ENGLISH HERITAGE

HISTORIC BUILDING ENGINEERING SYSTEMS & EQUIPMENT

HEATING & VENTILATION

Brian Roberts
Chairman, CIBSE Heritage Group

About CIBSE

With a membership of 15,000, one fifth of which is overseas, the Chartered Institution of Building Services Engineers is an international body that represents and provides services to the building engineering services profession. CIBSE predecessor organisations were the Institution of Heating & Ventilating Engineers, founded in 1897, and the Illuminating Engineering Society founded in 1909.

The IHVE and the IES merged in 1978. Today the role of CIBSE is to promote the art, science and practice of building services engineering for the benefit of all, and to advance education and research in this specialist field.

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www.cibse.org

The CIBSE Heritage Group

The Heritage Group was formed in 1973 with the main purpose of discovering and recording the various aspects of building services history, including systems and equipment, companies and pioneering engineers. The Group has lectured extensively and been responsible for numerous books and technical papers. All of this and much more is freely available on the Group's extensive website: **www.hevac-heritage.org.** The group includes retired and practising Chartered Engineers and Corporate members of CIBSE, former university lecturers and representatives of The Building Services Information and Research Association (BSRIA), English Heritage, The Institute of Gas Engineers and Managers, The National Trust, the Parliamentary Works Services Directorate and the Science Museum.

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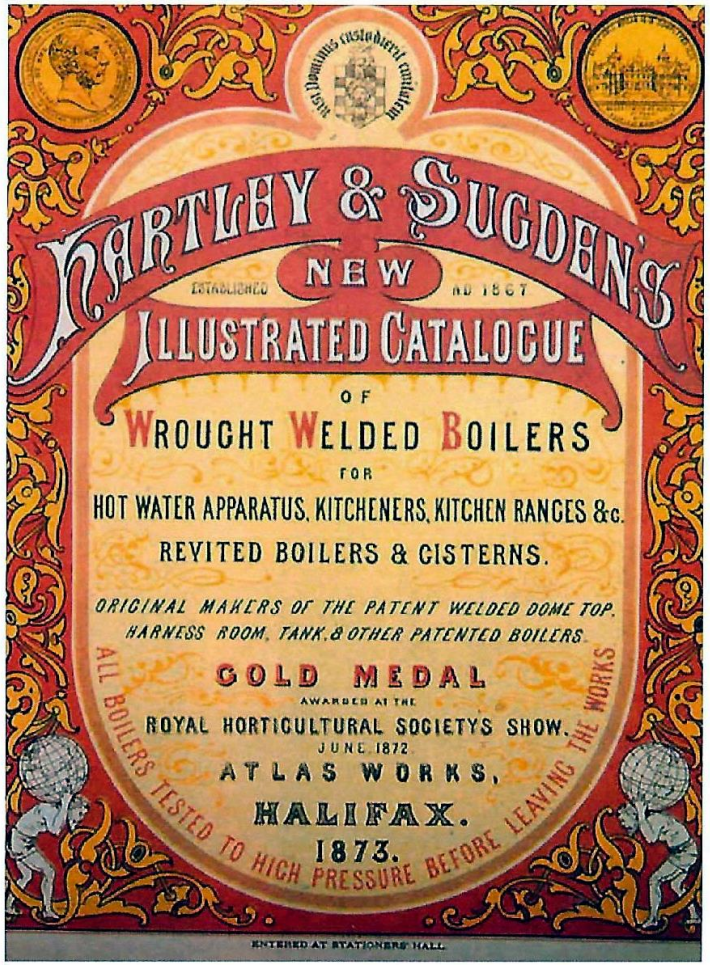
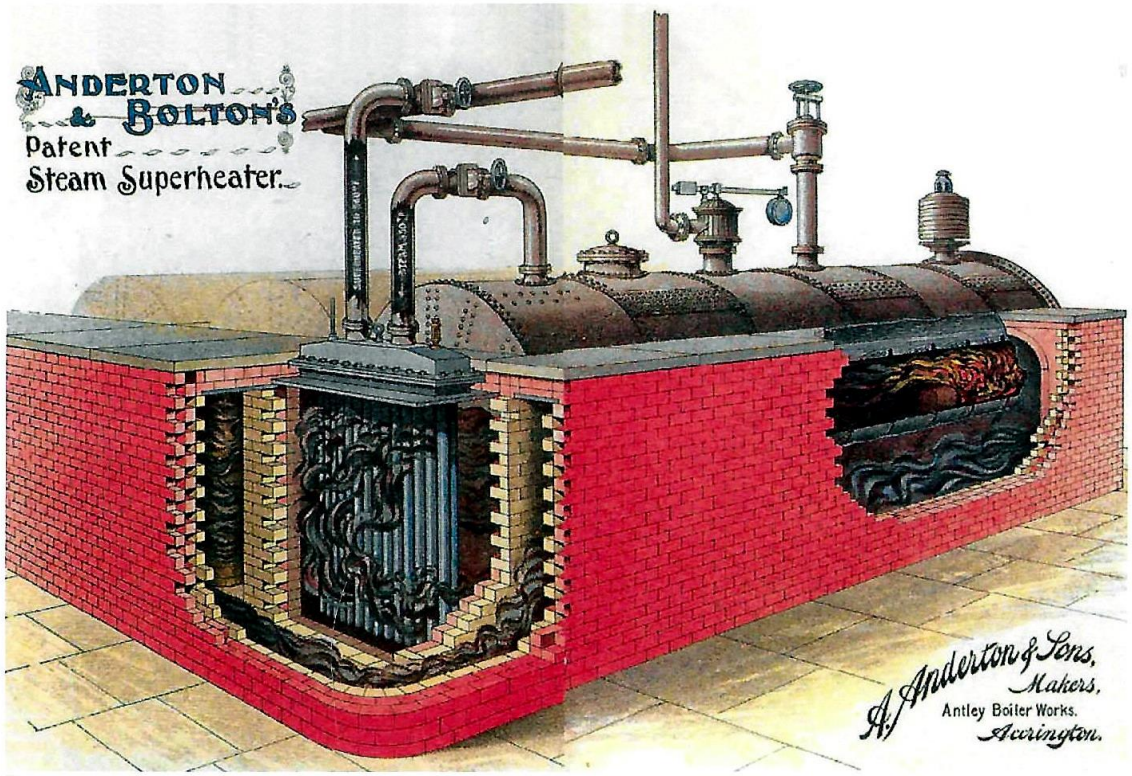
1 Cover of catalogue of Hartley & Sugden, boilermakers of Halifax, 1873



2 This publication has been produced by English Heritage in association with the Chartered Institution of Building Services Engineers



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It is a sad fact that many involved in building services engineering pay little attention to the history of the industry in which they are involved. While we obviously need to ensure that our buildings are serviced in such a way to meet the needs of the 21st Century, all too often we sweep away our engineering past to replace this with modern technology and hi-tech solutions without consideration of what is being lost.

In many instances this is due to that the fact that we do not recognise the significance of what is left. This publication, the first of a number providing an outline of some aspects of the history of building services engineering hopes in some small way to address this problem. We can learn much from the past to guide us in the future.

I would like to thank the CIBSE Heritage Group and especially Brian Roberts; without the dedication and enthusiasm of this group not only would we lose knowledge of our building services engineering past, but it would not have been possible to produce this publication.

DAVID DREWE
Head of Building Services Engineering & Safety
Conservation Department
English Heritage

Heating and Ventilating Systems and Equipment

The most basic type of heating system (other than an open fire) is the stove. The first stoves were made of cast iron, with a door into which a solid fuel, usually coal, could be fed. A low-level ash pit door enabled ash, stones and other residue to be removed. Smaller stoves could be moved and placed in position in one piece, requiring only a flue pipe leading outdoors, to be connected. These stoves were free-standing within the space to be heated. Larger stoves would be assembled in sections. Other stoves were installed either in builderswork chambers with a cold air inlet and with the warmed air discharged directly, or through masonry ducts, to the space served. Examples of both types may still be found, often in cathedrals and churches. Some are still in use, having been converted to oil or gas firing.

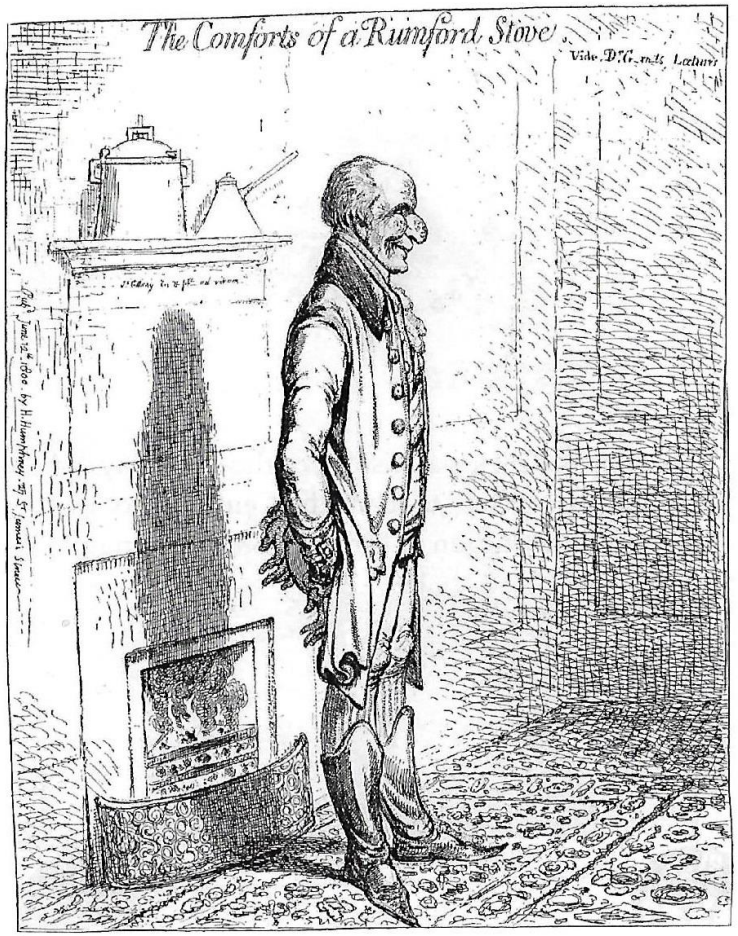
A heating system requires a heat producing apparatus (usually a boiler), a means of distributing the heat (pipes or ducts) and heat emitters in the space served. Types of heating medium include steam, low-pressure hot water and high or medium pressure hot water. The earliest steam boilers, c1700, were developed to drive steam engines and about a century passed before they were used for heating. Hot water heating boilers were manufactured in quantity from around 1860 onwards. The first room heaters were pipe-coils, often housed in decorative cases. Radiators were introduced in the 1880s.

