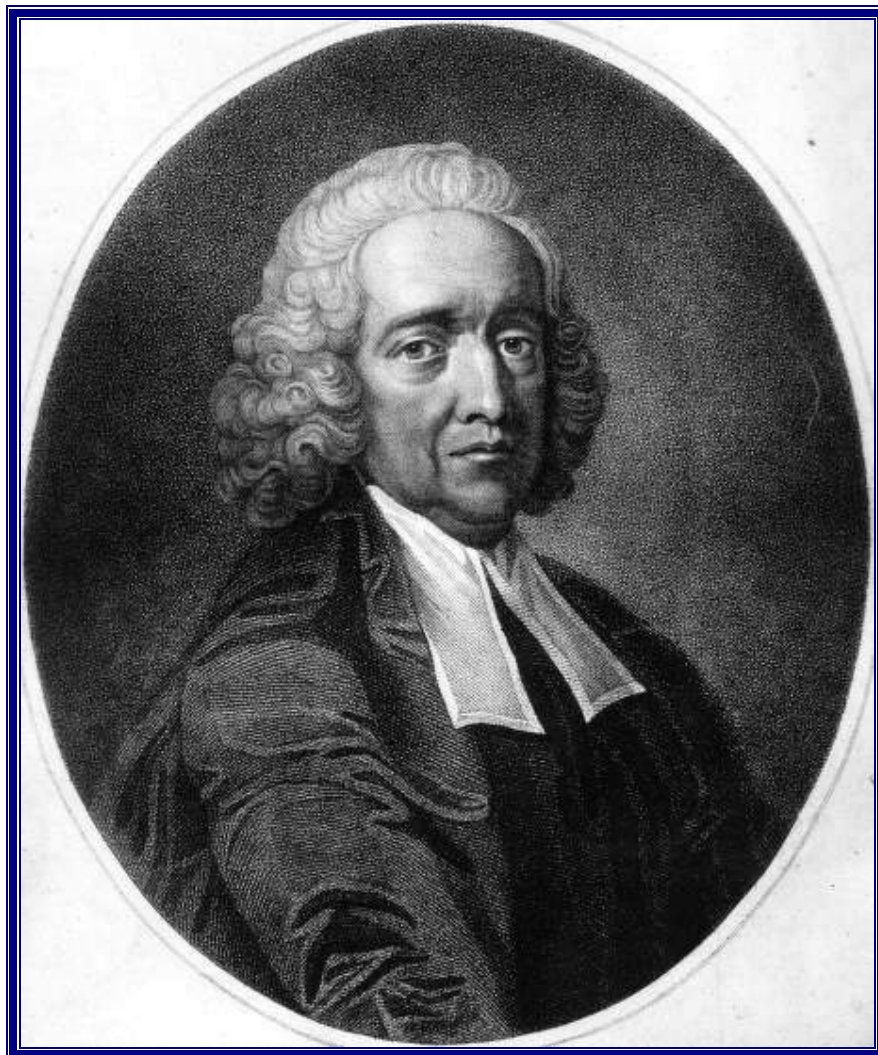




**Rev STEPHEN HALES**  
**c.1700-1761**



*Curate and Ventilation Engineer*

**[53] Rev. Stephen HALES**

**c. 1700-1761**

Perpetual curate of Teddington in Middlesex. Scientist, botanist, inventor, and ventilation engineer. Elected Fellow Royal Society (1717). His most famous work, *Vegetable Staticks* (1727), deals with his experiments on plants. He became interested in ventilation by fans and bellows. Wrote his *Treatise on Ventilators* (1758). Proposed to ventilate a ship “using 10-foot-long inject and exhaust pumps similar to a blacksmith’s bellows.” He estimated that his “machine would expel a ton of air at each stroke, or six tons a minute by two men working at the lever...” His methods are similar to those of Triewald [9]. Hales also worked on the design of bellows ventilation of the county hospital and county jail in Winchester, the Savoy Prison, and Newgate Prison. In his ventilated prisons, “the diminution in the annual mortality...seems to have been very great.”

*(Mini-biography from “The Comfort Makers,” Brian Roberts, ASHRAE, 2000)*

Ventilation by fans and bellows was proposed by the Reverend Stephan Hales in his *Treatise on Ventilators* of 1758. Hales’ main interest was with the ventilation of ships using 10-foot-long inject and exhaust pumps similar to a blacksmith’s bellows (Figure 3-7). He estimated that his “machine would expel a ton of air at each stroke, or six tons a minute by two men working at the lever . . .” but, according to Bernan, “modern experience would not, perhaps, rate its effect at more than two fifths of the doctor’s estimate.”<sup>15</sup> Hales also worked on the designs for bellows ventilation of the county hospital and county jail in Winchester, the Savoy Prison, and Newgate Prison.

*(From “Heat & Cold: Mastering the Great Indoors,”  
Barry Donaldson & Bernard Nagengast, ASHRAE, 194)*

Bellows were used by Martin Triewald (Sweden) in 1741 for ships' ventilation, and by Stephen Hales for ventilating hospitals, ships and mines in 1758. Hales' bellows comprised a box 3 m x 1.3 m x 0.3 m deep, with an internal midriff hinged at the centre of one end of the box. The other end of the midriff had fixed to it an iron rod which could be moved up and down by a lever. Movement of the midriff drew fresh air into the box, and on the next stroke discharged it into pipes leading to the spaces to be ventilated. Hales calculated that the bellows would expel a tun of air at each stroke, or 6 tuns a minute, by two men working at the lever.

*(From "Building Services Engineering," Neville S Billington & Brian M Roberts, 1982)*



*Rev Stephen Hales, Botanist*

STEPHEN HALES, vicar of Teddington in Middlesex, made the important discovery that plants absorb part of their food from the air. Hales invented artificial ventilators and numerous other mechanical contrivances as well as studying animal and plant physiology. From this he turned his attention to chemistry, and in his principal book, *Vegetable Staticks*, published in 1727, he stressed the importance of accurate weighing and measuring in chemical operations. Unfortunately, his quickness to see the need for accurate measurement restricted his vision in other directions. Having observed that plants inspire large quantities of air, he concluded that this air could be recovered, and proceeded to distil, in a gun barrel, a great number of miscellaneous substances, including tallow, hog's blood, peas, oyster shells, tobacco, a fallow deer's horn, camphor, beeswax and honey.

He collected the gases he obtained and made accurate calculations to show the proportion they bore by weight to the original substances. He says, for instance: "and since we are assured that the All Wise Creator has observed the most perfect proportions of number, weight, and measure in the make of all things, the most likely way, therefore, to get any insight into the nature of these parts of the Creation which come within our observation must

in all reason be to number, weigh, and measure. And we have much encouragement to pursue this method of searching into the nature of things from the great success which attended any attempts of this kind." For the Creator has "comprehended the days of the earth in a measure and weighed the mountains in scales and the hills in a balance." There is no doubt that Hales unwittingly prepared crude samples of many important chemicals, but he was so engrossed in weighing and measuring, at the expense of accurately observing the substances under experiment, that he failed entirely to appreciate the significance of much of his own work. He dismissed the various gases he had prepared as "air." He died in 1761, and was honoured with a memorial tablet in Westminster Abbey.

*(From "Ancestors of an Industry," ICI, 1950)*

A  
DESCRIPTION  
OF  
*VENTILATORS:*

WHEREBY

Great Quantities of FRESH AIR

May with Ease be conveyed into MINES, GOALS,  
HOSPITALS, WORK-HOUSES and SHIPS,

In Exchange for their *Noxious Air*.

An Account also of their GREAT USEFULNESS  
in many other Respects:

As in Preserving all Sorts of GRAIN Dry, Sweet, and  
free from being Destroyed by WREVELS; both in  
GRAINARIES and SHIPS: And in Preserving  
many other Sorts of Goods.

As also in drying CORN, MALT, HOPS,  
GUN-POWDER, &c. and for many other  
useful Purposes.

Which was read before the ROYAL SOCIETY  
in May 1741.

