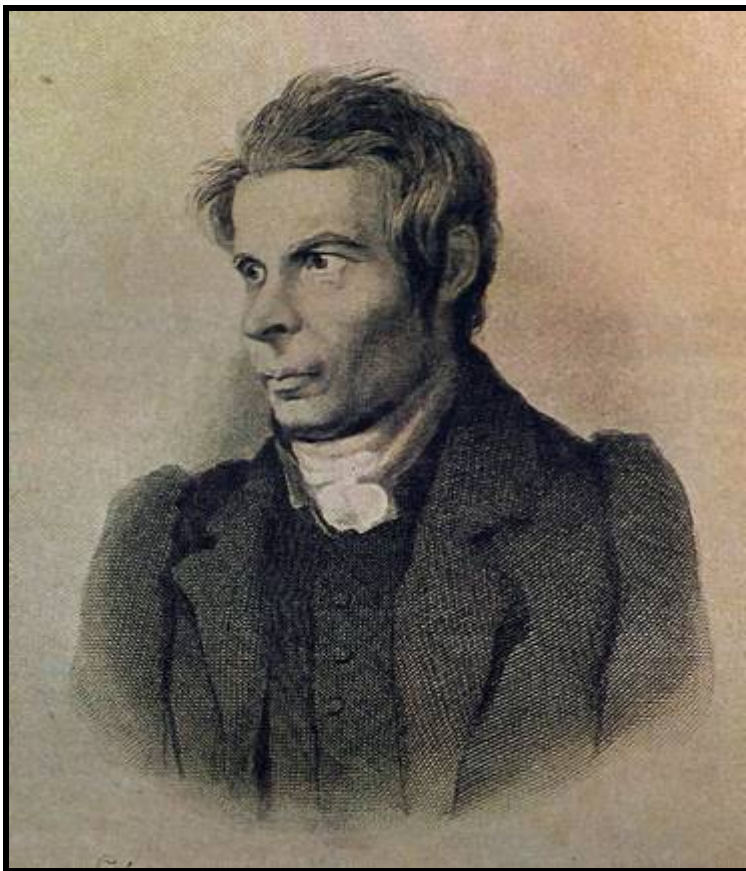


THOMAS TREDGOLD and HIS PRINCIPLES of WARMING & VENTILATING

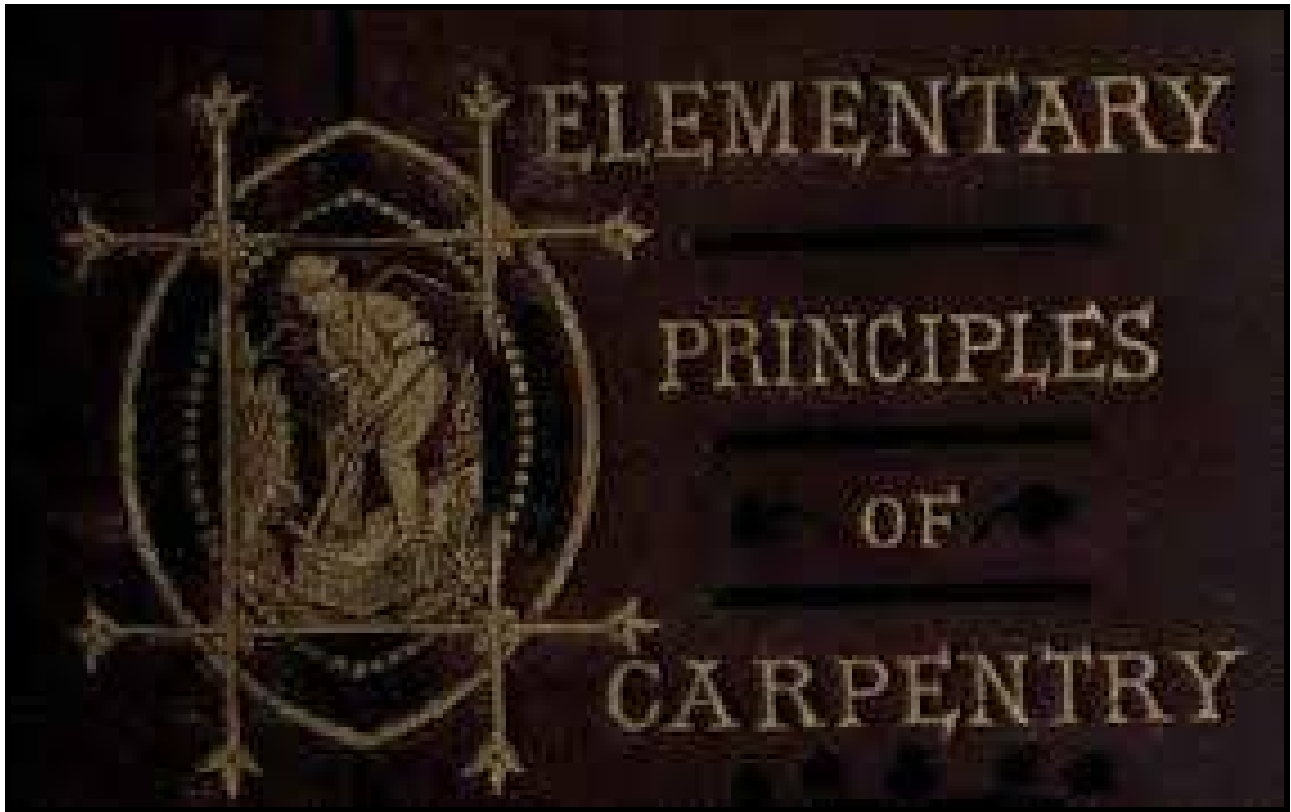
by Brian Roberts, CIBSE Heritage Group



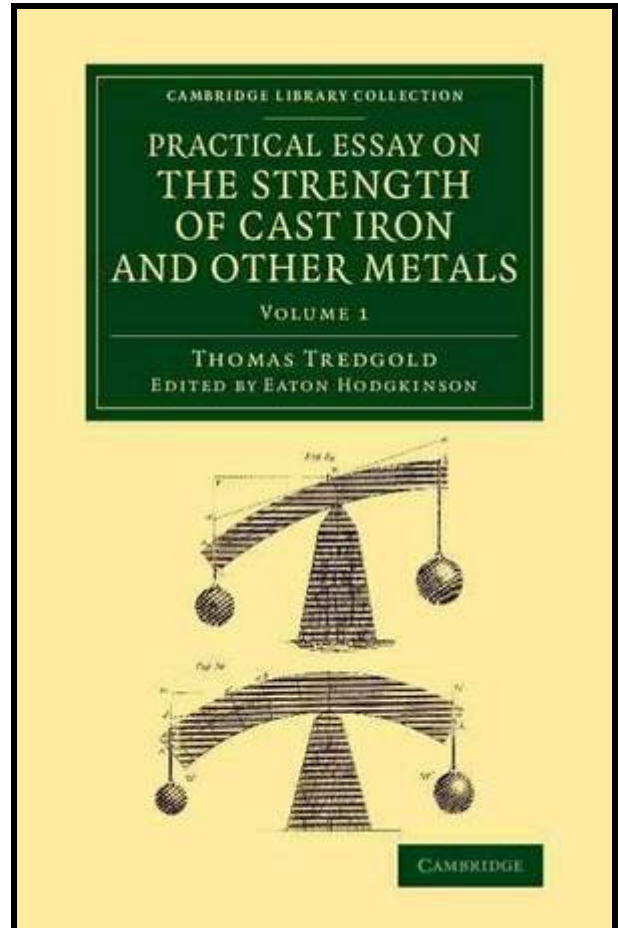
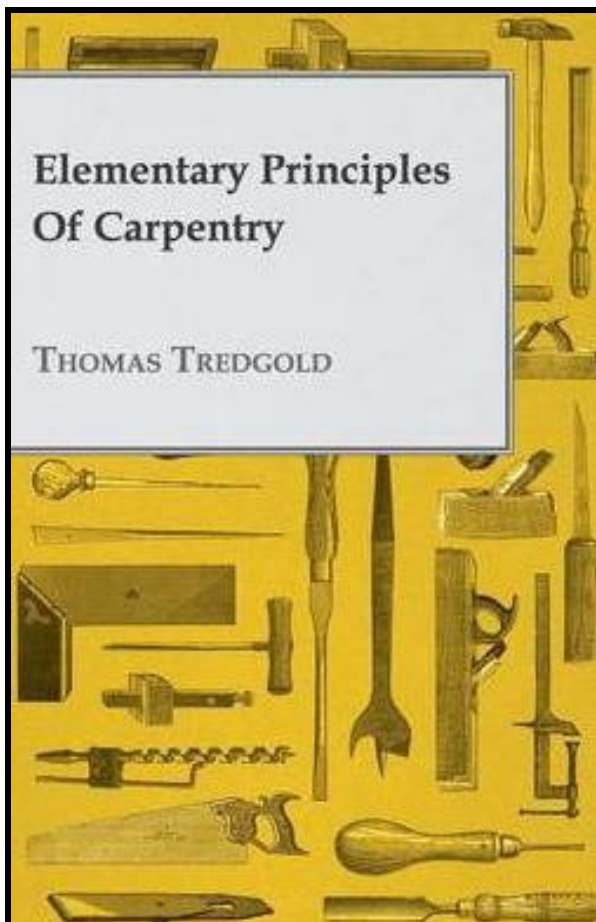
Thomas Tredgold 1788-1829

