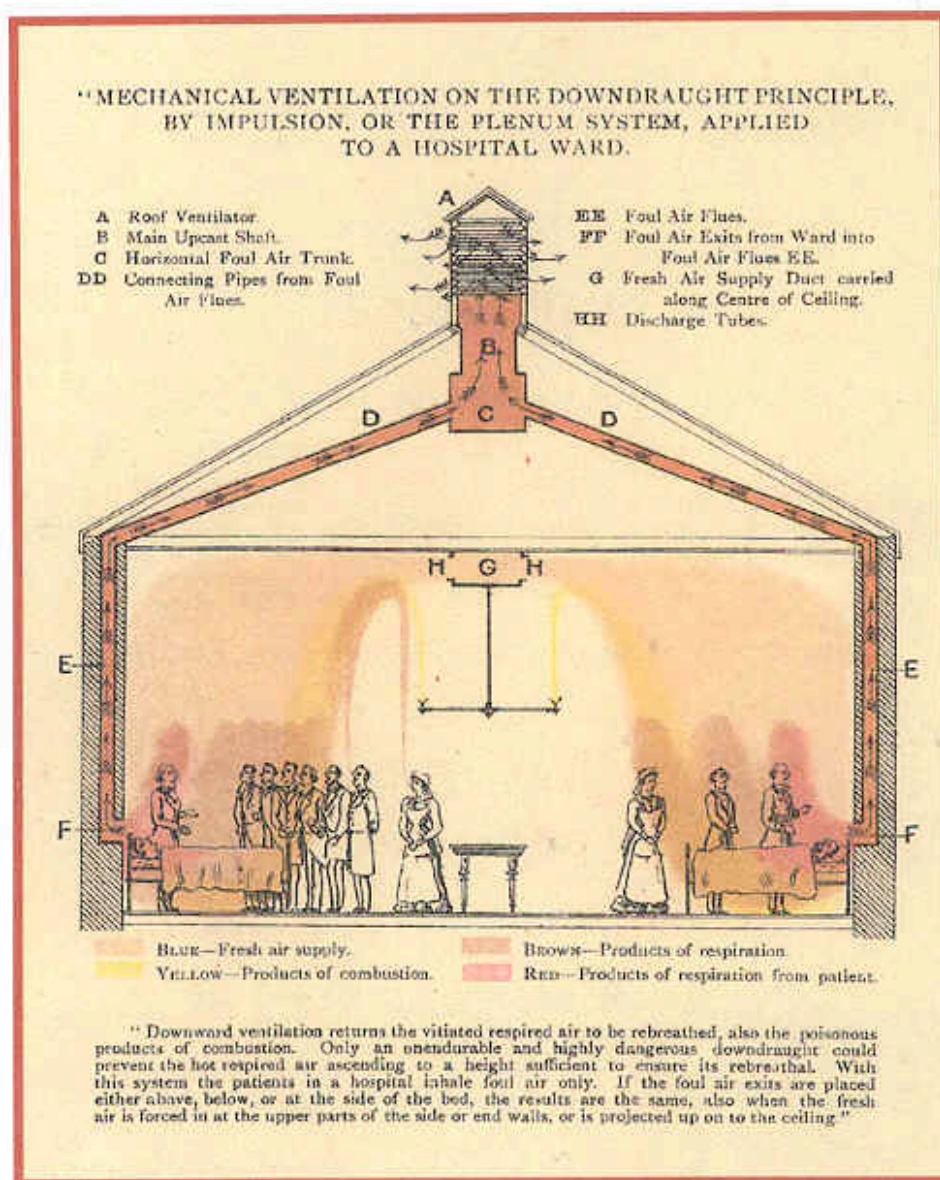
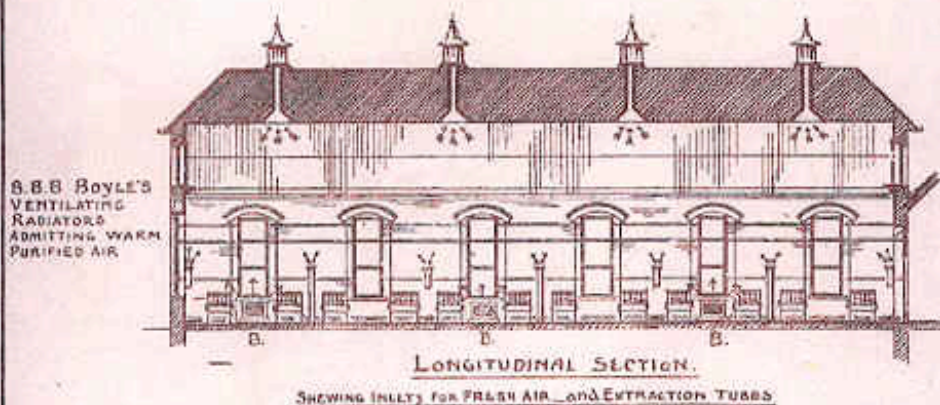
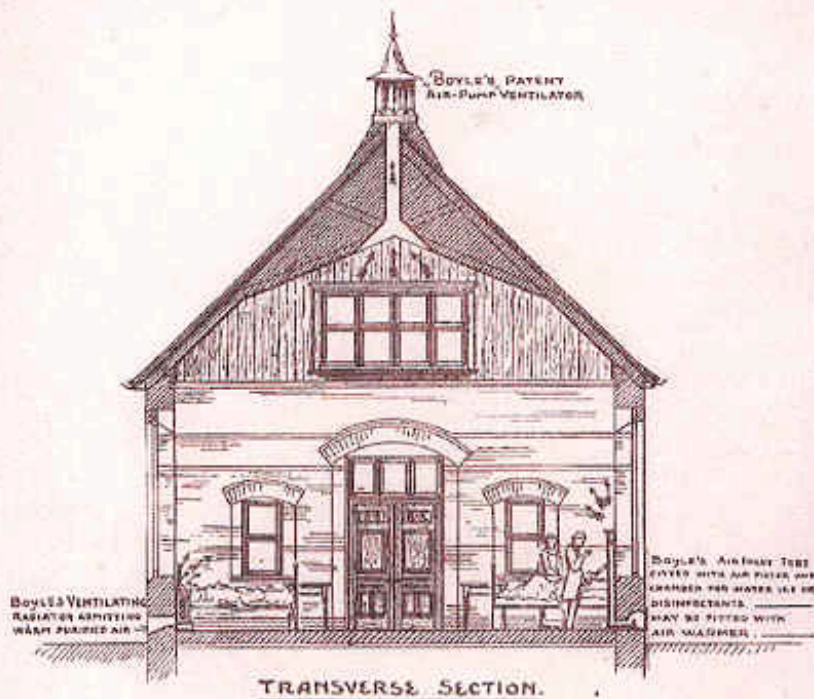


