9.02 Ventilation

a. air bricks
b. Arnott's ventilator
c. the Tobin tube
d. educt vents
e. ceiling vents
f. extraction ducts
g. induct ventilators
h. roof vents
i. Robert Boyle and the 'air pump'
j. later types
k. ventilating ridges

It is difficult to make much sense of early developments in the hardware of ventilation in Australia.[1] There were many British and other devices on the market, and many local patents, but identifiable remains are scarce, and they are in any case difficult to investigate. The main innovations in Australia, as in Britain, tend to relate not to the domestic market but to ships, mines, houses of parliament and gaols.

Sub-floor spaces do not usually form a part of the discussion. There were a few major public buildings which actually used the sub-floor space as a plenum or reservoir from which to draw air to the floors above. But as a rule any sub-floor ventilation was intended only to agitate the air somewhat and so to discourage rot and fungus in the floor structure, and no special systems or patent fittings were required for such purposes. Most early ventilation was on passive rather than mechanical principles, and when it made use of ducts and plenum spaces it was not always clear how they were expected to operate. The first stage of the Melbourne Public Library, completed in 1864, had open spaces above every bookcase, connecting with flues carried through the main walls; and also tubes leading from the back of the columns to the roof. This was regarded as highly satisfactory when it was complete, but within a few years was the subject of complaints by library users, and had to be modified.[2] An office building of 1879 had four inch [100 mm] terra cotta tubes built into the walls, opening to the exterior at the bottom, and to the interior at about 2.7 metres high in various rooms.[3]

a. air bricks

---

1 The earlier part of this discussion is partly summarised from Miles Lewis, 'J. G. Knight and the Prehistory of Architectural Science in Australia', in J D Kendrick et al [eds], *Design and Science* (Adelaide 1985), pp 1.18 ff.

2 Allom Lovell Sanderson Pty Ltd & Heritage Group, Public Works Department, Victoria, *State Library and Museum of Victoria Buildings Conservation Analysis* (Melbourne 1985), p 11, ref *Annual Report of the Trustees*, 1870-1.

3 F M White, 'General Conditions of Contract and Specification ... Certain Offices in Queen Street Melbourne ... F. W. Prell Esqre' (Melbourne 1879, p 8.

The common vent is a cast iron grille with a face size equal to that of two bricks or of one, to which the term 'air brick' properly applies. The term probably derives from John Burridge's patent of 1825 for an actual brick incorporating 'grooves or channels or bevels to allow air to pass through.[4] Air bricks, of both black and galvanised iron, were listed in Mayes's price book of 1862.[5] At 'Mount Rothwell' homestead, Victoria, of 1872, twenty 'galvanised iron air bricks' were specified 'for ventilation under the floors' of the billiard and smoking rooms.[6] Another specification of 1878 calls for '12" x 6" [300 x 150 mm] galvanised iron air bricks',[7] which is odd, because the size not that of a brick or its multiples. Both plain and galvanised air bricks were being advertised by Lassetters of Sydney in 1883.[8] All such references must be taken to refer to cast iron vents, for sheet metal vents with square perforations appeared only in the twentieth century.

Terra cotta air bricks are rare in the nineteenth century, but there were exceptions, such as those specified in South Australia for the outer faces of Tobin tubes, as discussed below. They were probably those from Trewenack's Pottery, which were awarded a prize at the Agricultural Show in 1876, being 'well and cleanly made, although the dark ones are not so well vitrified as the English'.[9] Others were produced at about this time by Koster's Premier Pottery, North Norwood, one example of which is a two brick size, 9 by 6 inch [225 x 150 mm], panel with a beautifully modelled foliated rinceau, executed in yellow terra cotta.[10] It does not seem that terra cotta air bricks were used nearly so early in the other colonies, and indeed they mostly date from the twentieth century.

b. Arnott's ventilator

The best-known English ventilator of the period was Dr Neil Arnott's, which had the form described by Lawrence Wright as a 'bottom-hinged scuttle' set in a rectangular box in the wall, and which could be adjusted to close the opening to a greater or lesser extent.[11] As initially conceived it was placed close to the ceiling of the room, opening into a chimney flue, so that the rising combustion products would suck air out with them, whereas the flap closed if there happened to be any pressure from the flue back into the room.[12] Even without a fire, it would benefit from the Pitot tube effect of wind passing across the top of the chimney. In practice the Arnott's fixture was also used in other locations and other ways.

---

4 Great Britain, patent no 5104 to John Burridge, 9 June 1825.

5 Charles Mayes, *The Australian Builders' Price-Book* (Melbourne 1862), p 111.

6 Researched by Jeananne Wells, 2001, by reference to the Chirnside papers, State Library of Victoria.

7 Reed & Barnes, 'Specification of Work to be done and Materials to be used in the Erection of Banking Premises at "Kooringa S.A." for the Bank of Australasia'), p 44.

8 Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), p v.

9 Noris Ioannou, *Ceramics in South Australia 1836-1986: from Folk to Studio Pottery* (Netley [South Australia] 1986), p 62.

10 Ioannou, *Ceramics in South Australia,* pp 52, 358

11 Lawrence Wright, *Home Fires Burning* (London 1964), p 173

12 Wyatt Papworth [ed], *The Dictionary of Architecture* (London 1853-92), sv Ventilation.

In 1851 the Independent Church in Lonsdale Street, Melbourne, was 'ventilated upon Arnot's [*sic*] principle, by flues and iron valves in the walls',[13] and in 1859 the St Kilda Town Hall was similarly provided with an Arnott's ventilator in each of the vertical shafts which admitted air along both sides of the hall.[14] In 1862 these ventilators were being advertised in the *Australian Builders' Price-Book* in a white front and bronzed, fancy bronzed, or in common black for large sizes.[15] In a building of 1879 (the one with the tubes in the walls, referred to above) the caretaker's room had an Arnott's ventilator opening into the chimney flue, but other rooms vented into a separate flue within the chimney stack.[16]

In Adelaide there were lozenge-shaped perforated zinc vents, apparently original, in the casement sashes of the Colonial Store of 1867, now demolished.[17] Although the principle of the ventilation system is not clear in each case, there were ventilating tubes found in the masonry of the South Australian Institute Building of 1859-60, the Parkside Lunatic Asylum of 1870, and 'Martindale Hall' of 1878. At Parkside the vents opened into the roof space, and this was in turn vented by means of lucarnes.[18] In March 1872 Stead's ventilator, which seems to be no more than a local variation on the Arnott type, was published in the *Australian Mechanic*.[19] In 1883 Arnott's ventilator was being advertised by Lassetters of Sydney, together with Currall's - a type yet to be identified.[20] In Melbourne McEwans advertised Arnott's, as well as Sheringham's Stead's and Boyle's ventilators, to which we shall return.[21] Hart's ventilator, which seems to have been something like Arnott's, has not been reported in Australia.[22]

c. the Tobin tube

In the Tobin tube, which was the next development, air admitted from the outside near floor level was brought up the inside face of the wall in a rectangular tube to at least 1.5 m high, or sometimes much more, admitted to the interior, and allowed to rise to the ceiling and thence be deflected down across the room. This produced much less of a draft than direct ventilation, and the air flow could be controlled with a damper in the tube, operated by means of a handle on the face. It had been devised by Martin Tobin, of Leeds, in 1873,[23] and was soon introduced in Victorian schools,

---

13 *Illustrated Australian Magazine*, II, 9 (March 1851), p 138.

14 *Australian Builder*, 24 December 1859, p 409.

15 Mayes, *Australian Builders' Price-Book* (1862), p 111.

16 'White, Specification, Offices for F W Prell', p 8.

17 Information from Bruce Harry, 1991.

18 Information from Bruce Harry, 1991.

19 *Australian Mechanic and Journal of Science and Art*, 15 March 1872, p 35

20 Charles Mayes, *The Australian Builders' Price-Book* (4th ed, Melbourne 1883), p v.

21 Mayes, *Australian Builders' Price-Book* (1883), p xvii.

22 It is illustrated in [J L Tarbuck (ed)], *The Builder's Practical Director*(Leipzig, no date[c 1858]), p 132, and was the type used in price Albert's Model Lodging Houses, Hyde Park.

23 Papworth, *Dictionary of Architecture*, sv Tobin's System of Ventilation. See also Joseph Gwilt [ed Wyatt Papworth], *An Encyclopædia of Architecture* (London 1899 [1842]), § 2278a, p 744. Papworth gives the date as 1875, but it appears to be Great Britain, patent no 1081 to M Tobin, 24 March 1873, though the description in the abridgment is unclear, and the first part of the patent is to do with ventilation by means of slots in the meeting rails of sash windows.

beginning at Wandiligong in 1876.[24] In the following year they were used at the Mickva Israel Synagogue, East Melbourne, where it was said that 'the fact that Mr Tobin's plan of ventilation has been adopted is a guarantee that the atmosphere of the interior will always be pure.'[25]

In the case of the Mickva Israel Synagogue the tubes were within the wall below the windows, and gave onto 120 mm circular vents in the sills. The height above the floor was anywhere between 1.0 and 1.6 metres, but for the gallery, where it was as little as 0.6 m.[26] A more problematic example is the Welsh Baptist Church at 17 Scallan Street, Stawell, Victoria, for it was built in 1869-70 and has an odd form of Tobin tube, which we must assume to be the result of later alterations, as it resembles one illustrated in Robert Boyle's catalogue of about 1900.[27] The inner face of the wall has a boarded wainscot which may go some way towards concealing the changes, and the tubes appear rising vertically a short distance out of the cills of the windows. Boyle refers to these as his 'air-inlet tubes for fitting to window sills' and explains that 'these tubes are usually employed where there is an objection to holes being made through the wall'.

