# The HEAT MAKERS

**Pages1-20**


*Plate 14. Catalogue: Gold Medal Boiler, 1872. Improved Wrought Welded Saddle Boiler. Hartley & Sugden, Atlas Works, Halifax. Paul Yunnie Collection.*

# The HEAT MAKERS

*Though much has been done by ingenious men in the art of distributing heat for household uses; it must be confessed, that in one or two instances only have they been able to make a permanent impression or bring their contrivances into that general use as to constitute them "machines of society."*

**Walter Bernan,** Civil Engineer, in his introduction to *On the History and Art of Warming and Ventilating Rooms and Buildings*, Vol. I, 1845.

**Thomas TREDGOLD [19]**

9. *Advertisement: Steel Radiator Furnace. The S.M. Howes Co., Boston.* The Metal Worker, *3 July 1897, p. 17.*

*The Oldest & Largest Makers in the World.* *Medals awarded wherever exhibited.*

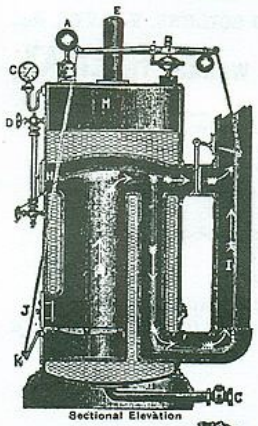
**Telegrams: "Lumby, Halifax."**

# LUMBY, SON & WOOD, LTD.,

**West Grove Boiler and Safe Works, HALIFAX,**

.. *ENGLAND.*

**EFFICIENT, ECONOMICAL, AND DURABLE.**

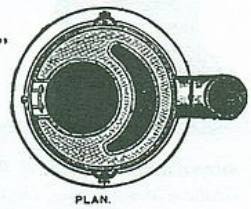



Sectional Elevation

**Prices and Particulars on Application.**

The "Marlor" STEAM HEATER.

Reg. No 273,408



PLAN.

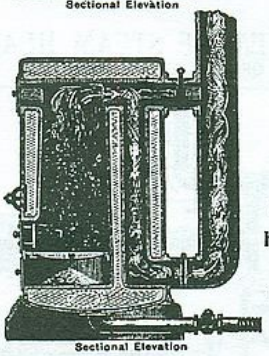
.. Makers of all patterns of ..

RIVETED AND WELDED BOILERS

FOR ALL PURPOSES.

**The LARGEST STOCK in the Kingdom.**

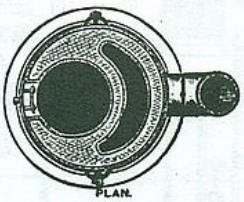
*The most complete Catalogue in the Trade post free on receipt of Trade Card.*



Sectional Elevation

The "Marlor" HOT WATER BOILER.

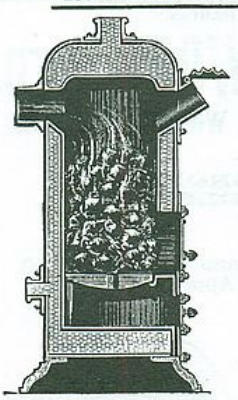
Reg. No. 271,532



PLAN.

*10. Advertisement: Steam Heaters and Boilers. Lumby, Son & Wood, Halifax, founded 1858.* Domestic Engineering, *March 1897, p. 77.*

ESTABLISHED 1854.



Dome Top Boiler
with water-way base.

# GRAHAM AND FLEMING

(Successors to S. T. Crook's Exors.)

INVENTORS & MAKERS of

## WELDED BOILERS

for Low Pressure Heating,

RIVETTED BOILERS, VALVES &c.,

PREMIER WORKS, HALIFAX,
ENGLAND.

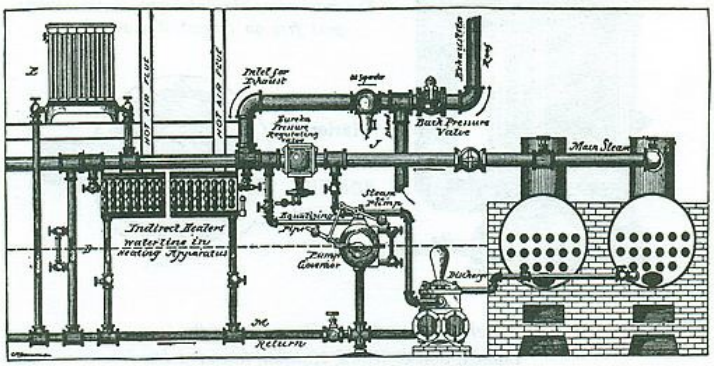
Complete Catalogue Free on application

Boilers quoted for and made to customers' own sketches

Telegrams:—' GRAHAM, FLEMING," Halifax.
Telephone No. 39.