Early ventilation was by natural means. By the 1840s, fire and then heat-assisted systems were in use, the latter using steam or hot water coils to create an up draught, often aided by the heat from gas lighting. Fans for mechanical ventilation were introduced about 1850, being driven by gas or steam engines. Fans driven by electric motors were used from the early 20th century.

3

3 Stove, formerly in the Royal Institution, probably by Count Rumford – metal casing surmounted by bust of Faraday [Royal Institution]

4 The Comforts of a Rumford Stove, 1800



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Heating Stoves

Masonry stoves of brick, earthenware and porcelain have been used for over 1,000 years in northern Europe, particularly in Scandinavia, Russia and Switzerland. Closed metal stoves were devised in Germany in the 15th century and improved over the next 200 years, spreading across continental Europe. But Britain preferred its open fires.

In England, around 1609, the first metal stoves were imported from Holland to heat the orange houses of the nobility. (It is said that the word 'stove' is of Dutch origin and the first English heated greenhouses were in fact called stoves.)

In the 1790s, Count Rumford devised a metal stove, while William Strutt with Charles Sylvester installed his Cockle (or Belper) stove at Derby Infirmary. This Cockle stove consisted of a circular iron pot with a rounded dome. Fuel was consumed on a grate at the bottom of the furnace, coal or coke being added through a charging door at the side. Air for combustion was supplied through a duct to a chamber below the grate.

A forced warm-air furnace was patented by Benford Deacon in 1812, using a fan powered by a descending weight, and used at the Old Bailey. In the latter part of the 19th century, ventilating and other improved grates (the distinction between grates and stoves is not always clear) were due to Sir Douglas Galton, George Jennings (*London* grate), T Elsey (*Lloyd's* patent ventilating grate), D O Boyd (*Hygiastic* grate) and the firm of Shorland (*Manchester* grate).

In 1818, the Marquis de Chabannes introduced his *Calorifere* stove (air warming furnace) from France. Just before this, in 1816, the firm of G & J Haden set up in business in Trowbridge to erect the steam engines of Boulton & Watt in the West Country. Within a few years Haden was manufacturing heating stoves for churches and the country houses of the gentry. Between 1824 and 1914 they manufactured and installed nearly 7,000 stoves. Atkins & Marriot introduced their *Thermo-regulated* stove in 1825, followed by the *Thermometer* stove of Dr Neil Arnott (Physician Extraordinary to Queen Victoria) in 1834. The 1830s also saw the development of the famous *Tortoise* stove by Charles Portway who went on to manufacture some 17,000.

5

5 Buzaglo stove, Knole Orangery, Kent, 1774

6 Stove at Edmondthorpe Church, Leicestershire

7 Tortoise slow burning stove designed by Charles Portway, the first being hand-built by him in 1830 to heat his ironmongery store in Halstead, Essex. Over 17,000 stoves were sold, many for use in churches, by 1880. He used a tortoise as his emblem with the motto 'Slow but Sure.'

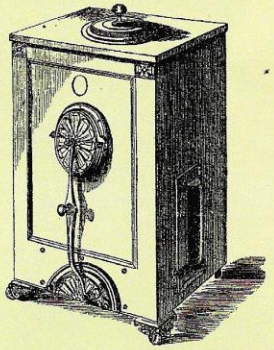
Use of the warm air stove grew considerably from the middle of the 19th century with the tremendous wave of Victorian church building and the construction of many and varied institutions – prisons, hospitals, schools, workhouses and asylums. Around this time Dr Goldsworthy Gurney brought out the large stove which bears his name. It was later sold by the London Warming and Ventilating Co who in 1897 claimed it had been used to warm 22 cathedrals and over 10,000 churches, schools and other buildings. They were also agents for the *Choubersky, Salamandre* and similar continuous burning stoves, which only needed refuelling once a day. Other stoves of the later Victorian period included Saxon Snell's *Thermhydric*, Mr George's *Calorigen*, Dr Bond's Euthermic, the *Manchester* stove of Shorland and the *Convoluted* stove of Joseph Constantine. Another notable heating apparatus manufacturer was John Grundy of London and Tydesley Ironworks, Manchester (the first president of the Institution of Heating & Ventilating Engineers in 1898) whose products included the *Helios* and *Sirius* smoke-consuming grates and the *Hestia* warming and ventilating stove. But the increasing use of hot water heating systems and the introduction of the radiator soon caused a marked decline in the use of warm air stoves.

6

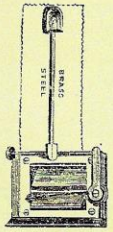
7

COMYN CHING & CO., CASTLE STREET, LONDON, W.C.

DR. ARNOTT'S
ORIGINAL SLOW COMBUSTION FUEL STOVES
WITH
Cook's Patent Regulator or Compound Bars.



Cook's Patent Regulator.

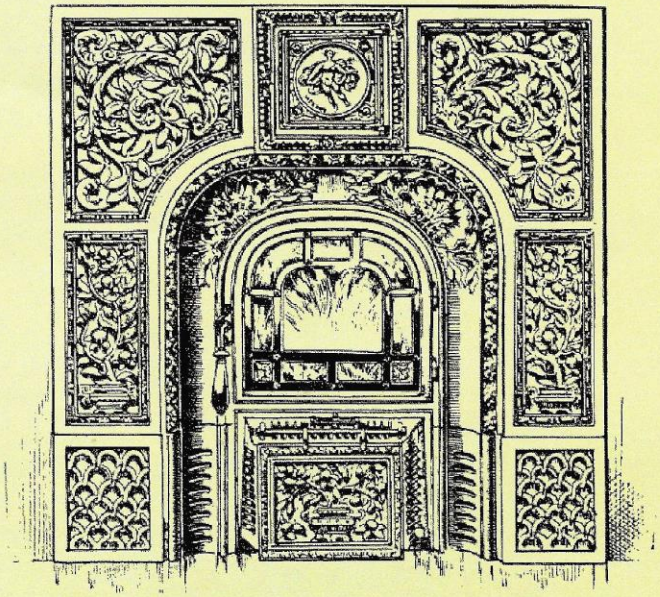


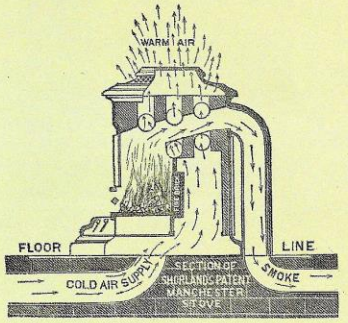
Many years since, this principle was perfected at our Works under the direct superintendence of Dr. ARNOTT, and though many new plans for economically and effectually heating apartments, churches, &c., have since been introduced, the continued and steady sale of these, prove, that they still compete successfully, with the many newer methods.

With these Stoves you reduce the supply of air to the smallest that can be, to support combustion; thus reducing to the minimum the amount of heat lost to use by escaping through the flue.

By Cook's Patent Compound Bar, you actually make your fire regulate itself, for as it begins to burn too fiercely, the Compound Bar becoming heated curves gradually and thus shuts off the supply of air.

8





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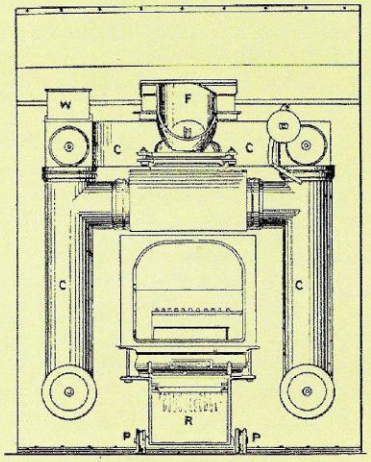

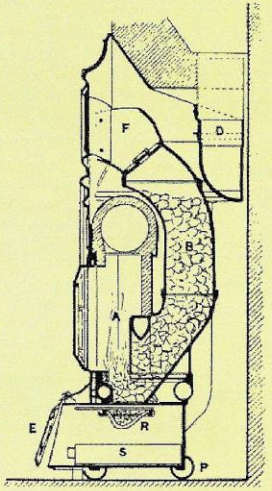

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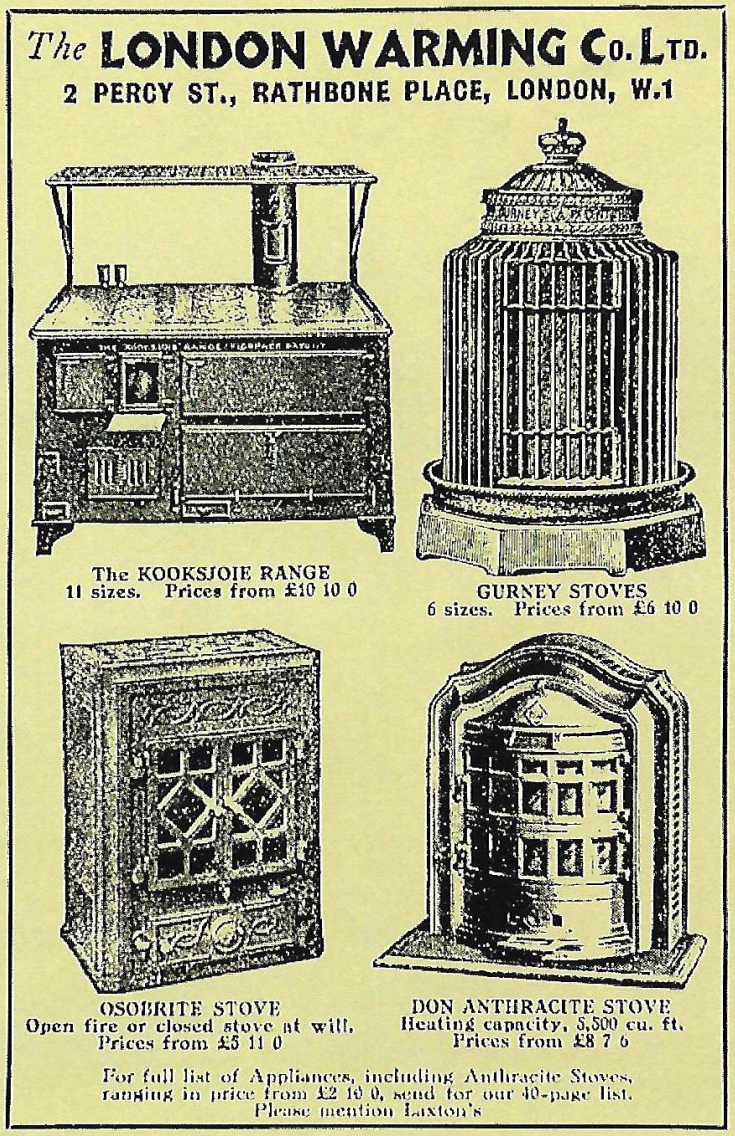