Tobin's ventilators were still novel enough to warrant comment in 1879-80 in the descriptions of William Boles's Wesleyan Church, Burwood, Sydney,[28] and the Congregational Lecture Hall in Russell Street, Melbourne, where they were said to form 'architectural features' in the room,[29] and they were being advertised by Lassetters of Sydney by 1883.[30] The description of the tubes as 'architectural features' relates to the use of them in the form of rectangular ducts rising up the inside face of the wall, with a moulded cap at the top and with the skirting wrapped around the base, so that they look like truncated pilasters. Commonly there appears in the face of the tube, close to the top, a knob which can be turned to open and close the damper inside the tube. In some other cases the tube is set in the corner of the room with its face across the angle, in others it is constructed entirely within the wall thickness. The former type is described in a specification of 1878 for a bank in South Australia: 'To provide and fix in angles of rooms 15 Tobin's ventilators quad shaped galvanised iron 6'6" long with elbows at bottom and ornamented cresting at top.'[31] A surviving building in South Australia, 'Paringa Hall' of Brighton Road, Somerton Park, of about 1882, has what appear to be Tobin tubes in the corners of rooms.[32] At the Geelong Orphanage there are surviving Tobin tubes of two sizes, 120 mm and 150 mm square, and without dampers, probably installed in the 1880s after the building had been criticised by the Central Board of Health for its inadequate ventilation.[33]

---

24 Lawrence Burchell, *Victorian Schools* (Melbourne 1980), p 160.

25 *Argus*, 4 September 1877, p 6, quoted in Allom Lovell & Associates, *Mickva Israel Synagogue, 488 Albert Street, East Melbourne* (Melbourne 2000), p 56.

26 Allom Lovell, *Mickva Israel Synagogue*, p 57.

27 Robert Boyle & Son, Ltd., *The "Boyle" System of Ventilation* (London, no date [c 1900]), p 125.

28 *Australian Engineering and Building News*, 1 January 1880, p 161.

29 *Argus*, 15 July 1879, p 3.

30 Mayes, *Australian Builders' Price-Book* (1883), p v.

31 Reed & Barnes, 'Specification of Work to be done and Materials to be used in the Erection of Banking Premises at "Kooringa S.A." for the Bank of Australasia' (Melbourne 1878), p 44.

32 Information from Peter Donovan, 1991.

33 Information from Allan Willingham, 2003.

In the extensions of the house 'Rippon Lea' in Melbourne, of the 1880s the tubes are placed in the corners of the rooms, with the face across the angle at 45º. Some are in inside locations, and they appear to connect to ducts below the ground floor, which lead across to the external walls of the building. They have been found to contain fabric filters to screen the incoming air.[34] There are similar tubes in the ballroom at 'Penola', Mount Macedon, dating from no earlier than 1887.[35] 'Trawalla' homestead, Victoria, of 1892, had as many as thirty-nine Tobin tubes, as indicated by a note on the plan, 'N.B. T.Tubes (39 in number) shown in blue thus "T.T.(20)".'[36]

It is possible, however, to be deceived by other systems using tubes of the same form as the Tobin, as in the Rymill house, 'The Firs', at the corner of East Terrace and Hutt Street, Adelaide, where much consideration is said to have been given to the latest ideas in ventilation,[37] there are 150 mm square ducts with dampers in the corners of the billiards room, but these are apparently part of an integrated ducted ventilation system.[38] Similarly, at 'Moorakyne' and 'Stonnington', two major houses built close to each other in the Melbourne suburb of Malvern in about 1888, the architect C A D'Ebro used sub-floor ducting, though it is not now possible to establish whether the air was admitted to the rooms by Tobin tubes. The sub-floor spaces were vented directly to the outside air at the perimeter, but where there were verandahs with solid floors, substantial brick ducts with vaulted tops were carried through them.[39]

'Martindale Hall', South Australia, of about 1878-80, had what can only be Tobin tubes behind the architraves in every room:[40]

> 4 wrot and tongued red gum air tubes 6 inches [150 mm] long and 2 inches [50 mm] deep extending from the terra cotta air bricks ... up to a height of 7 feet [2.1 m] above the floor line. ... provide and fix in the return lining opposite an aperture in the side of the ventilating tube 21/2-inch [75 mm] wrot and perforated Honduras mahogany hit and miss panels 9 inches [230 mm] long and 2 inches [50 mm] wide one fixed and one sliding to be fitted with brass slide in centre 3 inches [5 mm] long with slotted knob to fix shifting panel at any point with do. moulded stops complete.

In 1887 the ventilation of the Adelaide Hospital was thoroughly reworked, though the details are not entirely clear from the published report. Fresh air was said to be introduced into the wards on the Tobin principle, both through ventilators under the window sashes and through apertures 2.4 to 2.7 metres high in the walls, an unusual combination. The intention was to stop the incoming draught of cold air from

---

34 Information from Richard Heathcote, 2001.

35 The room is not mentioned in an advertisement for the sale of the house in the *Argus*, 6 November 1886, p 2.

36 Unsigned working drawing plans, apparently by James & Piper of Ballarat, held at the house. Copy lent by Kerry Jordan..

37 Susan Marsden et al [eds], *Heritage of the City of Adelaide* (Adelaide 1990), p 130.

38 Information from Ron Danvers, 1991.

39 For 'Moorakyne' see the architect's drawings, copies in the possession of Mr Ron Hay, Toorak, and the Stonnington Local History Archive, 1998. The physical evidence suggests that 'Stonnington' was similar.

40 Elizabeth Warburton, *Martindale Hall* (Adelaide 1979), pp 80-81.

descending on the patient's head when lying in bed, and instead to disperse it throughout the room. Extract vents were provided at ceiling height.[41]

In 1892 Tobin tubes were still being specified for the courthouse at Bairnsdale, Victoria, with galvanised wire netting screens at the openings.[42] Here the situation is slightly complicated by the fact that there are rooms on either side of the courtroom, so that the Tobin tubes cannot open directly to the outside air. The inner face vents are at about 2.1 m high along the side walls of the court room. From here the tubes descend below floor level, where a square duct crosses below the floor of the adjoining room to connect with what might be described as reverse Tobin tubes, for they rise in the external wall to admit the air just below sill height.[43] Somewhat similarly, at the Moonta Mines Model School in South Australia, originally of 1877-8, an induct ventilation system which was added probably in about 1903, is ducted below the floor. The major classrooms are back-to-back, with two fireplaces each on the common wall. From the opposite or outer wall two ducts appear to bring the air across below floor level, one leading to each fireplace, where each duct divides and supplies risers in the two sides of the fireplace, from whence the fresh air doubtless vents into the room.[44]

In the meantime in New South Wales W E Kemp, architect to the Department of Public Instruction, was by the 1890s installing in all schools his own rather free interpretation of the Tobin system:

> I find by experience, derived from my own practice, that by admitting the air with an upward direction, on what is known as Tobin's system, at about five feet from the floor, and providing ample outlets at the ceiling level, I get a more rapid change of air, without perceptible draughts, than I can achieve by any other arrangement. In adopting the Tobin tube, I have so far departed from the original practice that I do not introduce the air by vertical tubes from the ground level, but by horizontal pipes through the wall at about five feet from the floor, with shields to give the current an upward direction by this means I believe I get purer and cooler air than if I took it from the ground level.[45]

This was very much in keeping with current thinking in Britain. By 1890 Drysdale and Hayward were criticising Tobin's system, along with a number of others, because they thought it unacceptable to admit cold air directly into a room.[46] This might not

---

41 *Australasian Builder & Contractor's News*, 6 August 1887, p 204.

42 'Specification ... of New Court House, Bairnsdale', 14 November 1892, p 30.

43 Sections of the building reproduced in James O'Connor, *Bairnsdale Courthouse* (Bairnsdale [Victoria] 1993), pp 14-15; *Bairnsdale Advertiser*, 26 April 1894. It is the *Advertiser* report which makes it clear that there is a horizontal duct, not so easily discerned in the drawing.

44 Carolyn Wigg, 'Moonta Mines former Model School', Register of State Heritage Items, 6429-1178 (not dated). Carolyn Wigg has kindly supplied me with copies of two of the 1903 sheets of drawings. The central lantern is shown in elevation, and I take it to be for ventilation (and not a belfry). Elsewhere there seem to be one or two more flues than would be called for by the fireplaces, so it may be that they also had a ventilating function.

45 William Kemp, 'School Buildings', *Building and Engineering Journal*, 8 July 1893, p 16, quoted in Ian Sansom, 'The Life and Work of William Edmund Kemp' (BArch, University of New South Wales, no date), part 3, p 18-19'.

