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THE ARCHAEOLOGY OF A FURNACE: 550 COLOMBO STREET, CHRISTCHURCH

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Introduction

Following the Canterbury earthquakes of 2011 the southern portion of the Smiths City building at 550 Colombo Street, Christchurch, was demolished. When the floor slab was removed, two cast iron furnace doors and brickwork was exposed. Work ceased while an emergency archaeological authority was obtained (2012-202eq). Excavation uncovered an additional four furnaces. The furnaces were subsequently preserved in-situ, back filled with sand and reburied with the area resealed as a car park. They have been recorded in ArchSite as M35/545 (Figure 1).

Historical background

The furnaces were on what on a section surveyed as Town Reserve 120 in the original survey of Christchurch. This area was developed relatively late in comparison with the inner city sections, but the construction of the railway line to the south of Moorhouse Avenue in 1865 made this area attractive for industrial development.

In July 1860, Town Reserve 120 was purchased by Charles Kiver. Kiver purchased the adjoining Town Reserve 107 in April 1861 and appears to have built on the section shortly after his purchase (Christchurch Deeds Index: 1307). Although a number of the neighbouring sections had been built on, Town Reserve 120 was unoccupied in 1877 (Figure 2). August 1886 saw the subdivision of Kiver's property into 44 lots of 12 perches each, with the formation of Dundas Street (joining Colombo and Manchester Streets) through the centre of the block. The furnaces were located on what was Lot 41 of this

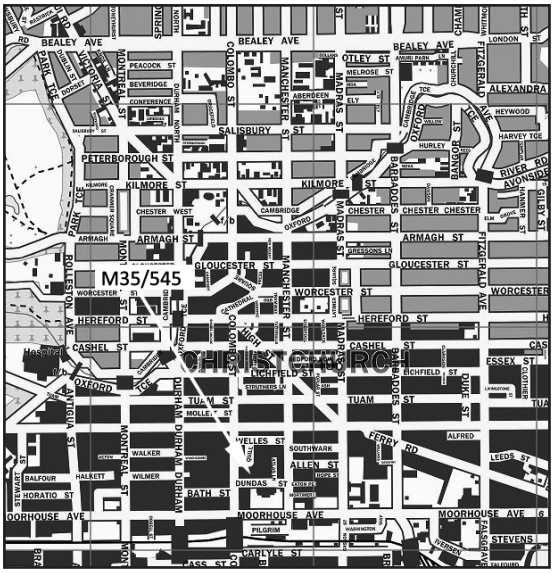


Figure 1. Central Christchurch, showing the location of M35/545.

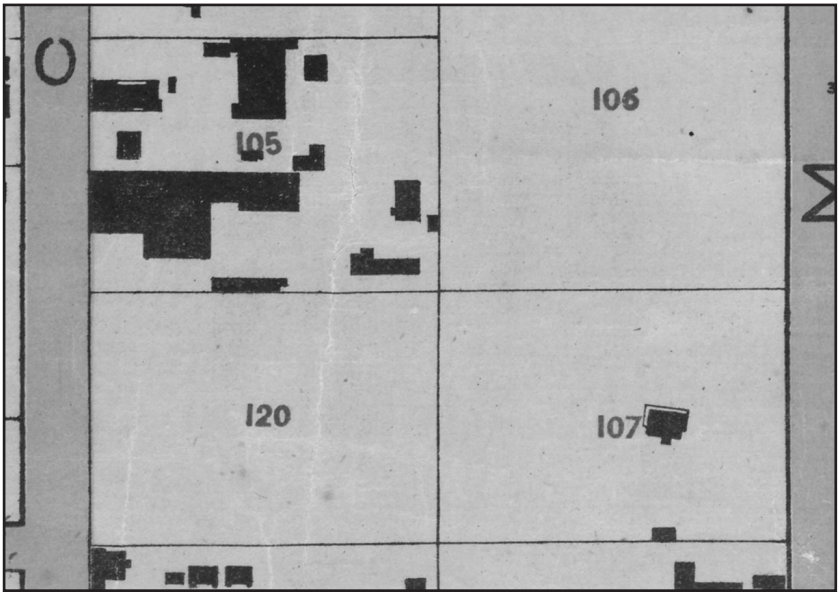


Figure 2. Town Reserve 120, 1877. Detail of Strouts's 1877 map of central Christchurch.

subdivision.