---

*And God made  
The Firmament, Expanse of liquid, Pure,  
Transparent, Elemental Air.* MILTON.

---

By STEPHEN HALES D. D. F. R. S.  
Rector of *Faringdon, Hampshire*;  
And Minister of *Teddington, Middlesex*.

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L O N D O N :

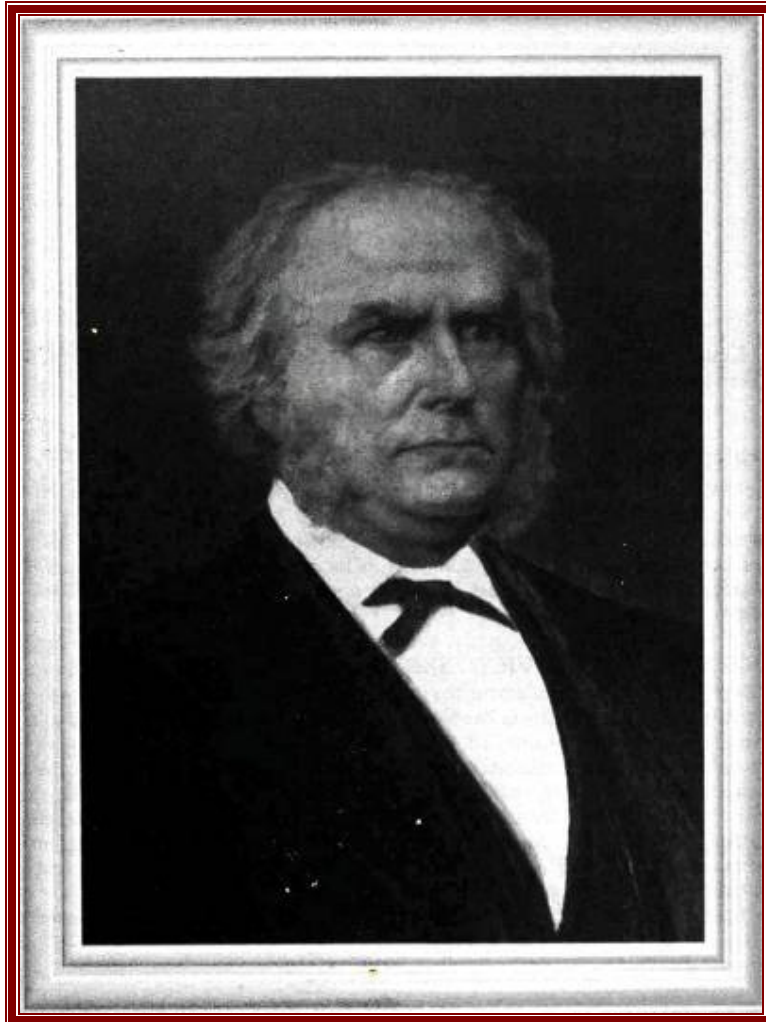
Printed for W. INNYS, at the West End of *St. Paul's*;  
R. MANBY, over against the *Old Bailey* on *Ludgate-Hill*;  
and T. WOODWARD.

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M. DCC. XLIII.



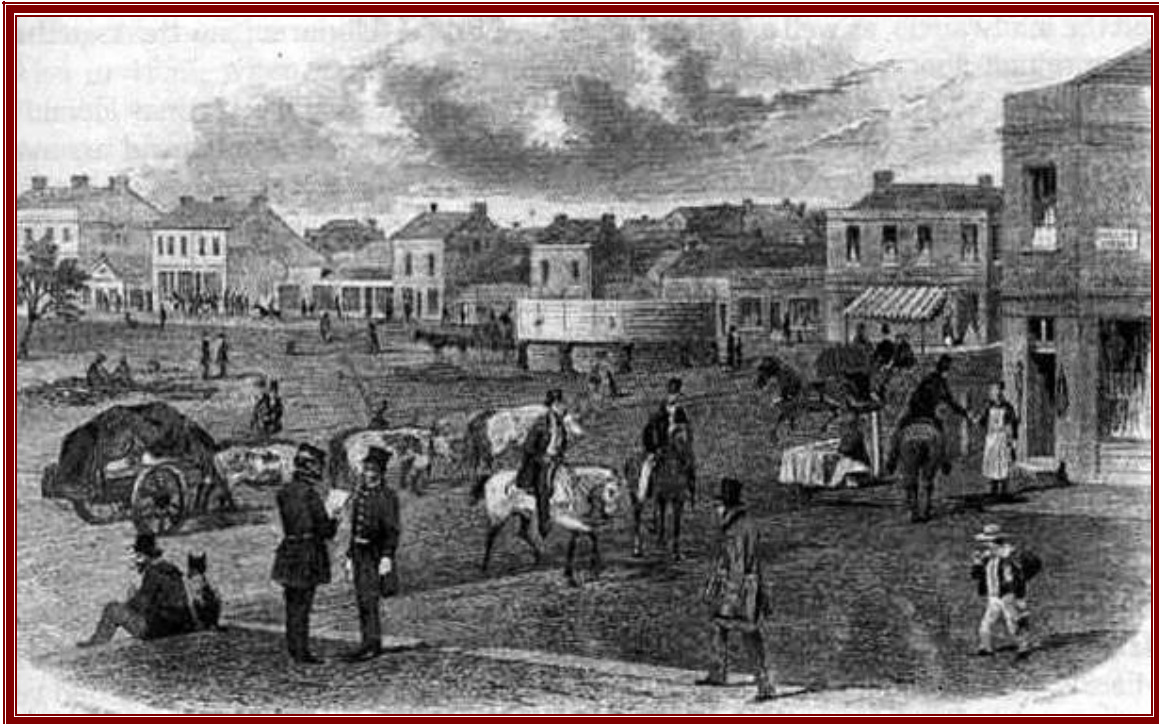
**JAMES HARRISON**  
**1816-1893**



*Refrigeration pioneer*

Scotsman who emigrated to Australia and settled in Geelong, near Melbourne. Took a strong interest in mechanical refrigeration for the meat export industry (1852). Made an unsuccessful ethyl ether compressor (1855), apparently unaware of the earlier work of Jacob Perkins [77]. Went to London, where he had an improved machine manufactured by Siebe Bros. Obtained various patents (BP 747: 1856; BP 2362: 1857). First machine of improved design was sold to the Truman, Hanbury & Buxton Brewery in London (1857). Harrison returned to Australia to promote his machine and set up an ice-making plant (1858). More machines were built by Siebe in London and by P.N. Russell & Co. in Sydney. Thus, Harrison has the distinction of being the first mechanical refrigeration pioneer to see actual commercial production of his invention.

