Some COMFORT ARCHITECTS

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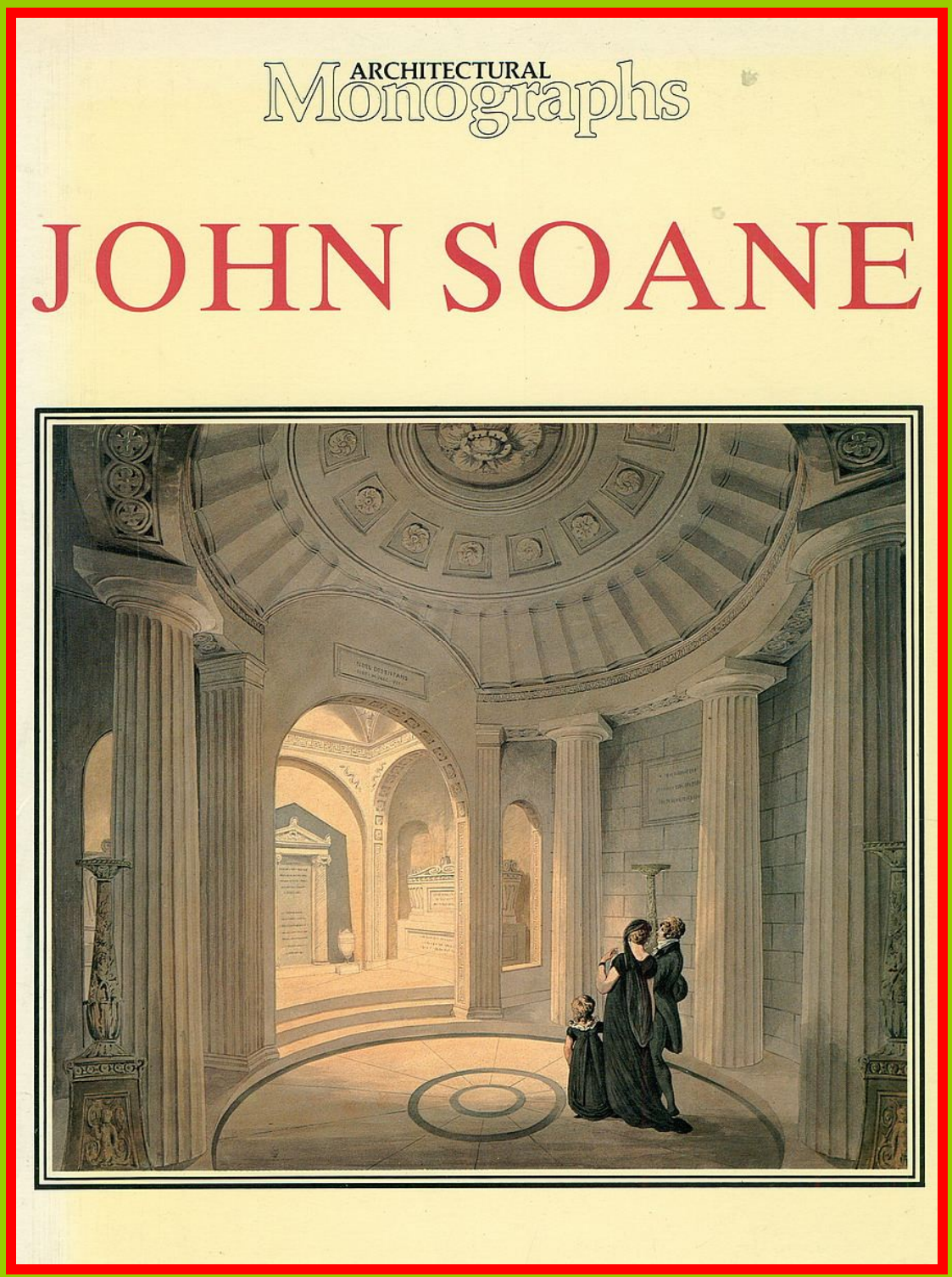
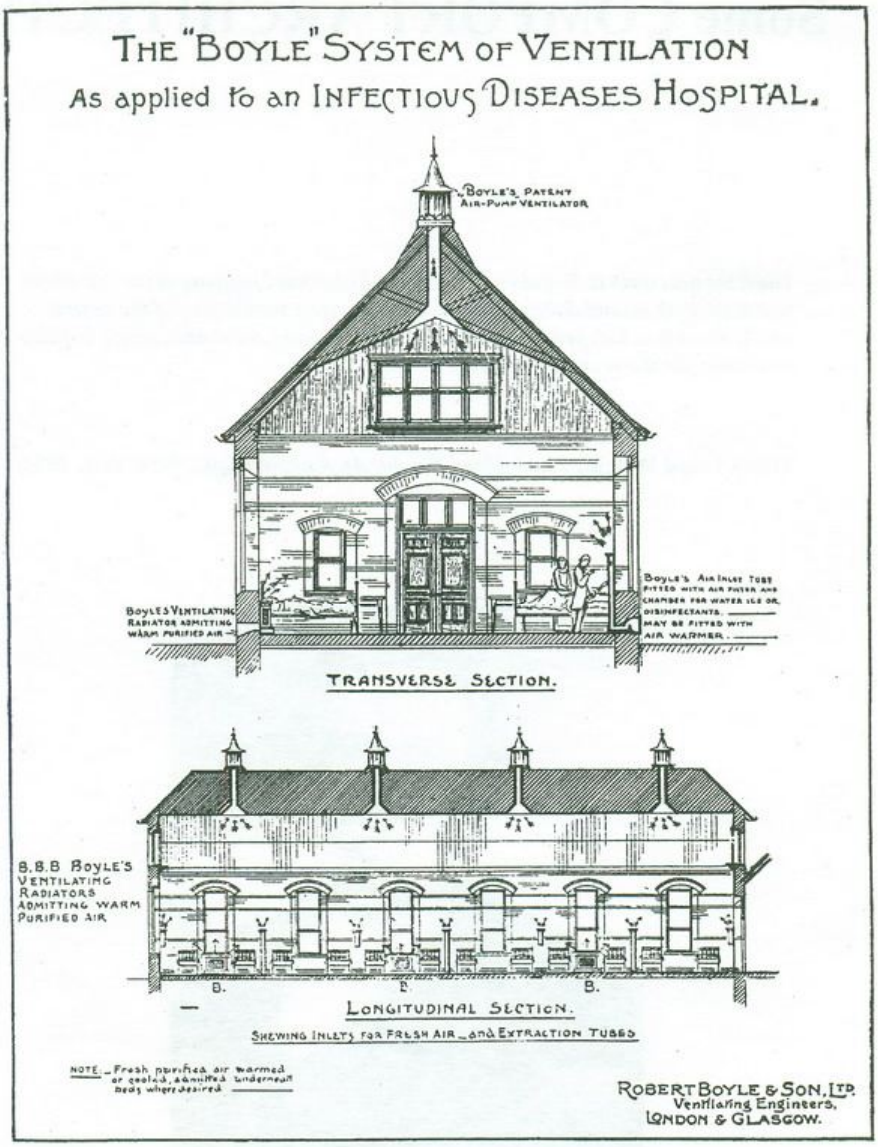