When Charles Kiver died his estate was transferred to his surviving family who sold it to the New Zealand Trust and Loan Company in September 1889. The Trust and Loan sold the sections between 1898 and 1906, with Lots 37-41 sold to George Scott in January 1903 (LINZ: CT CB138/177, CT CB179/3). Along with his brother Lee, Scott was owner of the Atlas Foundry. This foundry extended over much of Town Section 106 (on the eastern part of the block on Manchester Street between Welles and Dundas Street). Scott also purchased part of Lots 31-32 in April 1904 to provide access from Dundas Street to the Atlas Foundry.

Lots 37-41 were used by Scott as the location for his Atlas Biscuit and Confectionary Company premises. Advertisements for the Atlas biscuit company in Dundas Street appear in the Christchurch *Star* from April 1906, and *Wise's Street Directory* lists Atlas Biscuit and Confectionary Company at this location, with George Scott listed as director. In 1918 Lots 37-41 were sold to Dainties Ltd (LINZ: CT CB204/174). The Wise's Directory lists Dainties Ltd in Dundas Street from 1919.

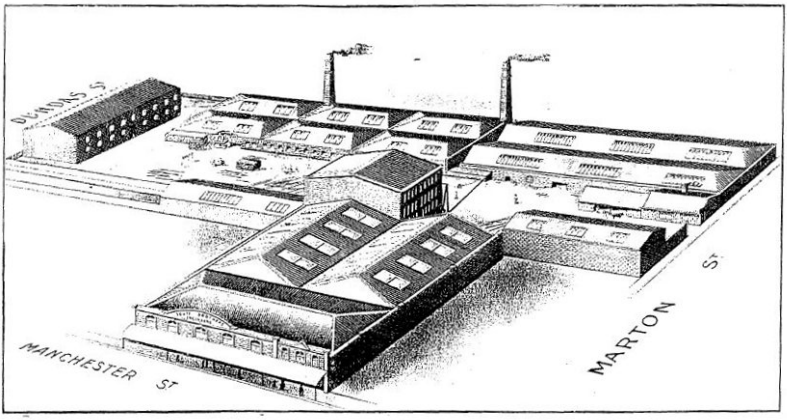
In May 1929 Lots 37-41 were amalgamated with Lot 3 DP 6894 (to the north) to form a single section (DP 9358), which was sold to the soft drink manufacturers Quill Morris Ltd, in July 1929. Quill Morris operated their cordial manufacturing business at 13-21 Dundas Street, before going into temporary liquidation from 1930-34, and resuming operations in 1936 (Donaldson 1991: 253). Architectural drawings produced by Trengrove and Blunt for Quill Morris Ltd in 1929 show proposed alterations and additions to an existing building on this site, including a new foundation 18 inches wide for a new brick wall between the bonded store and the aerated water factory. A concrete floor was to be reinstated on both sides of this wall.

A number of foundries operated on this block from the late 19th to mid-20th century. Two in particular were in close proximity to the Dundas Street lots and were researched for their potential connections with the site.

Scott Brothers' Atlas Foundry

The Atlas Foundry was established by John Lee and George Scott in Manchester Street, Christchurch, in 1876. The Scott Brothers' Atlas Foundry became a well-known producer of farming and industrial machinery, as well as infrastructure such as street lamps and bridges. The company became a household name in New Zealand through their manufacture of the Atlas stove ranges. A contemporary description of the Atlas Foundry can be found in an article in *Illustrated Guide to Christchurch and Neighbourhood* (Mosley 1885). This article contains descriptions of the building location, size, use and equip-

ment inside. The description mentions a building devoted to the manufacture of malleable castings, and also that Scott Bros were making numerous additions to their Manchester Street plant so they could build locomotives and also to enable them to manufacture cast steel. The locomotives in question were 10 D class steam locomotive, for which a contract was let in 1885. These locomotives started entering service on 21 December 1887, so the plant must have been set up in late 1885/early 1886 (Lloyd 1974). Figure 3 shows the foundry in 1908.



BIRD'S-EYE VIEW OF THE ATLAS FOUNDRY, WHICH COVERS TWO ACRES.

Figure 3. The Atlas Foundry, as shown in the Scott Brothers' catalogue of 1908.