VICTORIAN HOSPITALS & ASYLUMS AND THEIR BUILDING ENGINEERING SERVICES



Hospital mechanical plenum ventilation, c.1900 [BSV, ii]

THE "BOYLE" SYSTEM OF VENTILATION
As applied to an INFECTIOUS DISEASES HOSPITAL.



NOTE.— Fresh purified air warmed
or cooled, admitted underneath
beds where desired.

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

"In reply to your request that I should tell you how the 'Air-Pump' Ventilators recently fixed in the new building here are answering, I am able to inform you that they appear to fulfil their object in a completely satisfactory manner."
—DR. F. FORD CAZEB, *Medical Superintendent*, South Western Fever Hospital, London.

N.B.—For table of sizes and number of ventilators required for the ventilation of Fever Hospitals, see pages 148, 149.

Boyle ventilation for an infectious diseases hospital, c.1900 [BSV, 49].

VICTORIAN HOSPITALS & ASYLUMS

AND THEIR BUILDING ENGINEERING SERVICES



The Army Nursing Service, 1879 [FN, 237]

BRIAN ROBERTS
Chairman CIBSE Heritage Group

VICTORIAN HOSPITALS & ASYLUMS

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APPENDIX-1

OPERATING THEATRES

*ILLUSTRATIONS, NOT ALL VICTORIAN
IN GROUPS IN CHRONOLOGICAL ORDER*

1566-1880

1889-1892

1900-1905

1907-1910

1912-1923

1930-1979

REFERENCES

FOREWORD

One of the oldest and most notable examples of a medieval hospital is the 9th century Benedictine monastery of St Gall which included an infirmary and supporting facilities. For many centuries looking after the sick was carried out by religious orders. The development of hospitals has been described by architectural historian Nikolaus Pevsner [HBT, chapter 9]. But little is recorded about the engineering services in early hospitals. {Some examples of early medieval hospitals, all of which were still in use in the late 1960s, are shown in the photographs which follow.} A Florentine named Filarete produced an intended scheme for the Ospedale Maggiore in Milan in the early 1460s. Water was to be stored in a cistern and conducted through vaulted passages along the wards and then down to a river. Another set of passages were to contain lavatory seats with access by trapdoors between the beds.

The conditions in many early hospitals were frightful, sometimes with four or more patients in a single bed. A late 17th century attempt to improve conditions was the radial plan proposed by Antoine Desgodets which employed an octagon centre and sixteen radiating wards. The centre was to carry a dome “which served the purpose of sucking out used air.” In Great Britain, the 18th century saw a dramatic rise in the building of hospitals including famous London establishments such as St Bartholomew’s, St Thomas’s, and Guy’s.