46 J Drysdale & J W Hayward, *Heath and Comfort in House Building* (3rd ed, London 1890 [1872]), pp 2, 4, 18. ..

be so important in the more benign climate of Australia, but by 1900 more comprehensive objections were raised by William Henman, who wrote:

> Tobin tubes [are] an example of the popular appreciation of unscientific methods for securing ventilation. A vertical tube is not only unnecessary, but is a positive disadvantage, for it retards the flow of air by friction, and may become fouled within, and for ground-floor rooms the inlets openings are often placed too near the ground-level, and at times I have found them situated close to sources of impurity, such as gully-gratings and accumulations of refuse.. The direct upward tendency given to the inflowing air passing through such a tube causes it to rebound from the ceiling and come down like a cold shower upon the occupants of the room. Wall-papers and ceilings also become disfigured by dirt brought in with the air.[47]

This would seem to be a highly tendentious criticism. Not only does it raise ridiculous concerns about internal fouling, staining of wallpaper, &c, but it makes a fault out of the main virtue of the tube, which is that it encourages the air to rise to the top of the room before gently diffusing downwards. However it must have been partly due to such criticisms that Tobin tubes went almost entirely out of use soon after the turn of the century.

d. educt vents

The commonest educt vent is simply a grille close to the ceiling, venting directly through an external wall, with another register on the outer face. But even these are subject to some variations, such as dampers to open and close them, worked by a string from below. A house of 1890 was specified to have 'Wareham's patent vents 7/6 each including G.I. air brick valve and internal face.'[48] In the Metropolitan Gas Co building, Melbourne, of 1890, it is unclear where the internal registers were located, but the air was taken to the external wall through 100 mm earthenware pipes placed in the concrete of the vaulted ceiling system.[49]

The first local patent application of any consequence was unsuccessful. The Richmond plumber George Craven and the Melbourne tinsmith William Smith in 1859 proposed a telescopic arrangement of tubes fitted into the ceiling of a room and operated by cords and pulleys, with valves designed to release air from the room and to admit air from outside to replace it.[50] This appears to describe a well-established English device, Baillie's sliding ventilator,[51] which may explain why the patent was not granted, though as officially described the ventilator patented by Benjamin Baillie on 24 November 1844 consisted of narrow plates of glass fixed in louvre fashion,

---

47 William Henman, 'Ventilation', in G L Sutcliffe [ed], *Modern House Construction* (6 vols, London 1909), V, pp 190-191.

48 Hyndman & Bates, 'Specification, &c, Villa Residence Tank +c / Camberwell / Arthur J Fuller Esq / Normanby Chambers Chancery Lane' (Melbourne 1890), p 6A.

49 Reed, Henderson & Smart, 'Specification of Work to be done ... New Premises for the Metropolitan Gas Coy.' (Melbourne 1890), p 11.

50 Victorian patent application no 294, not granted to George Craven and William Smith, 10 December 1859.

51 Henry Roberts, *The Dwellings of the Labouring Classes* (London 1850), p 5.

with a moveable plate as a cover or valve.[52] There is no obvious way of gauging whether such a ventilator was in fact well-known or used in the colony.

Arnott's ventilator had initially been designed to open into the side of a chimney flue, so that air from the room would be sucked into the flue by the rising heat from the fire. But Thomas Tredgold had argued that all forms of ventilation using the fire were defective 'either from being wholly inefficient, or from causing the chimney to smoke.' He proposed instead an inverted syphon with one leg in the chimney, activated by the fire. A vent opening near the ceiling would enter a J-shaped tube leading downward past the fire, and then up again some distance to discharge into the flue.[53] It is not clear whether this was ever done, for it is quite unheard of in Australia. It was far simpler to provide a completely separate flue for ventilation purposes, and avoid the problems associated with the fire.

The use of a parallel flue had been discussed by Loudon, who made two points about it. The first was that it was essential to have an 'outer ventilator' [induct vent] to replenish the air being sucked off. The second was that the amount of cooking - it was a kitchen he was discussing - determined the heat in the flue, and hence the rate at which the air was extracted. Therefore there must be regulating valves to both vents: the one leading into the flue (circular as illustrated) should have a central pivot with handles to either side, worked by strings from below.[54] Again in England Henry Roberts had found the use of the flue a risky arrangement, because smoke sometimes came back through the vent, and he preferred to provide a separate tube, measuring 100 x 230 mm, from the vent to a higher point in the flue, or directly up to the chimney stack.[55] However as late as 1864 a municipal commission at Lille, in France, called for closets to be ventilated wherever possible by means of an open tube to an adjacent chimney,[56] presumably meaning that it should tap into a smoke flue.

In Australia one does occasionally find this sort of ventilation provided, either by using a tube, or else simply by using the leftover space beside the flue within the chimney breast. The presence of a vent in the chimney breast is a diagnostic. In two prestigious Melbourne buildings by William Wardell, Government House, of 1872-6, and the E S & A Bank of 1883-5, there are vents opening into the front of the chimney breast, close to the ceiling, and it seems likely that they enter dedicated ventilation flues. Something of the sort was proposed by John Kirkpatrick in 1889 in his unsuccessful competition entry for the Royal Bank of Queensland headquarters in Brisbane, where each room was to have a central fireplace, with a separate flue beside

---

52 Great Britain, patent no 10,402 to Benjamin Baillie, 25 November 1844; also his related patent no 7307 of 20 February 1877; Wyatt Papworth [ed], *The Dictionary of Architecture* (London 1853-92), sv Baillie's Ventilator, ref *Civil Engineer and Architect's Journal,* VIII, p 234, and *Builder,* III, p 319.

53 Thomas Tredgold, *Principles of Warming and Ventilating Public Buildings* (2nd ed, London 1824), pp 237-9.

54 J C Loudon, *Encyclopaedia of Cottage, Farm and Villa Architecture &c* (London 1846 [1833]), § 1775, p 855.

55 Roberts, *Dwellings of the Labouring Classes,* p 5.

56 Charles de Freycinet, *Rapport sur Assainissement Industriel et Municipal en France,* cited in Great Britain, Office of the Commissioners of Patents for Inventions, *Abridgments of Specifications relating to Ventilation. A.D. 1632-1866* (London 1872), p xxxvi.

it to remove the air. That is, it was not entering the fireplace flue itself, and was therefore not directly affected by the hot exhaust draught.[57]

Roberts's concerns about the use of the flue seem to have been addressed by the development of Hayward's Patent Self-Acting Mica Outlet Ventilator, in which a mica flap acted as a very sensitive valve, opening and closing continually to release air from the room but to prevent any reflux. It seem to have been used both in the flue itself and in a separate tube. The agency was held first by Mark Abrahams & Co of Melbourne and Sydney, them by Barnett Brothers of Melbourne.[58]

e. ceiling vents

By 1824 Thomas Tredgold had clearly enunciated the principle of using ceiling ventilators for the extraction of air, either taking it in tubes leading to outlets in the roof, or venting straight into the roof space, which would then itself be separately vented at the ridge.[59] An American specification of 1856, for the Custom House at Wheeling, Virginia, is an early instance of the use of a separate duct or trunk from the ceiling to the exterior of the roof. It provided that there should be an Arnott's ventilator or its equivalent in the upper part of each room. Hence a flue was to be taken to the attic, and from there a wooden trunk to the chimney top through which it would be vented, apparently in parallel with the smoke flues.[60]

It is not clear whether anything of the sort was done in Australia before the 1850s: however, the introduction of reticulated gas made ceiling ventilators essential above light fittings, because the combustion products included a considerable proportion of water vapour. At Royal Terrace, Melbourne, of 1853-7, some of the rear rooms have ceiling vents which may well have been above a gas light, as town gas became available at about the time of construction. They are octagonal, with an ornamental face containing twelve radial slots. It appears that these could be closed by rotating a second matching panel behind the face.[61] The same principle was used in some induct vents which will be discussed below. Some of the earliest vents above light fittings were those installed in 1859 at the St Kilda Town Hall, already mentioned above for its Arnott's wall ventilators.[62] At the Baptist Church, North Adelaide, of 1869-70, are large rectangular ceiling panels filled with perforated zinc, surrounding what must have been pendant gas lights. These panels vent into the roof space, which in turn was vented to the exterior by means of 'louvre openings'. Where these were placed is unclear.[63]

---

57 *Australasian Builder & Contractor's News*, 2 March 1889, p 213.

58 Charles Mayes, *The Australian Builders' Price-Book* (5th ed, Melbourne 1886), p xxxi; *Australasian Builder & Contractor's News*, 3 September 1887, p 268 & 7 September 1889, p 278.

59 Tredgold, *Warming and Ventilating*, pp 73-4, 91-5, 166-9.

60 *Specifications for Building the Custom-House at Wheeling, Virginia* (Washington [DC] 1856), reproduced in *APT Bulletin*, V, 1 (1973), pp 79-80.

61 RBA Architects, *Royal Terrace, 50-68 Nicholson Street, Fitzroy. Conservation Management Plan* ('final draft', Melbourne May 2003), p 32.

62 *Australian Builder*, 24 December 1859, p 409.

63 *South Australian Register*, 16 July 1870, quoted by Susan Marsden et al, *Heritage of the City of Adelaide* (Adelaide 1990), p 307.

The simplest form was a cone directly above the ventilating rose, and in some examples of the late nineteenth or earlier twentieth century this discharges within the ceiling space. but looks very similar to an external roof vent (such as the Kemp & Sheehan vent, below). The broad cone rises over the ceiling vent and leads into a cylindrical flue with a top which flares out and then back again, in the form of two frustra of cones, base to base, and above this four small struts hold up a conical cap which protects the mouth of the opening from anything dropping in. Vents of this type have been found in New South Wales lighthouse keepers' cottages at South Head and at Cape Byron, the latter branded with a stencilled triangle containing 'JCM' and 'PHOENIX'.[64]

Some sophisticated buildings are ventilated by means of a strip within the cornice, often concealed by an openwork decorative plaster filigree within the cove. An early example of this had been Sir John Robison's house in Edinburgh, by John Milner, where the air was removed through 'a continuous opening of about one inch and a half [40 mm] wide (behind one of the fillets of the cornice)'.[65] In 1889 it was reported that John Kirkpatrick's competition design for the Royal Bank of Queensland (mentioned above) was to have Hartnett's patent self-acting ventilators in the coves of the ceilings.[66] A cruder version of the same idea was used in 1887 at the Steam Packet Hotel, Taree, where at the instigation of the builder the main function room was treated in a novel way:[67]

> instead of the wooden ceiling being in close contact with the wall-plates around the four sides, small blocks are inserted, which leave an open space of a few inches between the wall plates and the ceiling, and allow free egress to the hot and vitiated atmosphere.