J. J. Niven and Company's foundry

One other foundry in the immediate vicinity was J. J. Niven and Company's foundry, which was located on DP 4498 (now a car park to the south of 18-24 Welles Street; Figure 4). J. J. Niven and Company started out as Galloway and Niven, an engineering workshop established by Galloway and James Niven in Napier in 1891. In 1893 Galloway's share was acquired by George Nelson and the firm was renamed J. J. Niven and Company. Niven retired in 1903, and between 1903 and 1908 Nelson expanded the firm, establishing branches throughout New Zealand. The Christchurch operation was established in Welles Street between 1908 and 1912 after the firm was floated as a private company.

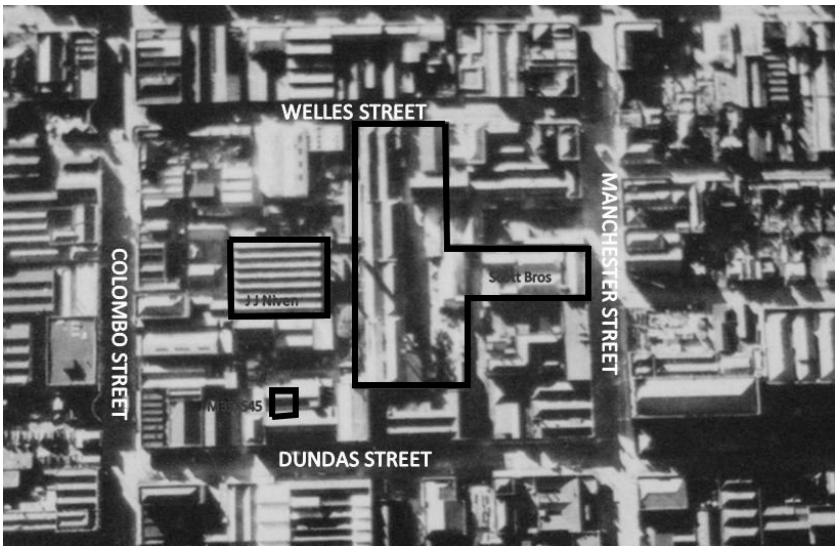


Figure 4. The location of M35/545 (furnaces) in relation to the foundries of Scott Bros. and J. J. Niven overlaid on a 1940s aerial photograph. Photograph courtesy of Gordon Dowler.

Archaeological investigation

The remains of the six furnaces were excavated from 29 August to 7 September 2011 (Figures 5 and 6). The furnaces were all constructed from a combination of red clay bricks and fire bricks, with cast iron metal work. The fire-grates in each of the furnaces were made of cast iron fire bars which are of a standard type (and are still made today for hand-fired boilers). Only the lower part of the original structures remained intact, with the upper parts missing.

Running through the centre of the site, parallel with Dundas Street, a concrete footing sheathed with wrought iron sheets bisected the furnace floor space. This corresponds with the concrete wall depicted in the Trengrove and Blunt architectural drawings of 1929.