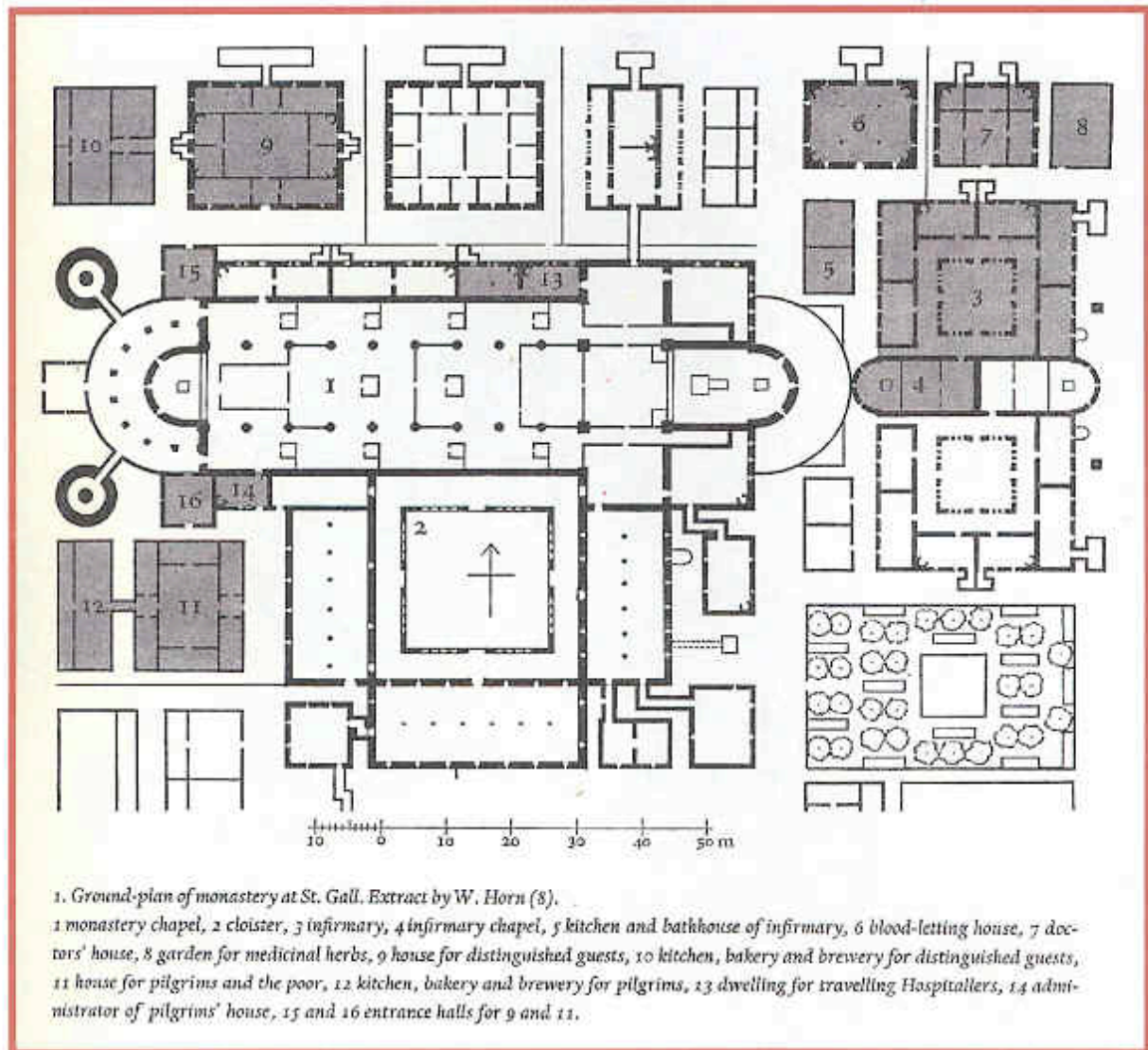
In 1773, the Frenchman Jean-Baptiste Le Roy described a ward as “a machine for treating the sick.” His scheme had wards with ample ventilation ducts in the roof since lack of ventilation was thought to be a major factor in the high mortality rates then being experienced in some hospitals. Earlier work on which this may have been based was the book by the Englishman, Stephen Hales (“A Description of Ventilators” of 1743.) In 1774, Antoine Petit produced a similar scheme, a series of radial wards linked to a high central dome and ventilating tower.

During the Crimean War, Florence Nightingale demonstrated the importance of proper hygiene when she reorganized the military hospital at Scutari, reducing the death rate by some 40%. However, despite her impassioned pleas, in the design of the new military hospital at Netley, near Southampton (1856-63), her recommendations were ignored. However, a revolutionary design was Brunel’s prefabricated hospital for the Crimea.

The design of Victorian hospitals in England saw increasing emphasis on providing warming and ventilation, proper sanitary and washing facilities, and kitchens and laundries. In some wards heating (and ventilation) continued to be provided by fireplaces with opening windows and in many places this continued until Edwardian times. However, the last quarter of the 19th century saw the increasing use of hot water heating by radiators.

