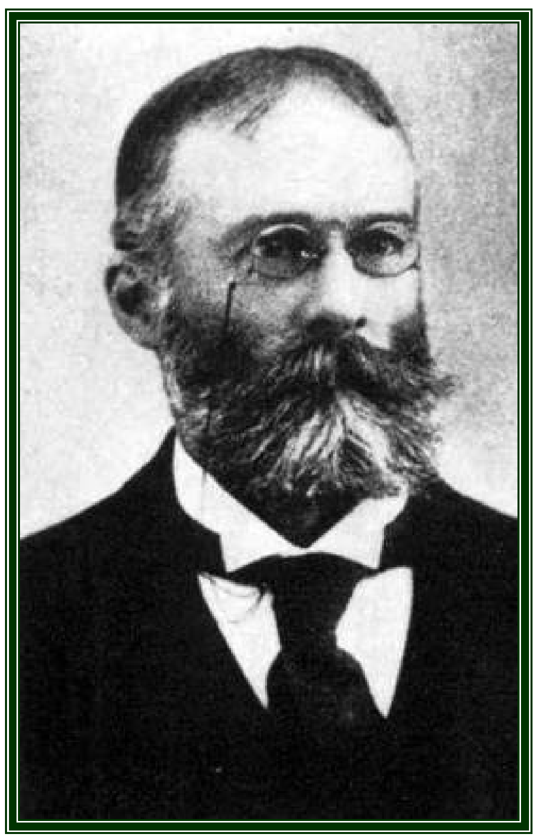
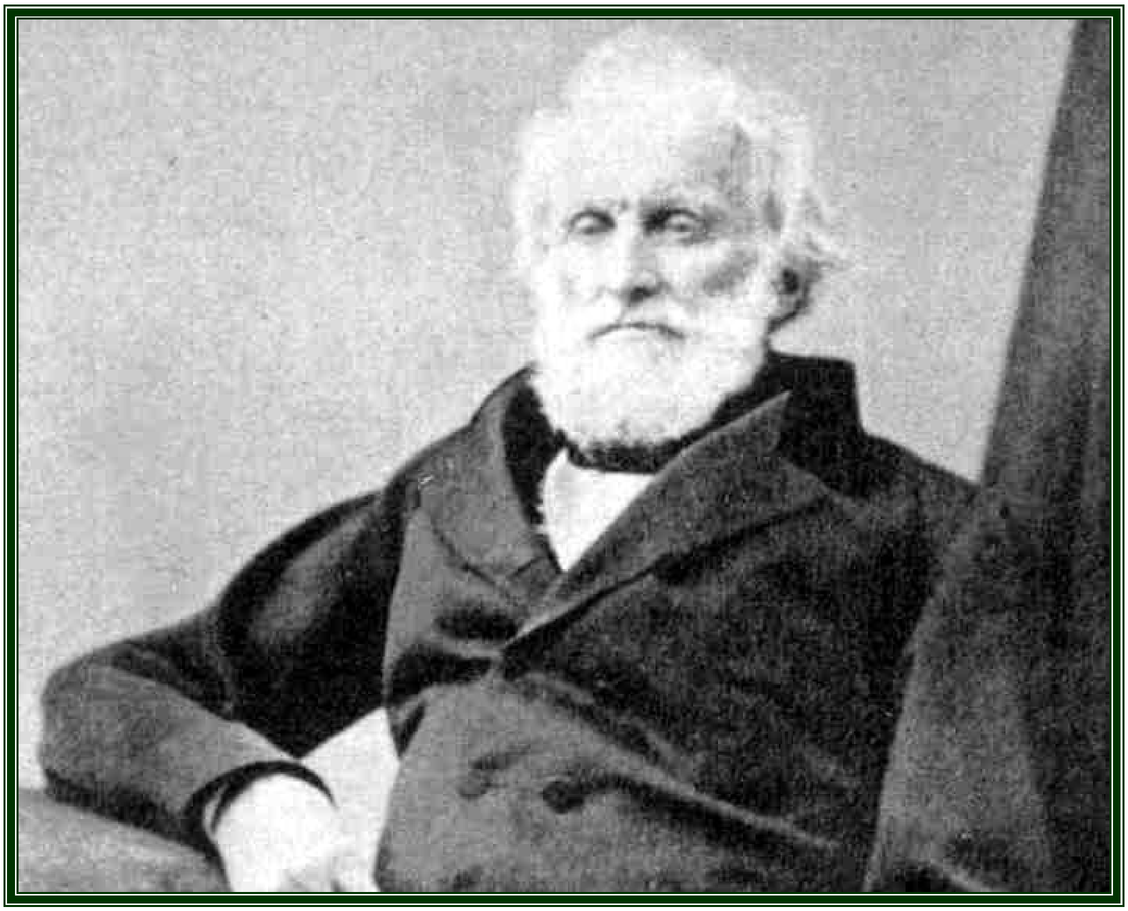
FREDERIC TUDOR
Active 1880-1910



Pioneer of steam heating
Son of the "Ice King" (below)



Frederick Tudor Sr 1783-1864 "Ice King of the World"
Harvested natural ice and shipped it across the world