11

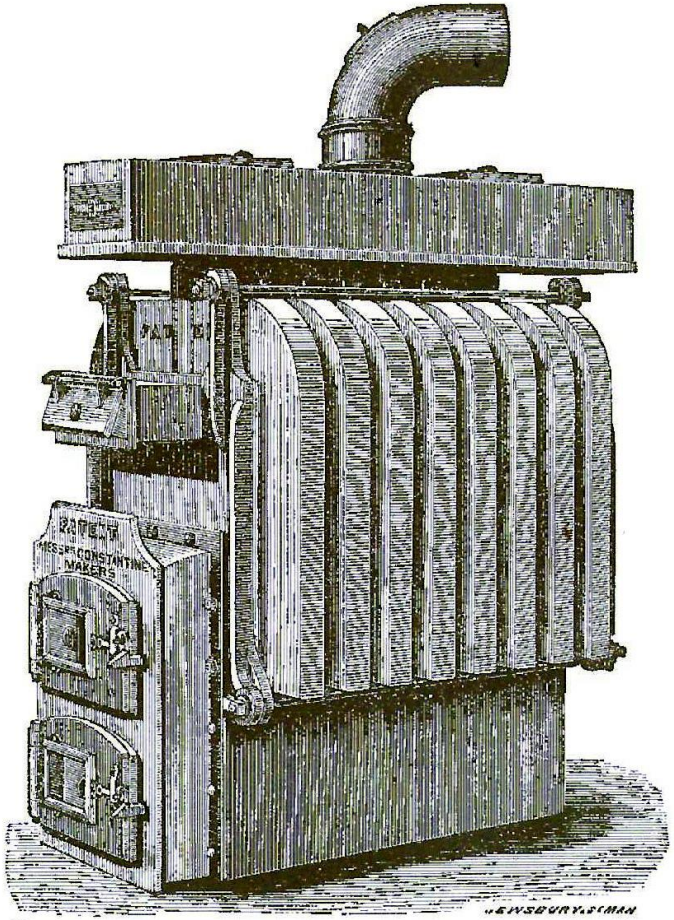
8 Dr Neil Arnott's Slow Combustion Fuel Stove marketed by Comyn Ching, London, probably c1880

9 Shorland Manchester stove, 1907

10 Helios smoke-consuming grate, really a portable stove on wheels, designed by a Mr Heim and sold by John Grundy of Islington, c1890

11 Victorian stoves, including the Gurney stove (top right) invented by Sir Goldsworthy Gurney and installed in many churches and cathedrals

12 The first Convoluted stove made by Joseph Constantine, Manchester, 1881. The stove illustrated has eight convolutes (sections). These stoves were made in sizes with 5 to 12 convolutes each. There were sizes of convolute weighing from 0.5 to 3.5 cwt each (about 19.7 cwt = 1 tonne).



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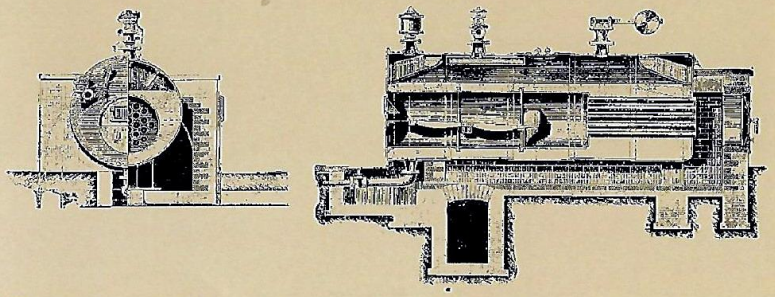
Steam Boilers

The first steam boiler proper was a spherical type described by the Marquis of Worcester in 1663. Other early examples include that of Savery (1698) and Newcomen & Cauley (1705). By 1725 the Wagon and Haystack types of boiler were in common use. James Watt used a steam boiler to operate his engine in 1769. None of these was used for heating. The first steam heating was for factories, from about 1799. A number of engineers including Count Rumford (1798), Richard Trevithick (1800 and 1804) and Thomas Tredgold (*c*1824), produced designs for steam boilers. Perhaps the most important early boiler was the Cornish type, with its single internal furnace, said to have been developed by Oliver Evans of Philadelphia, but given its name in recognition of the help received from Trevithick. A patent by Pearce (1853) was the forerunner of the Economic boiler. The even more famous Lancashire boiler was developed in Manchester by Sir William Fairbain (1855), who increased the length and diameter of the Cornish boiler and introduced two furnace tubes. However, while steam was widely used for power and process work, particularly in the textile industry, factories, breweries and the like, it was not widely adopted for heating and tended to be used only where steam was generated primarily for other purposes.

Notable British steam boiler manufacturers from the Victorian era include Babcock & Wilcox, Cochran, Clarke Chapman, William Fairbairn, Fraser & Fraser, Galloway, Marshall, Musgrave, Paxman, John Thompson and Yates & Thom. Some still exist.



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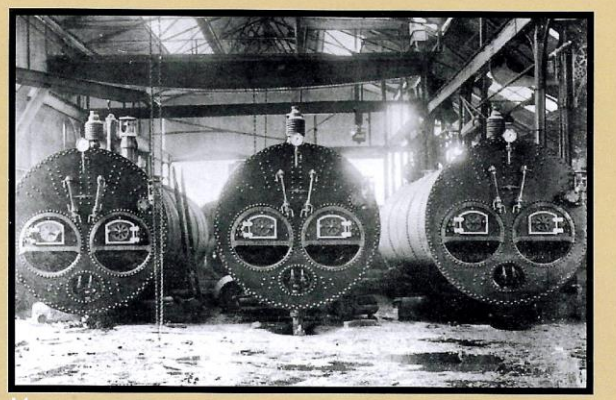
13 Cornish steam boiler with smoke tubes, Marshall & Co, 1898



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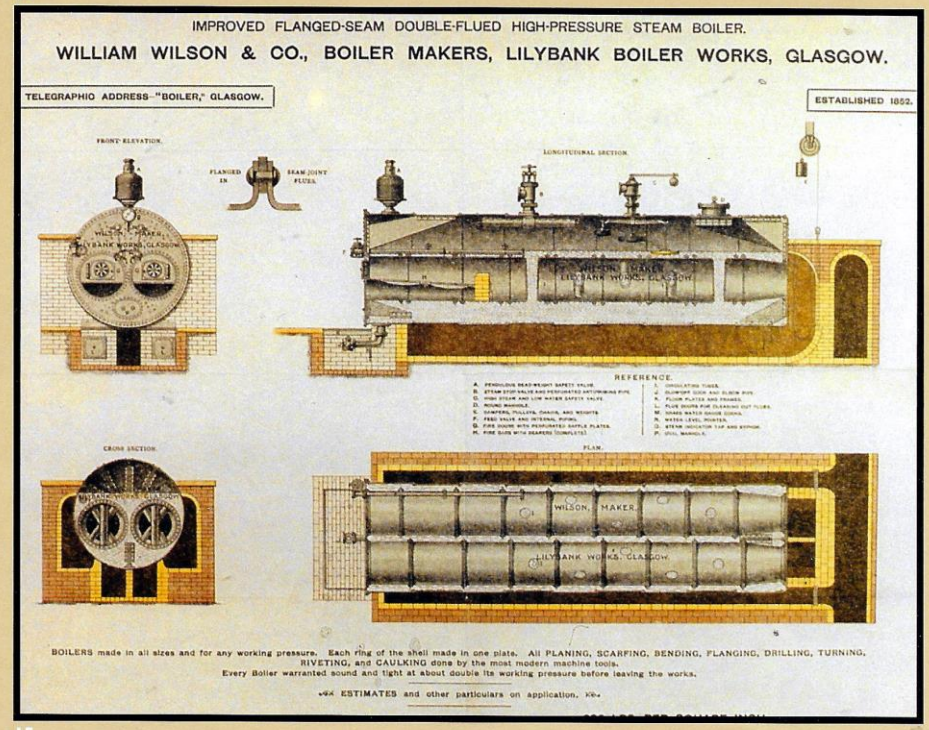


15

14 John Thompson Lancashire steam boilers, 1895

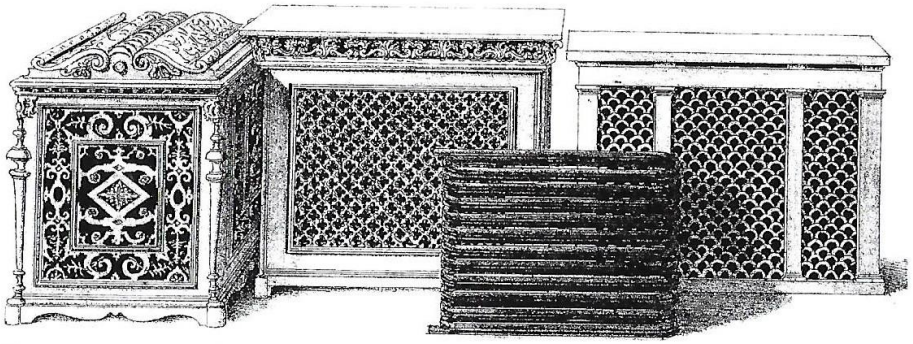
15 William Wilson, Lancashire style high-pressure steam boiler, Glasgow, *c*1900

Perkins' High Pressure Hot Water Heating

16 High-pressure hot water heating coil & decorative coil cases or pedestals [Patent Apparatus for Warming and Ventilating Buildings, A M Perkins, London, 1840]

Angier Marsh Perkins was born in Massachusetts in 1799. He accompanied his father, Jacob, to England in 1819. Jacob secured a number of patents relating to boilers and steam engines (and went on to patent a closed-cycle refrigeration machine in 1834). Meanwhile, Perkins developed a sealed high-pressure hot-water heating system, utilizing small diameter piping developed by the firm of John Russell & Son of Staffordshire in 1825. This was a radical alternative to the other heating systems then in use. In 1831, Perkins secured a patent (BP 6146) for this system. He used 25mm tube (seam-welded wrought iron) with a 6mm wall thickness and a furnace apparatus designed to maintain about 177°C (350°F), though this sometimes reached a dangerous 287.8°C (550°F) and an unacceptably high pressure. These tubes were tested before installation to 10kPa (3000 lb/in^2) gauge), but were known to fail at lesser pressures. Tubes were in lengths of about 3.6m (12 feet). Right and left-hand threads were used to pull the chamfered edge of one tube into the square-cut flat end of the other to make a joint.