In the United States, hospital development was spurred on by the Civil War, many examples of Union facilities being found in and around Washington DC. American examples from the 1880s and 1890s indicate that many heating and ventilation installations were in advance of those of the same period in England.

One interesting aspect of engineering services in hospitals relates to Operating Theatres [\(see Appendix-1\)](#) where radiator heating and ventilation by opening windows continued into the 1930s, with some early examples having open fireplaces.



Plan of Monastery of St Gall, c.820 [TCEH, fig. 1]

FOREWORD



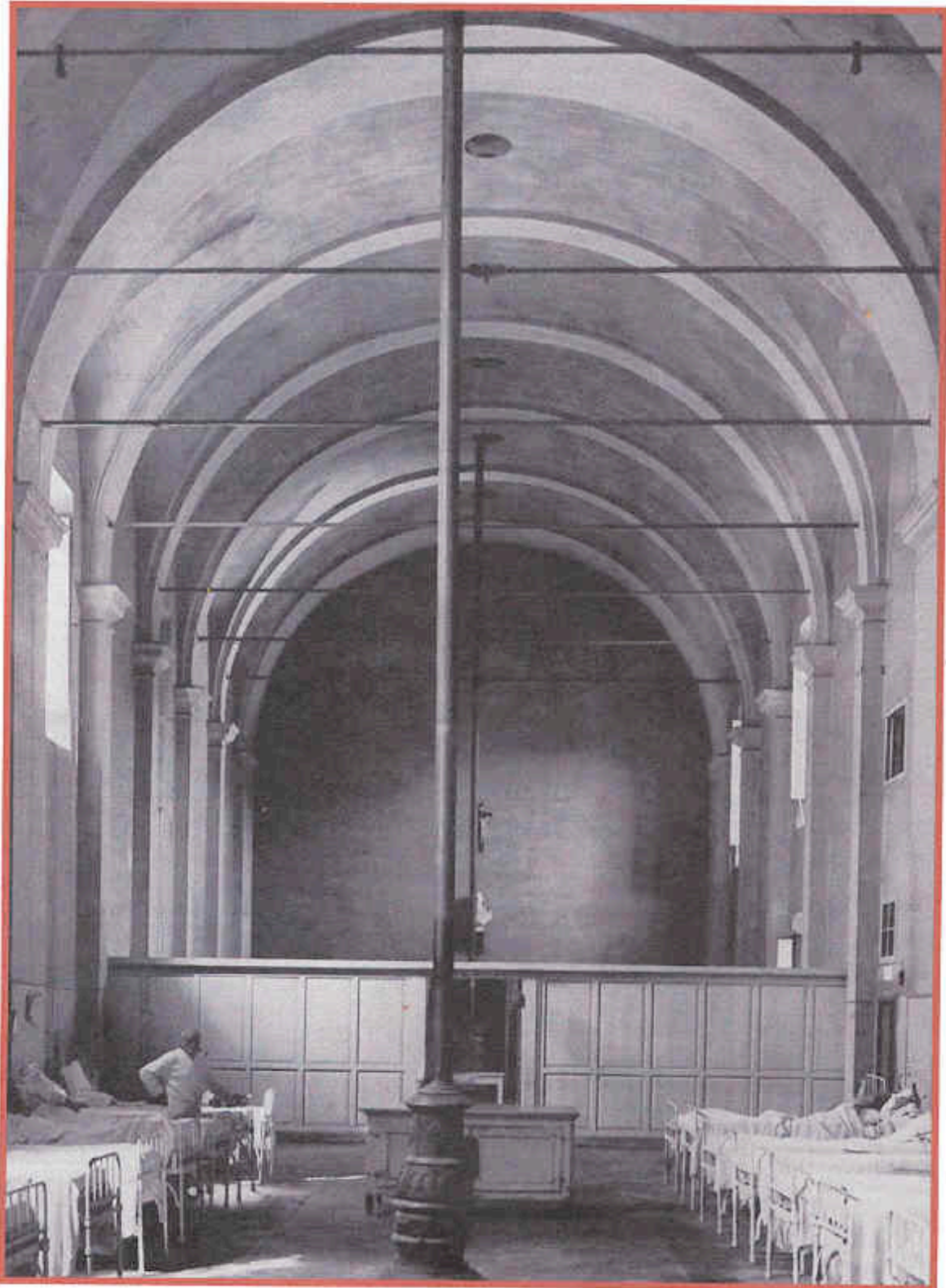
**Beaune (Côte-d'Or), France: Hôtel-Dieu, interior of hospital hall [TCEH, plate 133].
Built 1443-51, considered one of the most beautiful medieval hospitals in Europe.**