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



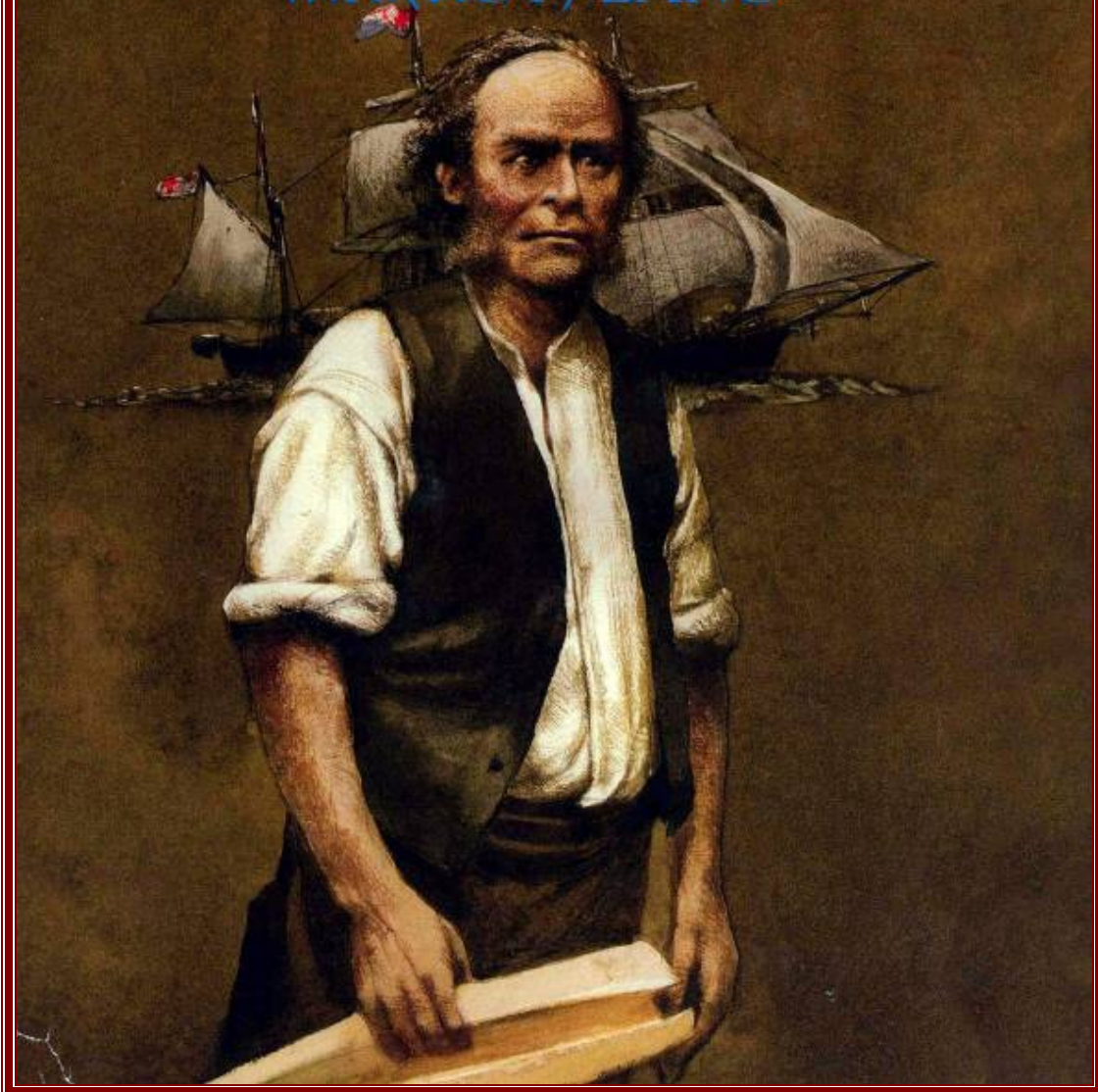
*Geelong in 1856*



# JAMES HARRISON

~PIONEERING GENIUS

W.R. (ROY) LANG



*“James Harrison-Pioneering Genius,” W R (Roy) Lang, 2002  
(CIBSE Heritage Group Collection)*

A.D. 1856 . . . . . N° 747.

Refrigerators.

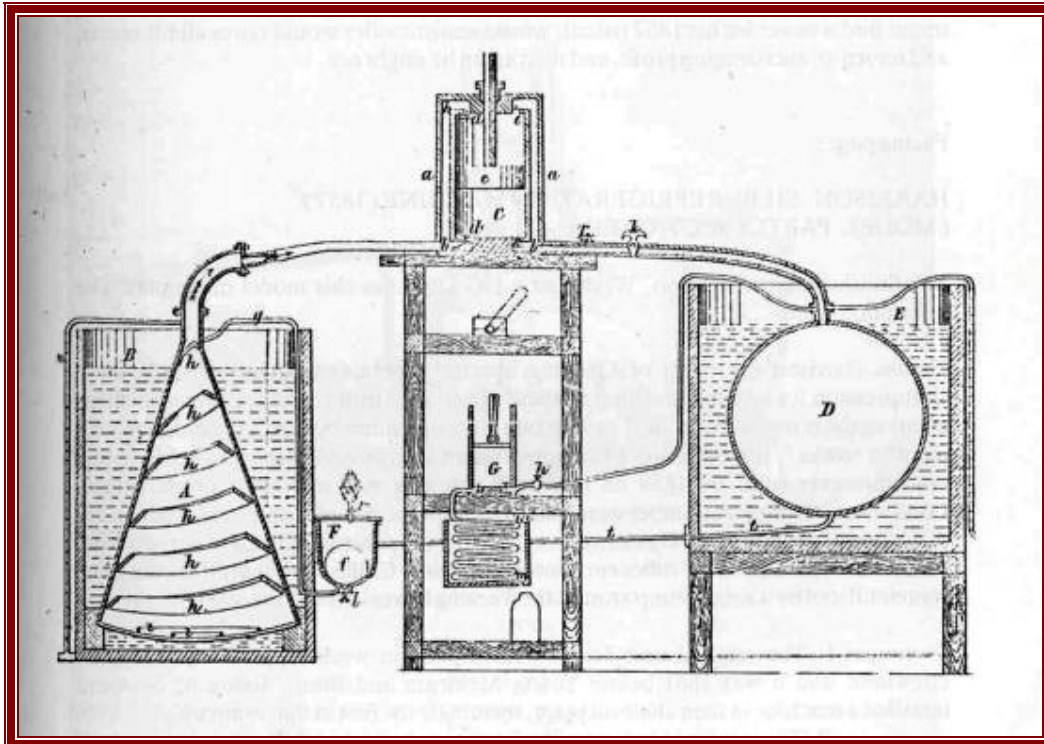
LETTERS PATENT to James Harrison, of Geelong, in the Colony of Victoria, Gentleman, Member of the Legislative Council of Victoria, for the Invention of "PRODUCING COLD BY THE EVAPORATION OF VOLATILE LIQUIDS IN VACUO, THE CONDENSATION OF THEIR VAPOURS BY PRESSURE, AND THE CONTINUED RE-EVAPORATION AND RE-CONDENSATION OF THE SAME MATERIALS."

Scaled the 23rd September 1856, and dated the 28th March 1856.

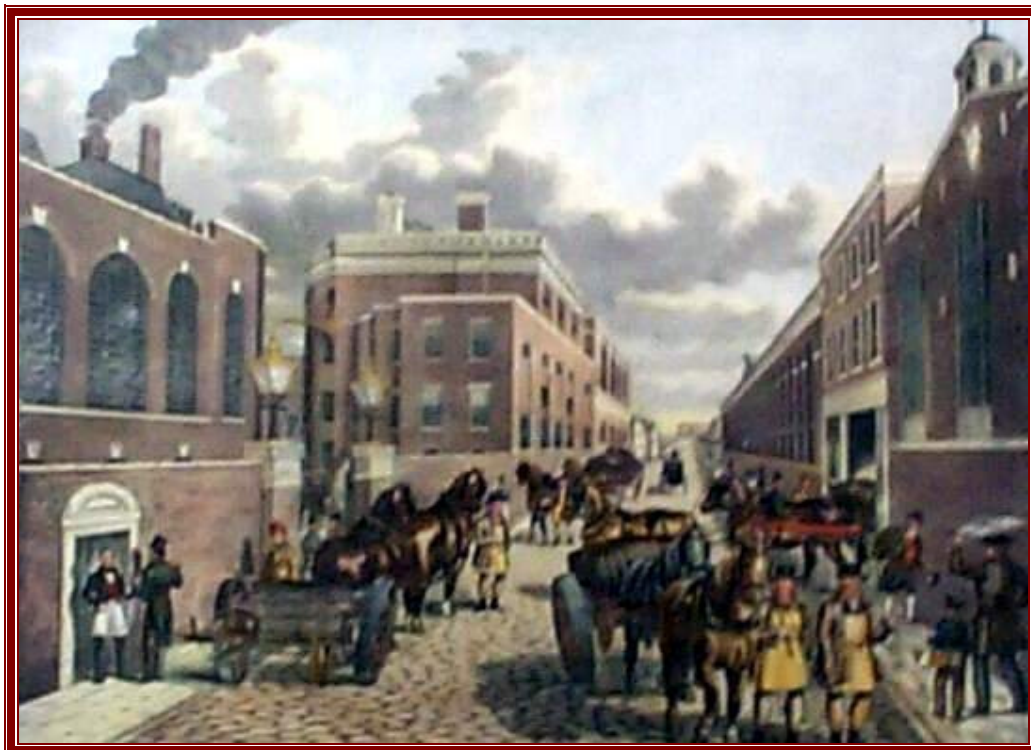
PROVISIONAL SPECIFICATION left by the said James Harrison at the Office of the Commissioners of Patents, with his Petition, on the 28th March 1856.