In Perkins' first furnaces about one-sixth of the total tube length was arranged in a sinuous coil inside a brick combustion chamber lined with firebrick. The remainder, apart from the circulating pipes, was formed into coils, either free-standing or located inside pedestals (decorative cases). By 1840, the furnace tubes were available within a metal-cased Perkins boiler, but the brick setting arrangement appears to have been widely used, as it was probably cheaper.



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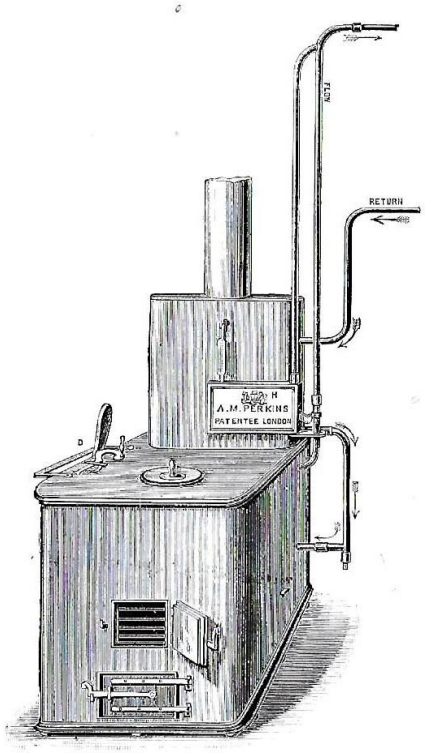
17 Perkins high-pressure hot water boiler, patented 1831

18 Hartley & Sugden, Gold Medal Boiler catalogue, Atlas Works, Halifax, 1872



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18

The high-pressure hot water system also required a governor (heat regulator), an expansion tube and air plug, and various suitable stopcocks and valves. A detailed description is available in Jones 1904 (see Further Reading).

Perkins went on in 1839 to develop a medium pressure system using a water supply cistern containing a relief valve in place of the expansion tube (BP 8311). This overcame most of the objections to the very high and dangerous temperatures and pressures used in the original system. It appears not to have been extensively used at that date, but was later copied by a number of other firms who made a speciality of this system. In 1840, Perkins published his book *A M Perkins' Improved Patent Apparatus for Warming and Ventilating Buildings*. In it he lists numerous examples of installations in public buildings (including churches), private mansions, hothouses, manufactories and offices.

The temperatures and pressures of the high-pressure system greatly concerned the fire insurance companies who eventually raised their premiums to a level where new systems were rarely installed. Many continued in use, particularly in churches, well into the 20th century. Sometimes the furnace was upgraded to oil-firing. More generally the furnace was replaced and the existing piping and pedestal coils retained to warm the building.

HARTLEY & SUGDEN'S
IMPROVED WROUGHT WELDED SADDLE BOILER

TO WHICH THE

GOLD MEDAL.

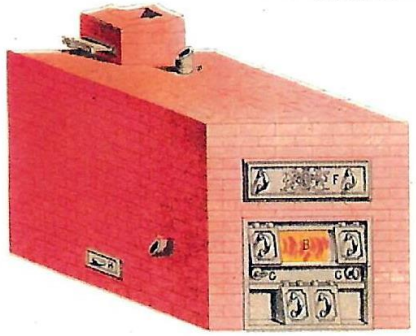
WAS AWARDED AT THE

ROYAL HORTICULTURAL SOCIETY'S SHOW.

AT BIRMINGHAM, JUNE, 1872

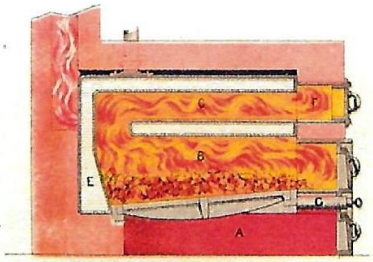
"GOLD MEDAL BOILER"

REGISTERED TITLE



ELEVATION, IN BRICKWORK

CROSS SECTION



LONGITUDINAL SECTION

ELEVATION, WITHOUT BRICKWORK

A *Ashes Pit*
B *Fire*
C *Centre Flue*
D *Right & Left Return Flues*
E *Water-way Terminal End*
F *Sliding Soot Door for Cleansing Flues, with Fire Brick Casing*
G *Sludge Plugs for cleansing internal part of Boiler*
H *Regulating Flues*
I *Hollow Space round Boiler utilizing Heat given off from external surface of Boiler.*

Hot Water Boilers

Although Britain pioneered the steam engine and the steam boiler, the use of steam for heating in other than factories was comparatively rare. Hot water heating is said to have been introduced into Britain from France c1816, but the Price Brothers of Bristol seem to have been largely responsible for its spread. They secured a patent (BP 5833) in 1829 for their system.

The first hot water boilers were smaller and cruder than steam boilers. A high-pressure hot water heating boiler and system was patented by A M Perkins in 1831, but this was an exception as most heating systems were of a low-pressure type (open to the atmosphere) with the water temperature below boiling point. S T Crook (some say Cook) discovered 'fire-welding' in 1854 and opened his Premier Works in Halifax in 1863. Yorkshire soon became a centre for the production of heating boilers. The majority were of the hot water type; a few were for steam heating. Early firms manufacturing boilers in Yorkshire include:

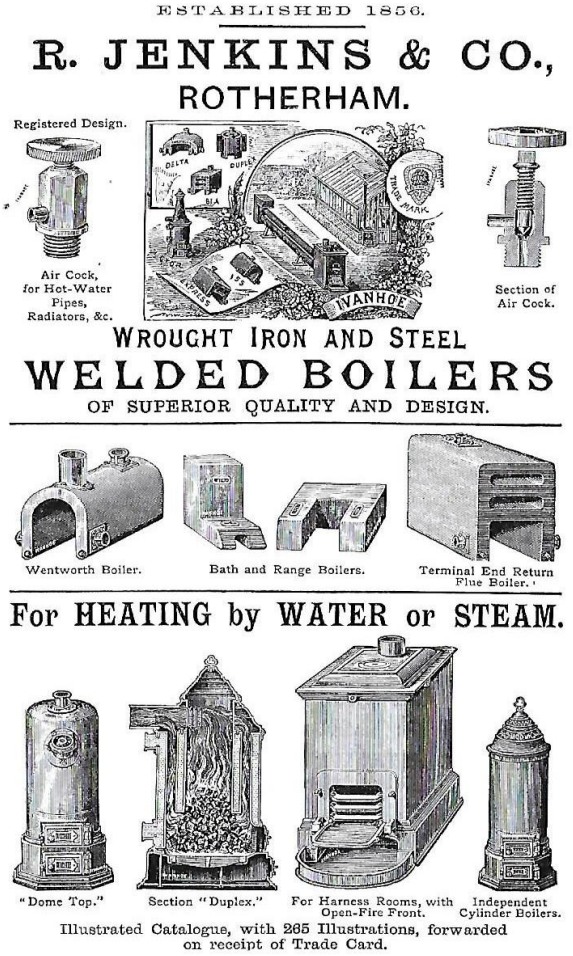
Graham & Fleming, Premier Works, Halifax (1863), successors to ST Crook's Exors;

Lumby, Son & Wood at the West Grove Boiler & Safe Works, Halifax (1858), trade name *Solar*;

Robert Jenkins, Rotherham (1856), trademark *Ivanhoe*;

Hartley & Sugden, Atlas Works, Halifax (1867), trademark *White Rose*;

Binns & Speight, Crown Boiler Works, Bradford.



19 Robert Jenkins, Rotherham, 1891 Established 1856

20 Wagstaff sectional saddle boiler, 1874

21 James Keith horizontal section hot water heating Challenge boiler, 1891 Horizontal sections are unusual

22 Cut-away view Challenge boiler

The Institution of Heating & Ventilating Engineers (now the Chartered Institution of Building Services Engineers, or CIBSE) was founded in 1897 and by 1900 had nearly 200 members; today there are some 18,000. In 1897, Kelly's Directory listed over 600 firms as heating apparatus manufacturers and fitters. The most prominent manufacturers included:

The Beeston Foundry Co, Beeston, Notts

T Fletcher & Co, Warrington

The General Iron Foundry Co, Broken Wharf, London

William Graham & Sons, Castle Yard, London

Jones & Attwood, Titan Works, Stourbridge

James Keith, Holborn Viaduct, London

Kinnell & Co, Southwark, London

Mather & Kitchen, Derby

Thomas Potterton, Cavendish Works, Balham

J Ashton Riley, Canal Boiler Works, Huddersfield

Steven Bros & Co, St Andrew's Wharf, London

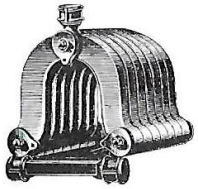
Weeks & Co, Kings Road, Chelsea, London

T C Williams & Sons, London Street Ironworks, Reading

From around 1890, H Munzing of Upper Thames Street, London, who styled himself an 'American merchant,' was a major importer of both hot water and steam boilers from the USA.

One of the earliest, possibly the first, sectional boiler (i.e. made and delivered in sections for site assembly) was Wagstaff's saddle type of 1874. Another early and unusual boiler was the *Challenge* by James Keith, which had horizontal sections (this had the disadvantage that the grate area was constant regardless of height). Hartley & Sugden produced a sectional boiler, the *European*, in 1902. American imported sectional boilers were superior at this time and used taper nipples instead of rubber rings for jointing. British firms quickly adopted this practice, one of the first such cast-iron sectional boilers being the *Robin Hood* of Beeston. The first American company to set up a factory in Britain was probably the American Radiator Co, who started manufacturing under the name of the National Radiator Co in Hull in the early 1900s. They introduced the *Ideal* boiler and the company later became Ideal Boilers & Radiators.

The major manufacturers of hot water heating boilers can often be recognised by the brand name of their main boiler series: Hartley & Sugden *White Rose*, Beeston *Robin Hood*, Ideal *Britannia*, Lumbys *Solar* and the Mather & Kitchen *Severn*. However, many makers had half a dozen or more trade names each. The list is considerable.



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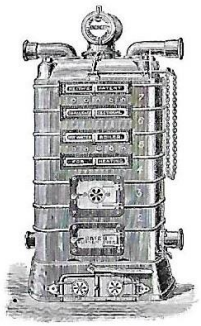

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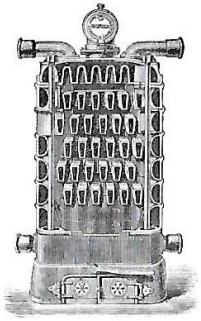

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Fuels and Firing

Wood was the most commonly used fuel until the Tudor period. Charcoal was also used, particularly in braziers, but the forests were being denuded of trees at an alarming rate at a time when timber was used for both ship and house building.