Thomas Tredgold was born in 1788 in the village of Brandon in County Durham, received an elementary education at the local school and at the age of 14 he was apprenticed to a Durham cabinet maker. For the next six years he spent all his spare time in studying mathematics and architecture. In 1808, he went to Scotland where he worked as a carpenter and journeyman joiner. It has been reported that to pursue his studies, he denied himself sleep and relaxation resulting in permanent damage to his health.

Tredgold's life changed when he went to London to work for a relative, William Atkinson, who was "architect to the ordnance." Having taught himself French and studied higher mathematics, chemistry, geology and mineralogy, he set himself up in business and went on to produce a remarkable list of publications on a wide range of subjects.



His first works were *Elementary Principles of Carpentry* (1820) and *A Practical Essay on the Strength of Cast Iron* (1822).



Modern reprints of Tredgold's books

In 1824, his most important book was published: *Principles of Warming and Ventilating Public Buildings, Dwelling Houses, Manufactories, Hospitals, Hot Houses, Conservatories, &c.* This was sub-titled: *And of constructing Fire-places, Boilers, Steam-Apparatus, Grates and Drying Rooms with Remarks on the Nature of Heat and Light.* This book was unique, setting out the current knowledge of thermodynamics and associated engineering practices. In the preface, Tredgold wrote “I found so little of this branch of knowledge reduced to a state fitted for use in practice.”

Tredgold’s book covered steam and heat distribution, fuel consumption, heat losses, ventilation, and boilers. It dealt with the heating and ventilation requirements of a wide range of buildings –from dwellings and greenhouses to factories, hospitals and prisons.

Tredgold made experiments on the cooling of cylinders and deduced figures for the heat given off by steam and water pipes and for the heat loss through a window. He made estimates of the quantity of fresh air needed to support life and remove exhaled moisture (4 cubic feet per person per minute) and to support combustion. His work on fluid flow enabled him to estimate air flow through doors and windows due to temperature difference and to determine steam flow in pipes and understand chimney draught. He devised a method of attenuating noise from air blowers, making use of resilient and massive materials.

Tredgold went on to oppose the idea that room heat requirements were proportional to room volume instead using figures for heat loss through glass plus ventilation loss, thinking that heat losses through solid structural elements were negligible.

A few years before this, in 1818, a meeting of young engineers at the Kendal Coffee House in Fleet Street founded the Institution of Civil Engineers. During the first two years of its existence the membership grew from the original six to only thirteen but when Thomas Telford accepted the Presidency its importance and future growth was assured.

On the 5th December 1819, Tredgold married Sally Burton. They had five children, of the two boys, one died early, while the other, Thomas, became an engineer and apprenticed to Bryan Donkin (Later author of *The Heat Efficiency of Steam Boilers*).

It was natural that Tredgold would wish to join the ICE and the support for his application of 27 March 1821 reads:

“T. Tredgold Esq, 20 Bentinck Street, being desirous of admission....
We the undersigned in consequence of his being engaged in the profession,
and from our personal knowledge, propose and recommend him as a proper
person to become a resident member thereof.”

Tredgold duly signed his Membership Certificate on 7 May 1821 and became the 47th member of the Institution.

N^o 47

J. Tredgold Esq. 20 Bentick street. being desirous
of admision into the Institution of Civil Engineers.
We the undersigned in consequence of his being
engaged in the profession, and from our personal
knowledge, propose and recommend him a proper
person to become a resident member thereof.

Witness our hands this 27th Day of March 1821

Willm. Pakenham
Isaac Lisle
Tho. Telford

Tredgold's Application of 1821 to join the Institution of Civil Engineers

PRINCIPLES
OF
WARMING AND VENTILATING
PUBLIC BUILDINGS,
DWELLING-HOUSES, MANUFACTORIES, HOSPITALS,
HOT-HOUSES, CONSERVATORIES, &c.;
AND OF CONSTRUCTING
FIRE-PLACES, BOILERS, STEAM APPARATUS, GRATES, AND
DRYING ROOMS;
WITH
ILLUSTRATIONS
EXPERIMENTAL, SCIENTIFIC, AND PRACTICAL.
TO WHICH ARE ADDED,
REMARKS ON THE NATURE OF HEAT AND LIGHT;
AND
VARIOUS TABLES USEFUL IN THE APPLICATION OF HEAT.

SECOND EDITION, IMPROVED,
WITH NINE PLATES AND SEVERAL WOOD CUTS.

BY THOMAS TREDGOLD,
CIVIL ENGINEER;
MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS; AUTHOR OF
"ELEMENTARY PRINCIPLES OF CARPENTRY;" AN
"ESSAY ON CAST IRON," &c. &c.

"We bring some new materials, and what's old
New cast with care, and in no borrow'd mould."—Young.

LONDON:
PRINTED FOR JOSIAH TAYLOR;
ARCHITECTURAL LIBRARY, 59, HIGH HOLBORN.
1824.

The 2nd 1824 improved edition of Tredgold's "Principles"

EARLY HEATING FIRMS

During the period when Tredgold was active, a number of pioneering contractors were engaged in the installation of heating systems though calculations were rule of thumb or based on experience.

The trade magazine *The Ironmonger* of 17th November, 1928, listed the following firms and their start-up dates, but suggests that those before the early part of the 19th century installed only stoves or firegrates.

1700 Edward Deane & Beale Ltd, London

1770 Rosser & Russell Ltd, London

1778 A Seward & Company Ltd, Lancaster

1800 (or before) Clements, Jeakes & Company, London (later Benham & Sons)

1800 (or before) Comyn, Ching & Company Ltd, London

1804 (about) H C Price, Lea & Company, London (previously Price Bros)

1816 G N Haden & Sons Ltd, Trowbridge (originally G & J Haden)

1818 Henry Hope & Sons Ltd, Birmingham (Hope's Heating & Lighting Ltd in 1928)

1825 J C & J C Ellis Ltd, Sheffield (Brightside Foundry & Engineering Co Ltd in 1928)

Note: Tredgold's textbook states that the steam apparatus for his heating design at the Portland Chapel in Cheltenham was erected by (W&D?) Bailey of High Holborn in 1821.