CHAPTER 1

The History of Refrigeration

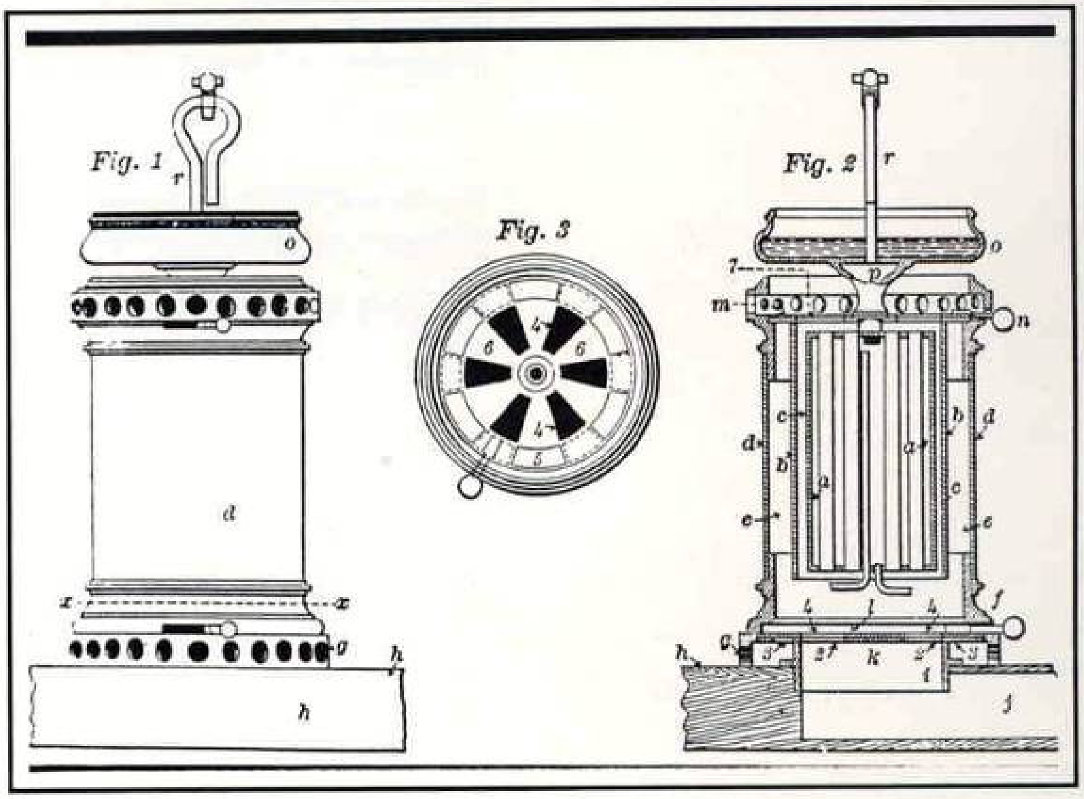
1.1. Refrigeration by Natural Ice. In the early part of 1806 the brig *Favorite* slid into the harbor of St. Pierre, Martinique, with 130 tons of cake ice in her hold. This was probably the first large-scale commercial venture in the refrigeration field, and the owner of this cargo, Frederic Tudor, lost some $3500 on the venture. Since ice was unknown in Martinique and no storage facilities were available for its preservation, the financial loss would have been much greater but for some quick thinking on the part of the man later destined to become known as the Ice King. Through arrangements with one of the eating-house proprietors he concocted and introduced ice creams in the West Indies, where frozen desserts were virtually unknown.

In later years, by the construction of an icehouse at St. Pierre and by the use of pine sawdust as an insulation during the transportation of his ice cargoes, Tudor turned his idea into an extremely profitable business. He contracted for the cutting of ice in ponds and rivers throughout New England and shipped it throughout the world, not only to the West Indies and to the southern part of our own country but also to such faraway places as South America, Persia, India, and the East Indies. In 1849 his cargoes totaled 150,000 tons of ice; by 1864 he was shipping to 53 ports in various parts of the world. The business he founded changed the lives and habits of people throughout the world, and the methods he used remained essentially the same until they were supplanted in the 1880's by the manufacture of artificial ice.

(Text from "Refrigeration and Air Conditioning,"
Richard C Jordan & Gayle B Priester, 1956

Frederic Tudor, son of the "ice king" (Figure 7-35), grew up in Boston familiar with the heating and ventilating industry and, like many of his colleagues, an inventor. He was interested in "the comfort and convenience of the average citizen, and especially the average woman (who) had not been considered by steam heating engineers."

> All these objections were perfectly plain to me when I entered into the business of heating, but previous to 1880, I had all that I could attend to in improving the art of ventilation in connection with heating, and I had very little to do with heating by direct radiation. After all its advantages have been summed up, in the important respects of health and comfort, it is seen to be a vile system, and it did not interest me, except to imagine how it could be improved. This feeling led to the invention of the jacketed direct radiator with definite air supply and immunity from freezing. The invention is shown in U.S. Patent No. 185,146 [Plate I, Figure 7-36, top]. This patent covers a radiator having a combination of castings and air passages with valves whereby the volume of fresh air admitted and the temperature of the air warmed are easily regulated; in combination with the radiator are a reservoir of water heated by the steam in the radiator. The drawing of this radiator pretty clearly explains it, Figure 3, showing the air damper.
>
> This system affords heat regulation without manipulating valves. It was installed in the Hotel Cluny and a Boston office building in 1876, no valves being used. The Cluny system is in use today.



The jacketed direct radiator with air supply US Patent No. 185,146

The evaporator has been used only with large radiators for indirect heating with fans, in connection with the air-mixing valves as shown. Bechem & Post usually omit the manual steam and return valves. It seemed to me about this time that the growth of the high office buildings would make it very desirable to adapt a system of graduated control to direct radiators, whether fresh air was in question or not.

Plate 2 (Figure 7-36, bottom) shows patent 278,636 (May 28, 1883), covering a combination steam and hot-water system, the principal parts of which are the boiler, A, the expansion tank, H, the indirect radiator, K, and a direct radiator at the top, put in later, in dotted lines.

The peculiarities of this system are, first: the air trap O, which acts both as a safety valve for the system, and as an air valve for the indirect radiators; and the stand pipe, I, above the expansion tank.