In 1866 Edward Murphy established a factory in South Melbourne where he manufactured centre flowers, and his patented 'bi-valve ceiling ventilator', for which he was awarded gold medals at various international exhibitions.[68] Two of these ventilators have been found in the house 'Glenfern', East St Kilda , and they appear to have been installed when gas was connected in 1876. The Murphy ventilator consists of a flat tin cone which is placed over the ceiling rose, with the apex of the cone leading into the bottom side of a short transverse tube, of rectangular cross-section. Immediately above the inlet from the cone is a pivoting flap in the form of an inverted V, which rocks from one side to the other according to the prevailing draft in the ceiling. This (as I infer) is designed to automatically close off any draft entering the tube, which might force the fumes back down into the room, and simultaneously ensure a negative pressure at the other end which will suck them into the ceiling.

---

64 Information from Ian Evans, 2004..

65 J C Loudon, *Encyclopaedia of Cottage, Farm and Villa Architecture &c* [London 1846 (1833)], § 2379, p 1197.

66 *Australasian Builder & Contractor's News*, 2 March 1889, p 213.

67 *Australasian Builder & Contractor's News*, 3 September 1887, p 269, quoting the *Manning River Times.*

68 T W H Leavitt & W D Lilburn [eds], *The Jubilee History of Victoria and Melbourne* (2 vols, Melbourne 1888), II, pt 3, p 16; *Catalogue of the Victorian Colonial Exhibition* (Melbourne 1875), advertiser p 76; *Australian Mechanic*, 15 October 1872, p 112.

Murphy showed what seems to have been the same ventilator at the International Exhibition of 1880.[69]

It is interesting to find that the same principle was being advocated in quite a different context forty years later, for ventilating stables through a monitor roof. The monitor was closed on either side by top-hung flaps. A transverse rod linked the flaps so that when one was closed the other was opened. A wind from one or other side would close the flap on that side, but open the leeward one, through which air would be extracted by the Pitot effect. But this was not all. The rod was broken into two at the centre with a hinge allowing it to bend upwards. From the hinge a cord passed up over a cable, then hung down into the space below, such that when the cord was pulled the hinge rose, pulling the flaps closer together until both sides of the monitor were sealed.[70]

f. extraction ducts

Educt ventilation by means of duct work through the roof space, leading to an external vent, seems to have been rare in Australia until late in the century. Davidson & Henderson's drawings of 1870 for 'Titanga' homestead, western Victoria, show inverted funnel vents over the kitchen, laundry and passage, from which angled tubes rise to the ridge, above which are simple cowled ventilating tubes.[71] At 'Ercildoune' homestead there is a system of this sort which seems to date from the work done to the house in the early 1870s by Sir Samuel Wilson. Each of the upper floor rooms has a square vent of about 300 mm square in one corner of the ceiling, closed with a plate of perforated zinc. From this vent runs a box-like pine board trunk, at first of a similar size, but then reducing to about 300 x 100 mm, raking up to the ridge of the roof. With what fixture the vent terminated is not known, as modern recladding of the roof has destroyed all evidence. For a Melbourne office building it was specified in 1879:

> In the centre of the ceilings of the Various rooms ... there must be provided and fixed over the centre flowers conical shaped G. Iron mouths 14 in diameter discharging into 4 in G. iron pipes which must be conducted into an Air shaft provided in each stack of chimnies.[72]

Such ducted educt ventilation achieved more general acceptance in public and school buildings. In 1873, in the state school at Buninyong, Victoria, the architect W H Ellerker had for the first time linked the ceiling vents to the external roof vents by means of 'ventilation funnels',[73] and then the idea had been temporarily forgotten in the Victorian Education Department. However, a similar provision was made in the hospital of the country town of Maryborough, and was inspected in 1880 by the

---

69 Melbourne International Exhibition, 1880-1881, *Official Record* (Melbourne 1882), p 659: 'Patent bivalve ventilator, self-acting; ventilating ceiling centre-flowers'.

70 *Town and Country Journal*, 15 February 1911, p 17.

71 Drawings in the possession of Mr & Mrs Chris Lang at the property: 'Davidson & Henderson / October 1870 / for A. Buchanan Esq.'.

72 F M White, 'Offices for F. W. Prell Esqr Queen St' (Melbourne 1879, p 15.

73 Lawrence Burchell, *Victorian Schools* (Melbourne 1980), pp 98-9.

Education Department architect, Henry Bastow, then copied by him in an attempt to rectify existing ventilation problems in a school at Timor. It worked, and was applied to another problem school in the following year, but was not provided in new buildings until 1891. In the Spensley Street school of that year the tubes from each ceiling vent were angled up to a central ventilating lantern, rather than carried directly through the roof.[74]

By the 1880s, it was becoming quite widely accepted in Australia as desirable practice to have a ventilating ceiling rose in every room, and for each to be connected to an air shaft.[75] This was put into practice extensively in public buildings, but appeared in domestic use only in the hotter parts of Australia. In the case of Daniel Garlick's Primitive Methodist Church in Wellington Square, North Adelaide, of 1881-2, the drawings clearly show two ducts leading from ceiling outlets up to what appear to be triangular gablet openings in the roof.[76] Soon a variety of roof ventilators and cowls came on the market, and many survive especially in Queensland, where fifteen double fringed galvanized iron vents surviving on the main building of the Kangaroo Point [Yungaba] Immigration Depot of 1885, are said to be original.[77]

In the same year the primary school at Clarendon, South Australia, had ceiling vents each giving into the base of a T-shaped tube, the two arms of which extended to opposite faces of the roof, opening as lucarnes.[78] This presumably guaranteed continuous extraction by the Pitot tube effect. In 1887 the revised ventilation system at the Adelaide Hospital included funnel-mouthed vents at ceiling level, connected directly to roof vents.[79] Meanwhile in South Australia the Moonta Mines Model School of 1877-8 (already mentioned), which was a direct copy of one of Bastow's Victorian designs, had added to it by 1903 a large central lantern which seems to have

---

74 Burchell, *Victorian Schools,* pp 158-9.

75 See for example P W Harrison, 'Healthy Homes', *West Australian Mining, Building and Engineering Journal,* 3 September 1904, pp 18-20, quoted by Kelly, 'Development of Housing in Perth', p 191, citing as a precedent G Gordon, 'Household Sanitation', Report to the Australasian Association for the Advancement of Science, *Building & Engineering Journal,* 8 March 1890, p 88.
The view was to some extent an outmoded one, but there is not much indication that the alternative approach had any impact in Australia, perhaps because it was a critical issue only in systems where heating was the major concern, as in Britain and North America, In 1862 Henry Rutten of Canada put forward the principle that the exit for foul and cold air should be at or below the floor level of a room rather than at the top. In 1866-8 the popular American lecturer Lewis Leeds stated that he would 'most emphatically ... condemn all systems relying upon openings in the ceiling for the escape of foul air, while depending upon the circulation of warmed air for obtaining the necessary additional warmth.' There were however circumstances in which a ceiling vent was acceptable. Unlike Leeds, Isaac Smead, a large manufacturer of boilers and other apparatus, acknowledged his debt to Rutten and more rigorously applied the principle of extraction at floor level. L L Leeds, *A Treatise on Ventilation* (2nd ed, New York 1871 [1868]), p 39; I D Smead, *Ventilation and Warming of Buildings* (Toledo [Ohio] 1889), pp 7-8. A schoolhouse designed by the architect Theo F Ladue, to be 'heated and ventilated by Ruttan's [*sic*] system', is illustrated in A J Bicknell & Co, *Bicknell's Village Builder and Supplement* (New York 1878), plates 37 & 37.

76 Susan Marsden et al, *Heritage of the City of Adelaide* (Adelaide 1990), p 314.

77 J S Kerr, *Yungaba Immigration Depot* (Brisbane 1992), p 28.

78 Paul Stark, *Meadows Heritage* (Meadows [South Australia] 1983), pp 51-2.

79 *Australasian Builder & Contractor's News,* 6 August 1887, p 204.

been the extract point for most or all of the building.[80] This would seem to imply ducting from each room, as the plan is too large for the roof spaces to have functioned effectively as a single plenum system.