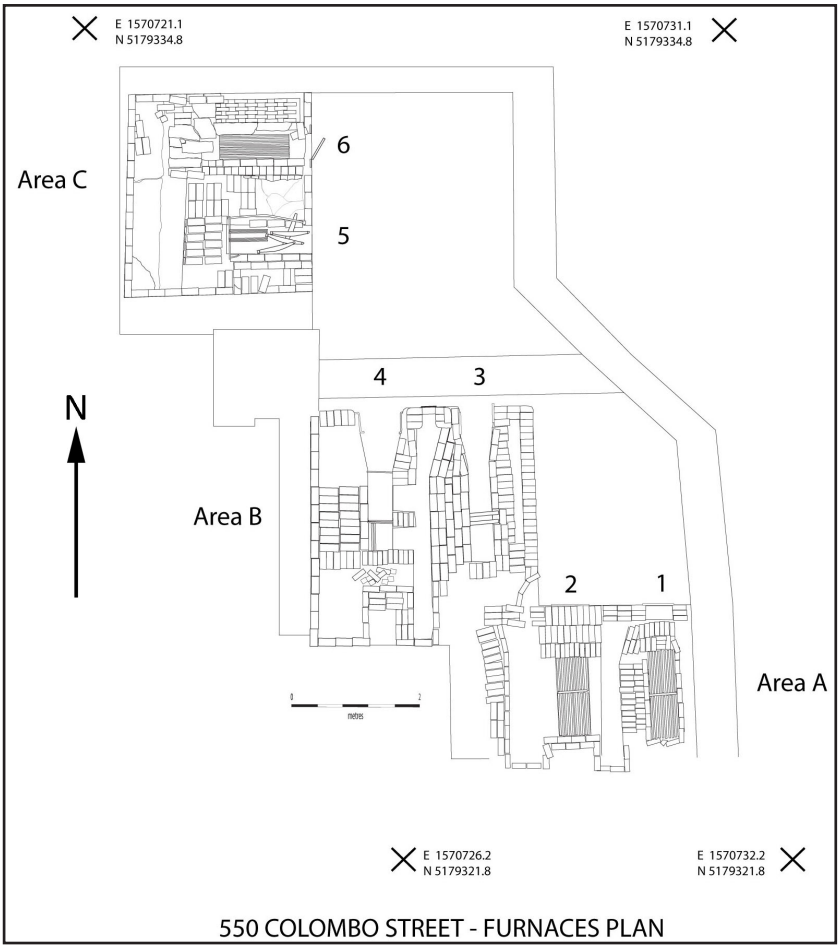


Figure 5. The layout of the furnaces. Map coordinates at corners in NZTM.

Area A

Area A (Figures 7 and 8) comprised two split-level furnaces, each two fire bars deep with the lower furnaces probably directing their heat to the underside of the oven floor. The heat would then pass through vents into the oven and with the heat from the higher level furnaces most likely rising over the top of the oven, which was acting as a reverberatory furnace (reflecting the heat back from the roof or arch down onto the material being treated).

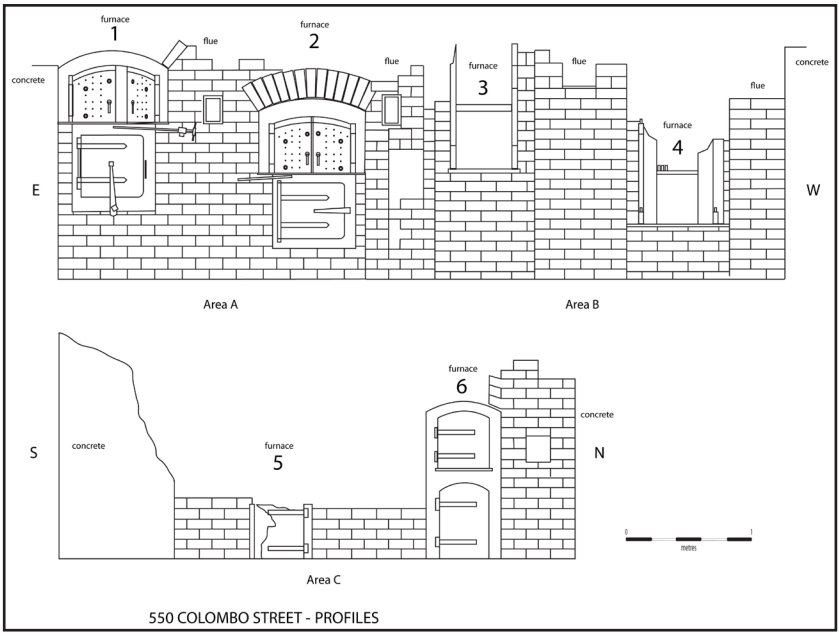


Figure 6. Profile drawings of the furnaces.

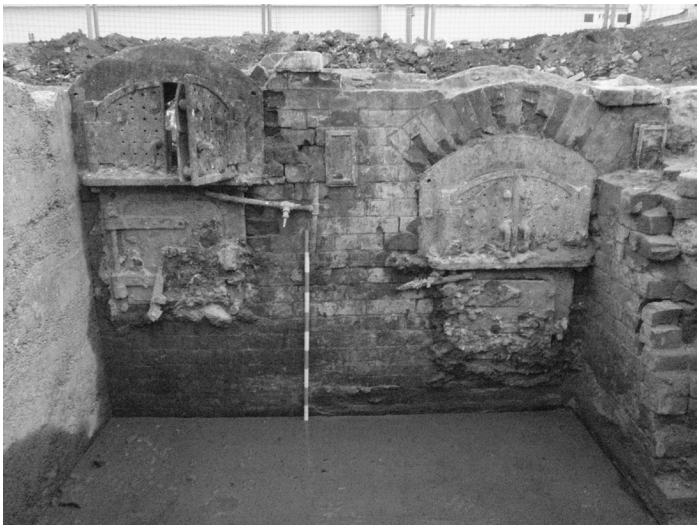


Figure 7. Furnace and inspection doors, Area A. Note the piping and tap for compressed air above the scale (centre) and the flue inspection door recessed into brickwork for Area B (right).