I, JAMES HARRISON, of Geelong, in the Colony of Victoria, Gentleman, Member of the Legislative Council of Victoria, do hereby declare the nature of the Invention for "PRODUCING COLD BY THE EVAPORATION OF VOLATILE LIQUIDS IN VACUO, THE CONDENSATION OF THEIR VAPOURS BY PRESSURE, AND THE CONTINUED RE-EVAPORATION AND RE-CONDENSATION OF THE SAME MATERIALS," to be as follows:—

10 To employ an air-tight apparatus of three vessels connected by tubes a vacuum is to be established throughout the apparatus, the air being expelled by the vapour of ether, alcohol, liquid ammonia, or other volatile liquid. The



*Harrison's machine from British Patent of 1856*



*The Truman, Hanbury & Buxton Brewery in London*

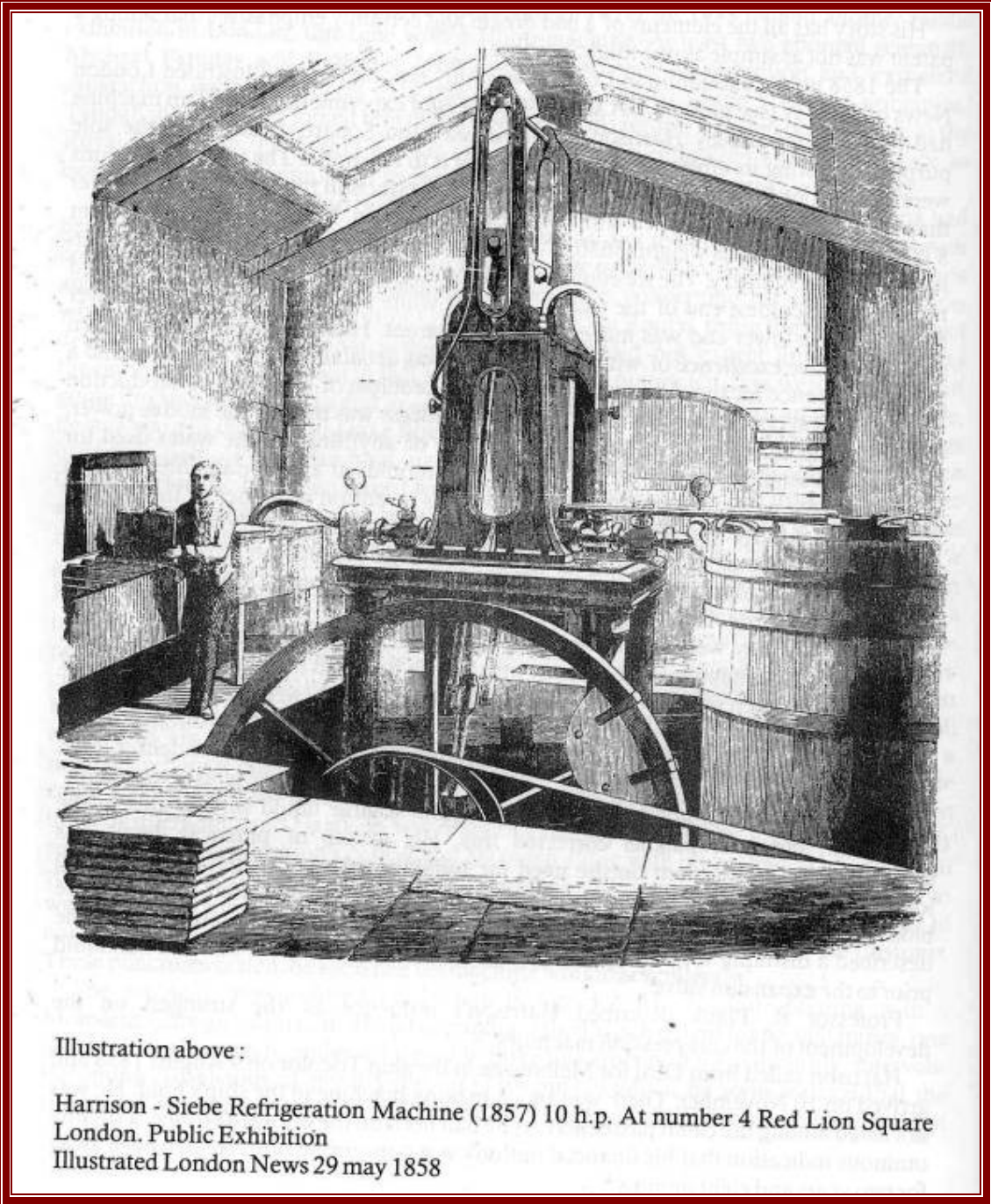


Illustration above :

Harrison - Siebe Refrigeration Machine (1857) 10 h.p. At number 4 Red Lion Square  
London. Public Exhibition  
Illustrated London News 29 may 1858

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A.D. 1873, 19<sup>th</sup> NOVEMBER. N° 3760.  
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**Preservation of Food.**

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LETTERS PATENT to James Harrison, of 52, Mornington Road, in the County of Middlesex, for the Invention of "IMPROVEMENTS IN THE PRESERVATION OF FOOD, AND IN THE CONSTRUCTION AND REFRIGERATION OF ENCLOSED CHAMBERS TO BE USED FOR THIS AND OTHER PURPOSES."

Sealed the 20<sup>th</sup> March 1874, and dated the 19<sup>th</sup> November 1873.

---

PROVISIONAL SPECIFICATION left by the said James Harrison at the Office of the Commissioners of Patents, with his Petition, on the 19<sup>th</sup> November 1873.

I, JAMES HARRISON, of 52, Mornington Road, in the County of Middlesex, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN THE PRESERVATION OF FOOD, AND IN THE CONSTRUCTION AND REFRIGERATION OF ENCLOSED CHAMBERS TO BE USED FOR THIS AND OTHER PURPOSES," to be as follows:—

