ft high, 12ft in diameter at the base, and 4ft at the top.... Between the chimney and the furnace, and abutting on to the former, condensing chambers, to occupy about 40ft of space, will be erected, also of brick. The 24 berdans now in the battery will be removed and re-erected in the tailings plant building ... in addition to the 35 berdans already working there; and in the space they occupied in the battery will be constructed a series of large settling pits, into which all tailings will pass direct from the stamper tables. From these pits the settled tailings will be conveyed by a tramway, (which it is intended to construct immediately above the water race leading to the tailings plant) close to the furnace house, where they will be spread out to sun dry for a time, after which they will be again trucked and tipped direct into the roast, from whence they will fall into the chlorodising chambers, and from there be trucked direct to the berdans. The fuel to be used will be wood. The estimated cost of erecting the furnace, etc, and alterations in connection therewith, is £2000. Judging by the results obtained from the many tests made on a small scale of treating ore in the manner proposed before it was decided to erect this new plant, it is confidently believed that this method of treatment will be the means of at least 10 per cent more of the precious metals being saved than is obtainable at present. We sincerely trust results will not only be fully equal to, but surpass their expectation, and the proprietors be handsomely rewarded for their pluck and enterprise as evinced by their erection of so costly a plant for the more efficient treatment of ore, and that too in the face of prevailing depression.<sup>91</sup>

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<sup>91</sup> *Te Aroha News*, 23 April 1887, p. 2.

In February 1887, the warden recorded that ‘17 hands are continuously employed (equal to 12 men),<sup>92</sup> the other workers being boys aged 15 and above. In July, a visiting reporter was most impressed, never having inspected ‘a plant so extensive and so well arranged’. He mentioned a ‘case-hardened shoe’ patented by Adams and Samuel Bateman Firth,<sup>93</sup> another of Firth’s sons, which had greatly improved the efficiency of the berdans, thereby saving £200 within a short period.

A very complete assay office, fitted with all necessary appliances, has been placed in an annex to the tailing house. In this office a large number of assays are constantly made of various gold and silver ores.... It is impossible to overestimate the value of such an assay office to the extensive works I am describing. When the new rotary furnace commences work, regular and systematic assays will show the percentage of bullion saved and lost.

This furnace was used in over 100 batteries in the United States; the one imported had ‘all the latest improvements’, which he described in great detail. By roasting the ore and using condensing chambers, condensations of gold, silver, lead, copper, antimony, arsenic, and sulphur were drawn off. It would be able to treat about a ton of tailings an hour.<sup>94</sup> Gordon much more concisely summarized the essential features of this White-Howell furnace, which he estimated could treat eight tons per day:

The furnace is a cast-iron cylinder 4ft in diameter inside and 24ft long. This is set at an inclination of 8in to 24ft, or 1 in 36, and revolves at the rate of four revolutions per minute. The inside of the cylinder is lined with fire-bricks, and it takes the ore twenty-one minutes from the time that it enters the upper end of the cylinder until it is discharged at the lower end. The furnace is fed by an elevator, which lifts the tailings from the level of the floor into a shoot leading into the furnace. The fire enters the discharge end of the cylinder, and the fumes from the roasted ore are passed through a series of condensing chambers before reaching the chimney. When the ore is put into the cylinder in a very dry state a jet of steam is used in the condensing-chambers

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<sup>92</sup> H.A. Stratford to Minister of Mines, 2 February 1887, Thames Warden’s Court, Warden’s Letterbook 1886-1893, BACL 14458/2b, ANZ-A.

<sup>93</sup> See Gordon, pp. 48, 161-162, 218, 282; *Waikato Times*, 15 July 1892, p. 2.