11. *Advertisement: Welded & Rivetted Boilers.*
*Graham and Fleming, Halifax. The company was founded in 1854.*
Heating & Hot Water, *Walter Jones (President IHVE, 1899), 1894, p. v.*

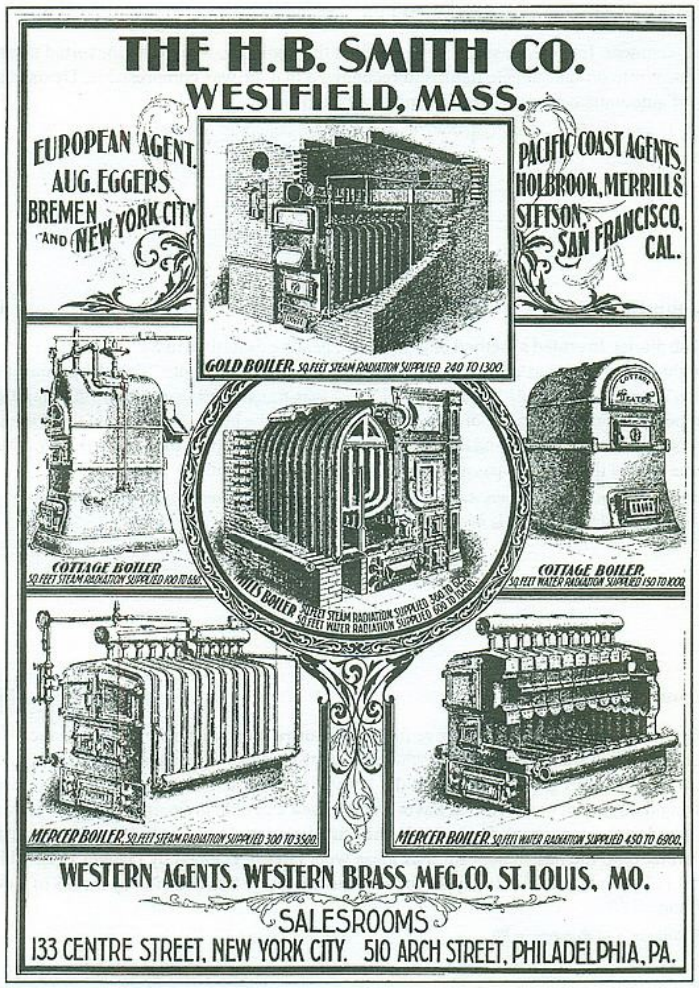
## KIELEY'S WATER-SEAL SYSTEM OF STEAM HEATING
AND AUTOMATIC RETURN OF CONDENSATION.




*By the use of this System a large saving of Fuel and a Noiseless Working Apparatus is guaranteed.*
*The specialties mentioned on opposite page are required to obtain this system.*

**KIELEY & MUELLER, 7 to 11 West 13th Street, New York.**

12. *Advertisement: Kieley's System of Steam Heating.*
*Kieley & Mueller, New York.* Baldwin on Heating, *William J. Baldwin, 1900, p. iv.*




*13. Advertisement: H.B. Smith Co., Westfield, Mass.*
Domestic Engineering, *April 1900, p. 46.*

### [1] HERO (HERON) of Alexandria — c. 60 AD

Greek engineer. Invented a steam device called the *aeolipile*, a toy that converted steam power to motion. Wrote on mechanics, light, and recognized that air was compressible. Devised simple systems of automatic control to work temple doors and statues.

125. *p. 37 and The Origins of Feedback Control, O. Mayr,* Scientific American, *October 1976.*

### [2] John EVELYN — 1620-1706

English diarist. Invented a method of greenhouse heating described in *Kalendarium Hortense* (1664). Thought iron stoves and subterranean caliducts often left the plants "sick, langorous and tainted." Evelyn's stove was outside the house, and "heat was transferred inside by air passing through very hot pipes; cold air from the floor area was drawn through a ground pipe to fan the flames of the furnace. Natural convection would therefore ensure a continual supply of fresh, warm air. This ingenious scheme solved the author's passion for fresh air as well as heat...."

Glass Houses, *Woods and Warren, Aurum, 1988, pp.30-31. Evelyn's Greenhouse Furnace is shown on p.* 62. *Roberts, fig.17, and described in* 11. *Bernan, Vol.1, Essay VIII.*

### [3] Louis SAVOT — active early 17th century

Made the first real attempts to improve fireplace construction and performance (France, 1600-1650). Introduced a fundamental innovation where the grate stood on a hearthstone to allow air a more ready access to the fuel. A fireplace of his in the Louvre in Paris also made use of convected warm air—his second important contribution. Savot also devised a double grate, in which the fuel was partially consumed on the upper bars. The partly burned fuel fell to the lower grate, where it was finally burned, ash falling onto the hearth beneath. His ideas were later developed by Gauger [54], while Sir John Winter (1658) introduced primary air for combustion direct from outside by means of a duct beneath the floor.

98. *Billington and Roberts, p.80.*

### [4] Sir Hugh PLATT active 1600-1650

English lawyer. Author of *Jewel House of Art and Nature* (1594) in which he proposed the use of hot water heating for the drying process in the manufacture of gunpowder. Also wrote extensively about fireplace construction. His favorite project was "to sweeten sea coal." He wrote *A New Cheape and Delicate Fire of Cole Balles* in which he advocated various mixtures of coal, sawdust, and earth. "Many," says Sir Hugh, "have thought my fire to consist of sea cole and cow dunge, but rash pens do soone run riot, yet I do not utterlie dislike this mixture." Proposed the use of steam for greenhouse heating in *The Garden of Eden** (1653): "To have Roses or Carnations growing in Winter, place them in a roome that may some way be kept warme, either with a dry fire, or with the steam of hot water conveyed by a pipe, fastened to the cover of a pot..." and "I have known Master Jacob of the Glasse-house to have Carnations all the winter by the benefit of a roome that was neere his glasse house fire...." Greenhouse heating was later attempted (1788) by T. Wakefield, Esq. of Norwich.