Some COMFORT ARCHITECTS

I took the next train to Buffalo to try and get the Larkin Company to see that it was worth thirty thousand dollars more to build the stair towers free of the central block, not only as independent stair towers for communication and escape, but also as intakes for the ventilating system.

Frank Lloyd Wright, *Frank Lloyd Wright: An Autobiography*, New York, 1943.

Sir Joseph Paxton [192]



29. Catalogue Illustration: Natural Ventilation by the Boyle System of the South West Fever Hospital in London. An example of collaboration between architect and ventilation engineer. The Boyle System of Ventilation, Robert Boyle & Son, Ltd., High Holborn, London, c. 1900.

Cost for Annual Maintenance of Apparatus
Working all day and night in Winter
Night only in Summer.

		£ s d
Fuel for 200 days and nights Warming and Ventilation for heating apparatus	210 Tons @ 16/	168. 0. 0
Fuel for Steam Engine 24 hours 365 days including service of Baths	84 Tons	77. 0. 0
Two Stokers at 30/- per week		156. 0. 0
Sundries Repairs Oil and Wipings &c.		38. 0. 0
		£ 439. 0. 0

Cost of Warming and Ventilation per bed per annum

The number of beds in the Hospital being 588 will shew taking into consideration the service of the Baths and Ventilation and Warming of the other Rooms, that the cost would be about 11/8 per bed per annum.

Cost of the Apparatus

From the best of my judgment I consider that the cost of the apparatus for carrying out my proposed plan will not exceed the sum of £1928. . .

This Sum would include all personal superviseing of the Work during the erection of the Building and supplying all the necessary apparatus, Steam Engine, Boiler, Fans, Gearing, Heating apparatus, Cast Iron Air Gratings for Escape and Inlet, Regulating Valves, Indicating Dials &c &c. but exclusive of all Brickwork for the formations of Engine Rooms, Air Chambers and Flues and Channels.