Figure 7. No. 1 (foreground) 2 (rear) furnaces, Area A, showing the fire bars and coke remains of last burning in the No. 1 furnace.

No. 1 and 2 furnaces used nine-inch straight fire bricks from the Brunner brickworks. These fire bricks were designed and used as a heat-resistant material to line areas subjected to flames or high temperatures. The fire bricks on these structures were used to line the furnaces, flues and oven floors. Unlike bricklaying on buildings, fire bricks are set in a very thin layer of fire clay mortar.

The remains of what is likely to be a pipe for supplying additional air were noted on the front of the brick work in Area A. This forced draught under the fire grates of Furnaces 1 and 2 to aid combustion and control of the fires. The section of missing pipe and valve was found sitting on the pit floor just below its original position. The small inspection doors in Area A are of the same design that were used on coal range ash doors. Bricks in and near the furnaces show signs of slagging, which is typically caused by high temperature, furnace conditions and fluxing impurities in the ash, combining with the surfaces of the refractory to form a molten slag which may run down the face and erode the surface on the bricks.

Area B

Area B (Figure 8) was similar to Area A, both in design and function, comprising a split-level furnace, two fire bars deep. Area B was a later addition to the original furnace layout. The brickwork was laid onto rough concrete footings, and a recess on the eastern side was incorporated into the design to provide for the continued use of the western flue inspection door of Area A. The brick work was of a noticeably different design to that of Area A, with cast iron doors set back into the face, and rounded bricks on the corners.

Figure 8. Looking south across Area B. Note the recessed flues at the rear of the furnaces. This photo shows the addition of two rows of bricks in the eastern flue (right) as well as bricks added to the western flue to reduce the flue size.

The structure used standard 9 inch straight and jamb red clay bricks that bore the frog mark 'W', indicating they were from the Wigram Brothers brickworks, which operated from 1886 until at least 1903 ('W' bricks have been recovered from buildings constructed in the 1930s; M. Hennessey, pers. comm.). These bricks were used as a facing and insulation brick for the furnaces, a common technique for building furnaces. In addition to Wigram bricks, 9 inch firebricks found in the re-bricked furnaces of Area B were made by Todd,

Thomas and Sons, brick and tile manufacturers of Waikiwi. Thomas Todd produced bricks from 1879 at least until 1903. Four different types of brick bearing the Todd frog were noted at the site.

The furnaces in Area B show evidence of being modified during their operational life. The first alteration was the reducing of the width of the flue in the rear of No. 4 furnace by adding two additional rows of firebricks. A further modification was to furnaces No. 3 and 4, which had been re-bricked with Todd bricks above the grate level and tapered through to the doors. The furnaces had not been fired since the re-bricking and replacing of the fire-grates. The fire bars would have been replaced fairly often when in use.

Area C

Area C (Figures 9 and 10) also comprised two furnaces, both on the same low level, directing all their heat on the underside of the oven floor before passing through vents into the oven. The fire grates were shorter than in Areas A and B and were only a single fire bar deep.

Figure 9. Area C from the northwest. Note the direction of flue splitting from the back of Furnace 6 and the lattice brickwork flue vents (left).

Figure 10. Area C showing the remains of the cast iron furnace doors and inspection doors.

The fire door dead plate and cheek plates on No. 6 furnace were burnt away, which only happens when too much heat is held back in the furnace (Figure 11). This occurs when the dampers are closed right down to hold the heat in the oven, causing the fire to burn back to the fire door.

Other observations

The concrete footings and pit floor appear to be a later addition, contemporary with the construction of Area C. The concrete perimeter which surrounds all three areas does not extend around the back of Areas A and B, but does completely enclose Area C. The concrete wall footing which bisects the pit floor separating Area C from the other two areas is also a later addition, most likely from the time of the Quill Morris alterations in 1929.

Furnaces 1, 2 and 6 had a fuel bed of coke still covering the grate from their last firing. The coke found in the furnaces on this site had high levels of volatile matter, thus the coke would have come from coke ovens or an early, less efficient gasworks. Scott's would have been using large quantities of coke as it was required in their blacksmith forges, rivet-heating furnaces and foundry cupolas (for melting metal).