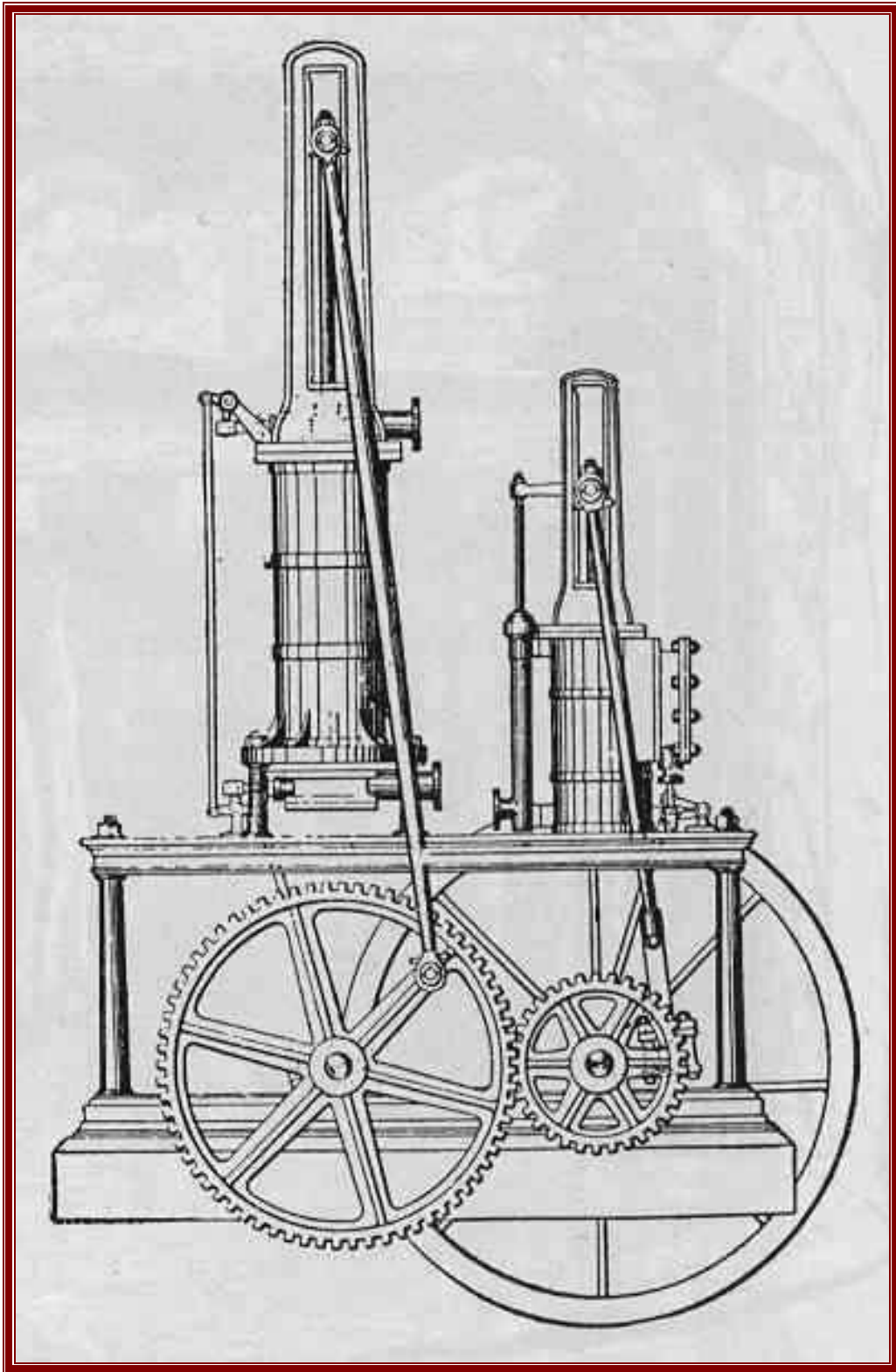
This Invention relates mainly to improvements in apparatus and processes for economically applying ice and freezing mixtures to the preservation of perishable animal and vegetable substances, and to the cooling of enclosed spaces in which they are kept, handled, or carried.

Australian printer and newspaperman James Harrison, although by trade a printer, apparently had extensive scientific and mechanical knowledge that enabled him to develop a can-ice-type ice-making system about the same time that Alexander Twining did. Harrison served his printing apprenticeship in Glasgow, Scotland, and availed himself of the educational opportunities there in the early 1830s. Harrison attended Anderson's University and the Glasgow Mechanics Institution. He was employed as a printer in London and was later hired by Tegg & Co. printers for a position in their Sydney, Australia, branch. Harrison allowed that he was only a printer and not a missionary and was able to convince the ethically minded Tegg to give him the position. Emigrating to Australia in 1837, Harrison later began experiments in vapor-compression refrigeration about 1854 (Figure 8-15). Harrison's biographer, W.R. Lang, concludes that about 1854, Harrison and his blacksmith friend John Scott built some form of ice-making machine of which "nobody was precise in recording it but many were imprecise in reporting it."<sup>37</sup> Harrison's first experiments resulted in his receipt of a patent from the Colony of Victoria in 1855.<sup>38</sup> This patent covers a simple vapor-compression refrigeration system using ether for a refrigerant and a compressor. The evaporator and condenser are simply metal vessels, the condenser being submerged in water. A high-side float expansion device is employed. Most interesting in

this patent is Harrison's listing of alternative means of compressing the ether, other than the piston-type compressor: a bellows, centrifugal blower, mercury or water column, diving bell, Archimedes' screw, reversed chain pump, or a reversed overshot water wheel.<sup>39</sup>

Recognizing the limits of available technology in Australia, Harrison and his family sailed for England for what was to be a two-year stay. Harrison's purpose in England was to consult with Daniel Siebe of the British steam engineering firm Siebe & Company. The result was a new design, suitable for production, which was covered by British Patent 2362 of 1857 (Figures 8-16 and 8-17). The first machine of improved design was sold to the Truman, Hanbury and Buxton Brewery in London in 1857.<sup>40</sup> Another machine, with an ice-making capacity of up to 8,000 pounds per day, was constructed by Siebe and exhibited in London before being exported to Australia.<sup>41</sup> In 1858, Harrison returned to Australia, set up an ice-making plant, and continued to promote and sell his ether machine. More machines were built by Siebe in London and by P.N. Russell & Co. in Sydney.<sup>42,43</sup> Thus, James Harrison was the earliest mechanical refrigeration pioneer to see actual commercial production of his invention. This commercial production, made possible by the expertise of a steam-engineering firm, was the first of many examples to come and demonstrated the usefulness of the advances in the technology of steam engines to the vapor-compression refrigeration industry.

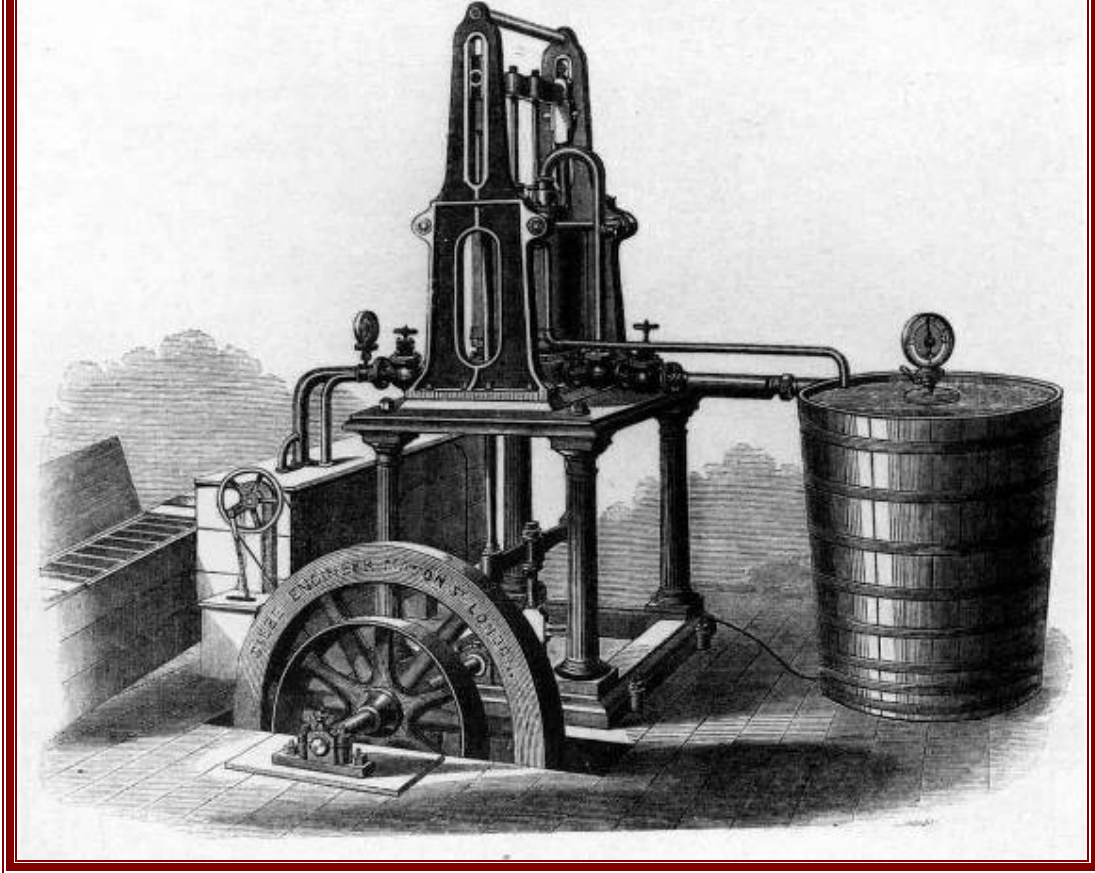
*(Text extract from "Heat & Cold: Mastering the Great Indoors,"  
Barry Donaldson & Bernard Nagengast, ASHRAE, 1994)*



*Harrison's sulphuric ether machine with steam engine, 1859*



HARRISON'S ICE-MAKING MACHINE.