General Remarks

This is in a few words the Plan, I should propose for the Ventilation and Warming of the new St Thomas's

/5

30. *Handwritten Report: Costs for Annual Maintenance and Apparatus. Proposals for Ventilation and Warming of St. Thomas's Hospital, Lambeth, London. Submitted by the engineer W.W. Phipson, dated 20 November 1865. The scheme was not adopted. (CIBSE Heritage Group Collection)*

[181] VITRUVIUS — active A.D. 70

Marcus Vitruvius Pollio. Roman architect and engineer who recorded the considerable knowledge of the Empire in *The Ten Books of Architecture.* He described the construction of Roman baths and of the underfloor warm air heating (hypocaust): "The hanging floors of the hot bath rooms are to be constructed as follows. First the surface of the ground should be laid with tiles a foot and a half square, sloping towards the furnace in such a way that, if a ball is thrown in, it cannot stop inside, but must return itself to the furnace room; thus the heat of the fire will more readily spread under the hanging flooring."

75. *Morgan (Vitruvius), p. 157.*

[182] APOLLODOROS OF DAMASCUS — died c. 149

Greek architect. Chief architect and engineer of the Emperor Trajan. Designed the great Baths of Trajan in Rome, built A.D. 104-109, a complex occupying some 23 acres, with heated, tepid, and cold baths. This was one of the Imperial *thermae*, which comprised 15 major public baths built over 300 years, where Roman citizens met to bathe and exercise, conduct business, and socialize.

See 99. *Donaldson and Nagengast, p. 11.*

[183] Lucius Septimus SEVERUS — 146-211

The giant Baths of Caracalla in Rome were begun by Emperor Severus and built about A.D. 206-216. They occupied nearly 30 acres, could seat some 1600 bathers, and were built over a large warm air heating system (hypocaust). The pool water was heated in 28 hypocaust chambers, supplemented by brass furnace heat exchangers (milarium), each surrounded by a leaden vessel filled with water circulating from the pools. Caracalla took all of the water from one of the 14 aqueducts serving Rome. (The baths are immortalized in the famous Victorian painting, *The Baths of Caracalla,* by Alma-Tadema).

99. *Donaldson and Nagengast, p. 14.*

[184] Ibn AL-AHMAR — reigned from 1237/died 1273

King Ahmar (Muhammad I of the Nasrid dynasty) commenced the building of the Alhambra Palace on a hill overlooking Granada, Spain. It was provided with a running-water system, a hypocaust heating system, and later a public bath-house.

64. *Barrucand and Bednorz, pp. 183-195.*

[185] Leone Battista ALBERTI — 1404-1472

Italian architect and artist. Developed the laws of perspective. His ten-volume treatise, *De Re Aedificatoria* (1485), was the first printed book on architecture. He suggested the chimney-register, a sliding metal plate, to reduce or close a chimney flue.

8. *Wright, p. 90.*

[186] Andrea PALLADIO 1508-1580

Italian architect, responsible for the Palladian style, much copied in England and America. Wrote *Quattro Libri Dell'Architettura* (1570), an architectural design sourcebook. He set rules for the construction of flued fireplaces. "Chimneys are made in the thickness of the wall; and in order that they may convey the smoke into the air, their funnels are raised above the roof. These funnels are not to be made too wide nor too narrow, because if they are made too wide, the air eddying through them will prevent the free ascent and escape of the smoke, and when too narrow, the vapor not having a free passage, will accumulate in the funnel and return to the room."

11. *Bernan, Vol. 1, pp. 131-132.*

[187] Sir Christopher WREN 1623-1723

English architect and scientist. Teacher of mathematics and professor of astronomy. His best known work is the redesign of St. Paul's Cathedral after the Great Fire of London. He was also involved with improving the chamber of the House of Commons (1692),and later (1701) with improving the ventilation. Wren provided exhaust air openings in the ceiling but it was not a great success; subsequently the challenge of ventilating the chamber was taken up by Desaguliers [52].

70. *Cooke, pp. 44-46.*

[188] Thomas JEFFERSON 1743-1826

Third President of the USA (1801-1809) with a strong interest in art and architecture. He designed and supervised the construction of his country house "Monticello," built on a remote hilltop in Virginia. The house expanded over the years, influenced by the designs of Palladio [186], an innovative feature being the portholes provided in his bedroom for natural ventilation. Jefferson also initiated the plans for the University of Virginia at Charlottesville (1816) when he was 73, taking a particular interest in the heating of the ten pavilions lining the central lawn. He had traditional wood-burning fireplaces installed on the ground floors but used the more efficient Pennsylvanian stoves of Franklin [8] on the upper floors.