By the time of Henry III coal was being shipped by coastal barge from the Tyne to London. This was known as 'sea-coal'. It was not popular and in 1306 the use of coal in London was forbidden. However, wood continued to be in short supply and the widespread use of coal as a fuel proved to be inevitable. Fireplaces, grates and chimneys were developed accordingly. At the end of the 18th century both Benjamin Franklin and Count Rumford developed rules for fireplace and chimney construction, making the combustion of coal more efficient.

The early 19th century saw the development and use of solid-fuel metal stoves and steam, then hot water, boilers. Both coal and coke were used but as boilers became larger their performance relied on the skill of the men who stoked them. The introduction of automatic draught regulators eased the work, but where shifts of stokers were required this was an expensive operation and automatic continuous methods were sought. Moving large quantities of coal or coke from storage areas to the boiler house could also be a problem. For the Great Stove (glasshouse) at Chatsworth and for the Palm House at Kew, hand-drawn trucks on an underground railway were employed. (The tunnel at Kew survives and houses modern pipes and services).

A type of mechanical stoker was used by Watt in 1785, but the principle of the underfeed stoker was invented by Hawkins & Downson of London in 1816. Brunton made a flat revolving stoker in 1819 and patented a travelling grate, the basis of many modern stokers, in 1822. Smaller boilers used gravity-fed hoppers or magazines.

Early attempts to use mechanical draught fans and oil-firing were largely experimental until the Edwardian era.

23 Patent cinder sifter [Strand magazine, 1904]

24 Decorative heating pedestal designed by William Burgess The heating engineer was Wilson Weatherley Phipson Cardiff Castle, c1880

25 Palm House, Kew, 1848 Originally, coke for the boilers was delivered by underground railway

26 Babcock & Wilcox patent mechanical chain grate (travelling grate) stoker, Renfrew, c1912

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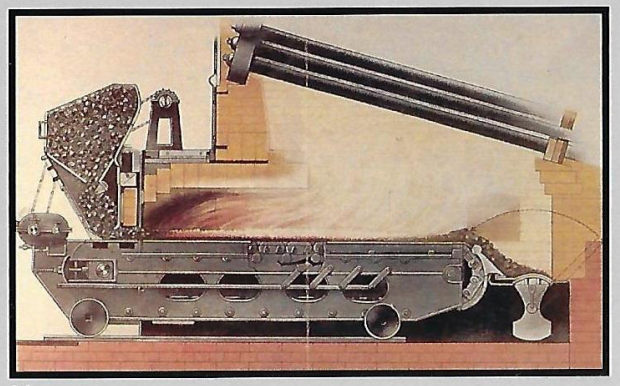

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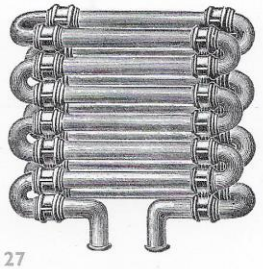
Heating Coils, Pedestals and Cases

The use of steam or hot water for heating required the development of a suitable heat exchanger to warm the air in the spaces being served. In 1784, James Watt used a tin-plate box filled with steam but the output was low because its bright metallic surface did not radiate heat efficiently. Thomas Tredgold, a pioneer of steam heating, suggested in 1824 that the exposed pipes then generally used as heating surface should be concealed or some alternative form of surface used. Earlier, Count Rumford had similar thoughts for his heating of the Royal Institution.

One early form of room heating consisted of cast-iron or wrought-iron pipes of 4 inch diameter (100mm) as commonly used for heating greenhouses (one of the first applications of central heating). This method was so common that it was usual to rate a boiler as suitable for so many 'feet of 4 inch pipe,' (100mm) a practice which continued well into the 20th century. The first alternative was the cast-iron pipe-coil, made by connecting short lengths of pipe by means of 180-degree return bends. Both socket and flanged bends were used. The 'box-end' coil, where the horizontal lengths of pipe, typically five or six in number, were connected at either end into vertical headers, came next. Small diameter pipes, perhaps 2 inches (50mm) or less, were used for steam coils while larger 3 (75mm) and 4 inches (100mm) size were employed for hot water heating. Heating coils could be either external or internal socket type.

In 1876 Walter Jones of Stourbridge patented a hot water heating coil that used rubber ring joints, compressed with nuts and bolts rather than flange or socket connections to the header. His first model was suitable for very low pressures, only 30 feet (9m) head of water. His later, improved model was suitable for 100 feet (30m).

The unattractive nature of these coils led to the use of decorative cases, usually a mesh of patterned metal or pierced tiles, but some stately homes had expensive stone or marble pedestals which incorporated urns or even statues.



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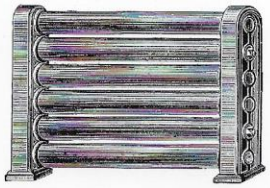

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27 Cast-iron heating coil made using socket return bends

28 Hot water heating coil with rubber joints

29 Box-end heating coil beneath Wm Burgess desk, Cardiff Castle. Heating designed by Wilson W Phipson, c1880

30 Decorative heating case, Montacute House

31 Vertical tubular radiator by Vincent Skinner, Bristol Church of St Andrew, Cheddar

32 Box end heating coil, Church of St Swithin, East Retford, Notts

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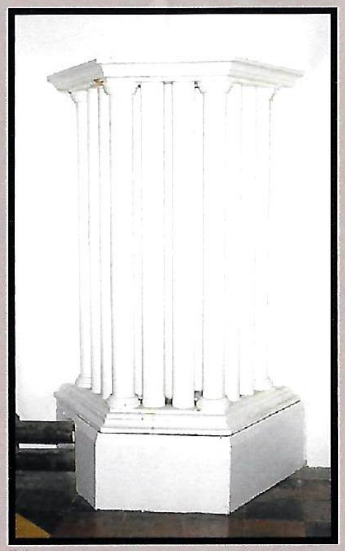

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32

Radiators

The term 'radiator' is a misnomer since for column radiators some 70 per cent of the heat output is by convection. The development and mass production of radiators was an American phenomenon, the first patents dating from around 1841. The first radiators were variously shaped 'heat distributors,' a mixture of pipes and metal plates. Next came vertical wrought-iron welded tubes fixed between horizontal top and bottom headers. These were followed by the 'looped tube' type, an inverted U, fixed to a base plate. These were used for both steam and hot water.

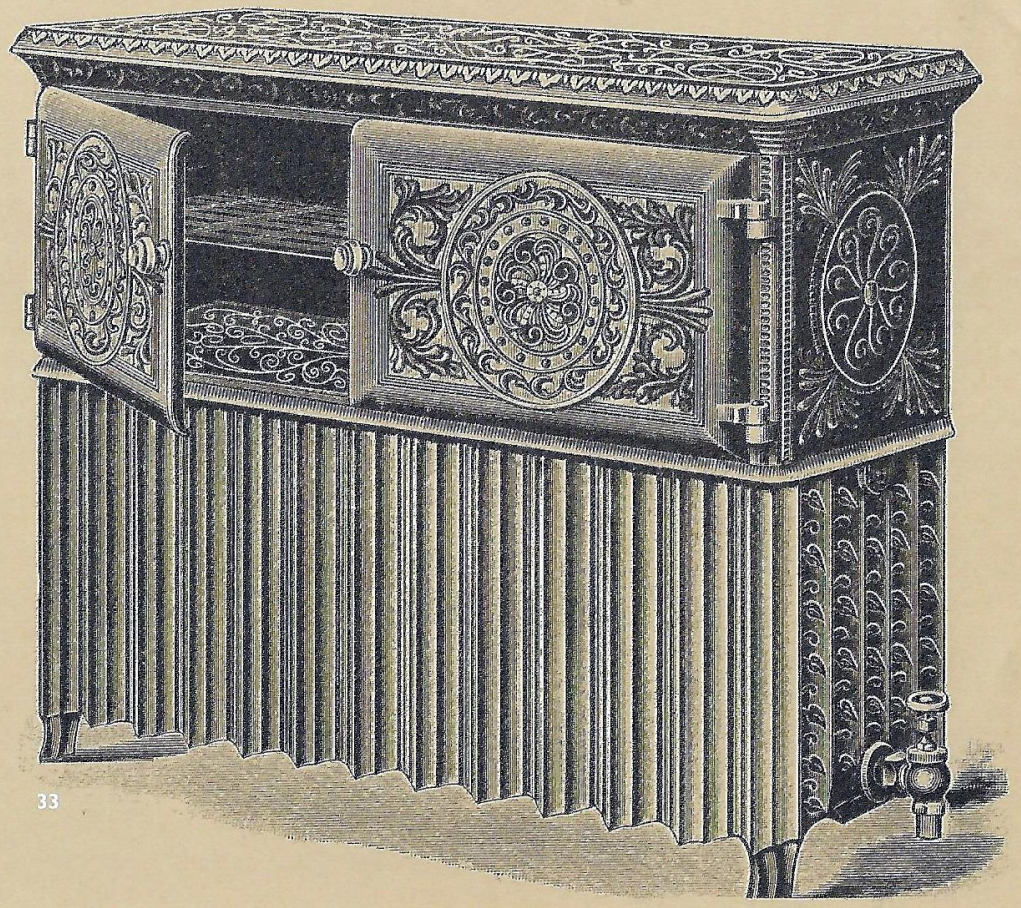
One of the early radiators was the *Mattress* design of Stephen J Gold in 1854, a flat panel with rows of recessed dimples. His son, Samuel, developed the *Pin* radiator around 1863, the attached pins increasing the heat transfer area, allowing it to be used as a convector in a heating chamber or duct. Tasker in Philadelphia patented a primitive sectional radiator in 1858. It is the factory mass production of radiator sections that could be connected together that distinguishes them from pipe coils. Another pioneer was Joseph Nason who had spent time working in England with A M Perkins (the high-pressure hot water heating specialist). He collaborated with Robert Briggs to patent a steam radiator in 1862. Bundy patented a cast-iron radiator for steam, with loops screwed into a cast iron base, in 1874. This and the Bundy Elite were manufactured by the A A Griffing Iron Co.

Until 1892 numerous American manufacturers produced a variety of designs, many highly ornamental, but in that year the three principal manufacturers merged to form the American Radiator Co. This firm, trading as the National Radiator Co, opened a factory in Hull in the early 1900s where they manufactured *Ideal* radiators. During the 1890s, radiators of American manufacture were imported into Britain, but from the turn of the century the home radiator manufacturing industry became predominant.

Early British patents for hot water radiators include those of James Keith (1882 and 1884), A Waters (1882), W G Cannon (1887) and T A Heap (1887). The *Universal* radiator of James Keith was probably unique, being cast in one piece; he claimed it was less liable to leakage.