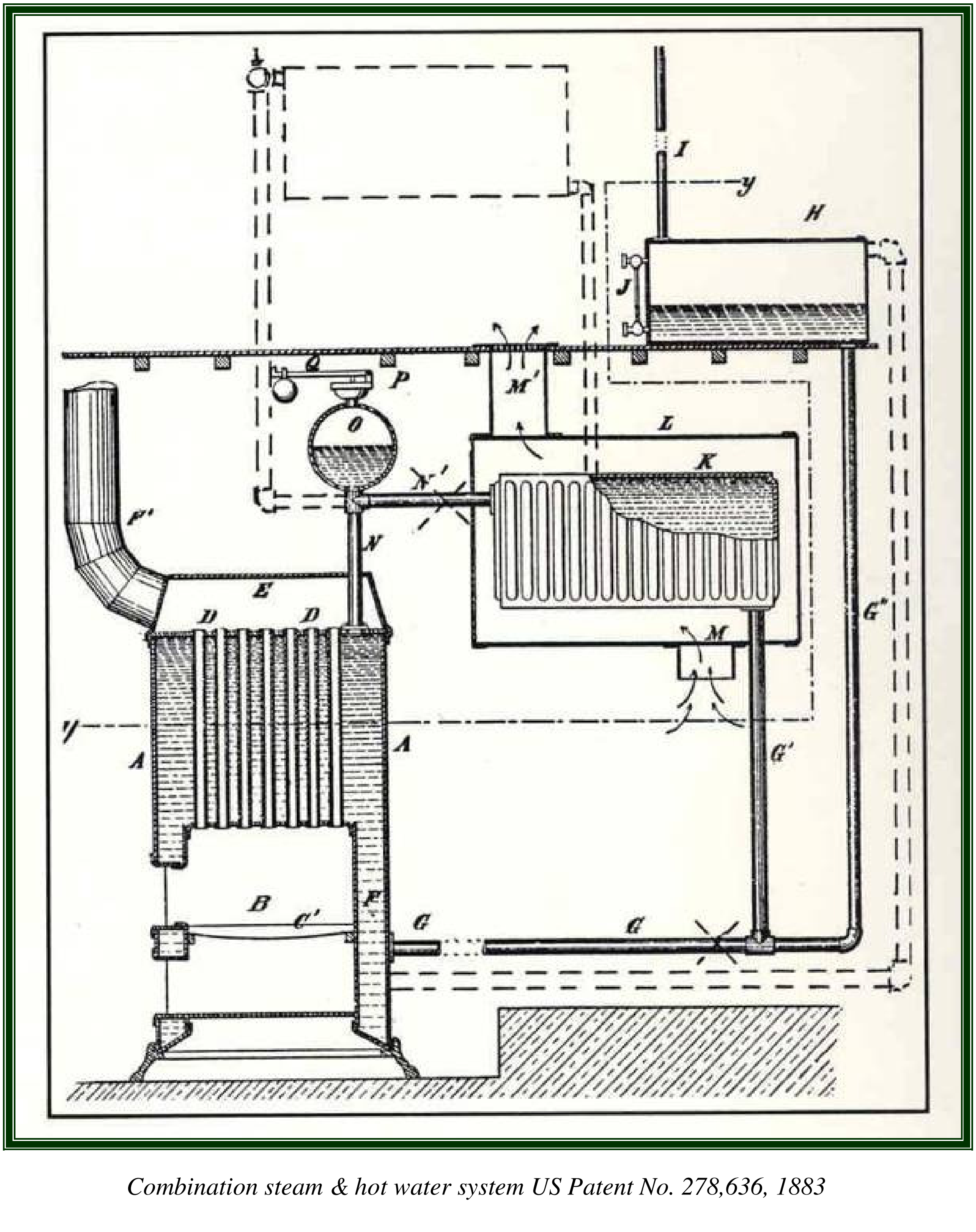
If in this apparatus the fire is forced so as to make steam, the steam will drive the water out of the air trap, O, the indirect radiator, K, and down in the pipe, G, and boiler, A, to the water line, y. In doing this it will raise the water in the expansion tank up into the stand pipe, I, to the upper water line, y, where it will be discharged and relieved of further pressure. In order to accomplish this the size of the expansion tank and the height of the stand pipe must be properly proportioned to the volume of water in the rest of the system.

In this condition the apparatus will run as a steam-heating plant and is equipped with the ordinary damper regulator to check the fire when it gets too hot.

When steam heat is no longer desired, and the fire is allowed to go down, the steam in the top of the trap and in the radiators will gradually condense, and the water will come down from the expansion tank and stand pipe and fill the boiler and radiators just as they were in the first place.[47]

Frederic Tudor continued to work on the design of ventilating systems and designed the heating and ventilating system for the Metropolitan Opera House (1883) and the Union League Club (1887), both in New York City; however, most of his innovations saw more use in Europe than in the United States.

(Text extract from "Heat & Cold: Mastering the Great Indoors,"
Barry Donaldson & Bernard Nagengast, ASHRAE, 1994



Combination steam & hot water system US Patent No. 278,636, 1883

The Metropolitan Opera House, New York, 1883
(From "New York 1900," Robert A M Stern et al, 1995)

Union League Club competition entry, northeast corner of Fifth Avenue and Thirty-ninth Street. Richard Morris Hunt, 1879. Perspective. CU

Union League Club, New York
(From "New York 1900," Robert A M Stern et al, 1995)

GEORGE LOUIS TUVE
1896-1980

Educator and Researcher

[114] George L. TUVE **1896-1980**

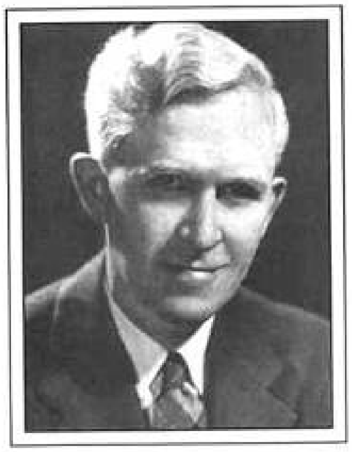
American professor of Mechanical Engineering, researcher, and author. Specialized in heat transfer and fluid mechanics. Coauthored textbook *Mechanical Engineering Practice* (1920s). Worked at Case Institute of Technology in Cleveland, Ohio (from 1930). Carried out fundamental research into the behavior of air jets (from 1942). President ASHVE (1948). Received ASHRAE's F. Paul Anderson Award (1957). Inducted into ASHRAE Hall of Fame (1996).