97. *Peterson, Chap. 17 by Nichols.*

[189] Sir John SOANE 1753-1837

English architect who embraced traditional heating by fireplaces and stoves but took advantage of the developing central systems using steam, hot water, and hot air. Responsible for the rebuilding of the Bank of England, London, where he used a variety of heating stoves and designed an underfloor hot air system (modeled on the Roman hypocaust), which was not executed. He initiated the installation of hot water heating by A.M. Perkins [224] in the Court Room (1833). In his own office and museum, at Lincoln's Inn Fields, Soane experimented with a variety of heating systems over a 45-year period. He tried fireplaces, stoves, steam apparatus, two types of hot water system, and various hot air systems with varying degrees of success. Many of the details were recorded by his assistant, C.J. Richardson [35]. At Dulwich picture gallery, Soane employed a steam system by Matthew Boulton and James Watt, sons and namesakes of their illustrious fathers [12 and 13], but it was not a success.

7. *Willmert.*

[190] John Claudius LOUDON 1783-1843

Scottish landscape gardener, architect, and builder of glasshouses. Prolific author on horticultural topics. Foresaw the use of central steam heating in glasshouses, for country estates, baths, laundries, and the like. Loudon tested flue and insulation systems for his garden hothouses: *A Short Treatise on Improvements recently made in Hot-Houses*, 1805. He experimented with artificial climates for plants with controlled heating, ventilation, and humidification, including the use of weight-driven and clockwork fans: *Remarks on the Construction of Hot-Houses*, 1817.

68. *Hix, Chap. III.*

[191] Sir Charles BARRY 1795-1860

English architect. Designed the new Houses of Parliament, from 1839, assisted by A.W.N. Pugin. Barry was in continual conflict with Dr. Reid [58] over the means of ventilation, and they each obstructed the work of the other. To break the stalemate, Reid was left to design the ventilation for the House of Commons, while Barry was given charge of that in the Lords. He employed a skilled engineer, Alfred Meeson, who appears to have carried out most of the work.

69. *Jones, Chap. 8.* 70. *Cooke, pp. 107-126.*

[192] Sir Joseph PAXTON 1803-1865

English gardener and architect. Built the Great Conservatory at Chatsworth in Derbyshire (1836), heated by eight boilers and seven miles of four-inch pipe. Best known for designing the Crystal Palace, erected in London's Hyde Park for the Great Exhibition (1851). As a temporary structure, it was unheated but was provided with innovative controllable ventilation louvres and sun screens. When the Crystal Palace was re-erected and extended onto a permanent site at Sydenham in South London, it was provided with a large central boilerhouse where "no less than 22 boilers were arranged in pairs, each holding 11,000 gallons of water....Four pipes of 9 in. diameter were attached to each boiler, two flow and two return, and each boiler heated a certain transverse section of the Crystal Palace; the length of one flow and return was a mile and three-quarters, and the total length of heating pipes of all kinds was nearly fifty miles." Paxton also designed Mentmore Towers in Buckinghamshire (1859) for Baron Rothschild. It was an early example of central heating and "unusually employed hot water, at a time when heating by warm air seems to have been the favorite."

72. *Chadwick, p. 148.Portrait from the painting by O. Oakley;* Palace of the People, *Graham Reeves, Bromley Library Service, Kent, England, 1986, p. 10.*

[193] Sir George Gilbert SCOTT 1811-1878

English architect. Worked in the Gothic style: Albert Memorial (1864), St. Pancras Hotel (1865), both in London. Also, the University of Glasgow (1870), where the extensive ventilation and warming systems were designed by Phipson [203] to a brief established by a learned Committee, which included Rankine [164] and Kelvin [168]: "No. 9. The fresh air should be drawn in where the air is pure. No. 10. The fresh air should be forced in by one or any required number of suitable machines." The scheme used a central plenum chamber with a massive network of subterranean passages and heating chambers and upcast air extraction shafts. It was not a success because it did not satisfy Rule No. 5, where the committee had requested individual temperature control by hot and cold supply air mixing for each room.

82. *Barber, pp. 49-50 and 54-56.*

[194] Harvey Lonsdale ELMES 1814-1847

English architect. Best known work is St. George's Hall in Liverpool (1851), with an interior inspired by the Roman Baths of Caracalla [see 183]; has been described as "perhaps the finest Neoclassical building in England." Dr. Reid [58] was engaged to design a heating and ventilating system on the recommendation of Dr. W.H. Duncan [170]. Air was taken into the building through two shafts and warmed by five batteries of hot water pipes served from four boilers. Circulation was aided by steam-engine driven fans. Cold water sprays cooled and cleaned the incoming air. Elmes died of consumption in Jamaica at an early age, and his great work was completed by Prof. C.R. Cockerell.