11. *Bernan, Vol.I, Essays VI (Fireplace) and VIII (Coal). * Facsimiles of the title page and pp.50-51 of Platt's book (of which only two copies are known to exist in the USA) are reproduced in* Fifty Years of New York Steam Service, *New York Steam Corporation, 1932, p.11.*

### [5] Denis PAPIN 1647-1712

French physicist. Went to England (1675) and worked as assistant to Boyle [142]. Developed the steam *digester,* a form of pressure cooker (1679). Later, working first in Italy, then in Germany, he pioneered the steam engine (1698), eventually returning to England to die in poverty.

47. *Asimov, entry 205. Portrait* 124. *p. 23.*

### [6] Thomas SAVERY c. 1650-1715

English engineer and prolific inventor. With England badly deforested, the mining of coal became a priority but was badly hampered by flooding of the pits. Guericke [140] had experimented with the power of a vacuum (1650-1654), and Savery used these principles when he developed the first practical steam engine and used it for "raising water by fire" (1698). This was known as *The Miners' Friend.* His patent was so detailed—and, unusually, he got it extended (until 1733)—that it prevented Newcomen [7] securing a patent for his steam engine. (Earlier, 1663, the Marquis of Worcester in his book *A Century of Inventions* described a spherical boiler used for raising water to a height of 12 m.) Savery's boiler "was in the shape of a cauldron with a flat top and could generate steam at 170 kPa. It was constructed of hammered copper, the flat top being of lead."

47. *Asimov, entry 206. Portrait* 124. *p. 138.*

### [7] Thomas NEWCOMEN 1663-1729

English blacksmith and gifted amateur engineer. Taking advice from Hooke [119] and Triewald [9], he constructed (1712) with the help of John Calley the first "atmospheric" steam engine, or *fire and air engine.* Owing to the earlier patent of Savery [6], he made little profit from his invention. After Savery's death (1715), he acquired some of these rights and later developed the engine, which came in general use (from 1725) until the superior engine of Watt [13].

47. *Asimov, entry 211.*

### [8] Benjamin FRANKLIN 1706-1790

American statesman, printer, and scientist. Started a fire service (1736). Developed bifocal spectacles. Founded American Philosophical Society (1743). Turned his attention to the problems of the open fire. Published a description (1745) of his *Pennsylvanian* fireplace commenting "my common room is made twice as warm as it used to be, with a quarter of the wood formerly consumed there." Heated a row of houses by means of an iron stove-furnace set in a chamber beneath the ground (1748). Best known for his experiments in static electricity, including his famous, but dangerous, flying of a kite in a thunderstorm (1752). This led to the invention of the lightning conductor. He devised a back-to-back revolving grate that could be turned to face either of two rooms (1785). Later wrote *Observations on the Causes and Cures of Smokey Chimneys*, his recommendations being expanded by Rumford [15]. Held many important posts, awarded many honors, and helped draft the American *Declaration of Independence* (1776). At an ASHVE meeting (1927), Thornton Lewis (ASHVE President 1929) declared Franklin "one of the greatest men the world has ever known, and strange to say the same gentleman, Benjamin Franklin, was also a heating and ventilating engineer." By resolution of the Council, Franklin was adopted as the Patron Saint of the ASHVE.

5. ASHRAE Journal. 6. *Hall.* 94. *ASHRAE, p. 15. Portrait: a painting by Charles Willson Peale,* 119. *p. 220.*

### [9] Sir Mårten (Martin) TRIEWALD active 1716-1741

Swedish gentleman. Military architect to the King of Sweden. Worked as an assistant to both Desaguliers [52] and Newcomen [7]. Lived for many years in Newcastle-on-Tyne. Said to have attempted the first successful use of hot water for heating a greenhouse (1716), though its original use has also been ascribed to Evelyn [2]. In Triewald's scheme, "The water was boiled outside of the building, and then conducted by a pipe into a chamber under the plants." He also experimented with bellows for ships' ventilation (1741) and "invented a machine to draw foul air from Swedish ships blockading the port of St. Petersburg."

98. *Billington and Roberts, pp.110, 208, and 215.*

### [10] Colonel William COOK — active 1745

Read paper on steam heating before the Royal Society, published in *Philosophical Transactions* (1745). He improved on the suggestions of Sir Hugh Platt [4] and "gave a diagram of an engine for heating all the rooms in a house from the kitchen fire." This is possibly the earliest reference to the use of steam for heating.

**99.** *Donaldson and Nagengast, pp.39-40.*

### [11] Johann Paul BAUMER — active mid-18th century

In continental Europe, early simple stoves were of clay bricks (c. 820). Around the 13th century, the *kachelofen* masonry stove was in use in northern Germany. By the 16th century, its use was widespread in Sweden, Russia, Poland, and Hungary while Holland and Germany used metal stoves. Early in the 17th century, Kesslar in Germany introduced the zigzag flueway, making more effective use of the flue gases. Around this period, there was a trend toward the adoption of the massive Swedish tile and brick stove giving continuous, slow combustion. Baumer is credited with the first scientifically constructed, economy tiled stove (1765).