(Mini-biography from "The Comfort Makers," Brian Roberts, ASHRAE, 2000)

GEORGE LEWIS TUVE **1896 – 1980**

Tuve had an enviable career in the engineering field. For 40 years, he was a professor of mechanical engineering at several universities. He was head of the Department of Mechanical Engineering at Case Institute of Technology from 1945 until 1957, when he was named Director of the Bingham Laboratories at Case. Professor Tuve was co-author of an engineering textbook used in over 100 engineering schools, which is still in use today. He was a researcher in heat transfer and fluid mechanics as applied to air conditioning systems. Professor Tuve was President of ASHVE in 1948 and served on many special and technical committees. He presented 12 technical papers at Society meetings and wrote several papers for ASME. He is listed in "Who's Who in America" and "American Men of Science." George Lewis Tuve was inducted into the ASHRAE Hall of Fame in 1996.

(Edited extract from ASHRAE "Hall of Fame" Citation)



1948

ASHVE

George L. Tuve

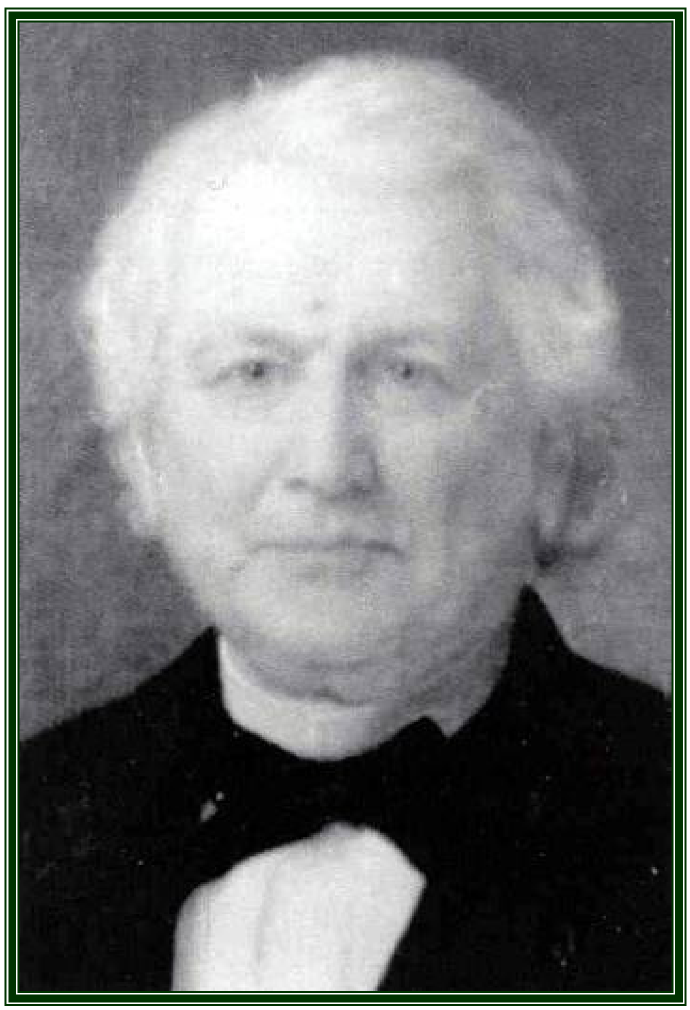
1896-1980

Cleveland, OH

"Among the year's accomplishments...Payment of the mortgage on our Research Laboratory...we have been able to increase our publications program... cooperation with other groups of engineers [and others]...Our research program has been broadened..." (p. 1, *ASHVE Trans.*, 1949)

(From "Proclaiming The Truth," ASHRAE, 1995)

ALEXANDER CATLIN TWINING
1801-1884



Pioneer of ice-making refrigeration

[79] Alexander Catlin TWINING **1801-1884**

American scientist, inventor, and civil engineer. He published a booklet entitled *Manufacture of Ice on a Commercial Scale* (1851). Filed various patents (BP: 1850 and USP: 1853). Designed an experimental ethyl ether freezing machine (1850) with a larger machine constructed at the Cuyahoga Steam Furnace Co. in Cleveland, Ohio (c. 1855), producing about 1700 pounds of ice per day. This latter plant was a forerunner of the "ice-can" system, where water was frozen in metal cans (1862). His system did not see commercial manufacture, largely due to the Civil War, and it would be James Harrison [80] who would succeed where Twining had failed.

(Mini-biography from "The Comfort Makers," Brian Roberts, ASHRAE, 2000)