<sup>94</sup> Special Reporter, ‘A Trip to Te Aroha’, *Auckland Weekly News*, 30 July 1887, pp. 28-29; another detailed description is given by Te Aroha Correspondent, *Waikato Times*, 13 September 1887, p. 3.

to assist in the condensation of the fumes, but if the ore or tailings be damp when fed into the cylinder, the moisture in them has the same effect on the condensation as a jet of steam.<sup>95</sup>

The furnace first started on 24 August, and for a time ran slowly using low fires to season the brickwork. 'When set in motion everything worked splendidly from the very start, and without the slightest hitch of any kind'. As this was the first such plant erected in New Zealand, the local newspaper considered that Adams, who had prepared the plans and supervised the work, was 'deserving of very great credit'. As he had provided electric lighting powered by a small Pelton wheel, the 57 berdans could be kept working day and night. Once again, the *Te Aroha News* stressed that 'the result of a thorough practical trial of the new plant' was 'anxiously looked forward to', being 'a matter of much moment' to New Zealand, and hoped it would revive the local mines and prove 'most remunerative' to the owners.<sup>96</sup> The electric light, according to a report in late September, gave 'great satisfaction, and will very shortly supercede the old system of lighting in the battery also'.<sup>97</sup> The Pelton wheel produced 'electricity sufficient to supply twelve or fifteen lights of two thousand candle power each, and in addition to its greater brilliancy it is expected to prove much more economical than the old system of lighting by kerosene lamps'.<sup>98</sup>

When Gordon visited in January 1888, Adams told him 'they have not yet got into the proper system of roasting, but more in the way of making experiments to get the best effects'. These experiments proved that roasted ore gave 'more than double the yield' of treating 'raw ore in berdans', some returns being 'as much as 95 per cent of the assay value'. The erection of the furnace was 'a step in the right direction', but for full effectiveness the ore should be 'crushed dry and afterwards roasted before final treatment', and it was still to be decided whether leaching or amalgamation was 'the most economical method'.<sup>99</sup> In his report for the subsequent year, Gordon

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<sup>95</sup> H.A. Gordon to Under-Secretary, Mines Department, 1 May 1888, *AJHR*, 1888, C-5, p. 29.

<sup>96</sup> *Te Aroha News*, 3 September 1887, p. 2.

<sup>97</sup> *Te Aroha News*, 24 September 1887, p. 2.

<sup>98</sup> Te Aroha Correspondent, *Waikato Times*, 13 September 1887, p. 3.

<sup>99</sup> H.A. Gordon to Under-Secretary, Mines Department, 1 May 1888, *AJHR*, 1888, C-5, p. 29.

described the furnace as ‘an improvement’ which had not proved ‘entirely satisfactory in treating the different ores’.<sup>100</sup>

The only addition made in 1888 was to erect a building 30 feet by 40 feet and 16 feet high to store tailings.<sup>101</sup> In April, the battery was included in the sale of all the Battery Company’s properties to the Te Aroha Silver and Gold Mining Company, which was to make further changes in an attempt to save more bullion.<sup>102</sup>

## ACCIDENTS

The only death was that of 17-year-old John Bernard Kilian, caused by his fooling around on the pipe bringing water into the building.<sup>103</sup> Just before Firth and Clark sold their battery, William Goldsworthy, aged 19,<sup>104</sup> had an accident in the tailings plant. To oil one of the shafts, he climbed onto a crossbeam immediately above the revolving furnace, slipped, and fell ‘with much force’ onto the furnace and then onto the ground, although the second fall was broken by a man partly catching him. The total drop was 14 feet.

The sufferer was stunned for a time, but soon recovered consciousness and was carried to the Battery Company’s office, where everything possible was done to make him comfortable and Dr Wright of Te Aroha telegraphed for. The sufferer received a very nasty deep cut and bruise over the right eye and on the mouth, as the result of his fall on the furnace, and was greatly bruised and shaken as may be supposed; and to add to the trouble some of the tailings got into his eyes and occasioned great irritation.<sup>105</sup>

The obituary of Michael Cronin, a battery hand who later became a farmer, mentioned his having ‘some narrow escapes’ when working in the battery. The worst one ‘was when some trucks of rubble were accidentally emptied on him and he was buried for over two hours. Fortunately, he

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<sup>100</sup> H.A. Gordon to Under-Secretary, Mines Department, 8 June 1889, *AJHR*, 1889, C-2, p. 44.

<sup>101</sup> *Te Aroha News*, 21 March 1888, p. 2.

<sup>102</sup> See paper on this company.

<sup>103</sup> See paper on the Kilian family.

<sup>104</sup> Birth Certificate of William Goldsworthy, 3 November 1868, 1868/9413, BDM.