*From* **106.** *Usemann.*

### [12] Matthew BOULTON — 1728-1809

English engineer. Partner of Watt [13] in the construction of steam engines. Employed William Murdock, *Father of Gas Lighting,* at his Soho Works, near Birmingham (1777). Also, George Haden, Sr., father of George Haden [223] was foreman of his copying machine shop. Boulton used steam to heat his bath at Soho House (1789) and was involved with steam heating systems for the libraries of the Marquis of Landsdowne and a Dr. Witherington. Both systems failed due to problems with pipe joints, as did his son's installation for Soane [189]. When Boulton extended Soho House (late 1790s) he therefore opted for a cockle and warm-air system, as pioneered by Strutt [22], the first warming installation in the UK for a large house since the Roman hypocaust systems. (Soho House has recently been restored and is open to the public.)

*Early Heating, Ventilating and Air Conditioning in the UK, Paul G. Yunnie,* ASHRAE Trans., *1995. See also* **105.** *Roberts, p. 111.*

### [13] James WATT 1736-1819

Scottish engineer. Working at Glasgow University he improved the steam engine (1765) by the addition of a separate condenser and a steam jacket. Obtained the backing of John Roebuck, who sold his interest to Matthew Boulton [12] of Birmingham. Watt successfully developed his engine (1775) and was taken into partnership by Boulton. Watt used steam to heat his writing room (1784). His radiator was a crude tin box, approximately 1 m long × 0.76 m wide × 25 mm deep, but it did not emit sufficient heat because of its bright metallic surface. The firm carried out a number of steam heating installations, including (c. 1800) Lee's Cotton Mill in Manchester (probably the Salford Twist Mill) where "the boiler was placed in the basement and the steam was taken through hollow cast-iron columns which served both as heating surface and as structural members." The firm may have been the first to use cast-iron pipes for heating. The unit of electric power, the *watt*, was named after him.

**9.** *Hart.* **98.** *Billington and Roberts, Chap. 3. See also* **105.** *Roberts, fig. 18. Portrait from the brochure,* Haden: A Short History of the Company 1816-1991, *inside front cover.*

### [14] Joseph BRAMAH 1748-1814

Versatile English inventor. Devised hydraulic press, water closet, and security lock. After his death, his company, J. Bramah & Sons, was responsible (1829) for one of the first large-scale applications of steam heating at the Orangery of the Royal Palace at Windsor. The system described by Tredgold [19] was intended to maintain temperatures in the Orangery at 55°F and to provide humidity, or *artificial dew*, by a manually operated valve that admitted steam to the space. Soon after (1830), the company installed a hot water heating system in Westminster Hospital.

**99.** *Donaldson and Nagengast, pp. 75-76.*

### [15] Count RUMFORD (Sir Benjamin Thompson) 1753-1814

Born Woburn, Massachusetts. Went to London where, for his experiments with gunpowder, he was elected Fellow Royal Society (FRS). Later, in the service of the Elector of Bavaria, introduced army education, drained marshes, established workshops, and provided relief for the unemployed. Credited with introducing the steam engine of Watt [13] to the continent. Made Count of the Holy Roman Empire (1791). Became interested in heat, then thought of as a fluid, *caloric.* Rumford, while boring cannon at Munich (1798), noticed the blocks of metal grew so hot as the boring tool gouged them out, they had to be cooled constantly with water. He concluded that the mechanical motion of the borer was being converted into heat and that heat was, therefore, a form of motion. Returning to England, he helped establish the Royal Institution (1799) and appointed Davy [153] a lecturer. He refused to patent his many inventions, which included a double boiler, a drip coffeepot, a pressure cooker, and a kitchen range. He also devised his rules for *Chimney Fireplaces* (1796) that "have hardly been bettered to this day." Settled in France (1804), where he made an unsuccessful marriage to the widow of Lavoisier [148] and where he died. Today, the *Rumford Club* of London (founded May 1947) remains a meeting place for engineers.

**99.** *Donaldson and Nagengast, pp. 28-30. For portrait of Rumford see page xii.*

## [16] Oliver EVANS 1755-1819

American engineer. It has been said he invented the *Cornish boiler** (1800) while working in Philadelphia, giving it this English name in recognition of the help received from Trevithick [18] in correspondence. While this appears uncertain, Evans was probably the first to completely describe the closed vapor-compression cycle (1805), later turned into a working machine by his friend Jacob Perkins [77].

98. *Billington and Roberts, p. 129. *The claim relating to the Cornish boiler is from* 25. *Woolrich, p. 32. Portrait from Smithsonian Institution, Division of Engineering and Industry.*

## [17] Marquis de CHABANNES (John Frédéric) 1762-1836

French aristocrat and engineer. Became interested in fresh air ventilation and respiration. Developed a system of heating and ventilation (1814). He advocated use of a centrifugal fan to force heated or cooled air through ducts to rooms (BP: 1815) stating, "My method of cooling air is by means of the air pump...causing the air to pass through a cool medium (evaporative cooling tower)." He also introduced the concept of hot water heating to England (1816) and claimed it as his own, though he appears to have absorbed the earlier ideas of Bonnemain [123]. Chabannes' *Patent Calorifère Fumivore Ventilating Furnace,* made at his factory and foundry at 121 Drury Lane in London, was used in a variety of commercial, industrial, and domestic heating and ventilating applications. He used his ventilating furnaces and gas ventilating chandeliers at Covent Garden Theatre to induce air movement and provide adequate ventilation "for drawing off continually the air breathed by two or three thousand persons." Chabannes (1817-1819) removed the apparatus of Wren [187] and Desaguliers [52] from the House of Commons and substituted a large air trunk over the ceiling, into which he led tubes that conducted vitiated air from the House. It is said he also provided steam heating. Around this time, he suggested the ventilating gas light. His calorifère, or fire-tube stove, system of heating became popular in both England and France. He wrote (1818), "The principle of the Patent Calorifère is to surround a fireplace with air tubes so disposed, that a much greater surface is brought into contact with the fire...." This system was later (1829) described in a pamphlet by Bruckmann [26]. He also designed a wrought-iron rivetted cylindrical boiler with a moveable fire grate.