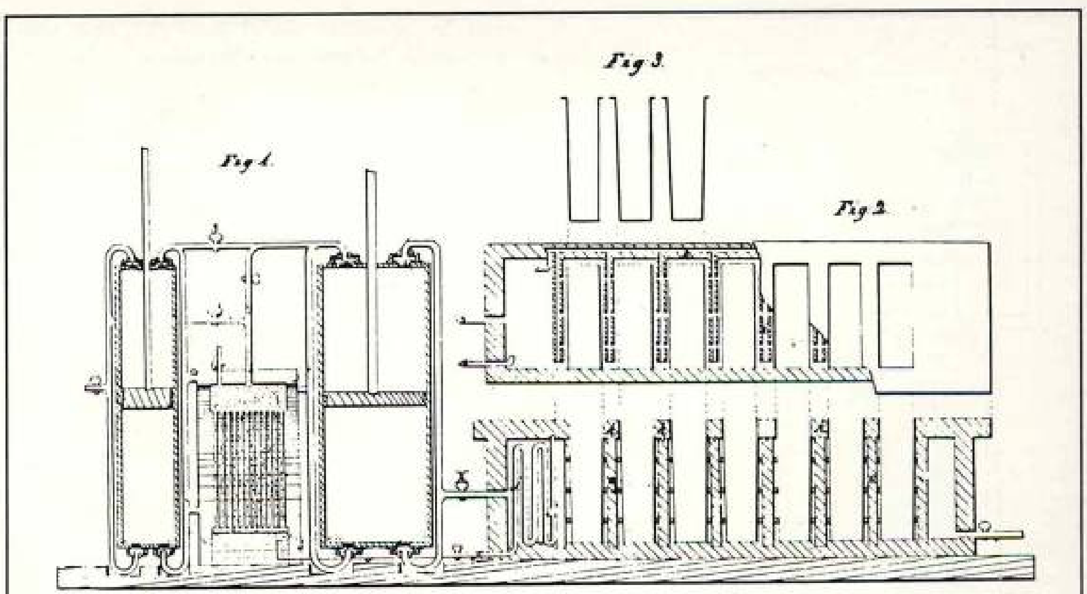


Figure 8-14 *Patent drawing showing Twining's ice-making plant of 1853 upon which the Cleveland, Ohio, plant was based. This plant is a forerunner of the later can ice plants, where water was frozen in metal cans. Twining's system used direct expansion coils wrapped around each ice can, whereas later plants used a secondary refrigerant, such as brine, around the cans. The ether compressor shown on the right side of the shell-and-tube condenser is double acting. The smaller compressor at left was used for nonrefrigeration purposes such as air evacuation. The* Cleveland Leader *reported in 1855 that Twining's machine was freezing ice blocks one-half cubic foot in size.*

Twining Builds the First Ice-Making Plant

The American civil engineer and professor Alexander Catlin Twining (Figure 8-13) is generally credited with being the first to advance the earlier work of Evans, Perkins, and Hague[28] with the vapor-compression method of refrigeration. None of the published information about Twining, his own publications, or personal papers indicates that he had any familiarity with Perkins' work.[29] In fact, there does not seem to be any indication as to why Alexander Twining pursued his interest in refrigeration. For whatever reason, Twining became interested in this area, and he summarized his pursuit as follows:

> The first experiments were mere elementary trials, made as far back as the year 1848. By maintaining a vacuum in a small reservoir of ether immersed in water, the weight of ice which the evaporation of a given quantity of ether would produce, was proved. Next, by computing the power necessary to effect that evaporation, there was found a sufficiently promising result to encourage a prosecution of the subject. The experiments were repeated, till 1850, under different forms and with accordant results.
>
> The next question arising was whether the ether vapor could be recondensed with sufficient rapidity. By numerous experiments it was ascertained that only two hundred superficial feet of thin copper pipes would form an adequate surface for the manufacture of 2000 lbs. of ice in a day

> of twenty-four hours—even employing water of the temperature of the Earth's Equator.
>
> It was next to be ascertained whether the evaporation itself could be made sufficiently rapid.
>
> The first attempt at a complete freezing machine was made in the summer of 1850. The machine had only capacity to freeze a pail full of water at one operation. It embraced the evaporating, the condensing, and the freezing parts of my present engine and apparatus. But the mode of applying the freezing power was widely different. Six months were consumed in trials with this machine; and the most discouraging practical difficulties were brought to light. It was not till long afterwards that the inventor could discover the proper modes of obviating these difficulties. Nevertheless this first small machine served as a complete verification of the facts, principles and numerous small experiments which had been relied upon; and it thus became an encouragement, in the end, to attempt a vastly larger construction.[30]

Twining had been so sure of success that he filed a caveat with the U.S. Patent Office in November 1849, and soon after filed for a British as well as a U.S. patent[31] (Figure 8-14).

The larger machine mentioned above was constructed at the Cuyahoga Steam Furnace Company in Cleveland, Ohio (where Twining was doing some railroad work), with freezing trials beginning in February 1855. By the summer, the machine was capable of producing almost 1,700 pounds of ice.[32] This machine, based upon Twining's patents, continued in operation for at least the next two years in Cleveland. Twining, like John Gorrie, attempted to interest financial backers for construction of an ice-making plant in New Orleans and issued a proposal to interested parties.[33] Unfortunately for Twining, the Civil War scuttled any progress on the venture. Twining had attempted to set up an improved system at the Morgan Iron Works of New York City in 1863, but "without fault of the invention itself, but through accidents, imperfections in the cold-producing constructions, and the failure of funds, the enterprise resulted in no profit, but in an increase of the inventor's outlays, in the aggregate of $40,000, of which only $3000 has ever been realized in return. . . ."[34]

Not only did the Civil War physically prevent Twining's efforts to make ice in the South, but Twining also felt that it gave others, particularly Ferdinand Carré and James Harrison, the opportunity to steal his ideas for their own use. Twining's feelings are obvious in reading his 1870 petition to the U.S. Congress for extension of his 1853 patent.[35] Still, Twining's method of making ice, to be known later as the "can ice" system, would become the most common method used throughout the world. Twining's 1855 ice-making plant at Cleveland was the earliest success at using the vapor-compression refrigerating system to manufacture ice beyond the experimental, in commercial quantities. Not only did the Cleveland system work successfully, but elements of his patent were incorporated into the first commercial ice plant operated in the southern U.S. at the Louisiana Ice Manufacturing Company in 1862.[36] Still, Twining's system did not see commercial manufacture. It was his contemporary, James Harrison, of Australia, who would succeed where Twining failed.