<sup>105</sup> *Te Aroha News*, 31 March 1888, p. 2.

escaped without serious injury'.<sup>106</sup> The only other accident whilst the battery was owned by the Battery Company occurred to a much more experienced hand, Alexander Jamieson, 'an old resident' of Thames,<sup>107</sup> who was injured when the stamps were first tested. He was 'about to pick up one of the stamps when he missed taking hold, and as the lever came round again it struck him on the jaw and knocked him off the platform, on to the table below. In his fall he suffered a severe contusion of the back of the head, which rendered him almost insensible'. For a week his condition went from 'somewhat critical' to 'precarious', but he recovered in hospital.<sup>108</sup>

## CONCLUSION

The complex nature of the ore made treatment difficult, and despite additions and improvements to a reconditioned mill an ideal process was never found, making many mines unprofitable because so much bullion was lost. This problem would continue throughout the history of the field, despite the efforts of local and overseas companies, as illustrated in particular in the papers on Joseph Campbell, Edwin Henry Hardy, the Te Aroha Silver and Gold Mining Company, and the New Zealand Exploration Company and Aroha Mines.

### *Appendix*

*Figure 1:* 'Machine Site Waiorongomai Applied for by J.C. Firth', Te Aroha Warden's Court, Mining Applications 1881, Machine Site License no. 201, granted 10 January 1882, BBAV 11289/8a, ANZ-A [Archives New Zealand/Te Rua Mahara o te Kawanatanga, Auckland Regional Office]; used with permission.

*Figure 2:* Portion of G.H.A. Purchas, 'Plan of Licensed Holdings Te Aroha Goldfield', 2 ed., 1884, showing site of battery, water races and pipeline from junction of the water races, and tail race to tailings site alongside the Waiorongomai Stream, with 1887 'proposed line of tramway' superimposed, Te Aroha Warden's Court, BBAV 11582/11a, ANZ-A

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<sup>106</sup> *Te Aroha News*, 31 December 1934, p. 1.

<sup>107</sup> *Thames Star*, 23 April 1883, p. 2.

<sup>108</sup> *Thames Star*, 23 April 1883, p. 2; *Thames Advertiser*, 2 May 1883, p. 2.

[Archives New Zealand/Te Rua Mahara o te Kawanatanga, Auckland Regional Office]; used with permission.

*Figure 3:* Burton Bros., showing (from left) water race with tank and pipeline to battery, trestle bridge linking tramway with battery, ore paddocks, flume to tailings plant and this plant beside the Waiorongomai Stream, 1884, Burton Brothers Collection, C.17241, Museum of New Zealand Te Papa Tongarewa.

*Figure 4:* View (from left) of assay house, pipeline to battery, the original battery building, and trestle bridge at end of tramway, n.d. [1884?], Arthur Mahon Collection, Te Aroha and District Museum; used with permission.

*Figure 5:* Fern Spur Incline, battery, and assay house, n.d. [1884?], Arthur Mahon Collection, Te Aroha and District Museum; used with permission.

*Figure 6:* Burton Bros., view (from left) of water race tank, pipeline to battery, and trestle bridge to tramway, 1884, Burton Brothers Collection, 91197, Alexander Turnbull Library.

*Figure 7:* Water race tank and pipeline, n.d. [1884?], Te Aroha and District Museum; used with permission.

*Figure 8:* Flume carrying tailings to tailings plant, n.d. [1884?], Arthur Mahon Collection, Te Aroha and District Museum; used with permission.

*Figure 9:* ‘Stampers and Tables Waiorongomai Battery’, *Observer*, 15 December 1883, p. 8.