FOREWORD



**Napoli (Campania), Italy: Ospedale di S. Maria della Pace [TCEH, plate 215].
Originally a palace in 1500. In 1571 donated to Friars for a hospital, but converted to
monastery, combining chapel and hospital, opening in 1620.
Converted and extended with barrel-roofed ward c.1765.**

FOREWORD

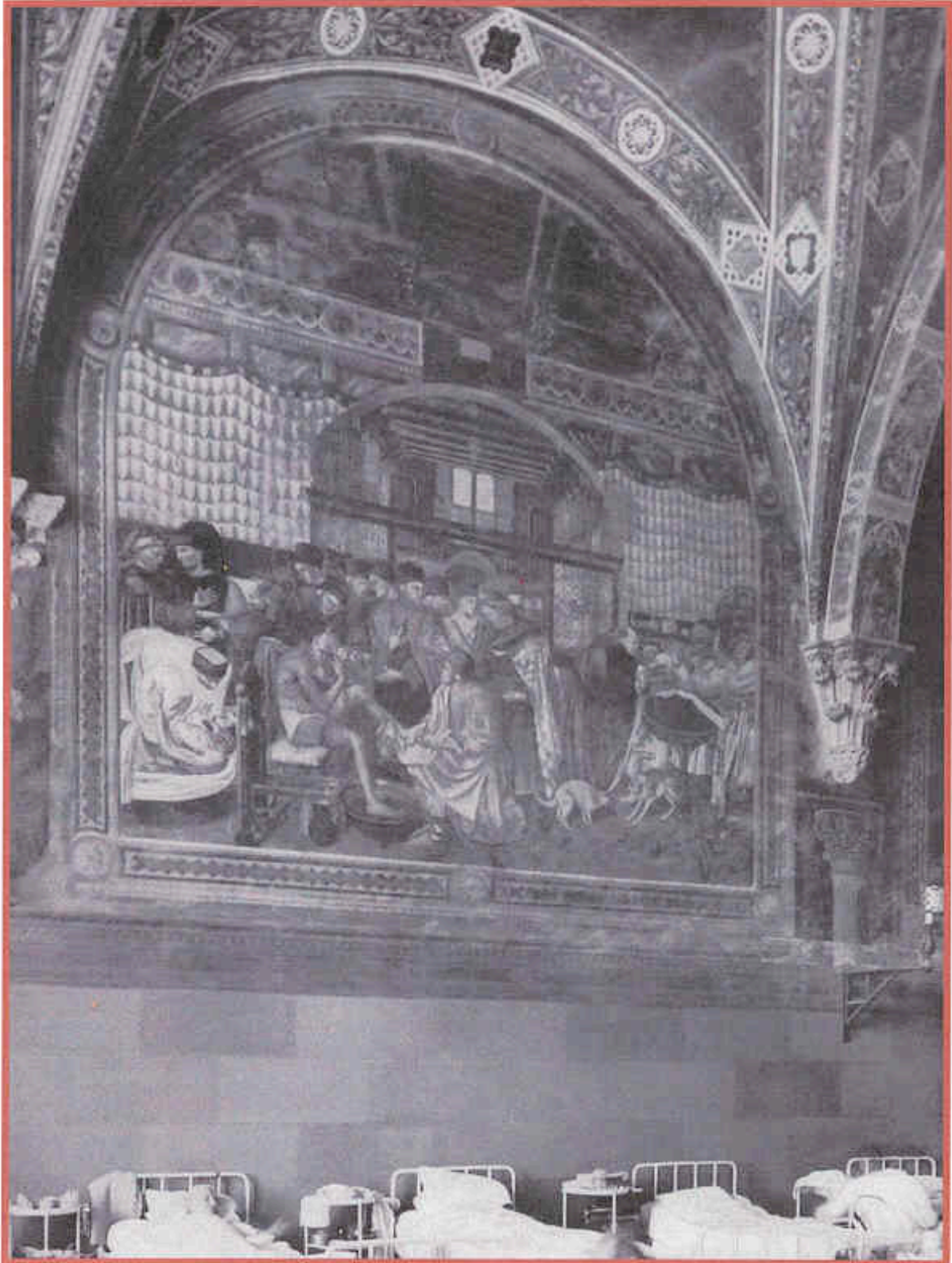


Prato (Toscana), Italy: Spedale della Misericordia e Dolce [TCEH, plate 219].

One of the wards, complete with heating stove and very tall flue.

Founded 1218, additional building 1250, renovated and converted c.1700 and after.

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**Siena (Toscana), Italy: Ospedale di S Maria della Scala [TCEH, plate 226].
Considered the best preserved medieval hospital in Italy.
Main buildings 13th century, frescoes c.1442.**

Founding hospitals and leper houses, or leper hospitals, are first mentioned in the 6th century. Derived from the latin *hospes*, which means the guest or host, the terms hospital, hospice, hostel and hotel all represent the functions of the medieval hospital. Other terms having a similar meaning include almshouse, asylum, orphanage, founding home, guest house for pilgrims and travellers, and poor house.