(Text and pictures from "Heat & Cold: Mastering the Great Indoors," Barry Donaldson & Bernard Nagengast, ASHRAE, 1994)

THOMAS WILLIAM TWYFORD
1820-1897

Company Founder

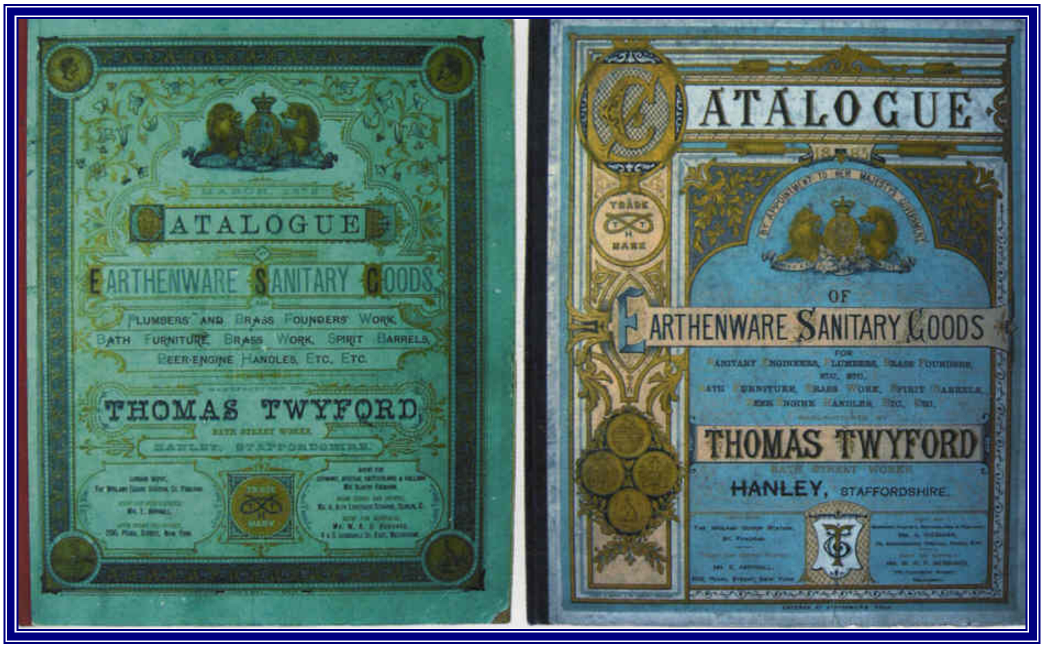
THE TWYFORDS had been involved in potting in north Staffordshire since the seventeenth century. In 1849 Thomas Twyford had turned almost exclusively to the manufacture of sanitaryware at new works at Bath Street, Hanley. Upon his untimely death at the age of forty-six, his son, Thomas William Twyford, found himself in charge of the family business.

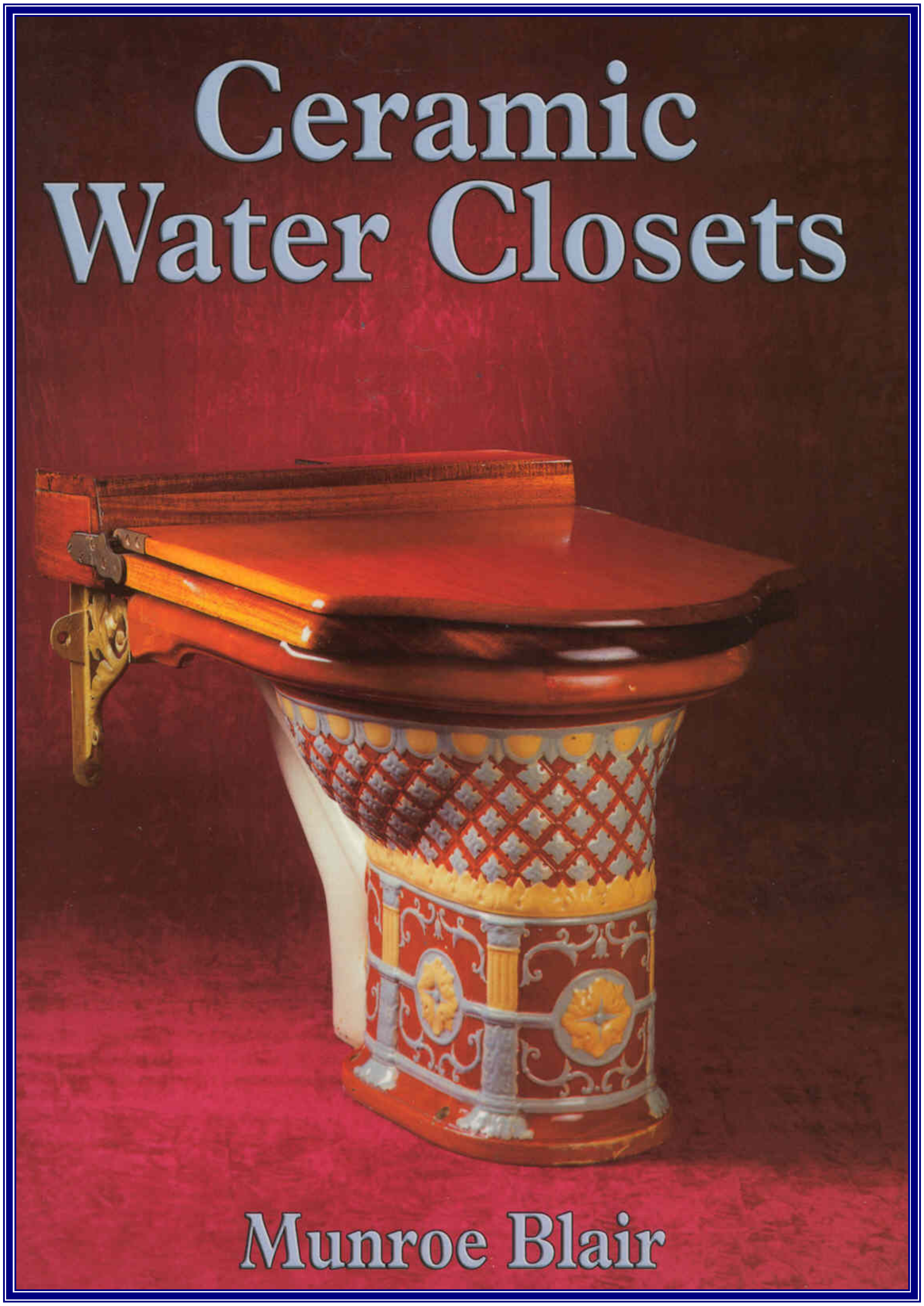
The business expanded rapidly with a second pottery, the Abbey Works, at Bucknall, Stoke-on-Trent in production by 1875, and then in 1887 the Cliffe Vale works was established. This occupied 9 acres of land alongside the Bridgewater Canal, Hanley. Twyford paid particular attention to the welfare of his employees in the design of these works, building spacious, well ventilated workshops to reduce the risk of pneumoconiosis – 'potters' asthma' – caused by the inhalation of fine sharp particles of silica dust. Twyford then brought some experienced fireclay potters from Scotland to Hanley, and by late 1890 had added 'porcelain enamelled' fireclay articles to his range of goods. Further expansion in the early twentieth century saw the opening of a factory at Ratingen, near Dusseldorf, Germany to avoid high German import duties. In 1911 new fireclay works were built opposite the Cliffe Vale site, and the following year a new pottery was established at Etruria.