12. *Meade and Saint.*

## [18] Richard TREVITHICK 1771-1833

English mining engineer. Invented a water-powered pumping engine (1798) and a high pressure steam engine (1802). He and Oliver Evans [16] developed the *Cornish* boiler. "Trevithick eventually raised the steam pressure to 1 MPa, this being accomplished even with such imperfect methods of construction as hammering the plates to shape by hand, punching and drifting the rivet holes into rough alignment, whilst it was customary to lay in the joint a piece of rope yarn before riveting up, to ensure steam tightness." He worked as a refrigeration consultant for J&E Hall, and his advice was sought by Jacob Perkins [77]. He also explained the working principles of the cold-air refrigerating machine (1828). Later, developed a portable stove (BP 6083: 1831). Died in poverty and buried at the expense of his fellow workers.

98. *Billington and Roberts, Chaps. 3 and 5. See also* 105. *Roberts, figs.16 and 19. Portrait* 124. *p. 29.*

### [19] Thomas TREDGOLD 1788-1829

English engineer. Received only an elementary education. Apprentice carpenter. Later (from 1813) worked in London office of William Atkinson, architect. Studied chemistry, mechanics, geology, mathematics, French, and German. Published many technical papers on elasticity, strength of materials, flow of fluids, and heat. Wrote books on carpentry, cast-iron, railways, and the steam engine. Published *Principles of Warming and Ventilating Public Buildings, Dwelling Houses, Manufactories, Hospitals, Hot Houses, Conservatories, etc.* (1824), which transformed an empirical art into a numerate technology and brought together engineering, physiology, and comfort. Tredgold made experiments on the cooling of cylinders, deduced the heat emission of steam and water pipes, and estimated the heat loss through a window. He determined the quantity of fresh air needed to support life and to remove exhaled moisture and combustion (gas lighting) products at 4 $ft^3$/min per person. Also, he described a method of attenuating noise from air blowers, making use of resilient and massive materials. Elected Hon. Member Institution Civil Engineers (1821) he is credited with defining the profession of civil engineering as "being the art of directing the great sources of power in nature for the use and convenience of man." He "worked himself to death."

**98.** *Billington and Roberts, Chaps. 3, 4, and 13.* **99.** *Donaldson and Nagengast, pp. 65 and 94. Also* **105.** *Roberts, p. 101. Portrait from* A Dictionary of Arts, Manufacturers and Mines, *Andrew Ure, 1856.*

### [20] John HOYLE active 1790

Engineer from Halifax, Yorkshire. Obtained a patent (1791) for improvements to steam heating apparatus, being "an apparatus for generating steam applicable to the warming of buildings." His system provided steam pipes in, around, and above the room to be warmed. The steam was led to the top of the system and the condensate allowed to return to a collecting vessel by gravity. Later (1793), Joseph Green patented a device "to heat air in double tubes, through which steam or water can circulate." This was a steam-to-air calorifier.

**98.** *Billington and Roberts, p. 101.* **99.** *Donaldson and Nagengast, pp. 39-40.*

### [21] Neil SNODGRASS active 1800

Generally credited with the first practical use of steam (1799) when he provided heating to a textile manufactory on the banks of the River Spey in Scotland. (Tredgold says it was carried out by Cook [10] and was a woollen mill in Glasgow. It is also reported that a few years earlier (1793) a mill in Glasgow was heated by steam.)

**98.** *Billington and Roberts, p. 101.* **99.** *Donaldson and Nagengast, pp. 40-41.*

### [22] William STRUTT — active 1806

Derbyshire cotton mill owner. Improved on the Dutch and German iron plate stoves by developing (1792) a confined fire chamber stove, or *cockle*, "for the purpose of warming his extensive cotton works (at Belper)." Also known as the *Belper* stove, the cockle had a furnace that "itself consisted of a circular iron pot with a rounded top or dome. The fuel was consumed on a grate at the bottom of the furnace. Coal or coke was added through a charging door at one side, while primary air was surrounded by a brick chamber where the air was heated by direct contact with the firepot." The warmth was distributed by gravity air circulation, a fresh air tunnel connection often being provided. Strutt's best known application of the cockle was at the Derby Infirmary (1807). The cockle was subsequently adapted and improved by his son-in-law Charles Sylvester [221] and marketed with some success.

**98.** *Billington and Roberts, p. 190 and fig. 4.5.*

### [23] Robertson BUCHANAN — active 1807

Scottish civil engineer. Sometimes regarded as the first author of a book to detail the practice of heating, though essays had been written by a number of pioneers in the field, including Gauger [54], Franklin [8], William Cook [10], and Rumford [15], but mainly directed at chimneys and fireplaces. Buchanan first wrote his *Essay on the Warming of Mills & Other Buildings by Steam* in 1807. His book *A Treatise on the Economy of Fuel and Management of Heat, Especially as it Relates to Heating & Drying by Means of Steam* followed (1810). He dealt with "On the Effects of Heat, Means of Measuring It, Fuel, etc.," "On Heating Mills, Dwelling Houses and Public Buildings by Steam," and "On Drying and Heating by Steam."