STEAM HEATING

Tredgold was a pioneer of steam heating and steam apparatus. This was an English innovation, first proposed by Colonel William Cook in 1745, though it was not immediately taken up. During the 1780's, both James Watt and Matthew Boulton carried out minor steam heating installations in their homes, but it was John Hoyle of Halifax who took out a British Patent in 1791. Rumford used steam to warm a church in Dublin around 1796. During the next few years, a number of cotton mills were heated by steam, including Lee's cotton mill in Manchester, the work carried out by Boulton & Watt.

One improvement, suggested by Tredgold, was the use of a separate condensate return line rather the single pipe system where steam and condensate flowed in opposite directions. Over the next fifty years or steam systems were developed extensively in the USA.

In 1816, hot water heating was introduced into England from France by the Marquis de Chabannes and this went on to become the most chosen method of warming buildings with the exceptions being factories or buildings where steam was available for other purposes.

HEATING AND VENTILATING DESIGN

The discovery that heat was a form of energy was made about 1798 when Rumford carried out his celebrated cannon boring experiment. Before Tredgold's time, the quantity of heat (or rather, the area of heating surface) necessary to warm a room was proportioned to the volume of the room, for example 1 square foot of steam pipe per 200 cubic feet, or 1 cubic foot of boiler per 2000 cubic feet. Tredgold realised there could be no universal ratio and that heat requirements must depend on the structure, window area and ventilation. His calculations were probably the first with any pretence to a rational scientific basis. Tredgold was also aware of the difference in heating requirements between steady state and intermittent operation and he tried to compute a suitable preheating period. The development of thermal transmittance values and heat loss calculations progressed only slowly during the 19th century.

A detailed history of heating and ventilating design is given in Chapter 13 (pp. 485-527) of *Building Services Engineering: A Review of Its Development*, Neville S Billington & Brian M Roberts (Pergamon Press, 1982). This chapter also list 65 further references.

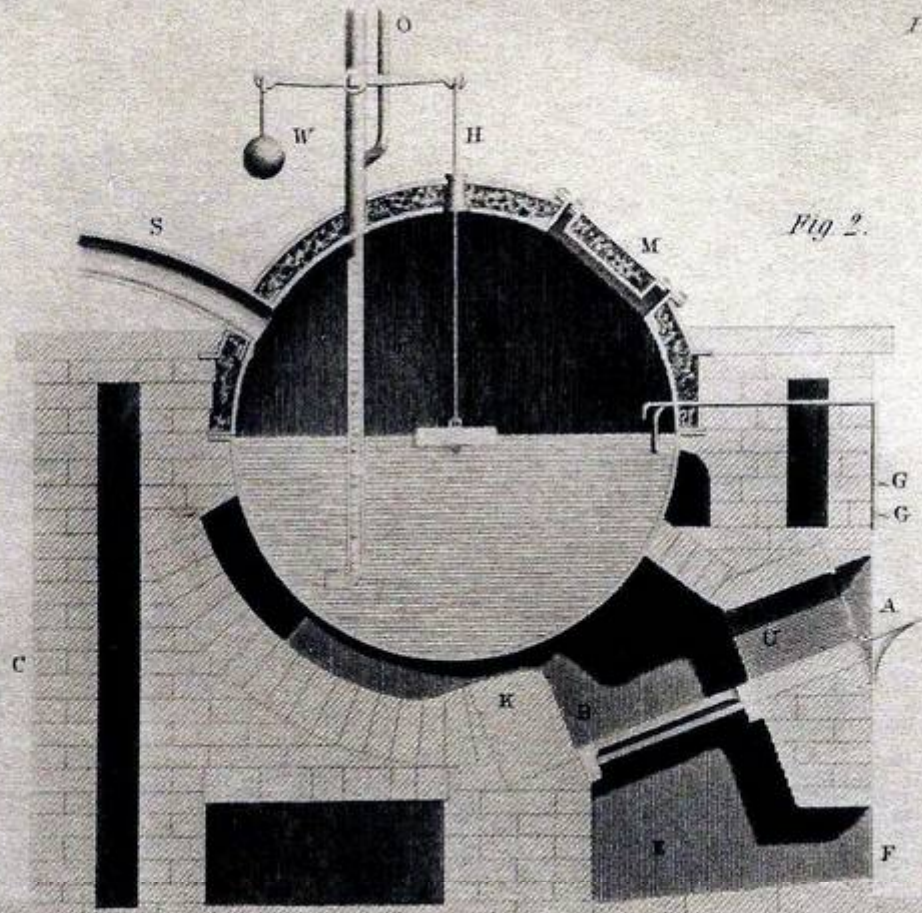


Fig. 2.

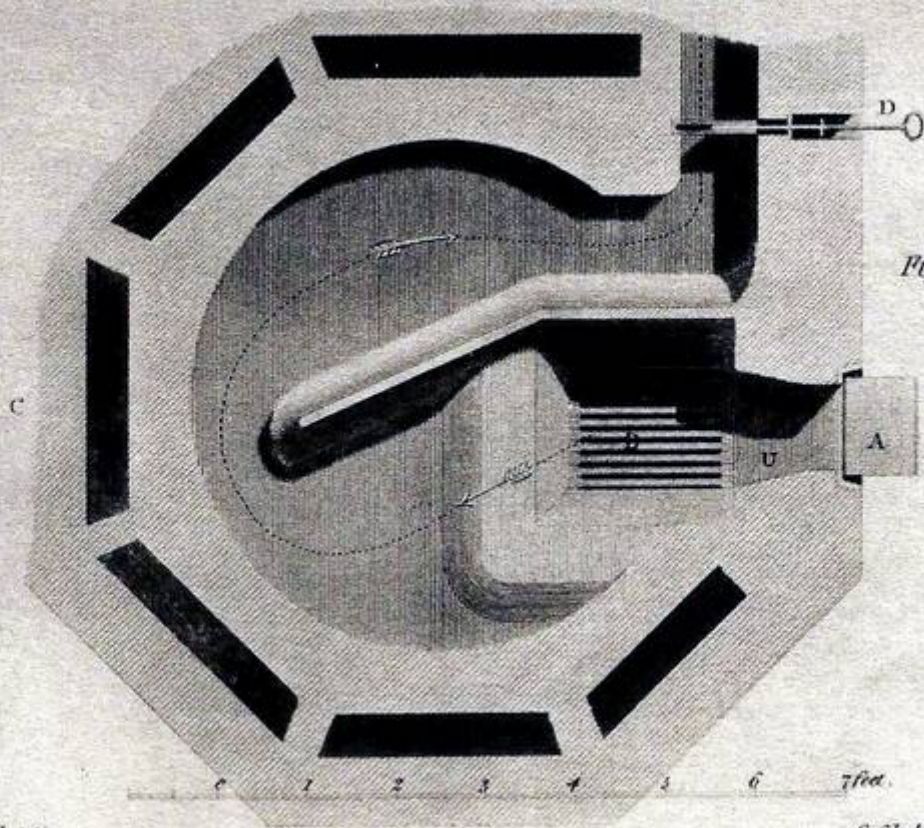


Fig. 1.

I. T. delin

G. Gladwin sculp

Tredgold's design for a spherical steam boiler

THE
PRINCIPLES

OF

WARMING AND VENTILATING
PUBLIC BUILDINGS,

DWELLING-HOUSES, MANUFACTORIES, HOSPITALS,
HOT-HOUSES, CONSERVATORIES, &c.

AND OF CONSTRUCTING

FIRE-PLACES, BOILERS, STEAM-APPARATUS, GRATES,
AND DRYING-ROOMS;

WITH

REMARKS ON THE NATURE OF HEAT AND LIGHT,
&c. &c. &c.

By THOMAS TREDGOLD,

CIVIL ENGINEER, &c.

THIRD EDITION.