During the establishment of the early hospitals, monasteries played an important role. A parchment plan from the 8th century shows that the Benedictine Abbey of St Gall was designed to include a separate infirmary for the sick. Similarly, records show that Cluniac and Cistercian houses also had their own infirmary. Eventually it became the task of special lay fraternities to look after the sick.

By the 10th and 11th centuries the military orders had made their impression, in particular that of St John of Jerusalem, otherwise known as the *Hospitallers*, who founded hospitals in Jerusalem, at Acre, on Cyprus, among others. In time the responsibility for providing and looking after hospitals passed from the religious orders to municipal councils.

Early developments

The most important Italian Renaissance hospital was the Ospedale Maggiore in Milan designed by Filarete in 1456. Built to the then new cruciform plan, it was intended that water should be stored in a cistern and conducted through vaulted passages, with a fall along the wards, and down to the river. Another set of passages equipped with lavatory seats were to be introduced with access arranged via trapdoors between the beds. These designs, along with many of Filarete's original ideas, were changed considerably over the years.

At the end of the 17th century, Antoine Desgodets had developed the radial hospital plan, comprising an octagon centre with 16 radiating wards. The centre carried a dome designed for the purpose of sucking out used air, while lavatories were to be installed in the inner angles between the radiating wards with more wards running round the periphery. In 1756 the pavilion design was introduced, incorporating widely spaced separate buildings to minimise risks of cross-infection. Designs of this type include Stonchouse in Plymouth (1756) and Lariboisière in Paris (1839).

In Britain, the 18th century produced an unprecedented crop of hospital de-

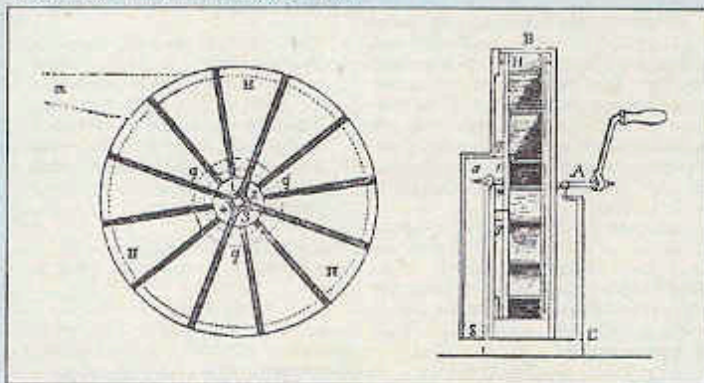
First aid

Brian Roberts delves once more into the CIBSE archives and reveals that services in hospitals goes back as far as the Renaissance period.



Above: Illustration from a German medical book of 1566. Three physicians are diagnosing an illness centre, while a surgeon is sawing off a leg. Note the instruments lying all over the floor. On the rear wall can be seen the heating apparatus, which appears to be a "kachelofen" or masonry stove.

Below: Desgodets mechanical "turning wheel" of 1734.



velopments. The medieval London hospitals of St Bartholomew's, St Thomas's and Bethlehem (Bedlam) were rebuilt, and new hospitals established including Westminster (1719), Guys (1720), St George's (1733), the London

Hospital (1740), the Middlesex (1745) and St Luke's (1751). Many of the provincial hospitals were built in the second half of this century.

A survey of hospital conditions at this time produced the following comments:

INTRODUCTORY ESSAY

- London Hospital: "There are no cisterns for water...the vaults are often offensive."
- St Bartholomew's: "The wards...were clean...the windows were open."
- St Thomas's: "The wards were fresh and clean...there were no water closets."
- St George's: "The kitchens...are underground and were neither neat nor clean."
- Leeds: "This is one of the best hospitals in the Kingdom."

Heating

Early hospitals usually had fireplaces or stoves, although some had no heating at all. Hot water heating proved popular in England and greatly impressed the French engineer, Péclet. And so it was under his recommendation that a pressurised hot water system, otherwise known as a Perkins system, was installed in the Charenton Hospital in 1840.

In France, a development of steam heating was the mixed system, whereby steam was used to heat water in radiators or calorifiers. The intention was to overcome the high and uncontrollable surface temperature associated with pure steam radiation. This system was first used in the famous Prison Mazas in 1850 and was also utilised in the Hospital Lariboisière.

The water in the stoves was heated by steam during the day and allowed to cool at night, from around 95°C to room temperature, thus effectively creating a very early example of a thermal storage system.

In 1869/71 the hospital at St Gallen was provided with a central boilerhouse with steam being distributed to associated buildings. This system would now be called a group scheme, in which all the buildings are under common ownership and the distances between them not too great. The steam was used to heat hot water in the main building and for air heating in the remainder.