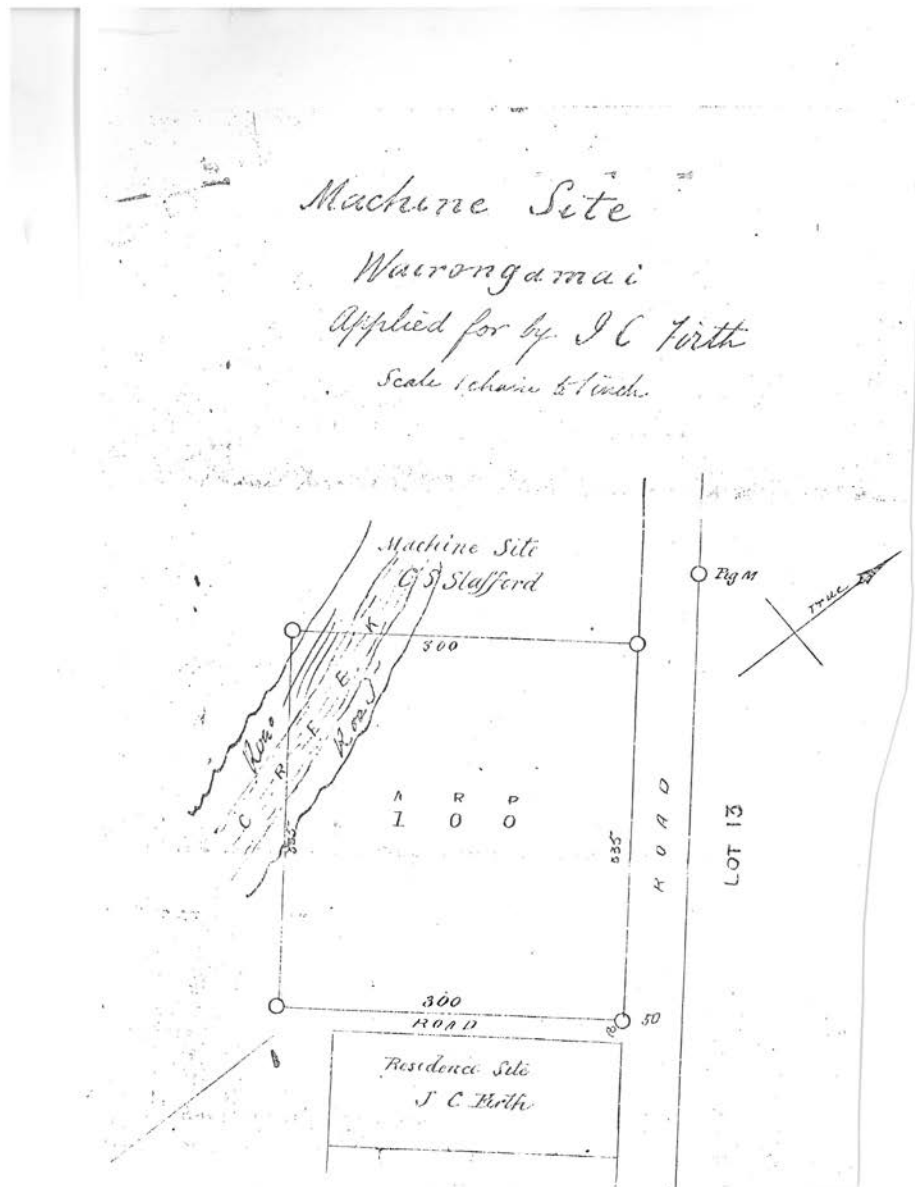
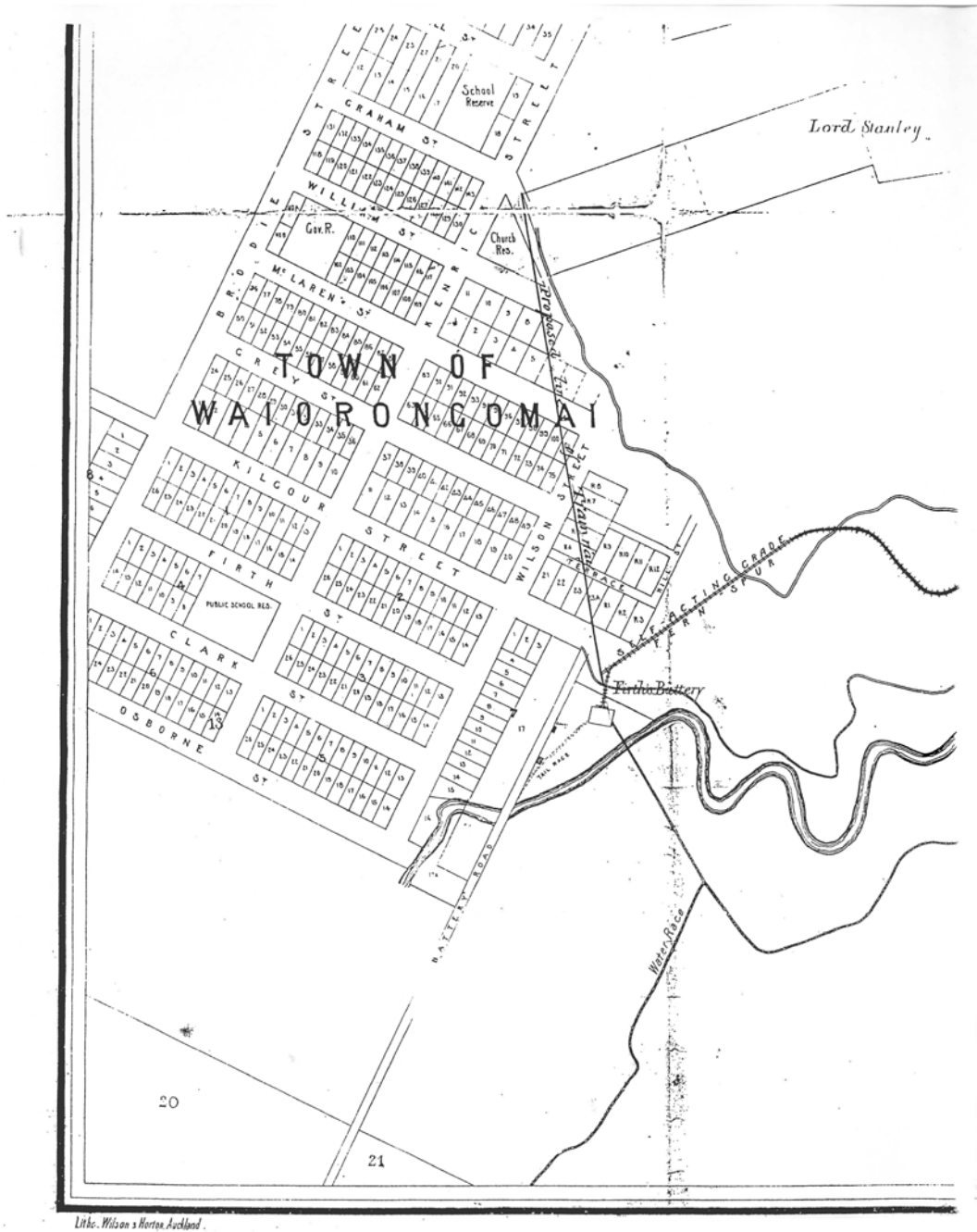