TO WHICH IS NOW ADDED,

AN APPENDIX,

By T. BRAMAH, CIVIL ENGINEER,

COMPRISING

OBSERVATIONS ON HEATING BY MEANS OF WARM WATER, WITH
DESCRIPTIONS OF VARIOUS APPARATUS IN USE.

LONDON:

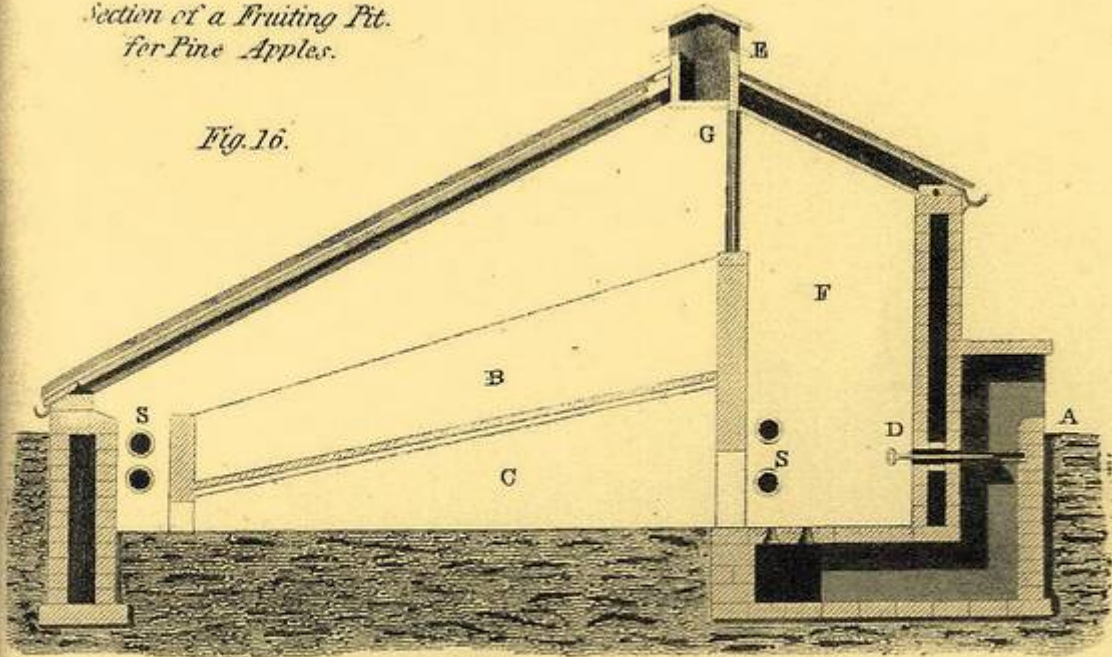
M. TAYLOR (NEPHEW AND SUCCESSOR TO THE LATE J. TAYLOR),
1 WELLINGTON STREET, STRAND,
REMOVED FROM HIGH HOLBORN.

M.DCCC.XXXVI.



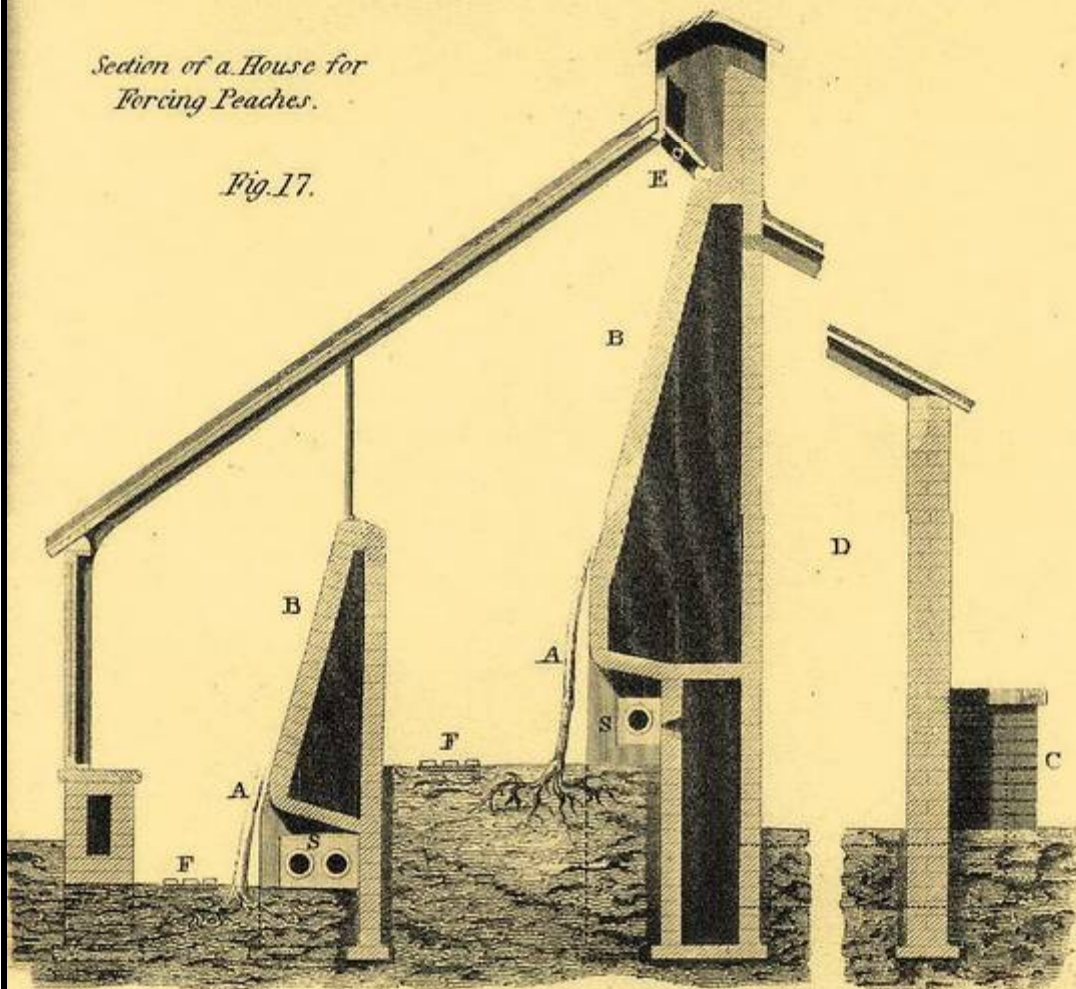
Section of a Fruiting Pit.
for Pine Apples.

Fig. 16.



Section of a House for
Forcing Peaches.

Fig. 17.