At the end of the 19th century, one expert claimed that British radiator design had fallen behind the current American offerings. However, this opinion was based on external appearance and not on technical performance. British designs were generally plain, though there were exceptions. American ones were ornate. Gradually, improvements in foundry technology enabled more elaborate castings to be made.

33 American ornamental radiator, 1896 complete with plate/food warming compartment



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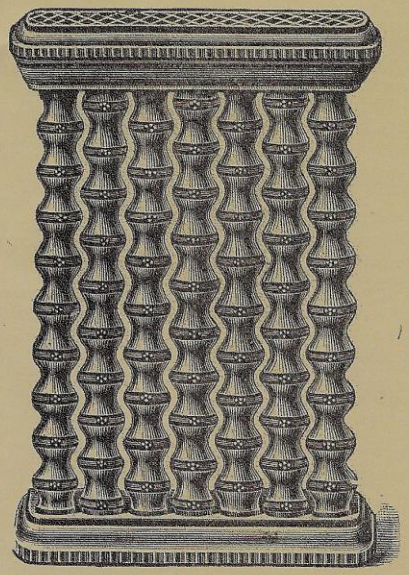

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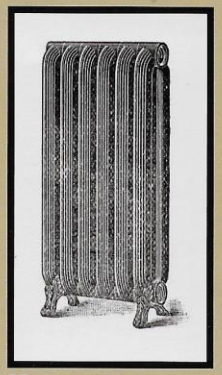

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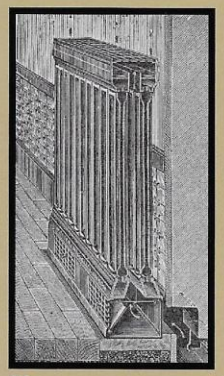

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Radiators having one, two and then three columns became available. By 1917, radiators with four columns were being used.

At the beginning of the 20th century, the *Ventilating* radiator was gaining acceptance in the USA. The idea was to remedy the lack of ventilation afforded by the ordinary 'direct' radiator. Essentially, the lower part of the radiator was blanked off against the entry of room air, and fresh air was led to the base of the radiator by a channel in the wall behind it. These were sometimes termed 'indirect' radiators when located outside the room being warmed. It is believed this type was first introduced about 1850.

In 1904, claims and counter-claims relating to the introduction of radiators into Britain abounded. Acknowledging that steam radiators were of American origin, the firm of Longden in Sheffield claimed to have played a major part in introducing hot water radiators to the British market.

Rosser & Russell of London claimed to be the original inventors of the ventilating radiator, but did not give a date. Other claimants include The Thames Bank Iron Co, and Weekes & Co. The case remains unproven, but one of the earliest ventilating radiators was introduced by Walter Jones in 1881 and was awarded â silver medal in the same year.

34 Unusual Bamboo pattern ventilating radiator, Meadow Foundry, c1900

35 Meadow Foundry, Mansfield Count (fluted)

36 C & F Sanderson, Mansfield

37 Bundy radiator, A A Griffing Iron Co, Jersey City, 1874

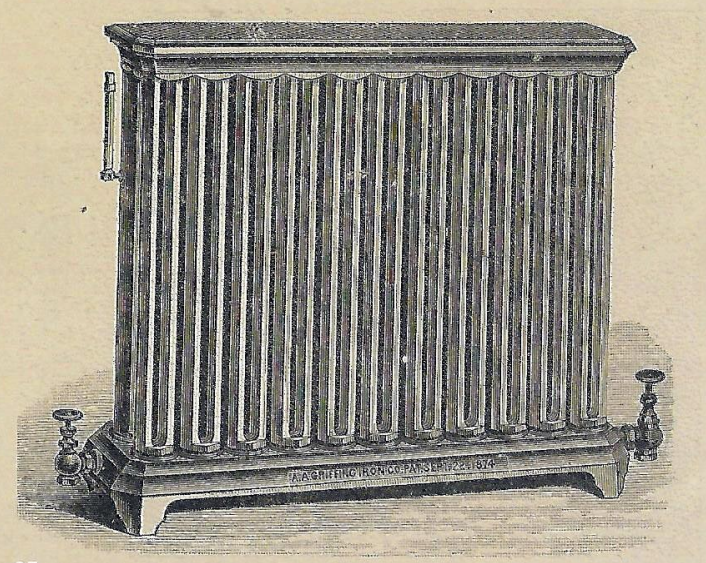
38 The General Iron Foundry Co, London

39 Bundy Elite radiator, 1877

The number and variety of radiator styles and pattern names available as the Victorian era came to a close is overwhelming.

In 1891, Keith was advertising both the *Universal* and the *Ornamental*, while the Coalbrookdale Co listed their *Hydro-Caloric* (Heap's Patent). By 1897, the American Radiator Co was promoting in London their *National Single Column* and *Rococo* designs. H Munzing in London was importing a variety of American radiators including *Royal Union*, *Coronet*, *Union*, and *Walworth Patent*. Longden of Sheffield featured the *Sunbeam* (Leed's Patent). Wontner-Smith, Gray of London had the *Finsbury*, while the Meadow Foundry of Mansfield made the *Count* and the *Peer*. Other British companies like Haden of Trowbridge, Williams of Reading, and Thames Bank Iron and W G Cannon, both in London, merely advertised their radiators as 'ornamental' or 'special.'

In 1906, the London catalogue for the American Radiator Co listed: *Astro Hospital Swinging*, *Circular*, *Colonial Wall*, *Corner*, *Curved*, *Detroit*, *Excelsior*, *Italian*, *National*, *Peerless*, *Perfection*, *Primus*, *Rococo* and *Sanitary Pin*. Many of these came in a choice of heights, widths, number of columns and arrangement, and in so-called flue, ventilating and non-ventilating designs.



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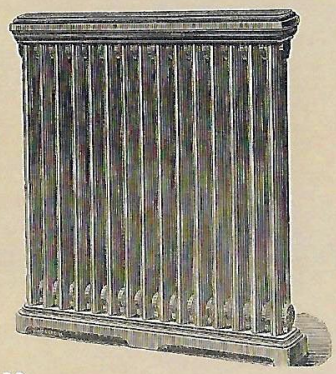

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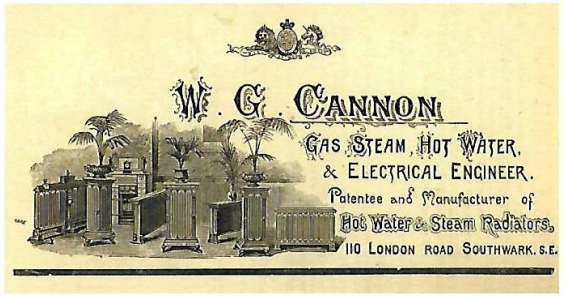
Heating Engineers

Many early firms styled themselves as heating engineers. Many were manufacturers. Some of these were also installers. A few firms were ventilation engineers. Arguments still rage as to the earliest pioneers, this judgement being clouded by the fact that a number of firms were engaged in other forms of business, usually related to metal working, before they were involved in heating work. Various claims were aired in *The Ironmonger* in 1928, and it was concluded that the oldest heating firm of installers was Edward Deane & Beal of London, founded in 1700, though they were probably not heating engineers at this time.

Comyn Ching of London first traded as ironmongers, possibly as far back as 1688, but a more realistic date for trading as heating contractors appears to be from the 1850s. Rosser & Russell, London, took over the business of Charles Sylvester, who had been involved in heating since the 1790s, but set up his heating firm around 1820. The company became S E Rosser in 1856 and Rosser & Russell in 1866. Abraham Seward & Co started as tin-plate workers in 1778 and appears to have engaged in heating from 1808. Clement, Jeakes & Co of London may have had their origins before 1800, having amalgamated in the 1890s. Certainly, Jeakes was active in heating around 1860. The firm was later taken over by Benham & Sons, Mr John Lee Benham having been engaged in heating work as far back as 1847.

G N Haden (originally G & J Haden) started in Trowbridge in 1816 as agents for Boulton & Watt steam engines. Within 10 years they were carrying out heating work, their steam experience standing them in good stead. J C & S C Ellis of Sheffield is recorded as carrying



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out heating installations in 1825. They were later taken over by Brightside Foundry.

Other well-known early heating contractors include Ashwell & Nesbit of Leicester (1879), Z B Berry & Sons of London (gasfitters in 1810, seemingly heating engineers from the 1870s), James Boyd & Sons of Paisley (1826 origins), Richard Crittall of London (1884), Matthew Hall of London (founded as plumbers in 1848), Arthur Scull of Bristol (founded as plumbers in 1881) and William Truswell & Sons of Newcastle upon Tyne (1870). Installations carrying nameplates of any of these contractors may be of historical importance.

Early heating firms, generally not so well-known, include John L Bacon of London (active 1870s), W G Cannon of London (1880s), Feetham & Co, London (1825 origins), J S Garland, London (1820s), Garton & King of Exeter (ironmongers in 1661, heating engineers from about 1840), Herring & Son of Chertsey (active 1876), Mr May of London (active 1857), Jones & Attwood, Stourbridge (1836 origins, in heating from 1860s), Henry

40 W G Cannon & Sons, London, 1897

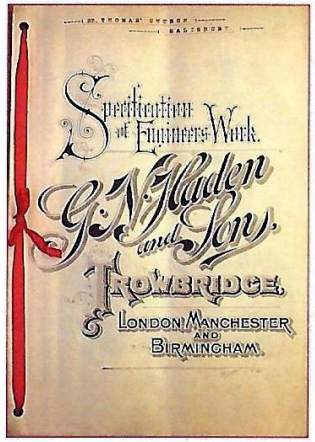
41 Specification 1910

42 Catalogue 1900

Warner of Ipswich (trading as a whitesmith in 1845), J Wontner-Smith, Gray, London (founded 1835, started with the installation of electric bells and speaking tubes), and Skinner, Board & Co, Bristol (also traded as Vincent Skinner, 1880s). Some of their installations still exist.

The early heating industry largely began in horticultural circles by providing warming in tropical glasshouses and the like. Glasshouses became very popular in Victorian times. Their builders often took the responsibility for installing (and sometimes manufacturing) the necessary heating apparatus. Firms undertaking this work included W & D Baily of London (active 1817), James Crispin, Bristol (1890s), W & S Deards, Harlow, Essex (1880s), Fletcher, Lowndes & Co, London (1880s), Chas Frazer of Norwich (being run by his executors in 1894), Gough & Felgate, Burton-on-Trent (1890s), A P Jevon, Birmingham (1880s), Mackenzie & Moncur, Edinburgh (believed to have started as horticultural builders c1815, was carrying out heating in the 1860s), Messenger & Co, Loughborough (horticultural works in 1858) and Henry Ormson of Chelsea (active 1880, 'By Royal Appointment'). Rosser & Russell, London, also held the Royal Warrant (granted in 1884) as 'Horticultural Builders and Warming Engineers.'