**107.** *Billington.*

### [24] Peter Christoph W. BEUTH — active 1820

German engineer. Helped organize the 1st International Exhibition for Heating and Ventilation (Kassel 1817). Founded the first school of Sanitary and Construction Engineering (Berlin 1819).

**106.** *Usemann.*

### [25] Léon DUVOIR — active 1840

French engineer, responsible for popularizing hot water heating in France (1840-1854). It is said the Price Bros. of Bristol introduced the high pressure system of A.M. Perkins [224] into France (1831 or 1841), this being developed by Duvoir. He later used salt solutions in place of water in his installation at the Palais du Luxembourg in Paris (1853), reaching temperatures of 120°C.

**98.** *Billington and Roberts, pp. 111-119.*

### [26] Captain Carl von BRUCKMANN — active early 19th century

Carried out the first scientific investigations of warm air systems based on measurement of air temperature and air velocity (1829).

*From* **106.** *Usemann.*

### [27] J. Claude Eugéne PÉCLET 1793-1857

French Professor of Physics and a university Inspector-General. Published books on chemistry and physics (1823), illumination (1827), and heat (1830). "His writings are distinguished by their clarity, logical argument and judicious views." Wrote a remarkably detailed account of heating in his *Traité de la Chaleur* (3rd edition, 1844). An avid experimenter, he investigated air flow and resistances in fittings, heat emission by radiation and convection, fresh air requirements, development of the open fire, and heat losses. He was probably the first to discuss intermittent operation of heating systems in a quantitative manner and appreciated the fact of heat storage in the structure. He stressed the importance of ventilation and considered class of building, occupancy, air change rate, fresh air amount, $CO_2$ content, and humidity. He also took an interest in fan design and evaporative coolers.

*Eugene Péclet as a Heating and Ventilating Engineer, P. Nicholls,* ASHVE Journal, *28, 7, October 1922, pp. 709-718.*

### [28] Walter BERNAN (R.S. Meikelham) active 1845

Civil engineer. Wrote a comprehensive two-volume study, *On the History and Art of Warming and Ventilating Buildings* (London, 1845). The title page of his classic history continues, *by open fires, hypocausts, German, Dutch, Russian and Swedish stoves, steam, hot water, heated air, heat of animals, and other methods; with Notices of the Progress of Personal and Fireside Comfort and of the Management of Fuel.* Bernan's great work is "Illustrated by Two Hundred and Forty Figures of Apparatus" and is essential reading for anyone interested in the historical development of heating and ventilating.

11. *Bernan.*

### [29] Charles HOOD 1805-1889

London ironmonger in business at Blackfriars. Became interested in practical science, astronomy, and later "the Chemistry of the Combustion of Coal." Being an ironmonger, he was able to manufacture various designs of stoves and grates. He experimented with different types of coal, noted how combustion varied according to thickness of fuel on the fire bars, and deduced equations for complete and incomplete combustion. For this work he was awarded the Silver Medal of the Society of Arts. Hood was encouraged to write *A Practical Treatise on Warming by Hot Water* (1837), which led to his election as Fellow Royal Society. Hood studied the heat emission of pipes and heat losses from buildings. He tabulated the amount of heating surface required for various types of buildings. Many of his rules and tables remained in widespread use until the turn of the century.

*From* 107. *Billington.*

### [30] Thomas BOX — approximately 1821-1885

English hydraulic engineer. Specialized in the design of mill-gearing. His interests were widespread and he wrote *Treatises: Hydraulics* (1867), *Heat as Applied to the Useful Arts* (1868), *Mill Gearing* (1869), and *Strength of Materials* (1883). Box wrote about ventilation requirements for life, removal of water vapor, removal of metabolic and other heat, and removal of odors. He discussed the design of aspirating chimneys and proposed a *Chapel System* of ventilation that employed a weight-driven fan. He attempted to calculate intermittent heat flows in buildings and compared fuel usage under continuous and steady-state heating operation. Box gave the symbol *U* to the quantity now termed *thermal transmittance*.

*From* **107.** *Billington. See also* **98.** *Billington and Roberts.*

### [31] Charles TOMLINSON — active 1850

English engineer. Author of the textbook *Rudimentary Treatise on Warming & Ventilation* (1844). He noted the metal stove "is a common article of furniture in Northern Europe" and its "popularity" is attributed to the scarcity and cost of fuel. He also described the art of natural ventilation, citing the roof of the Hall of Baths in the Alhambra at Granada as "being of the best possible form for the purposes of ventilation." In later editions, he quoted estimates of the heat requirements of buildings based on Arnott [126] and used the data of Hood [29] for heat emission of pipes.

**99.** *Billington and Roberts, Chap. 13.*

### [32] Stephen J. GOLD — active 1850

American inventor and iron stove manufacturer. Developed domestic steam boilers, obtained four patents (1854-1856). Formed (1859) the firm of Gold, Foskett & Gold to sell steam boilers, with manufacturing arranged by the H.B. Smith Co. (founded 1854), who later made boilers for Mills [37]. His son, Samuel Gold [40] worked with him. Stephen Gold's patents included his *mattress radiator*, in which two embossed sheets were fastened together by rivets, similar to the steam radiator of Watt [13].