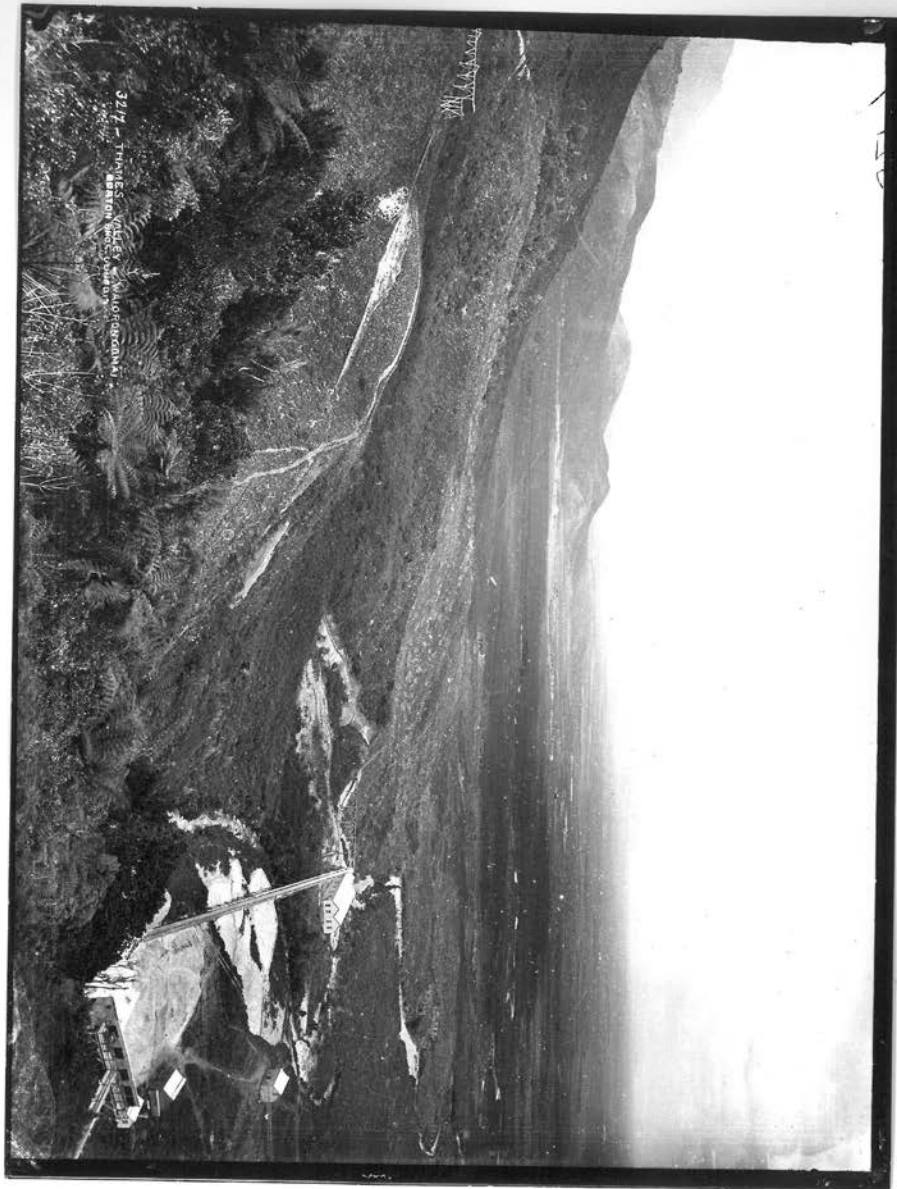