The difficulty of securing an adequate circulation of hot water in a heating system became apparent quite early on. Various forms of steam injection apparatus were devised to accelerate the circulation, one such system being installed in a Dublin asylum in 1890.

Ventilation

Heat as the motive power for ventilation dates from the 16th century when its use in mines was described by Agricola. Desaguliers, in 1723, used it for the House of Commons, and Sir George Paul also used it in the early 1800s to ventilate a hospital.

A Mr Fleming of Glasgow proposed a system of ventilation for hospitals, in which an aspirating chimney was used to draw air from the top or back of the beds by means of tubes.

Around 1840, Fleming also made a prototype of a ventilated hospital bed, which could be associated with a washing machine for the clothes of patients with an infectious disease.

The years 1850 to 1875 proved to be the heyday of warm air heating. One installation at St Petersburg City Hospital, in 1871, used a ceramic stove (4 x 1.5 x 2 m high) placed centrally in the building, with eight air passages through the stove supplying warm fresh-air to the wards. A number of extract openings, near the floor of the ward, were connected to the flue of the stove to provide the necessary pull.

Mechanical devices for moving air had been used in 16th century mines. These consisted of paddle-bladed devices turned by men or animals, or possibly by water or wind power. One such device, from Desaguliers in 1734, comprised a mechanical fan, or 'fanner', which had a wheel diameter of 2.1 m. The men who turned the wheel were called the ventilators.

In 1758 Stephen Hales used a bellows for ventilating hospitals and ships. Comprising a box 3 x 1.3 x 0.3 m, it was claimed that this ventilator could expel air at the rate of 6 tons per minute with two men working at the lever (about 0.12 m³/s). Hales again used fans at the County Hospital, Winchester and at St George's Hospital, London.

The system consisted of an extracting fan, powered by a windmill fixed on the top of the hospital, connected by ducts to each ward, extracting "foul" air at ceiling level. The system was planned so that fresh air would come in via ward doors to avoid discomfort from cold air passing through the windows.

Unfortunately, this system was apt to go out of action just when it was most needed.

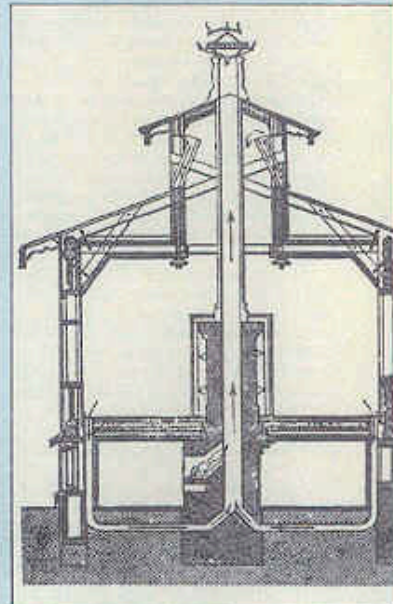
In 1784 the hopper window was first used by Mr Whitehurst of Derby, at St Thomas's Hospital, to promote natural ventilation and avoid draughts. The scheme proved most successful and a substantial reduction in the mortality rate ensued.

Neil Arnott introduced an automatic air pump at a York hospital, specifically to enable ventilation at night without the need for attendance. A significant feature of the device was its use of pumped stor-