*The Harrison-Siebe Machine*

COMMON COMMODITIES  
AND INDUSTRIES

COLD STORAGE  
AND  
ICE MAKING

*B. H. Springett*

*(Textbook of 1921, CIBSE Heritage Group Collection)*

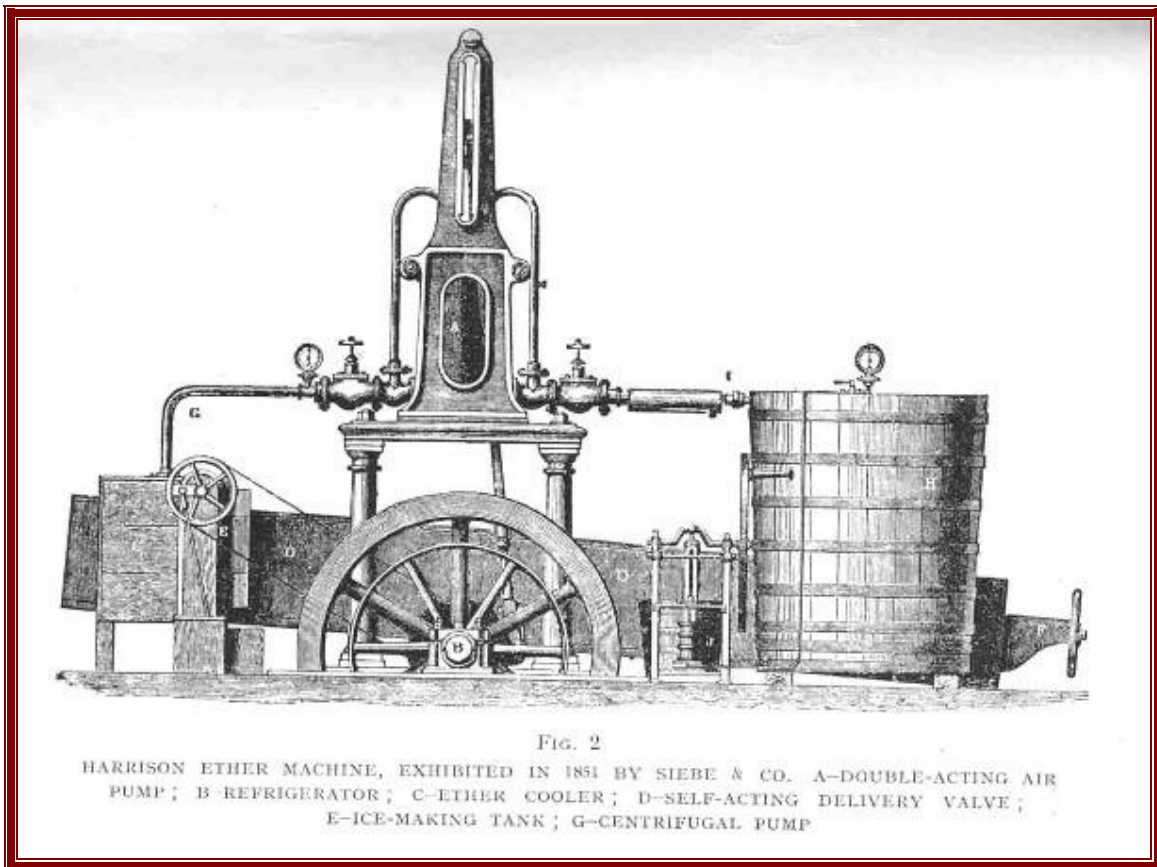
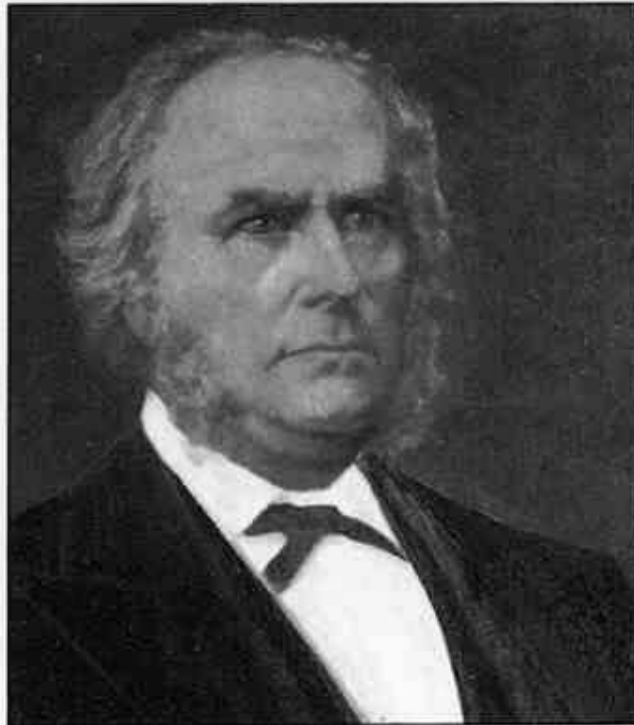


FIG. 2  
HARRISON ETHER MACHINE, EXHIBITED IN 1851 BY SIEBE & CO. A-DOUBLE-ACTING AIR PUMP; B REFRIGERATOR; C-ETHER COOLER; D-SELF-ACTING DELIVERY VALVE; E-ICE-MAKING TANK; G-CENTRIFUGAL PUMP

*Harrison's Ether Machine (From Springett)*

The Australian refrigeration and air conditioning industry is holding a number of events next month to mark the anniversary of the death of James Harrison, one of the great world pioneers of refrigeration.



James Harrison

A Scotsman, Harrison lived for much of his life in Geelong, a major provincial city in what is now the State of Victoria where he founded and edited a leading daily newspaper, The Geelong Advertiser.

Harrison was responsible for developing the first successful large-scale ice making machinery sold to industry and the first attempt to ship frozen meat on a long sea voyage, from Australia to Britain.

His ice making machine was built by the Siebe Company in London in 1858. It was an adoption of an earlier device Harrison invented in 1855 at Rocky Point, near Gelong. Harrison declared its purpose was not only to manufacture ice from salt or fresh water but to preserve provisions by congelation, to cool buildings and to distil oils, spirits and perfumes, etc at low temperature.

The Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) is set to open its new corporate headquarters, to be named James Harrison House, on 3 September, the date which marks the 100th anniversary of Harrison's death.

*(Building Services (CIBSE Journal), August 1993)*

## Engineer extraordinaire

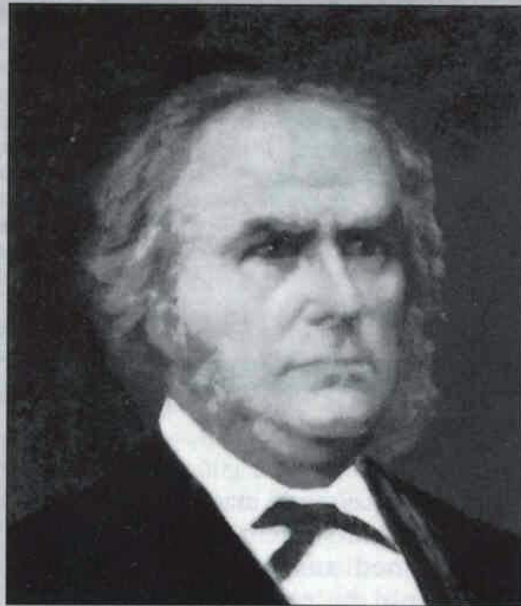
Printer, editor and publisher . . . it is likely that James Harrison would have made an ideal candidate for many of the positions with the AIRAH Journal of today. However, it is due to this man's efforts with refrigeration technology that today's industry is of the magnitude it is.