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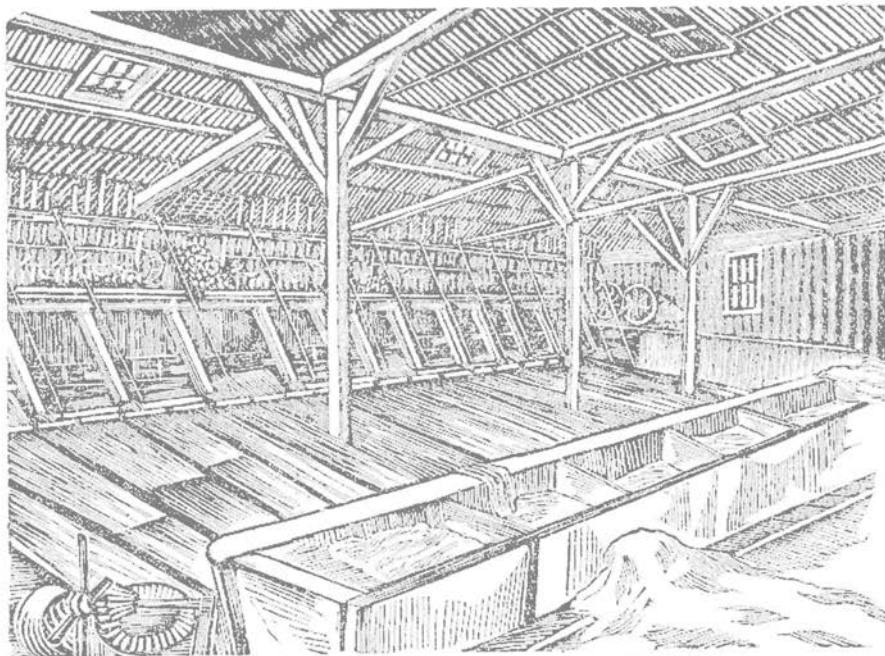
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STAMPERS AND TABLES WAIORONGOMAI BATTERY.

*Figure 9: 'Stampers and Tables Waiorongomai Battery', Observer, 15 December 1883, p. 8.*