Thomas W.Twyford.
(*Twyford Bathrooms*)

By the late nineteenth century Twyford's were indisputably the largest makers of ceramic sanitaryware in the Staffordshire pottery towns and one of the leading makers in the country with a worldwide reputation. Twyford always ensured that his products represented the latest thinking in sanitaryware, yet his role as an innovator may have previously been over-emphasised. Although he took out thirteen patents for sanitaryware between 1884 and 1892, none of the major, lasting developments of this period can be attributed to him. Thus the 'Unitas', while being one of the earliest fully enclosed pedestal wash-out closets, was not the first: it was preceded by George Jennings's 'Pedestal Vase'. But if Twyford lacked Jennings's originality, neither did he make his mistakes and the majority of Twyfords' products were extremely successful. They were, besides, some of the most aesthetically pleasing, and the range of decorative ceramic sanitaryware illustrated in colour in his highly ornate *Twentieth Century Catalogue* of 1901 arguably represents one of the all-time peaks in sanitaryware design. Today, as Twyford Bathrooms, based at Alsager, Cheshire, the company maintains its position as a major producer of ceramic sanitaryware.

From Bogs, Baths & Basins," David J Eveleigh, 2002 (CIBSE Heritage Group Collection)


CATALOGUE
EARTHENWARE SANITARY GOODS
PLUMBERS' AND BRASS FOUNDERS' WORK,
BATH FURNITURE, BRASS WORK, SPIRIT BARRELS,
BEER-ENGINE HANDLES, ETC. ETC.
THOMAS TWYFORD
HANLEY, STAFFORDSHIRE.
CATALOGUE
OF
EARTHENWARE SANITARY GOODS
THOMAS TWYFORD
HANLEY, STAFFORDSHIRE.



(CIBSE Heritage Group Collection)

T.W. Twyford, 9 3/4 Sanitary Potter,

Designs of the "Cardinal" & "Deluge" Wash Down W.C. Basins.

No. 28—" Mikado."
Blue Print on White Ware.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 29—" Mikado."
Brown Print on Ivory Ware.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 30—Printed, Blue on White Ware.
No. 31—Printed, Brown on Ivory Ware.
" Japanesque,"

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 16—" Chrysanthemum."
Printed.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 27—" Poppy."
Brown Print on Ivory Ware.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 26—" Poppy."
Blue Print on White Ware.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
54/-		46/6	8/-

No. 19—" Chrysanthemum."
Coloured.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
64/-		56/6	10/-

No. 25—" Venetian" Pattern.
Raised Ornament. Blue & Gold.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
131/6		124/-	18/-

No. 18—" Azalea."
Coloured.

The Cardinal.	White or Ivory.	The Deluge.	Paper Box.
64/-		56/6	10/-.

Cliffe Vale Potteries & Enamelled Fire Clay Works

T. W. TWYFORD.
SANITARY POTTER.
No. 8. "Dahlia" Pattern,
Blue Print on White Ware.
No. 9. "Florentine" Pattern,
Brown Print on Ivory Ware.
No. 10. "Florentine" Pattern,
Blue Print on White Ware.
Combining Water Closet Basin
"UNITAS"
Also Urinal & Slop Sink
No. 11. "Florentine" Pattern,
Blue and Gold on White Ware.
No. 12. Raised Ornamentation,
No. 13. Raised Ornamentation,
Traced in Blue is No. 14.
Hanley Staffordshire.
45

The "Twycliffe" Patent Syphon W.C. Closet Basin.

'Hot baths are by no means a class of agents to be trifled with.'