Figure 11. Detail of the No. 6 furnace showing slagging on bricks and the remains of coke along back of furnace. The cheek plate (right) has burnt away.

A small amount of the upper part of the structure of the No. 6 furnace (in Area C) was intact at the time of initial exposure, as was the brickwork covering the lower flue on the north side of this furnace and the ceiling over the furnace. Unfortunately, the excavation of supporting loose material and on-going seismic activity resulted in the loss of part of this structure.

Function

While the form and layout of the furnaces suggests that they are likely to have been general utility furnaces, other evidence was recovered during the excavation to suggest that the furnaces may have been more complex structures.

General utility furnaces were typically used for a variety of heating operations including annealing, hardening, tempering, and carburising. These processes all required temperatures below 1000˚C. The furnaces at 550 Colombo Street were typically operated on coal or coke, were hand-fired, and were probably capable of producing 1200-1400˚C (Bob Redfern and Ian Close, pers. comm.). General utility furnaces were often subject to intermittent use, so they needed to be of robust construction with hard fire brick surfaces and able

to provide rapid attainment of uniform temperature (Ministry of Technology 1958). Application of bottom heat and use of heating flues to circulate a uniform temperature, as was the case in the furnaces at 550 Colombo Street, provided this functionality. The design of the furnaces, then, allowed for flexibility in the types of processes carried out on site. Having furnaces of three slightly different designs probably allowed greater flexibility in the function. It appears that these furnaces were also amenable to minor modifications for even greater flexibility, such as the addition of bricks to decrease the width of the flues.

The 1885 description of the Atlas Foundry in the *Illustrated Guide to Christchurch and Neighbourhood* mentions a building devoted to the manufacture of malleable castings and that Scott Bros were making numerous additions to their plant to enable them to manufacture cast steel. It is therefore worth exploring these processes in more detail.

Malleable castings: production and annealing

Malleable castings were able to be worked after they were cast, and this was achieved using iron which had a high carbon content and through subsequent continued annealing. During annealing the carbon is converted into an amorphous or un-crystallised form, after which the strength of the casting is doubled, allowing for it to be twisted, bent or hammered into various shapes. The annealing process required the castings to be heated to sufficient temperature for a period of time during which the combined carbon would be converted to temper carbon. This required a slow fire, and also that the castings be packed in inert material such as sand or fireclay to prevent warping and burning. In order to achieve this it was necessary to keep air passages closed to prevent the ingress of cold air. Having one furnace heating from the underside, and the other heating from above (as at 550 Colombo Street) would achieve this. Compressed air on the underside of the furnace would also give good control of the rate of burning of the fuel and temperature (ICS Reference Library 1906).

Steel annealing

Steel annealing was carried out to create workable steel that could be easily machined, or to relieve stresses caused by working the metal and casting. The process required heating the steel to sufficient temperature and keeping the temperature constant for a period of time. Once internal changes had taken place in the metal it would then be cooled slowly, usually by shutting the furnace down and leaving everything to cool together (Chapman 1846).

Steel normalising

This process is similar to annealing, in that it involved heating the metal to relieve stresses in the steel caused by working. When steel is cold worked the

crystal structure is distorted and the metal becomes brittle. Once the metal is heated to annealing temperature, it is normalised by cooling it in the air back to its original temperature (Chapman 1846).

Probable sources for the coke used at this site were either the low temperature coke ovens at Brunner or Granity on the West Coast, or the coke produced as a by-product from gasworks. There were four of these locally, at Rangiora, Sumner, Lyttelton and Christchurch (the Christchurch gasworks were in Moorhouse Avenue). As noted above, the coke used at this site had high levels of volatile matter, suggesting it came from the dedicated coke ovens, or a less efficient earlier gasworks.

The flues around the furnaces and on top of the remaining section of oven floor had packed, heated red sand in them, which may have been sand used as a packing material for castings being annealed to make malleable castings.

A number of pieces of cast iron metal were found in the back fill rubble, including two broken pieces of cast iron small flue doors as used in Scott Atlas coal ranges from 1878. Figure 12 shows a range with two similar covers above the stove top in the top corners. Another artefact recovered from the fill was the remains of a tile lid, possibly used to seal boxes used for annealing malleable castings in the ovens.