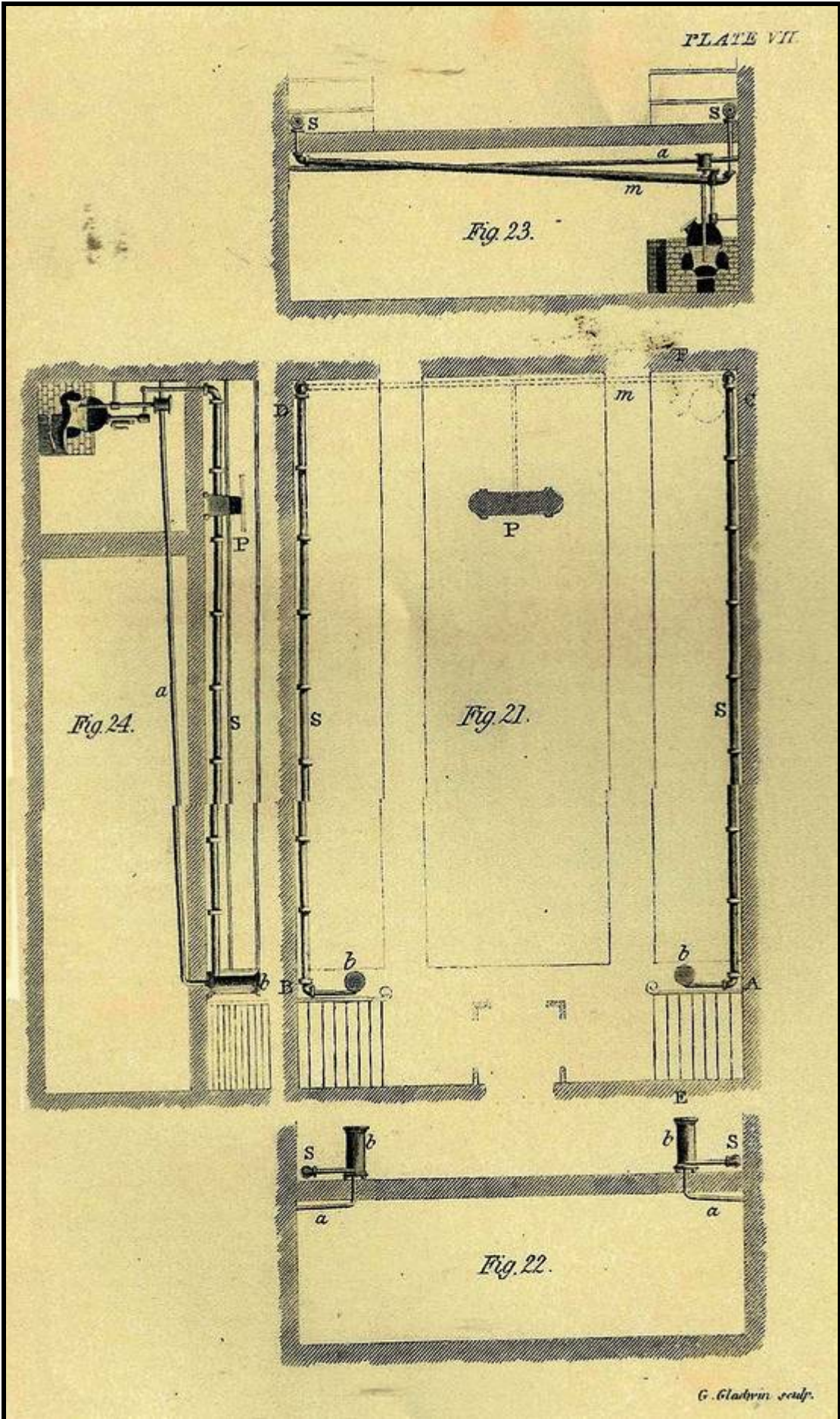


T. F. delin.

0 1 2 3 4 5 6 7 8 9 30 feet.

G. Gladwin sculp.

Plate V from Tredgold's textbook illustrating heating systems for a Pineapple Fruiting Pit and for a House for Forcing Peaches. Both buildings are heated by low-level steam pipes marked S.



G. Gladwin sculp.

Plate VII from Tredgold's textbook showing his steam heating system for the Portland Chapel in Cheltenham. The steam apparatus was erected by Messrs. Bailey of High Holborn in 1821

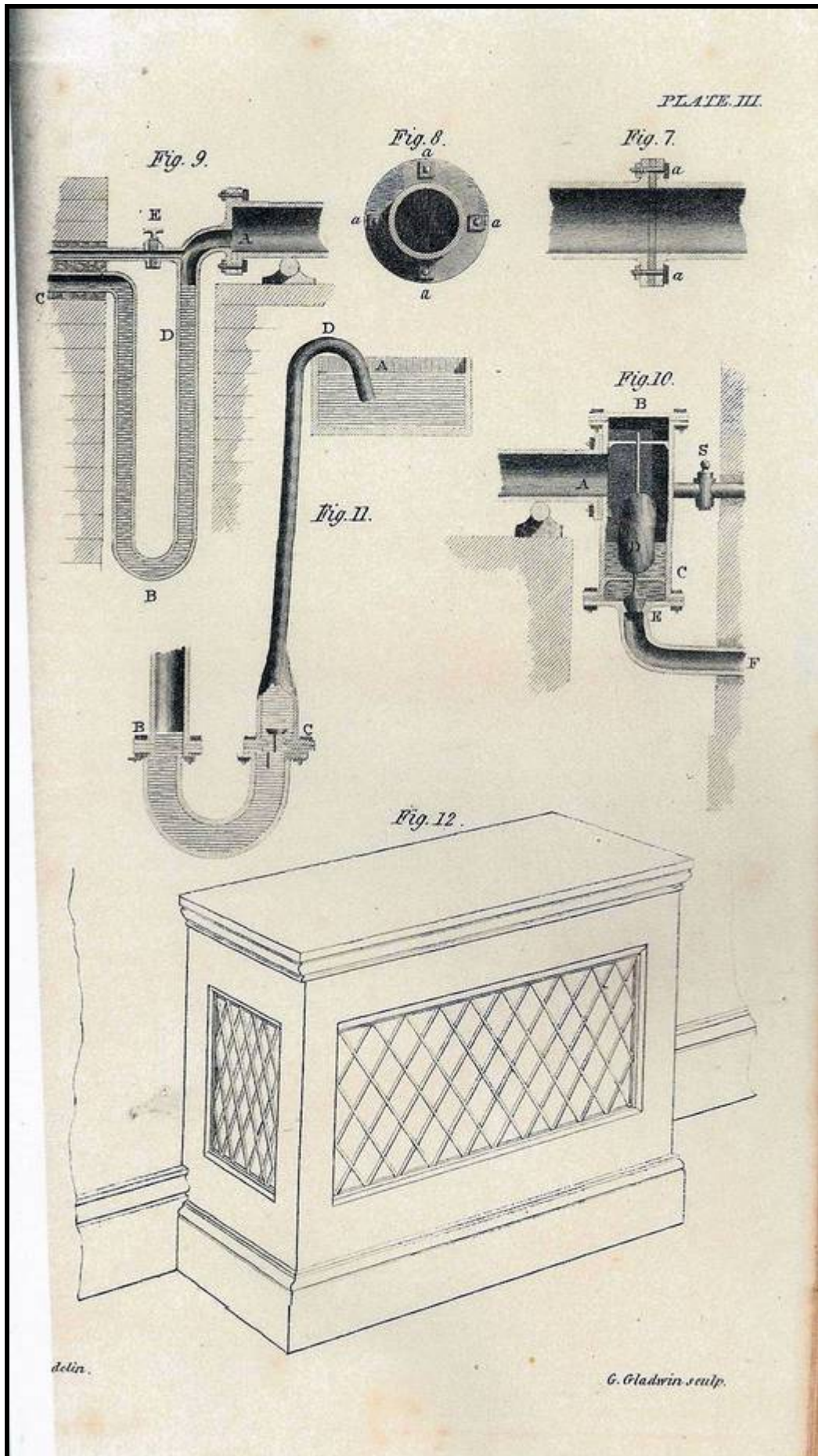


Plate III from Tredgold's textbook showing piping details and a heater enclosure

Section of a Small Stove for Tropical Plants

Fig. 13.