**99.** *Donaldson and Nagengast, pp. 80-81 with picture of his mattress radiator on p. 91.*

### [33] Nelson H. BUNDY — active 1860

American heating manufacturer. Early wrought-iron radiators were replaced by cast-iron, the earliest including the *Ox-bow and Wash-board* designs, with single castings or halves bolted together (from c. 1856). A primitive sectional radiator was devised by Thomas Tasker of Philadelphia (1858). Other early designs included those produced jointly by Nason [206] and Briggs [205]. Possibly the first true sectional radiator was the cast-iron design brought out by Bundy (1869), who had worked earlier for Nason. Manufactured by the firm of Bundy & Healey, this was "the first cast-iron radiator to catch the popular fancy." An improved version was manufactured by the A.A. Griffing Co.

**99.** *Donaldson and Nagengast, p. 84.* **105.** *Roberts, fig. 38.*

### [34] Adolf BECHEM — active 1870

Has been credited with the first low pressure steam heating system (1878) in continental Europe. Vacuum return steam heating systems had been patented in America at this time and were subsequently developed by Webster [47].
*From* **106.** *Usemann.*

### [35] Charles James RICHARDSON — 1809-1871

English architect. Assistant to Soane [189], with whom he shared an interest in heating technology. His book *Warming & Ventilation of Buildings* (1837) records details of many contemporary installations: "During the time of my professional duties in Sir John Soane's office, I had opportunities (even without leaving it) of studying the different systems of warming, all of which in their turn have been introduced in that building. The one which I prefer, and which I have chosen for examination, is Mr. Perkin's [224] system of warm water circulation." Richardson's elaborate drawings and descriptions include the high-pressure hot water installations at the British Museum and Stratfield Saye (home of the Duke of Wellington), but he offers no clue as to design procedures. He perceived the possibility of combining heating and ventilation.
**98.** *Billington and Roberts, pp. 115-118.*

### [36] William THOMPSON — 1814-1878

Founded (1834) a family boilermaking business in Bilston, Staffordshire, "when the Black Country earned its name, with the intensity of manufacture fueling the motivation of progressive individuals." It is said he was the first man to make a boiler from a template, which significantly reduced manufacturing costs, but he failed to protect his ideas from competitors. Eventually the business got into difficulties (1851). The management was taken over by his brother, Stephen, control later passing to William's son, John Thompson [39].
**10.** *NEI Thompson with portrait from p. 1.*

### [37] John Henry MILLS — 1834-1908

American heating contractor, consultant, and inventor. Patented a cast-metal sectional steam boiler, designed for use with an engine (1867). Later, designed boilers specifically for heating (1869-1874). His steam boilers were manufactured by H.B. Smith & Co. (from 1871). Mills then turned to water as "a superior heating agent." He also developed direct and indirect radiators. Wrote *Heating by Steam* (1877), then the two-volume *Heat, Science & Philosophy of its Production and Application to the Warming and Ventilating of Buildings* (1890). In the last quarter of the 19th century, he was considered "one of the most widely renowned engineers in the United States." Though he made a fortune, it is believed he finished his days virtually penniless.
**99.** *Donaldson and Nagengast, pp. 81-83. Portrait:* The Beginnings of a Century of Steam & Water Heating, *S. Stifler, H.B. Smith Co., Westfield, 1960.*

### [38] Paul KÄUFFER 1837-1897

Inventor of *controllable* low-pressure steam heating (1878) in continental Europe. See also Bechem [34].

*From* **106.** *Usemann.*

### [39] John THOMPSON 1839-1909

Bought back (1860) the boilermaking business started by his father, William Thompson [36]. Moved the factory to Ettingshall, near Wolverhampton, where the company, now John Thompson, prospered. "Most of the work still had to be manhandled, with boiler plates brought in by wagons. Few of the shops had roofs, and in winter, plates often had to be dug out from under snow or ice. After rolling, the plates were cottered up, three in a row for hand rivetting" (description c. 1885). By the time of John's death, the company, now with some 600 employees, specialized in the manufacturing of large dish-ended steel Lancashire boilers, shipping them to locations all around the world.

**10.** *NEI Thompson with portrait from p. 6.*

### [40] Samuel Fay GOLD 1840-1907

American engineer. Son of Stephen Gold [32]. Patented a low pressure, cast-iron, vertical-section steam boiler (1859), adapting the earlier designs of George B. Brayton. This *Gold* boiler was manufactured by H.B. Smith Co. Later (1862), with William Foskett, devised the Gold Pin radiator. His boiler and radiators "not only caught the public fancy, but practically changed the entire heating methods of the whole country."

**99.** *Donaldson and Nagengast, p. 81.*

### [41] Thomas POTTERTON 1847-1926

English engineer and businessman. Expanded his father's building business, first improving the efficiency of kitchen ranges and boilers (BP 5182: 1894). Introduced what is claimed as the world's first gas boiler for central heating using town's gas (1902). Other inventions followed, including the first cut-out valve system and an ether capsule thermostat, "which he designed for the comfort of a relative dying from consumption." He developed the *Victor* boiler, the *Seal-ed* oven cooker and the *Queen* combined gas and coal ranges. Potterton was a pioneer in the introduction of multiple gas boiler installations for large systems of hot water supply, such as the 16-boiler plant provided for bath service at Sandow's Curative Institute in Piccadilly, London (1909). Later (1922-1923) he perfected the *Victory* combination boiler for the use of solid and gaseous fuels. He was an IHVE founding member (1897).