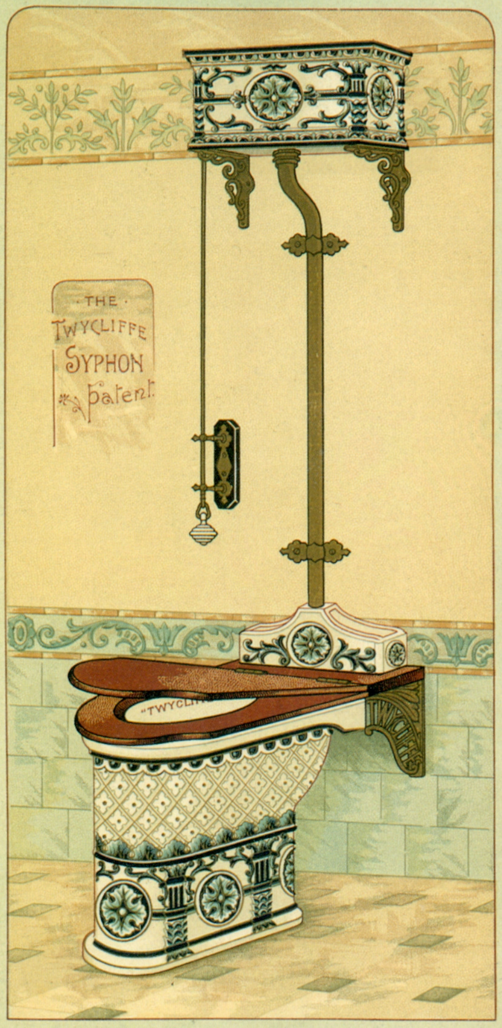
J.H. WALSH, 1857

'The rich have no easy task to keep water closets in order – so how would the ignorant, the poor and the careless who form the vast majority of town populations cope?'

JAMES HOLE, 1866

'Men will do much for glory and vainglory, even to using cold shower baths in winter and boast of breaking the ice in them but I never yet heard of a man who took the trouble to empty his bath after using it.'

FLORENCE CADDY, 1877

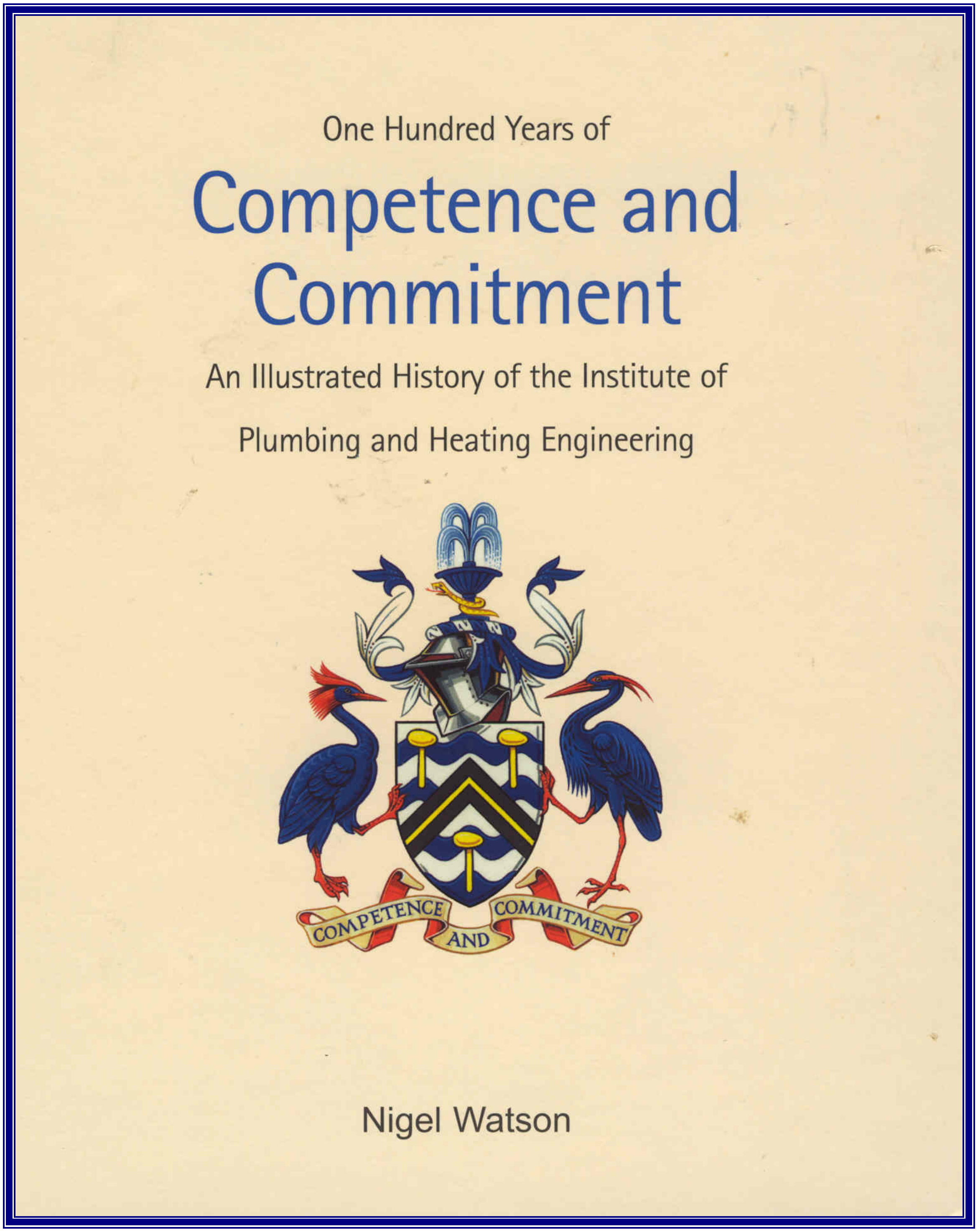


'Miss Lane took what she called her "canary dip" in a large, shallow saucer shaped bath in her bedroom in a few inches of warm water well laced with eau de cologne.'

FLORA THOMPSON, 1945

'It is doubtful if a bathroom should be provided in an agricultural labourer's cottage . . . as a rule there is no demand for baths. . . . the bath when provided being almost invariably used for storing coal, potatoes, soiled linen, etc.'

C. WINKWORTH ALLEN, 1914



2005 (CIBSE Heritage Group Collection)