At the Bairnsdale Court House in Victoria, the Tobin tubes of which have been discussed above, there was an extract system using a large central flèche or lantern. It appears that this carried down to a large grated opening in the centre of the court room ceiling, but that there were four further ceiling vents along the axis, one per bay, from which ducts ran through the roof space to enter the trunk of the flèche. The flow of air through the flèche was regulated from inside by means of a cord attached to a throttle valve, a pivoting octagonal plate to fill the shaft. The top part of the flèche, though the details are not entirely legible on the drawing, appears to have been of a form designed to create an upward current, with two downward-raking flanges surrounding the central stem, through which the air must have escaped.[81]

Such systems were rarely used in private dwellings, but at 'Moorakyne', Melbourne, in 1888 C A D'Ebro installed two funnel-mouthed vents in the ceiling of the central hall, each leading directly upwards to a rotating cowl above the roof. The hall was the only space running through the two levels of the house, and was probably conceived as a sort of plenum - or vacuum - space by means of which the surrounding rooms would be exhausted.[82] Galvanised iron pipe ducts in the 1859 section of the house 'Nithsdale', Melbourne, are thought to have been installed in 1889. In each case a wooden box has been formed between the ceiling joists, over the light fitting, and the tube runs from this box to a flue in the chimneystack.[83] A Melbourne house newly built in 1889, by the architect Philip Treeby, contained one room with two ventilating ceiling roses, above which galvanised iron pipes slanted up to join below a single ridge vent.[84] A house in Brisbane, which may be as early as 1890, has no less than six ceiling vents, all connected by tubular ducts in the roof space to a central outlet. It is thought that the architect may have been H D G Stanley, who would have been very familiar such matters from his long period in government service.[85]

---

80 Carolyn Wigg, 'Moonta Mines former Model School', Register of State Heritage Items, 6429-1178 (not dated). Carolyn Wigg has kindly supplied me with copies of two of the 1903 sheets of drawings. The central lantern is shown in elevation, and I take it to be for ventilation (and not a belfry). Elsewhere there seem to be one or two more flues than would be called for by the fireplaces, so it may be that they also had a ventilating function.

81 Sections of the building reproduced in James O'Connor, *Bairnsdale Courthouse* (Bairnsdale [Victoria] 1993), pp 14-15; *Bairnsdale Advertiser*, 26 April 1894.

82 Architect's drawings, copies in the possession of Mr Ron Hay, Toorak, and the Stonnington Local History Archive, 1998.

83 Anne Tyson, in a study of 'Nithsdale', 133 Kambrook Rd, Caulfield; Australian Architecture B, University of Melbourne, 1997.

84 Simon Reeves, in a study of 836 Hampton St, Brighton; Australian Architecture B, University of Melbourne, 1997.

85 The house is 96 Kadumba Street, Yeronga, kindly drawn to my attention by Ian Evans. It was built for Adolph Feez, and the owners, Dr Tyson Donelly & Mrs Joan Donelly, have noted a stylistic resemblance to a house by Stanley.

g. induct ventilators

The range of induct ventilators being advertised in Australia by the 1880s included Arnott's, Hayward's Venetian, Sheringham's and Stead's,[86] and indeed some of them were still being sold in England at the turn of the century, fifty years or more after their first introduction.[87] The distinctions between them are quite difficult to follow. For example, Sheringham's ventilator is of very much the same coal scuttle form as Arnott's, a bottom-hinged flap opening into the room on an angle. But the intended function was totally different, in that Arnott's opened into a flue or vertical duct, for the purpose of extracting air, while Sheringham's was for the purpose of admitting air, and was installed on an external wall, near the ceiling and in direct connection with an external vent. The theory was the air would be forced across the ceiling and warmed up before it descended, so as not to give rise to a cold draught.[88] The inventor was probably John Sheringham, though it seems unrelated to the patent of 1852 in his name.[89]

Barnett Brothers of Melbourne were the agents for Sheringham's ventilator, and it appears that it was intended for installation near the ceiling of the room, and even then to discharge the incoming air in an upwards direction, no doubt so that it would diffuse with the minimum of draught.[90] Sheringham's vent is referred to in a Queensland text as late as 1955, and the discussion relates less to the coal scuttle form of the vent than to the principle of the external inlet being well below the internal outlet, linked by a rectangular section duct rising within the wall thickness - which is really the Tobin principle, but close to the top rather than the bottom of the room.[91] A system of precisely this sort is shown in the working drawings for the Maryborough Railway Station, Victoria, in 1890. However there are ventilating grilles of a diagonal lattice pattern on both the inner and outer face, labelled 'Reilly's approved ventilator'.[92] It seems likely that Reilly was a local maker. Hayward's Venetian Ventilator had an array of adjustable louvres in the face to control the volume of air, and by 1889 was claimed to be being installed in almost all Victorian government buildings.[93] It is in a tradition of louvred vents which goes back to the pioneering period of Dr D B Reid and earlier.[94]

---

86 Charles Mayes, *The Australian Builders' Price-Book* (5th ed, Melbourne 1886), advertisements, pp xix, xxxi, and p 150.

87 In 1901 Comyn Ching & Co of London advertised Sheringham's, Arnott's and silk flap ventilators, along with more advanced types such as their own new patent silk flap ventilator for chimney breasts. Hayward Brothers and Eckstein Ltd sold Sheringham's, silk flap and mica outlet vents. J E Sears [ed], *The Contractors,' Merchants,' and Estate Managers' Compendium and Catalogue* (15th ed, London 1901), pp 171, 175. The silk flap, like Hayward's mica flap already discussed, would have been an educt vent.

88 Wyatt Papworth [ed], *The Dictionary of Architecture* (London 1853-92), sv Sheringham's Ventilator; *Builder*, XI, 530 (2 April 1853), p 222.

89 Great Britain, patent no 1015 to John Sheringham, 10 December 1852, which deals with ventilating a room by means of air passed around a fire in a grate..

90 *Australasian Builder & Contractor's News*, 7 September 1889, p 278.

91 C J Virgo, *Australasian Building Knowledge*, vol II (Brisbane 1955), pp 224-5.

92 Details of original drawings kindly supplied by Janet Beeston, 2001.

93 *Australasian Builder & Contractors' News*, 7 September 1889, p 278.

94 D B Reid, *Illustrations of the Theory and Practice of Ventilation, with Remarks on Warming, Exclusive Lighting, and the Communication of Sound* (London 1844), p 79.

A specification for a bank in 1878 calls for a number of 'Pepper's patent wall ventilators' in two sizes, values at 5s. and 2s.6d.[95] Because they were to be supplied by the plasterer, one can assume that they were for the inside wall face, but they seem to have been more than mere grilles or registers, for they were specifically identified in a newspaper report in 1880 as being the means used to ventilate rooms added to the coffee palace in Smith St, Collingwood.[96] In another building, of 1879, Pepper's vents were fitted both to the external faces of ventilating tubes, near the ground, and to the internal openings in each room, about 2.7 metres above floor level. A sketch indicates that they were grilles measuring 7½ x 14 inches [190 x 356 mm] with vertical slots, possibly of the type in which a matching plate slid horizontally behind the face, so as to open or close the slots as required.[97] Elsewhere in the same building 'peper's [*sic*] ventilating perforations' were used, being a continuous perforated strip. This strip faced a metal box or trunk around the base of a major skylight, doubtless to remove air from the whole of the volume beneath. From the four corners rose vertical tubes leading to vents above the roof.[98]

By the turn of the century British makers produced a number of vents to be used in conjunction with windows. H W Cooper of London had a sliding glass ventilator (perhaps the same as Baillie's, mentioned above?) consisting of a horizontal strip with slots in it, which could be moved laterally so that the slots either coincided with or closed off other similar slots in the window pane. The same principle was used in a circular ventilator with wedge-shaped radial slots, which was rotated a little way to open or close the matching slots in the window pane. The circular vent for a chimney breast advocated by Loudon in 1833, and referred to above, was of this form except that it consisted of two circular plates, each radially perforated. The name of he original inventor is not clear, but there were British patents in the 1840s for vents which were opened and closed with perforated plates, such as that of James Kite. In fact Baillie's ventilator as sold more resembles Kite's patent, including 'a perforated plate, which is itself covered by a second sliding plate, by which the apertures are closed or opened.[99] It likewise resembles James Lochhead's patent of 1848 for a ventilator using 'glass plates so fitted as to slide over them and open and close ... the aperture.[100] In 1852 William Beattie patented a version of the circular type, but with coloured glass in each alternate radiating slot.[101] Later in the century these circular vents were made by Coopers, as well as by Josiah Moore & Sons of London.[102] Examples of these have yet to be identified in Australia, though they must almost certainly have been used.

A slightly unusual British induct vent was one designed for drains, Beard, Dent & Hellyer's 'Air-Inlet Revolving Cowl'. It was a rotating one with a vane on top, like the rotating roof extract vents referred to below, but in this case designed to face into the

---

95 Reed & Barnes, 'Bank at Kooringa', p 40.

96 *Argus*, 27 September 1880, p 5.

97 White, 'Offices for Prell', p 8.

98 White, 'Offices for Prell', p 113; White 'Office for Prell' drawings, SLV, H37133/2&3.

99 Great Britain, patent no 10,273 to James Kite, 26 July 1844.

100 Great Britain, patent no 12,081 to James Lochhead, 19 March 1849.

101 Great Britain, patent no 14,160 to William Beattie, 8 June 1852.

102 Sears, *Contractors' Compendium* (1901), pp 172, 173. They appear, with no maker's name (and five slits) in J R Welsman, *Trade Prices of British and Foreign Plate and Window Glass, &c* (Bradford 1880), pp 40-41.

wind rather than away from it. S S Hellyer recommended its use in association with an educt vent at the opposite end of the drain.[103]

h. roof vents

In 1876 a skillion on the Townsville Magistrate's Court carried a vent in the form of a steep cone with openings in the side,[104] though this would not necessarily have been ducted. In the United States 'this matter' was said in 1850 to be better understood in Boston than elsewhere, and Frederick Emerson had developed two forms of roof vent for 'injecting' and 'ejecting' air. The injecting vent terminated in a series of four conical frustra spaced apart, apparently with a flat plate closing the top, and it was to be connected to a furnace or 'ventilating stove' which would warm the incoming air before it was distributed. The ejecting ventilator had a downward raking flange encircling the top of the pipe, and spacer rods carrying a flat plate or 'fender' a little way above. It was to be placed 'on top of the house' to allow the impure air to escape. It was not connected to tubing, but simply opened into the roof space.[105] Four Emerson vents above the roof were provided to ventilate the skylight of Queen Street office building mentioned above.[106]

The frustrum of a cone was a shape amenable to tinsmithery, and continued to feature in inventions such as that of W H Dupré and Clement Le Sueur in 1852, in which the top of the chimney was a frustrum, above which was a second frustrum, and above that a closed cone with spiral plates around the outside.[107] By 1883 Frederick Braby, of London and elsewhere, was advertising Dr Alfred Hall's patent 'Perfect' ventilator as the most useful of those available,[108] which is puzzling, as there appears to e no British patent in Hall's name.