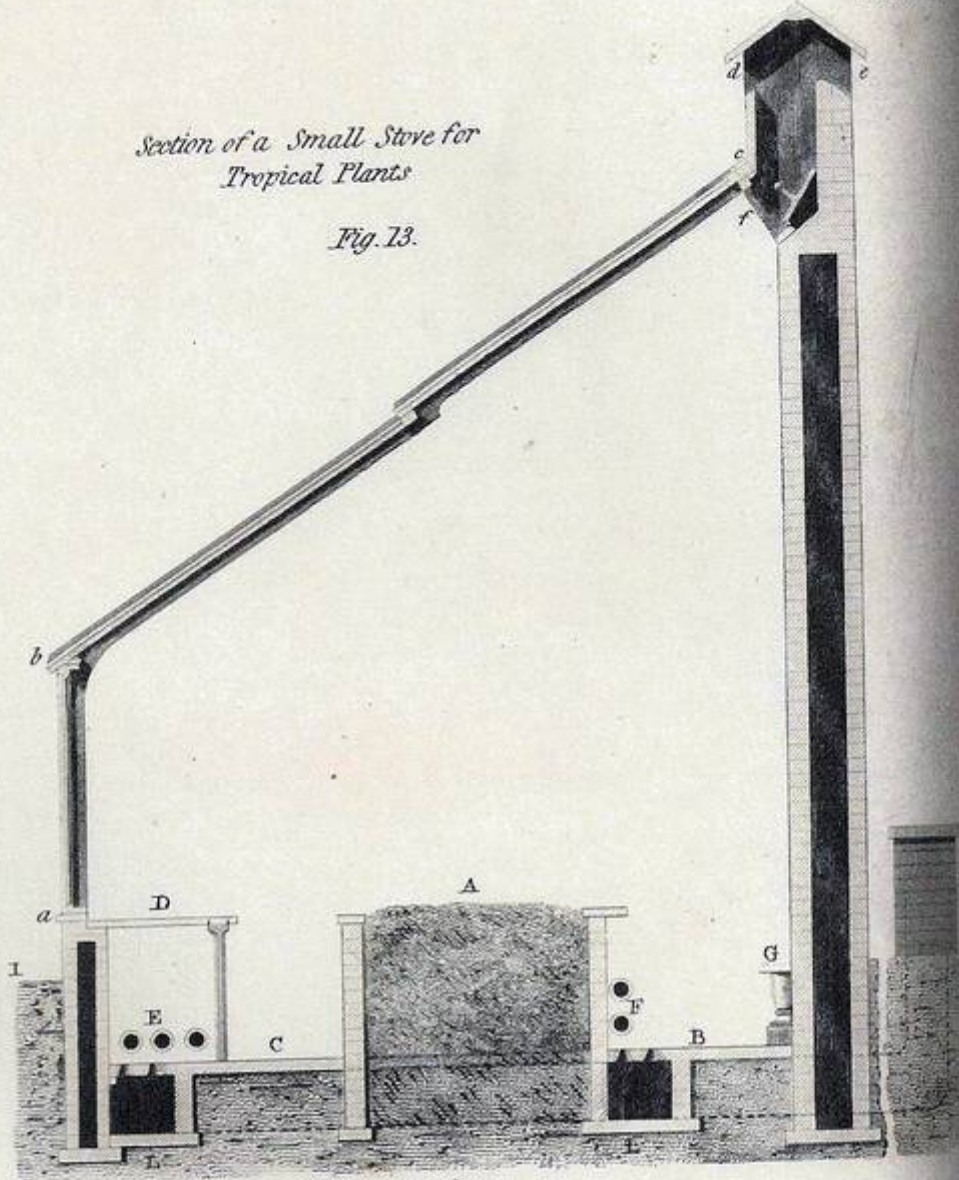


Fig. 15.

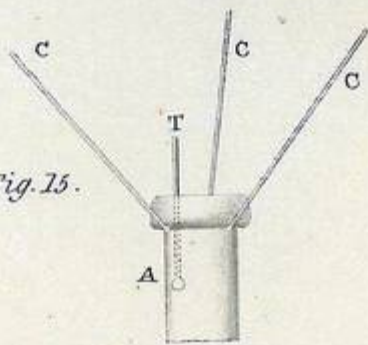
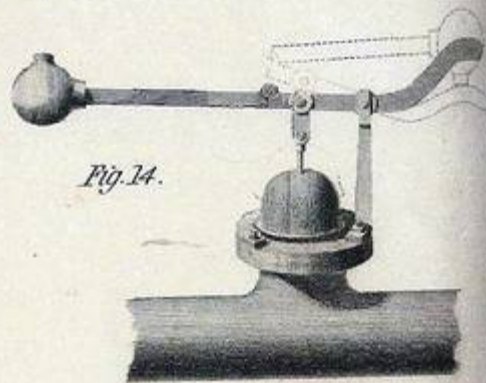


Fig. 14.

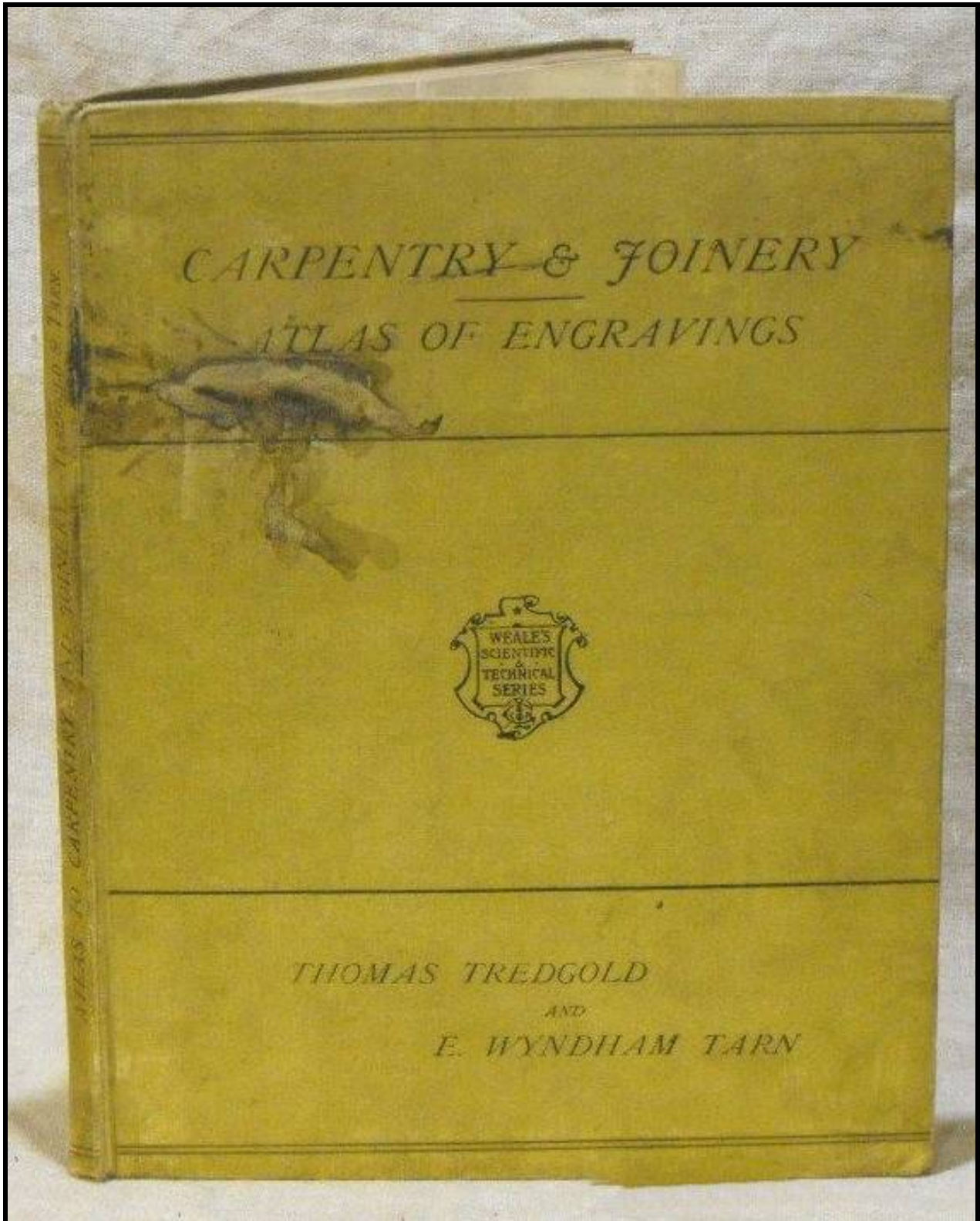


T. T. delin.

G. Glavin. sculp.

Plate IV from Tredgold's textbook showing heating of a small hothouse

During the next eight years Tredgold became the author of more *Original Communications* than any other member but was a spasmodic attender at weekly meetings. However, Tredgold's eminence within the ICE and the profession was recognised when in June 1824 he was elected an Honorary Member, "having by his writings on various subjects connected with the Profession of a Civil Engineer conferred benefit on that science."