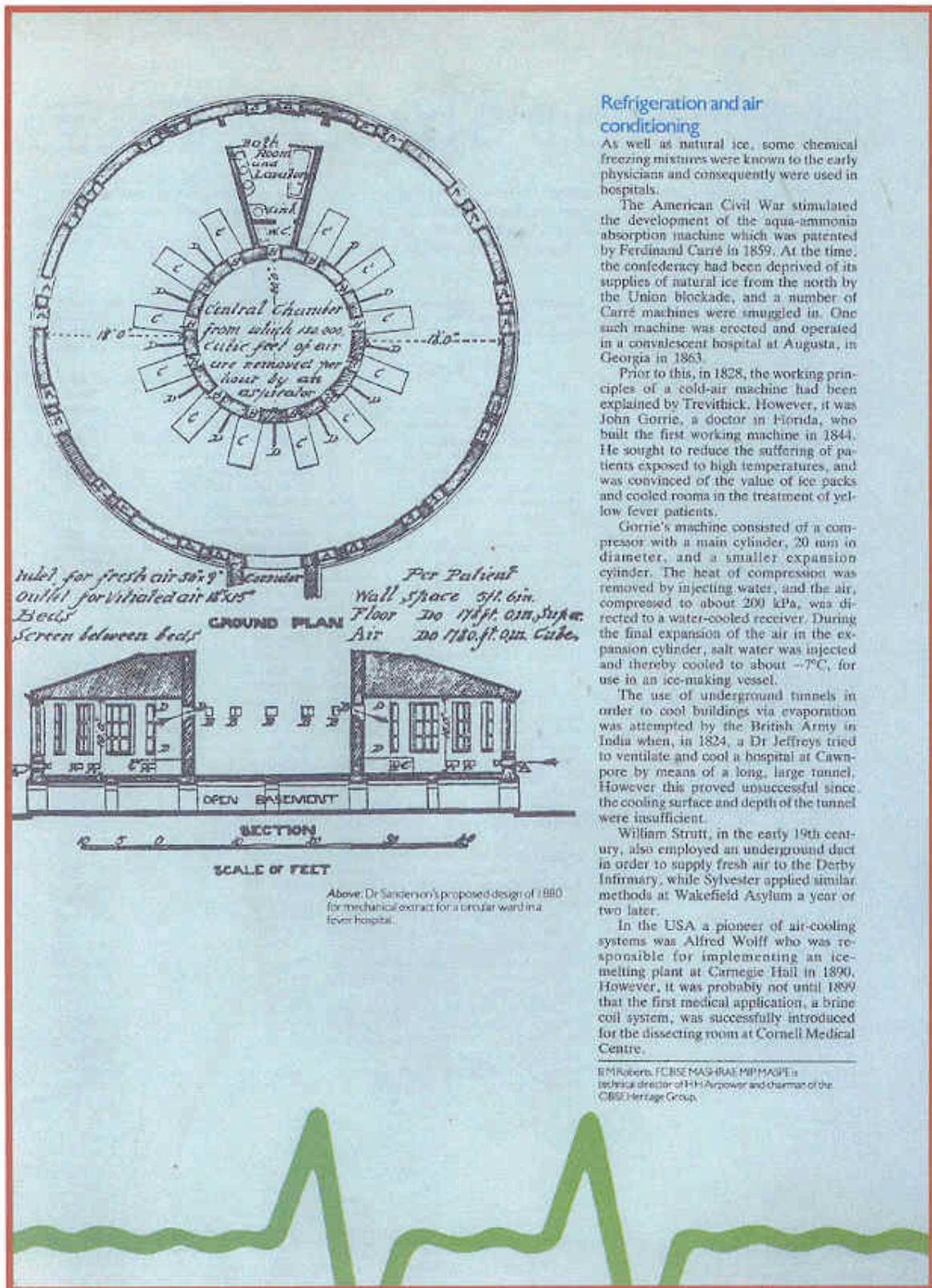
age. During the day water was pumped into the tank by exhaust steam. At night it was used to drive the air pump when no other source of power was available.

About 1880, mechanical extract was suggested by a Dr Sanderson in his proposed design for a circular ward in a fever hospital. The incoming fresh air was to be warmed by hot water pipes while the vitiated air was to be passed through a furnace before discharge to the atmosphere. During this process the windows had to remain closed. Wards of this type were apparently built at Antwerp and Baltimore, together with a few in England.

Below: The warm air ventilation system of St Petersburg Hospital (1871)



INTRODUCTORY ESSAY



Above: Dr Sanderson's proposed design of 1880 for medical extract for a circular ward in a fever hospital.

Refrigeration and air conditioning

As well as natural ice, some chemical freezing mixtures were known to the early physicians and consequently were used in hospitals.

The American Civil War stimulated the development of the aqua-ammonia absorption machine which was patented by Ferdinand Carré in 1859. At the time, the confederacy had been deprived of its supplies of natural ice from the north by the Union blockade, and a number of Carré machines were smuggled in. One such machine was erected and operated in a convalescent hospital at Augusta, in Georgia in 1863.

Prior to this, in 1828, the working principles of a cold-air machine had been explained by Trevithick. However, it was John Gorrie, a doctor in Florida, who built the first working machine in 1844. He sought to reduce the suffering of patients exposed to high temperatures, and was convinced of the value of ice packs and cooled rooms in the treatment of yellow fever patients.

Gorrie's machine consisted of a compressor with a main cylinder, 20 in in diameter, and a smaller expansion cylinder. The heat of compression was removed by injecting water, and the air, compressed to about 200 kPa, was directed to a water-cooled receiver. During the final expansion of the air in the expansion cylinder, salt water was injected and thereby cooled to about -7°C , for use in an ice-making vessel.

The use of underground tunnels in order to cool buildings via evaporation was attempted by the British Army in India when, in 1824, a Dr Jeffreys tried to ventilate and cool a hospital at Cawnpore by means of a long, large tunnel. However this proved unsuccessful since the cooling surface and depth of the tunnel were insufficient.

William Strutt, in the early 19th century, also employed an underground duct in order to supply fresh air to the Derby Infirmary, while Sylvester applied similar methods at Wakefield Asylum a year or two later.

In the USA a pioneer of air-cooling systems was Alfred Wolff who was responsible for implementing an ice-melting plant at Carnegie Hall in 1890. However, it was probably not until 1899 that the first medical application, a brine coil system, was successfully introduced for the dissecting room at Cornell Medical Centre.

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