In 1892 the Sydney Water Supply and Sewerage Board mounted an exhibition in connection with the Intercolonial Medical Congress, and this provided a sort of conspectus of educt and induct ventilators, including the very effective Whitehead fixed induct vent, which had been invented by an officer of the Board itself:[109]

	efficiency	**base wind power in miles**
stationary exhaust cowls:		
Jordan	24.51	6.28
Torpedo	25.74	6.34

103 S S Hellyer, *The Plumber and Sanitary Houses* (London 1877), p 70.
104 Information from Peter Bell, 1991.
105 A J Downing, *The Architecture of Country Houses* (New York 1850), pp 190-194.
106 White, 'Offices for Prell', p 11; White 'Office for Prell' drawings, SLV, H37133/2&3.
107 Great Britain, patent no 14,071 to William Henry Dupré & Clement La Sueur, 17 April 1852.
108 *F. W. Braby & Co. No. 9* [catalogue] (London 1883), p 122.
109 *Australasian Builder and Contractor's News,* 8 October 1892, p 187.

revolving exhaust cowls:		
Walker	25.79	5.10
Standard Adelaide (Gray's)	11.86	9.96
fixed induct cowls:		
Whitehead	45.94	5.71
Robey	39.74	6.71
revolving induct cowls:		
Acme	43.24	4.90
Jordan	41.65	6.22

Such systems had their limitations, and a Melbourne architect wrote in 1883 of the 'entire failure of the System of Ventilation in the Government Offices in Melbourne' as being conclusive proof of 'the utter absurdity of using so-called patent Systems on the Self-Acting Principle.'[110] The Torpedo and the Standard Adelaide or Gray have been mentioned above as chimney cowls - the Torpedo failing to perform satisfactorily at Professor Allan's house, and the Gray proposed by Mrs Allan to replace it - ill-advisedly, as these figures would suggest. However the architects Reed, Smart & Tappin (as they became) seem to have been persuaded. In 1890 they specified 'Gray's vacuum vent valve 5/- each' on top of four inch [100 mm] pipes in the roof of the Metropolitan Gas Offices, Melbourne.[111] Five twenty inch [500 mm] Torpedo vents were installed in the Langtree Avenue hall, Mildura, in 1892, and in combination with induct hopper vents, were reported to meet the standard set by the Central Board of Health.[112]

Some other prominent types are known only by name, and cannot be definitely categorised here, as with Kershaw's patent ventilator or exhaust cowl, used in the New Oddfellows Hall, Sydney, in 1887,[113] and in the ridge of the A U S N Co's building, Brisbane, in 1888.[114] In 1889 a New South Wales application for 'ventilating caps' was made by Charles Swindell of Sheffield, England,[115] but it is impossible to know whether this was a model actually marketed in the colonies. Only in 1899 did 'upcast shaft vents', as opposed to central ventilating lanterns, become a

---

110 'New Public Offices: Brisbane: Report Accompanying Drawings: Bearing Motto', 30 November 1883 (transcript held by Historic Buildings Branch, Brisbane), p 17.

111 Reed, Smart & Tappin, 'Specification &c, Erection of New Premises Flinders Street the Metropolitan Gas Co Limited' (Melbourne 1890), p 57.

112 *Mildura Cultivator,* 16 January 1892, quoted in Andrew C Ward & Associates, *"Rio Vista" Conservation Analysis* (no place 1988), p 177.

113 *Australasian Builder and Contractor's News,* 18 June 1887, p 103.

114 *Australasian Builder and Contractor's News,* 8 December 1888, p 515.

115 *Australasian Builder and Contractor's News,* 16 March 1889, p 262.

part of standard design practice in Victorian schools. These upcast vents were on the Kemp & Sheehan model, of a cylindrical flue with a flat conical cap supported above it. Below this the top of the flue proper broadened out into a flange which was supposed to deflect the ambient air currents upwards, and thus induce upward draught in the tube more or less regardless of external conditions.[116]

In Queensland that prolific inventor Harry J Marks in 1903 patented a form of roof vent which became a trademark of his buildings, and was also used as the termination of a flue. It came in a great variety of forms, but basically the outlet through the roof was square rather than circular, and as the square tube rose it bellied out in one dimension and then returned to square, giving a pot bellied effect. Within the distended portion a V-shaped (or sometimes otherwise shaped) channel ran transversely, and served to catch the rain which fell down the open top of the vent, and discharged it sideways. The rising hot air was divided into two streams as it passed, and then reunited above the V. Whether this was thought to have some aerodynamic advantage is not clear.[117]

Other systems of extraction without mechanical power had been known in England from before the mid-century. In 1844 Dr D B Reid illustrated a rotating cowl vent, and reported that he had used one as large as 4.5 metres diameter at the Old Bailey, weighing two tonnes, and moving on rollers.[118] In 1845 the British ironmonger John Porter advertised the fact that about fifty of his patent 'ventilating chimneys (with external propelling power)' had been successfully installed at Buckingham Palace.[119] C B Allen described two ventilating systems, in one of which the top of the flue tapered and entered an outer tube so designed as to create suction, while the other contained a moving screw and was similar in principle to rotating vents used today. In this latter system the top of the flue carried a finned wheel, like a paddle wheel placed on the flat, which would be rotated by any passing breeze. The vertical axis of this wheel continued down the shaft and served also as the axis for an archimidean screw in the shaft. Thus the turning of the wind vane automatically turned the screw, which then drew air up the shaft.[120] This device had already been used in chimney flues to help in extracting smoke. Charles Tomlinson, in his *Warming and Ventilation,* was doubtful of its efficacy, but discussed it in the context of other quasi-mechanical devices such as revolving bonnets and cowls, which were already well-known in Britain.[121]

This revolving type of ventilator was perhaps that used in the old Legislative Council Chamber, Adelaide, in 1855 - 'a ventilating turret which acts like a windmill and

---

116 Burchell, *Victorian Schools,* pp 158-160. Kemp & Sheehan were in Little Collins Street, Melbourne, in 1926: J S Gawler [ed], *The Architects' and Builders' Index (Victorian Edition)* (Melbourne 1928), p 16.

117 Morag Papi, *James Marks and Sons, Architects, Toowoomba* (no place or date [?Brisbane]), pp 21, 25, 77-8; Queensland patent no 7382, lodged 22 July 1903.

118 Reid, *Theory and Practice of Ventilation,* p 79.

119 Akira Satoh, [ed Ralph Morton], *Building in Britain, the Origins of a Modern Industry* (Aldershot [Hampshire]1995 [1986]), p 201, ref *Builder,* III (1845), p 484.

120 C B Allen, *Rudimentary Treatise on Cottage Building* (London 1854 [1853]), pp 50-51.

121 Charles Tomlinson, *Warming and Ventilation* (London 1860), pp 88-9; Thomas Tredgold, *Principles of Warming and Ventilating Public Buildings, Dwelling-Houses* (2nd ed, London 1824), pp 91-2.

keeps the place cool besides forming an appropriate ornament to the building'.[122] Another type was a stationary roof vent which was indented to provide both induction and eduction. It consisted of a pair of concentric vertical tubes, with two cowls one above the other, the upper one connected to the inner (and purportedly educt) tube, the lower one to the outer (or induct) tube. This type was patented by J McKinnell of Glasgow, and was available by the early 1860s.[123] It has not been reported in Australia, and it seems questionable whether it would have worked at all. A type which did appear in Australia, but of which no detail is known, is Banner's patent ventilating cowl, which was used in 1878-9 to ventilate each of the principal rooms of the Australian Club, Melbourne.[124]

In 1858 James Howarth received provisional patent protection in Britain for a smoke vent with 'curved or spiral openings at the sides for the discharge of smoke', but it was intended to be used also as a general educt vent or, by reversing the action, an induct vent.[125] By the 1870s J Howarth & Co of London were manufacturing the rather elaborate looking archimidean ventilator,[126] some models of which were exhibited at Sydney in 1879 and Melbourne in 1880,[127] and by the turn of the century they were producing a whole range of rotating vents including the 'Radial', 'Archimidean', 'Horizontal' and 'Champion' types.[128] By the 1880s Frederick Braby of London was also making a range of 'Improved Archimidean Ventilators', and the 'Fitzroy' improved revolving ventilator, which was patented.[129] The French *Tourne-au-Vent*, on the system of Hugo John, was being advertised at the turn of the century in a number of rather fancy vaned models, but although it was geared partly to the French colonial market, there is no reason to anticipate finding it in Australia (though if it were, it could be recognised by the firm's squirrel trademark).[130] The distant successor of these types was the 'Rotor' vent, which turned on ball-bearings and, according to C J Virgo in 1955, achieved a suction of from 100 to 700 cubic feet [2.8 to 19.8 m^3] per minute.[131]

i. Robert Boyle and the 'air pump'

---

122 *Australian Journal*, quoted by E & R Jensen, *Colonial Architecture in South Australia* (Adelaide 1980), p 143.