Harrison was truly a remarkable inventor who saw the potential in Australia and migrated in 1837. He settled in Geelong, Victoria, in 1840 and concentrated on inventing mechanical refrigeration.

These were busy times for a man who began and ran his own newspaper while discovering refrigeration technology. However, it was not until the 1850s that Harrison was noted for creating machinery which could chill at an effective level; through the evaporation of ether.

By 1856, he returned to London to take out patents and commence construction of machinery. Within five years, units from Europe to Peru, and Argentina to Australia bore his name.

By 1861, Harrison was declared financially insolvent back in Australia. His efforts to improve refrigeration technology pushed him into constant financial hardship and the only way he could keep alive his dream of designing machinery for preserving meat was by continuing to jockey between the



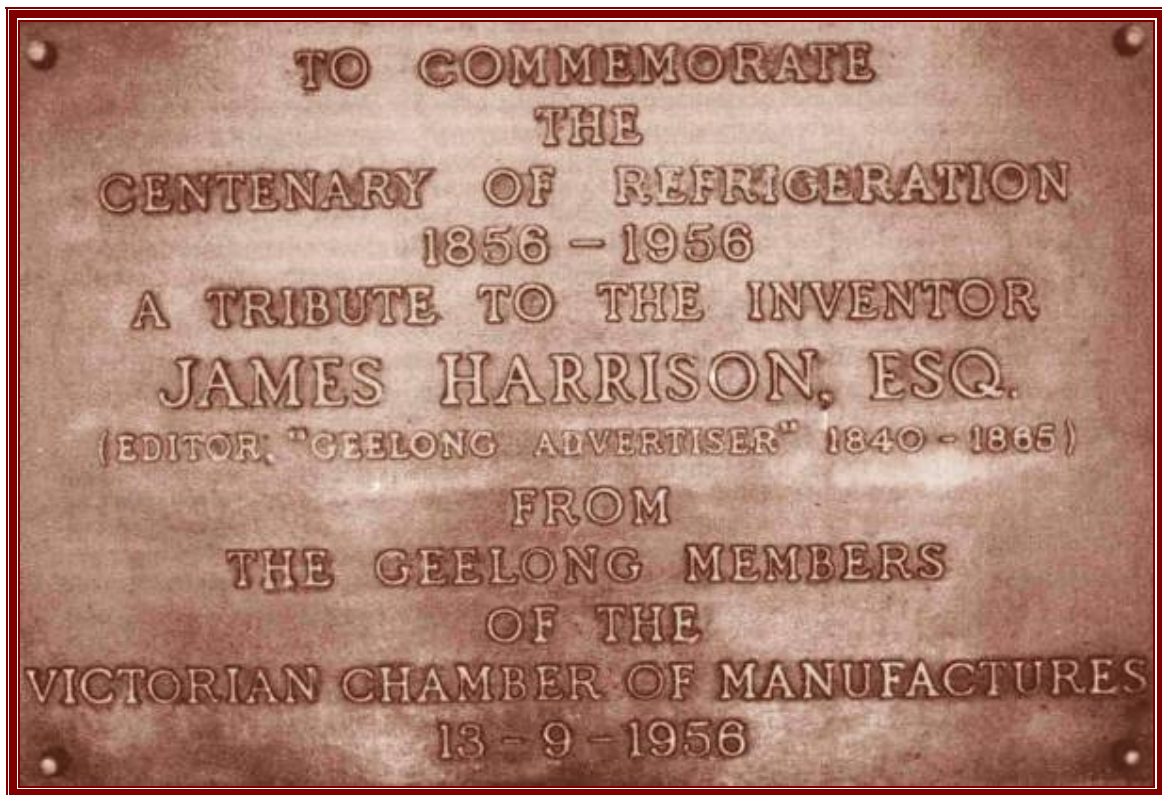
**James Harrison**

worlds of journalism and inventing.

In 1873 he exhibited this technology but his test of shipping meat stock to London failed and was enough to ruin his career. He remained in London for nearly 20 years, moving back to Geelong in 1892. He died the same year, aged 77.

It is widely known that the man who invented refrigeration went for all his life unrewarded, although his achievements have been ranked alongside the invention of the steam engine.

*(From AIRAH Journal, July 1997)*



*Commemorative Plaque in Geelong*



**HERMANN LUDWIG FERDINAND  
VON HELMHOLTZ  
1821-1894**



*Pioneer in Acoustics*



**Hermann  
1821-1894**

**Ludwig**

**Ferdinand**

**von**

**HELMHOLTZ**

German physiologist and physicist\*. Studied medicine. Graduated Berlin (1842). Served as a surgeon in Prussian Army. Later taught physiology at Königsberg, anatomy at Heidelberg (1858) and physics at Berlin (1871). Made a close study of the human eye. Also studied the ear and “advanced the theory that the ear detected differences in pitch through the action of the cochlea, a spiral organ in the inner ear.” He noted the quality of a tone depends on the nature, number and relative intensities of the overtones (harmonics). He also analysed music and found that “combinations of notes sounded well or discordant on the basis of wavelengths and the production of beats at particular rates.”