Two complete aerated water bottles and a glass bottle base fragment dating to the early 20th century were recovered from the rubble above the concrete floor in front of Area A.

Discussion and conclusions

The concrete footing that bisected the site and the concrete floors either side correspond to those depicted in the Trengrove and Blunt architectural drawings, which specify that the concrete floor was to be reinstated. This suggests that an original concrete floor predated 1929, and was likely to have been poured for the conversion of the site to the Atlas biscuit and confectionary company factory building (constructed in 1903). This suggests the furnaces were decommissioned prior to the construction of the biscuit factory and are likely to be of 19th century origin.

The furnaces appear to be a batch-type general utility furnace capable of generating sufficient temperatures for annealing malleable cast iron fittings, and the annealing and normalising of steel work and castings. Surprisingly, the site was clear of any process waste, implying the process carried out produced none other than that produced from the furnaces, or that the waste was reused or cleaned up. While the evidence is limited, the scenario advanced here is that these furnaces functioned as an off-site addition to the Atlas Foundry, constructed to fulfil the contract for the construction of railway locomotives

in 1885. The owner of the property at this time was Charles Kiver and subsequently the New Zealand Trust and Loan Company, both of whom may have sought additional income from leasing the land to the Scott Brothers. Further archival research may provide some additional details.

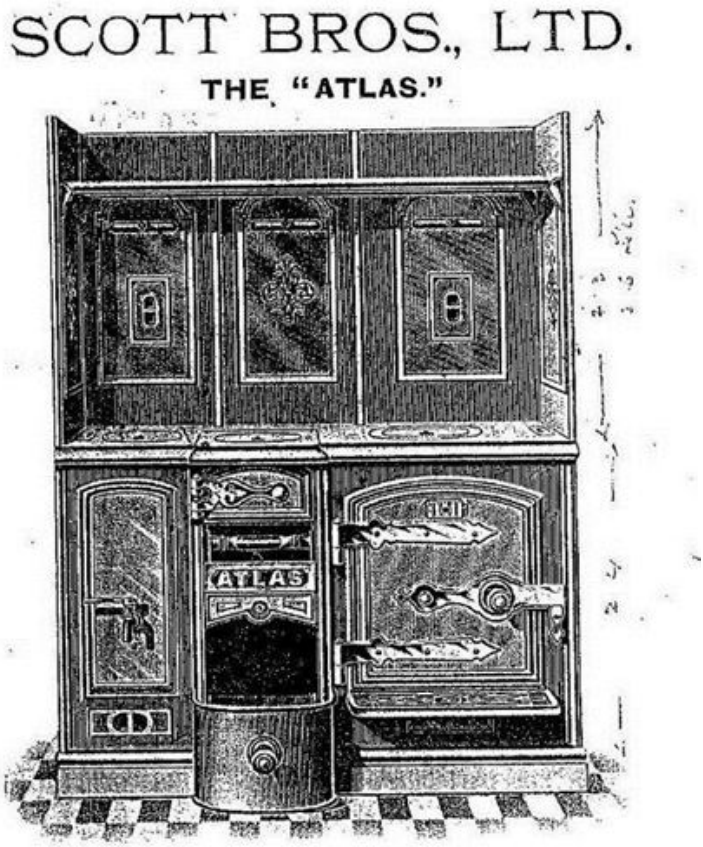


Figure 12. The covers shown above the stove top in this image are very similar to the broken pieces of cast iron flue doors recovered from the fill. Image from a 1908 Scott Bros catalogue.

The Todd and Brunner bricks were available at this time, although Todd bricks do not appear to have been used in the original construction (Area A) and Wigram's brickworks at Heathcote was established in 1886, so the location

of these bricks within the furnace layout may provide further insight into a timeline for the expansion of the operation.

After the excavation and recording of the site it was deliberately buried to provide protection until such time as the future of the site can be determined.

Acknowledgements

Gordon Dowler for aerial photograph and information on twentieth century industry in vicinity of site, and Ian Close and Bob Redfern for insights into furnace function and capability. Christine Whybrew and Matt Carter for archival research. Smith's City for providing funding and allocating time for investigation, and Nikau Contractors Ltd for assistance with mechanical excavation. Andy Brown, Bridget Mosley, Matt Carter, Matt Hennessey and Katharine Watson for assistance with archaeological investigation. Blyss Wagstaff for comments on the draft article.

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