Published in 1878

A.10

*Royal Engineer Library
Woolwich.*

THE

STEAM ENGINE:



ITS INVENTION AND PROGRESSIVE IMPROVEMENT,

AN INVESTIGATION OF ITS PRINCIPLES,

AND ITS APPLICATION TO

LONDON

NAVIGATION, MANUFACTURES, AND RAILWAYS.

BY THOMAS TREDGOLD, CIVIL ENGINEER,

MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS; AUTHOR OF ELEMENTARY PRINCIPLES OF CARPENTRY;
A PRACTICAL TREATISE ON THE STRENGTH OF IRON, &c.

A NEW EDITION,

ENLARGED BY THE CONTRIBUTIONS OF EMINENT SCIENTIFIC MEN, AND EXTENDED
TO THE SCIENCE OF

Steam Naval Architecture.

REVISED AND EDITED

BY W. S. B. WOOLHOUSE, F.R.A.S., &c.,

ACTUARY TO THE NATIONAL LOAN FUND LIFE ASSURANCE SOCIETY.

IN TWO VOLUMES,

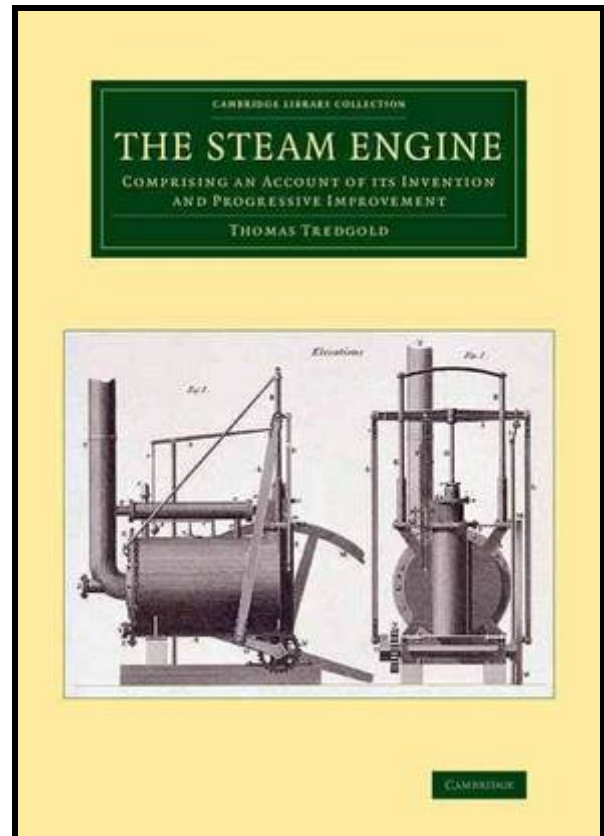
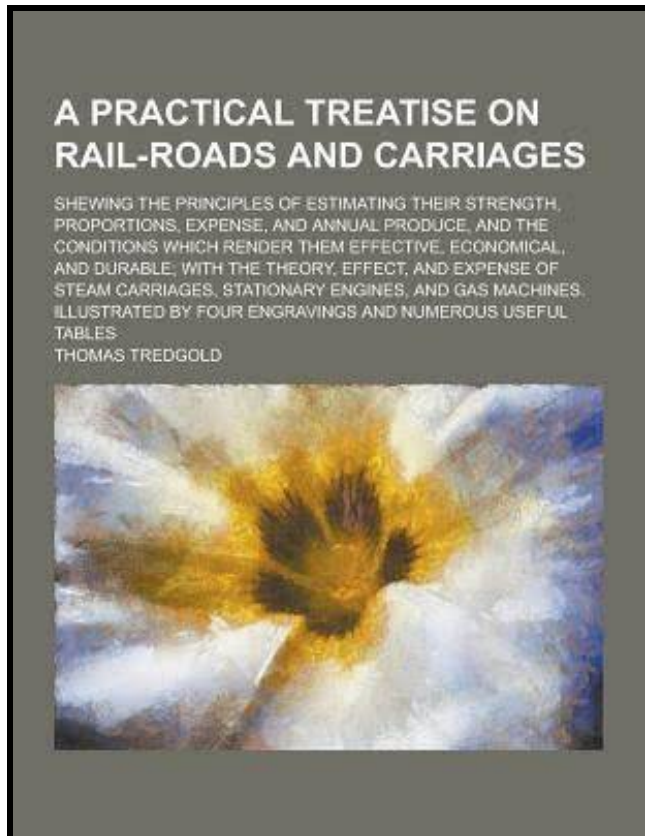
WITH ONE HUNDRED AND TWENTY-FIVE ENGRAVINGS AND NUMEROUS WOOD-CUTS.

VOL. I. *369.*

LONDON: JOHN WEALE.

MDCCCXXXVIII.

Tredgold's 1827 book on Steam Engines, revised and published in 1838 after his death



Modern editions of Tredgold's books

It seems that on account of ill health he was often not present when his papers were read. In a post script to his letter of 23 October 1826 to Francis Bramah he wrote:

“If I thought I should see you at the Engineers on Tuesday evening I should be there, but I am fearful the attendance is very thin, and that little is stirring there. I do not like to go much because I cannot go there without a great risk of cold from the indifferent state of my health.”

The installations shown in his book are ones designed by Tredgold and installed under his supervision. For dwelling houses, he recommended the use of open fires, warm air and steam heating for the various spaces. For factories steam heating was preferred. Both St Thomas's Hospital and the Guildhall incorporated systems designed by Tredgold. He influenced the heating work of others; for example, Bramah installed a hot water heating systems in the Windsor Palace Orangery (1829) and one “with recognisable radiators” in the Westminster Hospital (1830).



Joseph Bramah, 1749-1814

Tredgold has close connections with the Bramah family. Joseph, like Tredgold, served an apprenticeship as a carpenter, but later turned his attention to improving Cumming's valve water closet and in 1778 patented his own design. He went on to take out another 17 patents and made important improvements to locks and pioneered the hydraulic press. He had four sons and a daughter.

The eldest son, Timothy (1784-1838), specialised in developing hot water heating, corresponded extensively with Tredgold and wrote the Appendix to the 3rd Edition of Tredgold's book.