The heating installers organised in 1904 with the founding of the Heating & Ventilating Contractors' Association (originally called the National Association of Heating, Ventilating and Domestic Engineering Employers). There were 20 founding members; today there are some 1,300.



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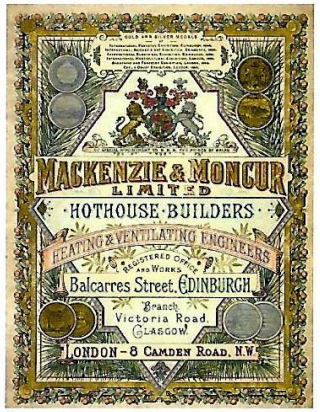

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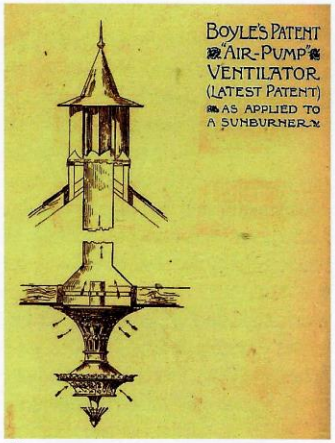
Assisted Ventilation

The term 'ventilator' was used in 1735 to describe the man employed to turn the crank handle which operated the Fanning Wheel of Dr Desaguliers, used in the House of Commons. Bellows were used by Sir Martin Triewald for ventilating ships (1741) and by the Rev Stephen Hales to ventilate a hospital (1758) and a prison. The architect Barry used a steam jet (ejector pump) for the ventilation of the House of Lords (c1847). Meanwhile, Arnott used an automatic air pump for night-time ventilation of York Hospital: it was driven by water, pumped into high-level storage during the day.

The use of heat as the motive power for ventilation can be traced back the mines of Saxony in the 16th century. The use of fire-assisted ventilation (using the principle that heated air rises) first appears to have been applied to buildings by Desaguliers, who used it for the House of Commons in 1723. It failed because the housekeeper refused to keep the fires alight; hence the later installation of a Fanning Wheel.

Major Joshua Jebb used fire-assisted ventilation in 1844 for Pentonville Prison. When the House of Commons was rebuilt after the fire of 1834, it was the Scottish chemist, Dr David Boswell Reid, who was entrusted with the design of a fire-assisted ventilation scheme. This was never satisfactory, partly due to the never ending arguments between Reid the engineer and Barry the architect. (However, Reid's design for the heating and ventilating of St George's Hall, Liverpool in 1851, where he used steam-driven fans, was eminently successful).



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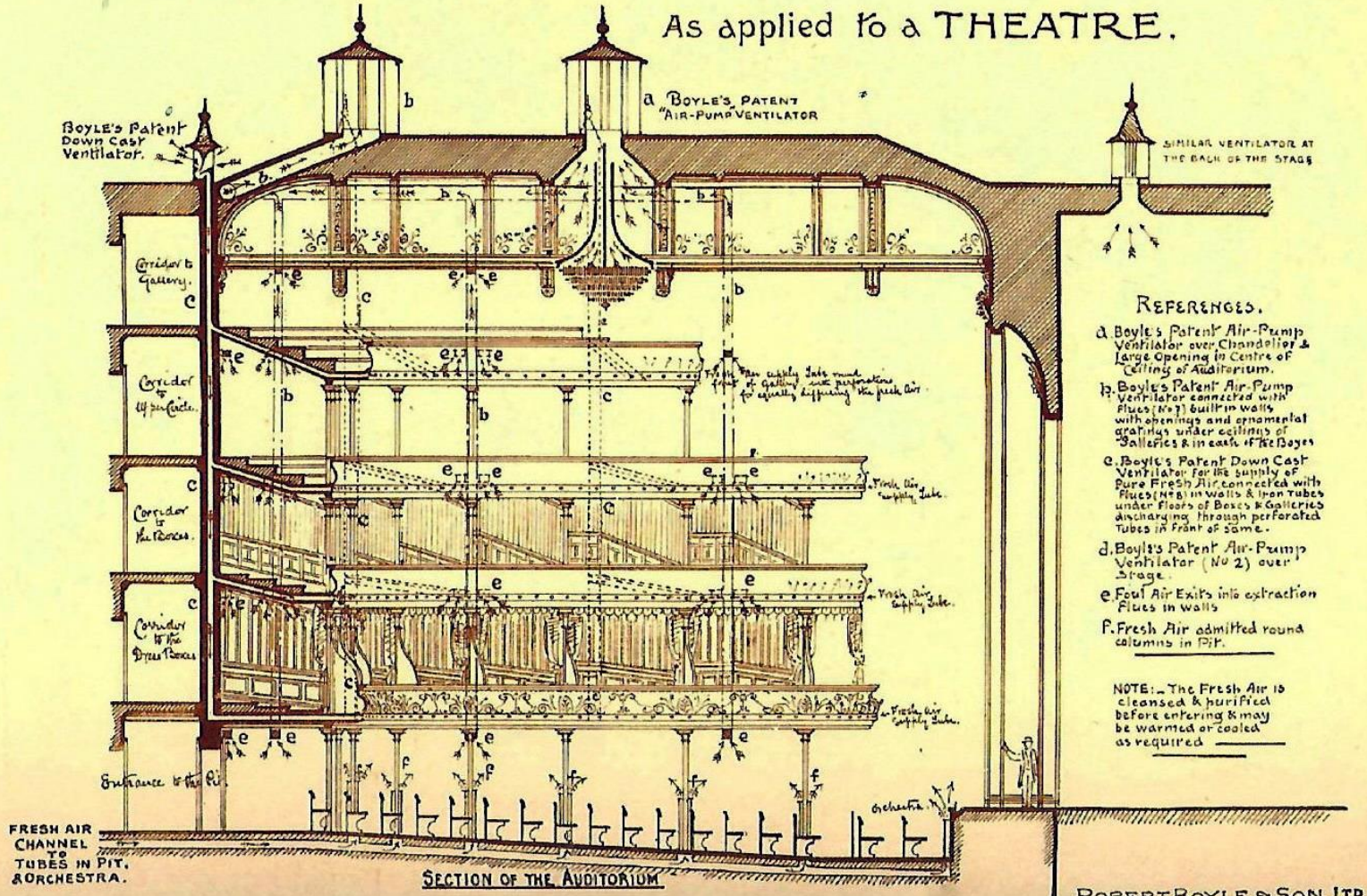
43 Boyle's Patent Air-Pump Ventilator combined with gas Sunburner lighting fixture, c1900

44 Natural ventilation of a theatre, Robert Boyle and Son, London and Glasgow, c1900

An impassioned advocate of natural ventilation was Robert Boyle Jr, who carried on the mid-19th century business of his father, Robert Boyle Sr, and published numerous leaflets, books and catalogues around 1900. Father and son extolled the merits of natural ventilation and shunned mechanical methods. Their company, Robert Boyle & Son, manufactured a wide variety of apparatus and fittings for natural ventilation, including a patented air pump which relied on wind effect. Their catalogues list an amazing variety of inlet and outlet grilles and tubes, duct fittings, self-acting and regulating air valves, brackets and panels. Boyle equipment was used in hundreds of buildings, and many examples can still be found.

THE "BOYLE" SYSTEM OF VENTILATION

As applied to a THEATRE.



SECTION OF THE AUDITORIUM.

REFERENCES.

a. Boyle's Patent Air-Pump Ventilator over Chandelier & Large Opening in Centre of Ceiling of Auditorium.

b. Boyle's Patent Air-Pump Ventilator connected with Flues (No 1) built in walls with openings and ornamental gratings under ceilings of Galleries & in each of the Boxes

c. Boyle's Patent Down Cast Ventilator for the supply of Pure Fresh Air, connected with Flues (No 3) in walls & Iron Tubes under Floors of Boxes & Galleries discharging through perforated Tubes in Front of same.

d. Boyle's Patent Air-Pump Ventilator (No 2) over Stage.

e. Foul Air Exits into extraction Flues in walls

f. Fresh Air admitted round columns in Pit.

NOTE:- The Fresh Air is cleansed & purified before entering & may be warmed or cooled as required

ROBERT BOYLE & SON, LTD.
Ventilating Engineers.
LONDON & GLASGOW.

45 Acme Ventilating and Heating, Liverpool, 1904

46 Centrifugal fan driven by double enclosed steam engine Ventilation and Heating, Sturtevant, Boston and London, 1906

47 Direct-drive electric fan, steel-plate pattern, Mechanical Draft, Sturtevant, Boston and London, 1899

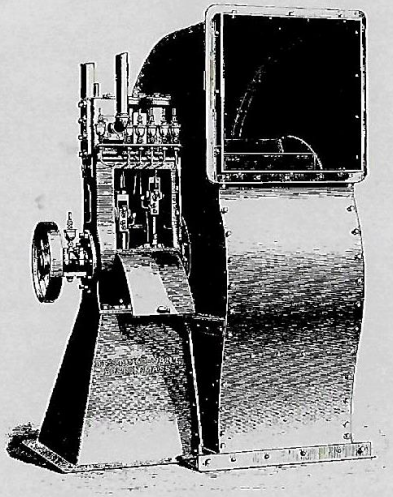


FIG. 26. SPECIAL STEEL PLATE STEAM FAN, WITH DOUBLE ENCLOSED ENGINE.

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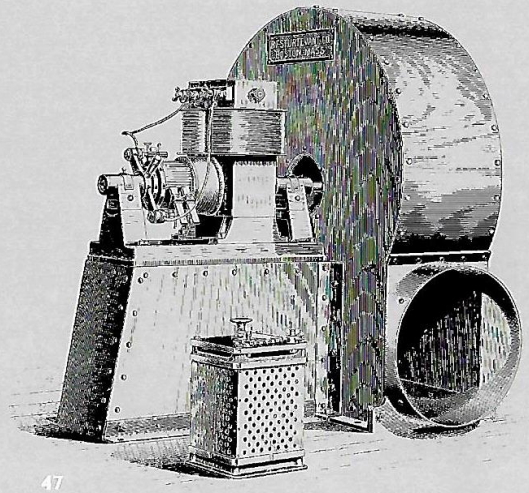

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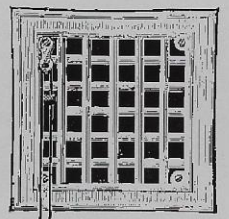
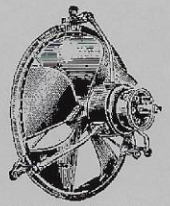
Acme & Spherical Ventilators, Smoke Cures, and High Pressure Heating.