123 E S Eyland, Francis Lightbody, & R S Burn, *Working Drawings & Designs Architecture and Building* (Edinburgh, no date [c 1863]), 4-15; R S Burn, *Modern Building and Architecture* (London, no date[c 1870]), p 143.

124 Great Britain, provisional patent no 853 to James Howarth, 19 April 1858.

125 Michael Clarke, *Clarke of Rupertswood 1831-1897* (Melbourne 1995), p 125. It was illustrated as a device for curing smoky chimneys in *Cassell's Household Guide to every Department of Practical Life* (4 vols, London 1869-71), IV, pp 353-4.

126 Howarth's Patent Revolving Archimidean Screw Ventilator, illustrated in Hellyer, *The Plumber*, p 70.

127 Sydney International Exhibition 1879, *Official Catalogue of the British Section* (London 1879), p 219; Melbourne Exhibition 1880, *Catalogue*, II, p 319.

128 J E Sears [ed], *The Contractors,' Merchants,' and Estate Managers' Compendium and Catalogue* (15th ed, London 1901), p 171.

129 *Braby, No. 9*, pp 120-1 & inserted page, pp 118/9, of 1886 or later.

130 *Prospectus C, Spécialité Appareil Perfectionnée pour Fumisterie, &c* (September 1902), flier bound in with Comptoire de l'Industrie, L Laurent & Carrée, *Tarif des Fournitures Générales pour l'Industrie* (Reims, nd [c 1890]).

131 Virgo, *Australasian Building Knowledge*, II, pp 221, 226.

The field of ventilation was dominated in the late nineteenth century by Robert Boyle, a London manufacturer. He deserves particular mention because he produced an extensive range of extract ventilators, many of which appear to have been used in the Australian colonies, and also because of the special interest he took in the region. The 'air pump' ventilator, which was the cornerstone of his business, appears to be that described in British patents of 1870 and 1871.[132] The first local reference to Robert Boyle's products also appears in the 1880s. It is by one of the competition entrants for the new Public Offices ['Treasury'] in Brisbane in 1883, who proposed a system of vents leading to the corners of the roof 'surmounted with Boyle's air pump exhaust'.[133]

Boyle was said to have perfected his air pump ventilator in 1887, and apart from selling individual versions of it, he apparently developed an integrated system of ventilation for workhouses and hospitals in 1882, using the air pump and 'air inlet brackets', to ventilate cheaply, efficiently, and without draught.[134] Boyle actually visited Australia 'in the interests of sanitary science and of the well-known ventilating and sanitary appliances of which he is the inventor'. An account of the trip appeared in the *Building News* of 2, 9 and 16 September 1892, and was then reprinted as a booklet.[135] He later produced an extraordinarily handsome and self-consciously artistic catalogue-cum-treatise, in which a number of the products look familiar in relation to Australian examples.[136]

Boyle's ventilators were being advertised by McEwans of Melbourne in 1886,[137] and the specification for the Bairnsdale Courthouse in 1892 required the closets to be fitted with four inch (102 mm) galvanized iron vent pipes, each with an approved cowl of the 'Boyle' pattern (which, unusually, was actually sketched in the margin).[138] In Western Australia Boyle's vents appear in public buildings only in the period of G T Poole, that is after 1896.[139] In Queensland Boyle's ventilators, obtainable from James Campbell & Sons of Brisbane, were specified for the Post and Telegraph Office at Barcaldine in 1899.[140] The drawings for the Roma and Gympie court houses, both of 1900, each show a large ventilating cupola with a vertical shaft and two branch ducts serving three vents in the courtroom ceiling, rather in the manner of the Bairnsdale Court House, but whether the fittings are by Boyle or some other manufacturer is not immediately apparent.[141] They are not named on the drawings,

---

132 Great Britain, patent no 2,120 to R Boyle, 28 July 1870\, and provisional patent no 221 of 27 January 1871. No particular significance seems to attach to no 1296 of 30 April 1872.

133 'Esperance: Description etc. of Designs of Proposed New Public Office: Brisbane' [1883] (transcript held by the Historic Buildings Branch, Brisbane).

134 Joseph Gwilt [ed Wyatt Papworth], *An Encyclopædia of Architecture* (London 1899 [1842]), § 2278k, p 742. 'Air pump' was a term previously used by the Marquis de Chabannes in his own ventilating system: Great Britain, patent no 3963 to Jean Fréderic, Marquis de Chabannes, 5 December 1815; no 4192, 19 December 1817.

135 Robert Boyle & Co, *A Sanitary Crusade through the East and Australasia* [London 1892] - not yet sighted by the present writer.

136 Boyle, *The "Boyle" System*, passim..

137 Mayes, *Australian Builders' Price-Book* (1886), advertisements, p xix.

138 The sketch shows a flatter pitched top than most of the more Gothic examples in Boyle's catalogue, *infra*, but otherwise resembles his models 230 and 231. 'Specification ... of New Court House at Bairnsdale', 14 November 1892, p 32.

139 Information from Ingrid van Bremen, 1991.

140 Queensland Archives WOR/A 1899/1293, Post and Telegraph Office, Barcaldine, quoted in a letter from Ian Evans, 4 June 1991.

141 Extracts of drawings and specifications kindly supplied by Paul Burmester, 1991.

but a contemporary report states that Boyle's patent ventilating towers were used at Gympie, and also describes 'air shaft ventilators [that] admit the air from below the building and opening out at the height of the dado moulding.' These latter were Tobin tubes, and in the case of Roma they are identified as such in the *Annual Report* of the Department of Public Works.[142]

Boyle's patent ventilators 'of all sizes and descriptions' were advertised in 1907 by G E Crane & Sons of Sydney.[143] Some of Boyle's vents were installed in 1903 in the Supreme Court at Perth, where two of them survive.[144] In Brisbane two 'Boyle's patent ventilators eighteen (18) ins. diam' were specified for the roof of the Boggo Road Gaol in 1901, each with a shaft down to a bell bottom over a ceiling ventilator.[145] The Male Ward at the Ipswich Hospital for the Insane had four thirty inch [760 mm] Boyle's vents along the ridge, with a larger one at the centre. In two other locations standpipes rose from near the eaves and terminated in ten inch [255 mm] Boyle vents, apparently serving to exhaust the plumbed areas. The ridge vents were all connected by means of tubes to between four and six ceiling vents in the rooms on the first floor, or, in two or three instances, by an indirect route to the ground floor.[146] At the Peel Island Lazaret of 1907 a typical leper's hut had a Boyle ventilator with a nine inch [225 mm] shaft down into the room.[147]

Ron Douglas of Toowoomba holds two locally obtained Boyle ventilators in his collection, one with a four inch [100 mm] and one an eight inch [200 mm] throat, labelled respectively 'Robert Boyle & Sons Patented CC ventilator D41490' and 'Boyle's Patent Air Pump Ventilator no. 968484'. Ian Evans reports a photograph of the Brisbane premises of H A Chadwick, gas and hot water engineer, and importer of stoves, sanitary fittings, &c. The picture dates from about 1900, and shows on Chadwick's verandah something which resembles a Boyle vent[148] - but it is not identifiable, and so may be another British manufacturer, such as Donald & Sime, or Hayward Brothers & Eckstein Ltd, both of whom made similar models.[149] A surviving vent at the house 'Craigellachie', Melbourne, raises the question of whether local makers may have produced Boyle's vents under licence. It is labelled as a chimney cowl, but the evidence suggests that it was one of two ventilating a passage or covered way. It cannot be dated, for the house has a complex history, but it bears two separate labels:

[oval containing:
[upward arc:

142 'The Gympie Court House', *Gympie Times*, Christmas Supplement, 24 December 1901, p 3 [copy held by the Gympie and District Historical Society; A B Brady, 'Annual Report of the Department of Public Works for the Year 1901-02', *Queensland Parliamentary Papers*, III (Brisbane 1902), p 3: both sources quoted by David Rowe of Geelong, letter of 12 October 1994.

143 Walter Jeffries, *The Australian Building Estimator* (Sydney 1907), advertisements, no page.

144 Information from Ingrid van Bremen & Robin Campbell, 1991.

145 Extracts of drawings and specifications kindly supplied by Paul Burmester, 1991.

146 Thomas Pye, Government Architect, 'Ipswich Hospital for the Insane New Ward for Males', contract drawings sheets 2, 4, 5, 6, 7, 8, signed 18 April 1907: copies kindly supplied by Michael Kennedy.

147 Information from Robert Riddell via Ian Evans, 2000.

148 Information from Ian Evans, 2000.

149 William Henman, 'Ventilation', in G L Sutcliffe [ed] *Modern House Construction* (6 vols, London 1909 [1900]), V, pp 195, 201; Sears, *Contractors' Compendium* (1901), p 175.