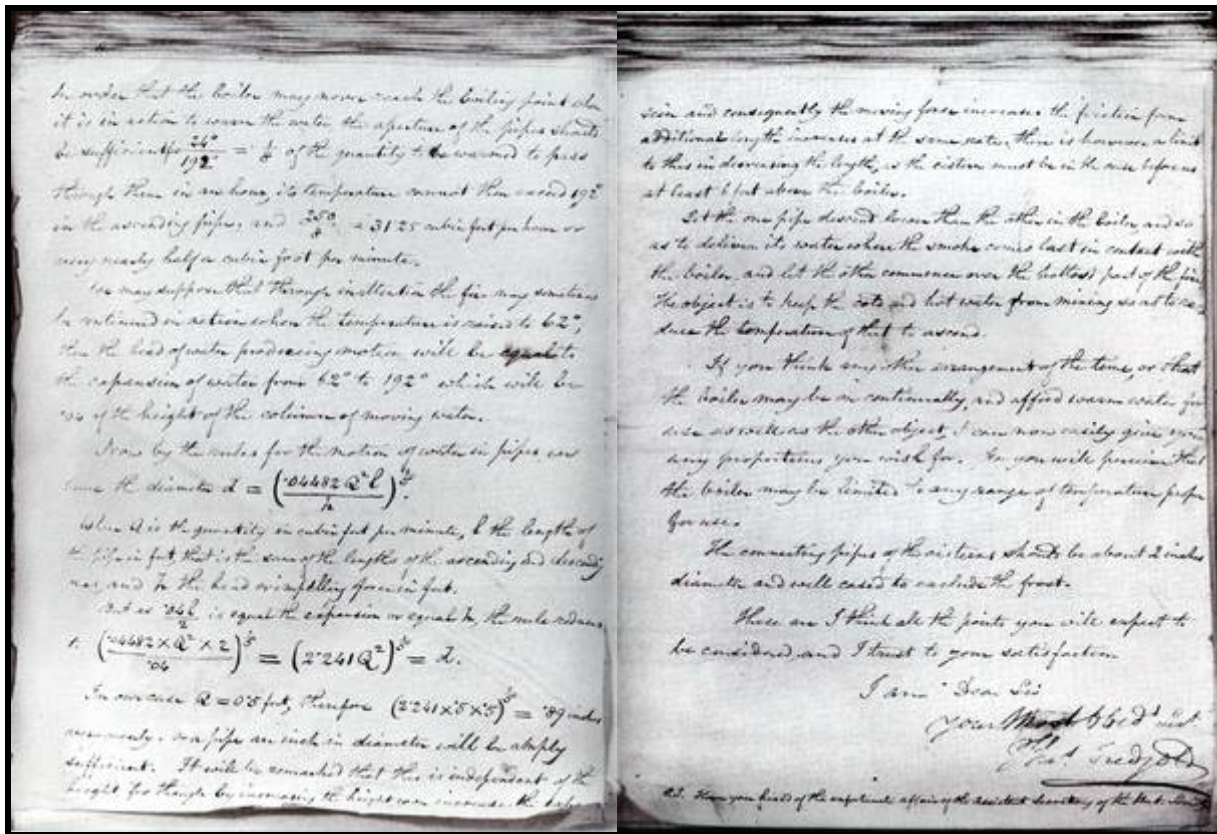
The second son, Francis (1786-1840), sought to verify the principles laid down by Tredgold in connection with the deflection and strength of cast-iron beams. Tredgold also wrote to Francis regarding formulae relating to fluid flow in pipes.



The original St Thomas's Hospital in Southwark, 1225-1865



The Guildhall, London c.1809



Tredgold's letter of 23 October 1826 to Francis Bramah on fluid flow in pipes

BIBLIOGRAPHY

1824 *The Principles of Warming and Ventilating Public Buildings*: Thomas Tredgold; M Taylor, London, 2nd Edition (Improved)

1836 *The Principles of Warming and Ventilating Public Buildings*: Thomas Tredgold; M Taylor, London, 3rd Edition

----- *Thomas Tredgold (1788-1828); Some Aspects of His Work*: The Institution of Civil Engineers

----- *Early Heating and Ventilating Systems 1790-1850*, Richard Griffiths (source unknown)

----- *Notes of N S Billington*: Includes *Dictionary of National Biography*; *Trans. Newcomen Soc*

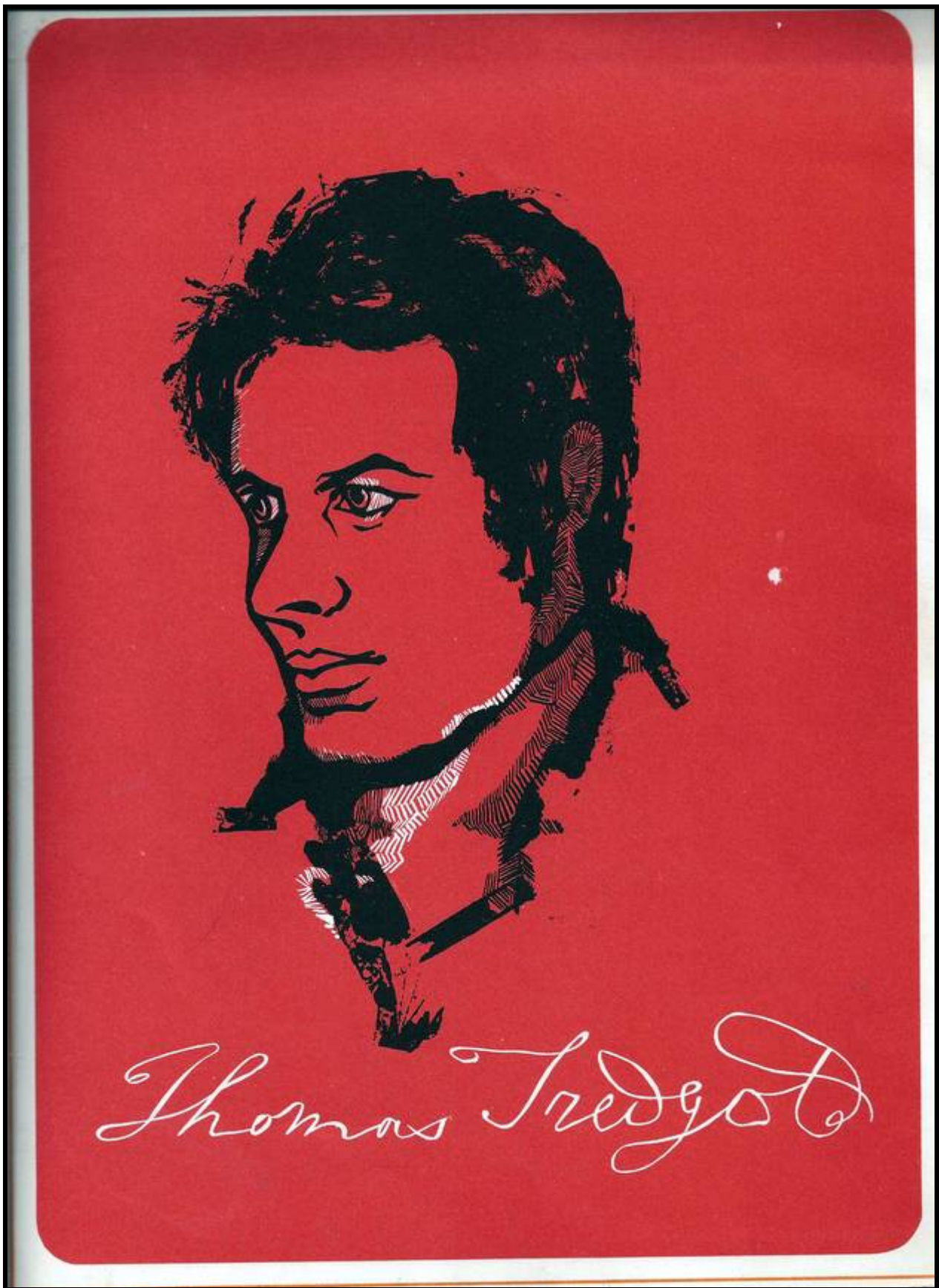
----- *Thomas Tredgold: The Heatmakers No.3*, Thomas Potterton Ltd, London

----- *Tredgold, Thomas*: *Dictionary of National Biography*

1982 *Building Services Engineering: A Review of Its Development*, Neville S Billington & Brian M Roberts, Pergamon Press

2000 *The Comfort Makers*, Brian Roberts, ASHRAE

POSTSCRIPT &: FURTHER READING



Thomas Tredgold: The Heatmakers No.3, Thomas Potterton Ltd, from 1980's

EPILOGUE

Tredgold “worn out by study” died at the early age of 40, leaving his widow, three daughters and a son in very poor circumstances. He was buried in St Johns Wood chapel cemetery. To use his own words, he had devoted his life to “The art of directing the great sources of power in nature for the use and convenience of man.” This statement was immortalised by inclusion in the Charter of the Institution of Civil Engineers, of which he was made an Honorary Member.



St Johns Wood Chapel was built in 1814. Tredgold was buried in the Chapel's cemetery