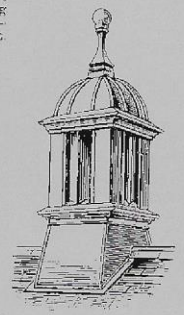
No. 200.—Acme Wrought Steel Regulating Louvre Ventilators—**Inlet or Outlet.**



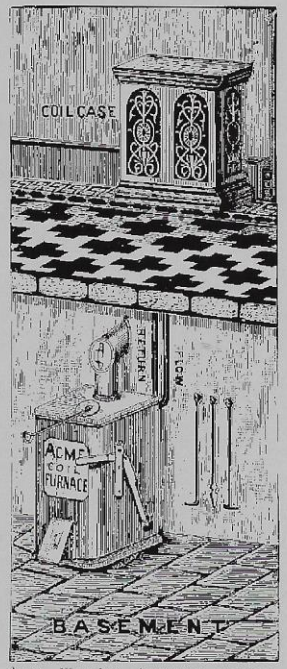
No. 28 E.—Electric and other Fans for every purpose.

Spherical Ventilators.

Fig. R.9.—Made of 11 G.V.M. Zinc, Copper or Steel, Galvanised after manufacture, and enamel painted. May be fixed vertically or horizontally.



No. 77.—This design is double the prices given for Nos. 75 and 76.



Acme Warming Apparatus, showing Furnace in Basement with coil of piping and ornamented case in entrance hall, etc. Neatest and most efficient high pressure system.

Fig. 4.—Acme Louvres in Frame, without flange, for Dormers, Walls, &c.

Section of Acme Patent Curved Exhaust Louvres. The arrows show the action of the wind and exhaust.

No. 3a.—Acme Terra Cotta (red) Chimney Cowl with suspended cone, 35/-; and other smoke cures.

30 Years' Experience.

Acme Ventilating & Heating Co.,

LIVERPOOL.

Apply for fuller particulars.

Telegrams—"Keyworth." Telephone 1877.
A.B.C. Code, 4th Edition.

No. 24.—Venetian Outside Wall Inlet. 9 in. by 3½ in., 9d. 12 in. by 3 in., 1/3. 9 in. by 6½ in., 1/6. 12 in. by 6½ in., 2/-. 9 in. by 9 in., 2/-. 12 in. by 12 in., 4/6. Admits three times more air than ordinary perforated air-bricks. Walls kept perfectly dry. Superior make. Largely used in Smoke Stacks.

Fans and Mechanical Ventilation

The first recorded use of ventilating fans is probably that shown in a series of woodcuts and described by Georgius Agricola in his book of 1556, *De Re Metallica*, on German mines. Motive power was provided by human or horse power, windmills or watermills. The early part of the 19th century in Britain was largely concerned with the development and manufacture of large fans for mine ventilation.

The first significant fans in the United States were those designed by Nason & Briggs for Washington's Capitol in 1857. Bennett Hotchkiss of New Haven patented the first true multiblade centrifugal fan in 1863. The major and most important manufacturer of centrifugal fans from about 1860 was undoubtedly Benjamin Franklin Sturtevant of Boston. He opened a London office in the 1890s. The majority of these fans were driven by steam engines since large reliable electric motors and power supplies were not widely available in late Victorian times.

In continental Europe, considerable effort went into fan development from the 1830s, in which France, and later Germany, played leading roles. In Britain, scroll casings had been described by Dr Ure (1844) and by Reid about the same time. Professor Rankine designed a fan with a spiral casing (1857). Early fan designs and patents include those by Charles Barlow of London (1878), Henry Aland of Wandsworth, London (1883), George Greig of Kincardineshire, Scotland and the most famous of them all, the *Sirocco* of Samuel Cleland Davidson, Belfast (1898). The James Keith & Blackman Co of London also developed an important centrifugal fan in the early 1900s, but fought a series of court cases with Davidson over the validity of the *Sirocco* patent. With the widespread availability of electric motors in the 1920s, mechanical ventilation became increasingly common in industrial, commercial and institutional buildings.

A number of British firms were manufacturing fans when the Institution of Heating and Ventilating Engineers (IHVE) was founded in 1897. Some of the better-known ones included the Blackman Ventilating Co, London (later Keith Blackman), James Howorth & Co at Victoria Works, near Bolton (describing themselves as inventors, patentees and sole manufacturers of their patent revolving Archimedean, Radial & Horizontal Screw ventilators & air propellers), James Stott of Manchester, B Verity & Sons of Birmingham, The Waddle Patent Fan & Engineering Co of Llanelli (first made a colliery fan in 1864), Walker Bros of Wigan (active before 1850) and Musgrave of Belfast (made fans from the 1890s). The company that became one of the best-known makers of fans for heating and ventilating work was Matthews & Yates, Cyclone Works, Swinton, near Manchester; their main known range of fans was the *Cyclone*. Later, notable British

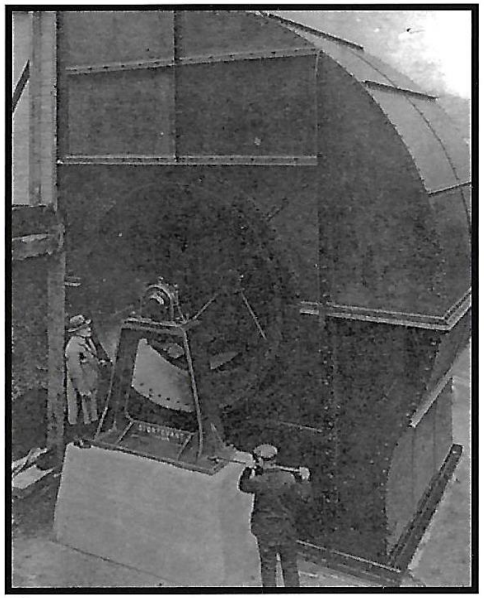
48 Two Sturtevant fans for Mersey Tunnel ventilation 1934

49 Sturtevant fan, 174,000 ft3/min

50 Fan delivery by horse and cart Matthews and Yates, Manchester, 1890s

fan manufacturers were Alldays & Onions of Birmingham, Andrew Machine Co of Stockport and Standard & Pochin of Leicester. Fans made prior to 1940 have been found at a number of heritage sites.

The years after the Second World War saw the development of the axial-flow fan. Early makers included Aerex, Airscrew and Keith Blackman, but it was Woods of Colchester that in 1947 introduced the first standardized range on a batch production basis. In 1951, the first edition of '*Wood's Practical Guide to Fan Engineering*' was published and quickly became a standard textbook on the subject.



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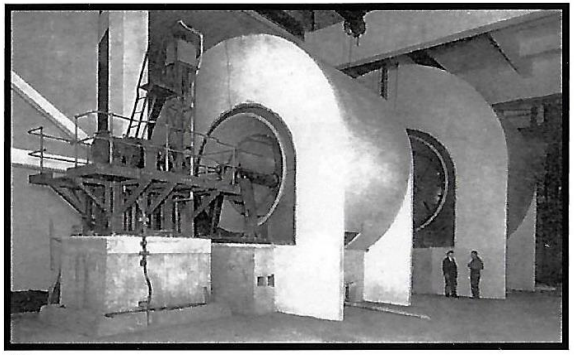

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Nameplates

It may seem obvious that looking for nameplates in plant rooms or on equipment is an essential step in determining the manufacturer or installer of heating and ventilating apparatus or systems in buildings of probable historic engineering interest. However, it should be borne in mind that examining a building of historic value is no guarantee that its engineering will be of interest. In fact, historic items of engineering may sometimes be found in undistinguished buildings.

Makers' names may be found on stoves, boilers, radiators, fans, pumps, oil burners, electric motors, steam engines and controls. A pattern or model name may be included or, in the case of a stove or radiator, may be the only marking.

In Victorian times, the installer often left his mark in an inconspicuous place. Examples include on water feed or expansion tanks, valve bodies, cast-iron plaques, floor tiles, fan plates, gauge boards, or even as labels fixed to the ends of radiators.

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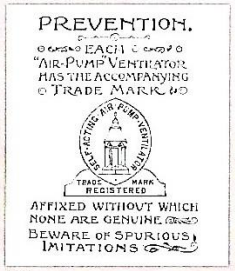

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51 The London Warming & Ventilating Co, [Gurney stove]

52 Boyle Trade Mark [Air Pump]

53 Mitchell's Patent Reverberating Smoke Consuming Hypocaust for warming churches

Further Reading

54 Constantine Convoluted stove in brickwork c1881

Some modern information sources

Billington, N S & Roberts, B M 1982 *Building Services Engineering: A Review of its Development.* Oxford: Pergamon Press, (an illustrated history)

Donaldson, B & Nagengast, B 1994 *Heat & Cold: Mastering the Great Indoors.* Atlanta: American Society of Heating, Refrigerating and Air Conditioning Engineers (an illustrated history of heating, ventilating, refrigeraton and air conditioning, published for their centenary)

Roberts, Brian 1997 *The Quest for Comfort.* Privately published for the CIBSE Centenary (a selective pictorial history of all building engineering services)

Roberts, Brian 2000 *The Comfort Makers.* Atlanta: American Society of Heating, Refrigerating and Air Conditioning Engineers (270 mini-biographies of pioneers of heating, ventilating, refrigeration and air conditioning)

Victorian and Edwardian references

Walker, William 1850 *Useful Hints on Ventilation.* Manchester: J T Parkes,

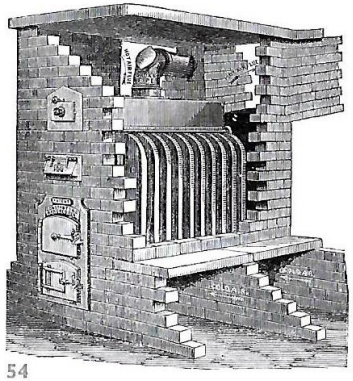
Constantine, Joseph 1881 *Practical Warming & Ventilation.* London: J & A Churchill

Hood, Charles 1891 *A Practical Treatise upon Warming Buildings by Hot Water,* Rewritten by Fredk Dye London: E & F N Spon

Jones, Walter 1904 *Heating by Hot Water.* London: Crosby Lockwood & Son

Sturtevant 1906 *Ventilation & Heating.* London: B F Sturtevant Co

Additional information is available at the website of the CIBSE Heritage Group, **www.hevac-heritage.org.**



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55 Perkins high pressure hot water furnace. Royal High School, Edinburgh, c1900.

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