*(Mini-biography from CIBSE Heritage Group Records)*



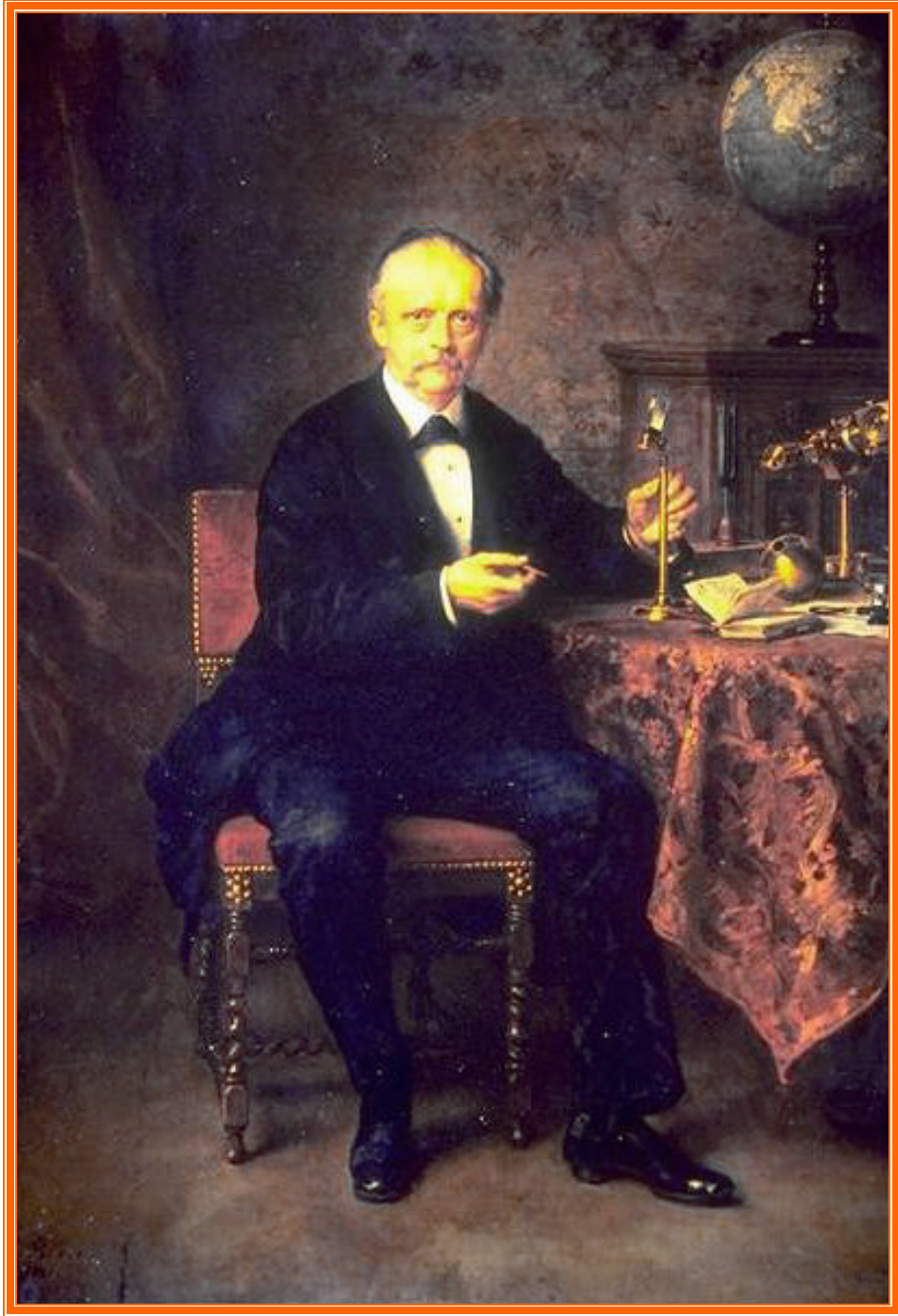
*Postage Stamp of 1971*



*Postage Stamp of 1950*



*Postage Stamp of 1994*



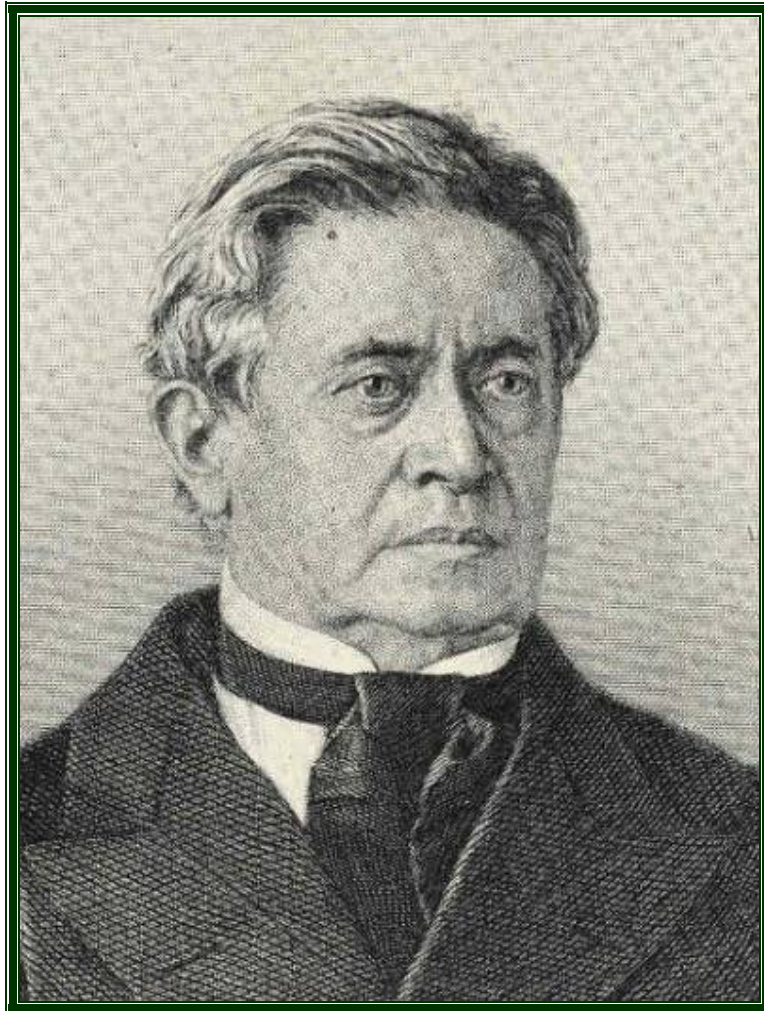
*Helmholtz Portrait 1881*



# JOSEPH HENRY

1797-1878

I

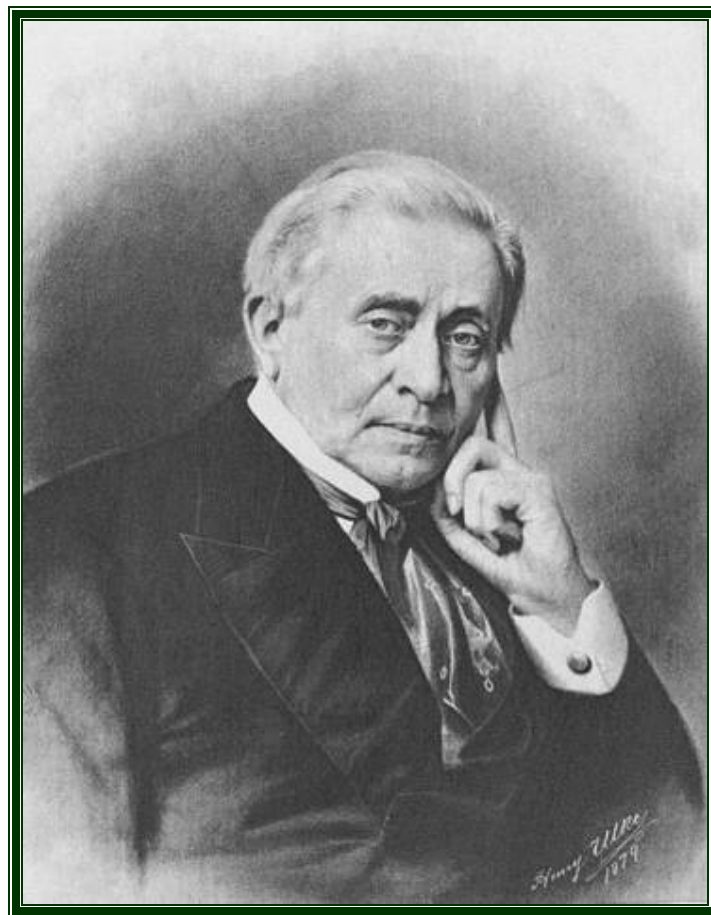


*Discovered the Principle of Induction*

**Joseph HENRY****1797-1878**

American physicist. Came from a poor family and had little schooling. Is said to have come across the book *Lectures on Experimental Philosophy* when playing in a church and this fired him with enthusiasm for education. Graduated from Albany Academy, NY where he went on (1826) to teach mathematics and science. Became the first American to conduct serious experiments with electricity since Benjamin Franklin [8]. Investigated electromagnets and invented a telegraph (c1835) which he did not develop or patent. While at Albany (1830) he discovered the principle of induction which was found independently by Faraday [158]. Henry went on to design a practical electric motor (1831)\*. He became Professor of Physics at Princeton (1832/46), first Secretary of the Smithsonian Institution (1832/78) and was largely instrumental in founding the US Weather Bureau. The SI unit of electrical inductance, the *henry*, is named after him.

*(Mini-biography from CIBSE Heritage Group Records)*



*Portrait of Joseph Henry*

Mr William Rogers of Virginia is well known as an ardent and successful cultivator of science. I am personally acquainted with him and have a very high opinion of his talents and acquirements. He is one of those who do not content with retarding the untested opinions and discoveries of European Philosophers endeavor to enlarge the boundaries of useful knowledge by experiments and observations of their own.

Should Mr. Rogers' life and health be spared I am confident he will do much towards elevating the scientific character of our country.

Nassau Hall  
 July 6<sup>th</sup> 1835

Joseph Henry  
 Prof. Nat. Phil.  
 College of N. Jersey  
 Princeton

Henry letter of 1835



*Henry Statue, Smithsonian Castle*



*Grave of Joseph Henry*