J DANKS & SON
]
MAKERS
[downward arc
MELBOURNE]

and

[oval containing:
[upward arc:
J DANKS & SON
]
MAKERS
[downward arc
MELBOURNE]
][150]

Boyle's ventilators seem to have been even more extensively used in South Africa, where by 1902 they were sold through Ross & Co of Cape Town.[151] In New Zealand James Hargreaves was selling a range of cupola and flèche-type ventilators in about 1916 which look so much like Boyle's models as to arouse suspicion. They were advertised under the 'Ideal' brand, with no mention of Boyle, but a patent number was cited, 24,178, which may prove to be the means of establishing their origin.[152] Salmond illustrates a soil pipe ventilator at Wanganui which looks very like Boyle's no 175A.[153] The local dominance of the Boyle vents probably ceased by about the time of the Great War, but the firm was still prominent in Britain in the 1930s, still marketed the patent 'Air-Pump' Ventilator,[154] and undoubtedly continued to play some role in Australia.

j. later types

By the first decade of the century there were a number of competing products in Australia, some of them locally made, and Jeffries lists not only named brands, Breach's, Excelsior, and Jordan's, but also ventilating cowls of an unspecified make which were cheaper.[155] Jordan's was one of the stationary exhaust cowls included in the Sydney test of 1892 (see above). Breach's ventilator was one of those which run from a funnel above a ceiling opening up through a tube extending above the roof with a circular top. It was specified in 1907 for the Peel Island Penitentiary at Moreton Bay, Queensland, where examples still survive.[156] Robertson's ventilator, a common industrial type by the 1950s, contained no moving parts, and looked like a

---

150 Inspected 2001.

151 Desirée Picton-Seymour, *Victorian Buildings in South Africa* (Cape Town 1977), p 27.

152 James Christie, *New Zealand Houses* (Auckland, no date [c 1916]), p [64].

153 Jeremy Salmond, *Old New Zealand Houses 1800-1940* (Auckland 1986), p 141 (right); Boyle, *The "Boyle" System of Ventilation*, p 94.

154 J E Sears & J E Sears [eds], *The Architects' Compendium and Annual Catalogue* (London 1936), p 508.

155 Jeffries, *Australian Building Estimator*, p 222.

156 Information from Thom Blake, Brisbane, April 1993.

squat cylinder supported above the roof on a stem. It was made either of galvanised steel or of the 'protected metal' produced by the same company.[157]

In Queensland a large vent commonly surmounts the roof of a house, and this has become an almost vernacular characteristic, typically circular with a shallow conical top and a frilly edge. There is nothing to indicate that these contain any moving parts or any special internal components, and they are probably little more than vertical tubes with decorative tips according to the taste of the tinsmith. One possible maker is R G Verney & Sons, 'jam & canister makers, tinsmiths & ironworkers' whose factory in Fortitude Valley had four such vents on the ridge (in addition to a large louvred ventilating monitor as the front).[158] Verney had started as a tinsmith and only later diversified into jams and preserves.[159] More specialised vents continued to be used in major urban buildings. In 1934 'John Tann's patent steel galvd. vents, size nine (9) ins, by three (3) ins, [229 x 76 mm], complete wth galvd. steel gauze panels' were specified for the last stage of the Treasury building.[160] Both 'Breaches' and Boyle's vents were still cited as current types by the Queensland architect C J Virgo in 1955.[161]

The Excelsior 'Daylight' ventilator, said to be patented, was in the same general category, but had a disc of 1/4 inch [6.4 mm] plate glass at the top, so that light would shine down it. The agents were the Excelsior Reinforced Concrete and Engineering Co of Sydney.[162] It was similar to the skylight or glass top 'Star' ventilator made in the United States by Merchant & Evans.[163] Another such combination, but one in which lighting was the primary consideration and ventilation the secondary, was the 'Patent Deluge Safety Skylight' produced by J Florant of Melbourne. This was a rectangular framed glazed skylight designed to fit into corrugated roofing, with some sort of apertures around the frame for ventilation. It was claimed that it would 'exhaust more foul air than any other ventilator known'.[164]

k. ventilating ridges

There is no sharp line of distinction between ridge ventilators on the one hand, and on the other those roof ventilators which may be a source of light as well as of ventilation. Lugar's *Country Gentleman's Architect* of 1807 illustrated and described what he called a 'ventilator' for the roof of a dairy, which was no mere attachment, but a substantial element of the architecture. It rose 2 ft 6 ins [0.8 m] above the roof, with luffer-boarded sides, and it was not a major source of light, for there were adequate

---

157 F W Ware & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1957), § 13/3.

158 Photo c 1900, Queensland Newspapers (*Courier Mail)*, copy kindly supplied by Ian Evans, 2000.

159 *Queenslander*, 28 July 1900, p 26, courtesy Ian Evans.

160 'Specification, Completion of Treasury Building, Queen and George Street, Brisbane' (typescript, 1924, copy held by the Historic Buildings Branch, Brisbane) p 14]

161 Virgo, *Australasian Building Knowledge*, II, p 226.

162 C E Mayes, *The Australian Builders & Contractors' Price Book* (Sydney, 8th ed, 1914), p 165 & advertisement p 3.

163 *'Sweet's' Indexed Catalogue of Building Construction* (1st ed, New York 1906), p 178.

164 *Cazaly's Contract Reporter*, XXIV, 25 (23 June 1908), p 99.

windows below.[165] In general, longitudinal ridge ventilators were not common until late in the nineteenth century, despite the fact that one type, Kyte's, had been reported in England as early as the 1840s.[166] An illustration of the Townsville Hospital, built in 1868, shows some sort of ventilator looking like a little gable roof, which runs continuously along the full length of each of two parallel roof ridges.[167] A more elegant solution was to have the top of each corrugated iron roof slope flare upwards a little, with a gap at the apex, and above the gap a semi-cylinder of corrugated iron to weatherproof it.[168] More straightforward is ventilation ridging which consists only of the regular ridge and hip capping raised slightly so as to provide continuous ventilation under its edges, which was used and still survives on the iron roofing of Bishop's Lodge, Hay, in New South Wales, built in 1888 to the design of John Sulman.[169] It does not seem to have been in general use at this time, but by 1890 it was regularly installed in the car sheds of the Melbourne cable tram system, designed by the architects Twentyman & Askew.[170]

In 1897 the architects Hall & Dods designed a house at Heathfield, South Brisbane, which had tray and roll metal roofing, with a ridge at the top vented through the spaces corresponding to each tray. They used the same detail in other buildings of the period.[171] A large ridge with a curved top was provided for the Wesleyan Church in Darwin, prefabricated by Simpsons of Adelaide in 1897. Ventilating ridging is listed in Walter Jeffries's *Australian Building Estimator* in 1907,[172] but does not appear in Mayes's *Australian Builders Price Book* until 1914.[173] In Bates, Peebles & Smart's drawing for what is probably the sanctuary added to Sale Cathedral in 1911, is a ventilating ridge framed up in timber, but superseded by a note 'substitute Wunderlich's patent ridge for this'.[174] Ventilating ridges, as well as individual roof vents, were being made in asbestos cement by the 1930s.[175] By 1949 Lysaghts were illustrating a wide range of ventilating ridges in galvanised iron, but they were all intended for factory use,[176] and it seems generally true that such ridges disappeared from domestic building, while becoming more and more common in industrial work. A regular ventilating ridge in galvanised iron is illustrated by C J Virgo in 1955.[177]

---

165 Robert Lugar, *The Country Gentleman's Architect* (London 1807), p 13, pl xiii

166 *Builder,* III, 132 (16 August 1845), p 391: this vent appeared to have three baffles along the sides.

167 Reproduced in Peter Bell, *Timber and Iron* (St Lucia [Queensland] 1984) p 122.

168 Buildings with this form, and believed to date from the 1880s, are found at the Clyde Woolscour, South Geelong. Information from Chris Gordon, Geelong, 1996.

169 M L Gardam, *The Bishop's Lodge* (Hay [NSW] 1993), p 12, quoting *Riverine Grazier*, 20 August 1889.

170 Research notes by Robert Green et al, Port Melbourne Cable Tram Car Shed file, National Trust, Victoria.

171 Information from Robert Riddell, 1991, referring especially to the drawing of the house in Oaklands Parade, Heathfield , dated 8 December 1897. It was later moved to Laidley and became the music school of the Church of England Grammar School.

172 Walter Jeffries, *The Australian Building Estimator* (Sydney 1907), p 215.

173 Mayes *Australian Builder's Price Book* (1914).

174 Bates, Smart & McCutcheon drawings collection, Melbourne University Archives, 3.4.

175 See for example, *Hardie's "Fibrolite" Asbestos Cement Corrugated Roofing* (Sydney 1937), p 48.

176 F Wentworth & W L Richardson [eds], *Ramsay's Architectural and Engineering Catalogue* (Melbourne 1949), § 13.2.

177 Virgo, *Australasian Building Knowledge,* II, p 224.

John D Moore's *Home Again!* of 1944, designed to meet an anticipated housing boom at the end of the World War II, included three designs for country houses with something more than a simple ventilating ridge - 'ventilating panels' at the ridge and a continuous 450 mm opening at the eaves. Air would enter at the eaves and be drawn up through the ridge, except in winter when the eave opening would be closed by folding down asbestos cement flaps.[178] In about 1954 the living quarters at Maralinga township in South Australia, built to service the eponymous British rocket range, were provided with a similar arrangement: a continuous ventilating ridge, and a continuous opening into the roof space from under the eaves. The building was a prefabricated one of aluminium, manufactured in England by the Bristol company just before it abandoned the building side of its business, which had been responsible for hundreds of school buildings sent to Australia in the post-war period. It appears to be specifically designed for hot climatic conditions, and though it is designated on the drawings as a 'Mark III' structure, it bears no resemblance to the schools, Mark I and Mark IA, or to the multiple storey buildings, Mark II (none of which has yet been identified in Australia). If it was designed specifically for Maralinga then it may be attributable to Sir Alexander Gibb & Sons, the British engineers responsible for the complex as a whole.[179]

---

178 J D Moore, *Home Again!* (Sydney 1944), pp 51, 52.

179 Information from Terry Sawyer, 1994.