*Thomas Potterton, The Heatmakers No. 4 with portrait.* **105.** *Roberts, figs.40 and 41.*

### [42] John James ROYLE c. 1850-1919

English engineer. Founded the firm of J.J. Royle of Manchester. Specialized in the manufacturing of steam traps, reducing valves, feed water heaters, and calorifiers. It is said the word *calorifier* was originated by Royle, probably derived from the French calorifère.

*See* **105.** *Roberts, fig. 31.*

### [43] Joseph STREBEL 1851-1897

German engineer. Developed a sectional boiler with O-shaped cast iron sections (1893) that was patented by Rudolf Otto Meyer.

*From* **106.** *Usemann.*

### [44] James A. TRANE active 1885

Founder of American steam heating system manufacturer, later Trane Company, in La Crosse, Wisconsin, built up by his son Reuben [108].

**99.** *Donaldson and Nagengast, pp. 261-262.*

### [45] Captain Andres Borch RECK active 1900

Danish engineer. Produced the forerunner, the *Reck System*, of a number of *accelerated* hot water heating systems that relied upon steam to produce water circulation (1902). It was an improvement on the Rouquad system used in Russia (1899) and later in France (1901-1902), in which steam losses were as high as 20%. Variants were introduced by H. Hamelle in Paris (1904), Nessi Frères in France (1905), and Bruckner in Austria. The Reck system was widely used in some 21 countries around the world (by 1910). An early catalogue (James Boyd & Sons of Paisley, Scotland, 1911) records a total of 806 installations around the world, though only 11were in the USA. A superior system, the *Cable System,* was developed (1903) by Barker [216].

*See* **98.** *Billington and Roberts, section 3.5, which describes a number of accelerated systems.*

### [46] David (Dave) LENNOX 1855-1947

American engineer. Son of an expert railway mechanic, he "inherited an astonishing mechanical ability from his father." Went to Marshalltown, Iowa (1881). Started a machine shop and then founded Lennox Machine Co., which manufactured architectural materials, boilers, engines, and farm implements. At this time, home furnaces were made of cast iron, which warped and cracked after extended use. Dave Lennox built the first rivetted steel, coal-fired furnace (1895). His superior furnace became popular but Lennox soon tired of the business and sold out to D.W. Norris and other investors (1904); the new company sold 600 furnaces in the first year. The humble machine shop started by Dave Lennox grew into one of the major heating and refrigeration manufacturers in the USA, becoming Lennox Industries (1955) and then Lennox International (1984).

**1.** Century of Comfort *with portrait from p. 2.*

### [47] Warren WEBSTER 1863-1938

American engineer. Pioneer in vacuum steam heating. The first developments were due to DeBeaumont (USP: 1878) and Williames (USP: 1882). Webster first purchased (1888) an interest in the vacuum steam heating patent of George Barnard. His firm, the Warren Webster Co., shortly thereafter acquired the first patents of DeBeaumont and Williames, becoming the principal manufacturer of vacuum return systems for many years. System operation was considerably enhanced by the thermostatic return trap of Willis Hall (USP: 1891). (A competing system, designed by William Skiffington in New York, was developed by Andrew G. Paul, who sold the rights to Andrew Cryer (1898). Cryer established the Paul System Co., which equipped many hundreds of buildings with the system.)

**99.** *Donaldson and Nagengast, pp.107-109. Portrait from* Heating & Ventilating Magazine, *26 June 1929, p. 99. Additional information is available in the book:* The Life and Times of Warren Webster, *Warren Webster Jr., publisher/date unknown.*

### [48] J.E. HARTLEY 1867-1928

English industrialist. Worked for boilermakers Hartley & Sugden, Halifax. Appointed Managing Director at the age of 25. Served on IHVE Boiler Rating Committee. Later became the 15th President IHVE (1913). Presidential address, *Expansion of the Institution.*

**93.** *Proc. of IHVE, 1913. See also* **105.** *Roberts, fig. 30 and plates 14,18.*

### [49] Sam NAYLOR 1897-1941

English engineer. Joined Halifax boilermakers (1876), which became Lumby, Son & Wood (1886). Director (1896). Took a keen interest in "the evolution of the boiler" and secured a number of patents. Founding member IHVE and served on Boiler Rating Committee. Gave IHVE papers *Boilers for Low Pressure Hot Water Heating* (1900), *French System of Steam Heating* (Silver Medal, 1902), and *Comparisons Between Forced Firing & Slow Combustion* (1915). Served two-year term as the 18th President IHVE (1916 and 1917). Presidential address, *Suggested Readjustment in Standardization.*

**93.** Proc. of IHVE, *1916. His portrait is included in the composite of the IHVE Council, 1910 in the section "The Comfort Organizations," p. 113. See also figure 10.*

### [50] Sam FOX 1870-1960

English engineer. Joined Halifax boilermakers Hartley & Sugden (1886). Director (1907). Managing Director (1916). Gave IHVE Paper *Half a Century of Boiler Making* (1930). 31st President of IHVE (1931). Presidential address, *The Heating and Ventilating Industry.* Responsible for introducing the *IHVE Journal* (1933).

**93.** Proc. of IHVE, *1931. See also* **105.** *Roberts, fig. 30 and plates 14,18.*