St. George's Hall, Liverpool, *Loraine Knowles, National Galleries and Museums on Merseyside, 1988, pp. 8-11.* 99. *Donaldson and Nagengast, pp. 70-73.*

[195] George Edmund STREET 1824-1881

Notable church architect. Won the competition for the Royal Courts of Justice in the Strand, London (completed 1882), where the Great Hall has been called, "One of the grandest secular rooms of the Gothic Revival." According to George Haden [223], whose firm carried out the ventilation installation, "The Law Courts in London were fitted with Air Washing Films (achieved by a film of water flowing down a screen, being produced by a jet impinging on a small disc). The fans were driven by Steam Engines; one of the Lancashire Boilers under the main Hall being a Steam Boiler. In this case the water was cooled by refrigerating Apparatus. The Refrigerator was supplied by Halls of Dartford (Kent). Had a capacity of two tons of ice per hour."

85. *Haden documents, Wiltshire Record Office, England, WRO 1325/216.*

[196] Sir Edmund Frederick DU CANE 1830-1903

Major-General in the Royal Engineers. He was an assistant superintendent at the Great Exhibition, London (1851). After a period of supervising convict labor in Australia, he was appointed (1869) Chairman of the Board of Directors of Convict Prisons, Surveyor-General of Prisons, and Inspector-General of Military Prisons. He was responsible for the provision of extra prisons and his greatest work was Wormwood Scrubs in London. "Du Cane's scheme is remarkable for its clean, logical plans, and for the heating and ventilating system which served each cell. Staircases, vents and sanitary stacks were expressed in the building...(his) model plan for Wormwood Scrubs influenced the design of prisons for many generations afterwards."

73. *Curl, pp. 235-237. See also Major Jebb [204] who was earlier responsible for Pentonville Prison, London.*

[197] Alfred WATERHOUSE 1830-1905

Leading English architect. Works include Manchester Town Hall (1877) and Manchester Assize Courts. Haden [223] recorded, "I believe the first Installation for Air Washing was put in at the Manchester Assize Courts in 1863.... The Courts were opened in the Summer, and at the first sitting the Judge complained of the heat as the weather was very hot and asked that the windows, all of which were closed, should be opened. Frederick Blake our Manager sent a note to him to say that if the windows were opened the temperature would probably rise, but the Judge asked for the windows to be opened, which was done, and the temperature went up in a very short time five degrees." Waterhouse's most famous work is London's Natural History Museum (1881), where the order for the warming and ventilation was secured by Phipson [203] in competition with Haden. Phipson's successful proposal included a surprisingly tight performance schedule, guaranteed to supply three air changes per hour, as well as balancing the humidity. In his tender analysis (1873), Waterhouse wrote that Haden did not give an estimated air change and that "they now inform me that in consequence of the Great Rise that has taken place in the cost of labour and material since they delivered their Tender, twelve months ago, they could not undertake the work except at an advance upon their tender of from 15 to 20 per cent." The ventilation scheme employed large masonry ducts under the basements, conveying cold (unheated) fresh air and warm air in a dual-duct arrangement, which could be mixed locally. (From his earlier experiences with Scott [193], Phipson had apparently learned the value of Rule No. 5). Waterhouse was also Company Architect for the Prudential Assurance Company and designed their new head office in High Holborn (1878-1906), where his association with Phipson continued. In 1886, Phipson was involved in specifying Marshal steam-driven dynamos for the electrical services with exhaust steam utilized for space heating—an early and significant example of combined heat and power. The installation was carried out by Drake and Gorham [236 and 237].

55. *Cook.* 65. *Hinchcliffe.*

[198] Dankmar ADLER 1844-1900

Engineer. Partner of Sullivan [199] in Chicago and between them successfully designed many theatres, most notable being that in the Auditorium Building, Chicago (1889). The Auditorium Theatre has been described as "a happy marriage of science and art" and with a capacity of 4237, was among the largest ever erected. Adler's engineering talents included a thorough knowledge of acoustics. The rake of the stalls and the rise of the balconies were designed on a principle called the "isocoustic curve," while "the shape of the ceiling was determined almost entirely by acoustic considerations.... Adler's calculations involved absorption, reflection, and reverberation...the result was miraculously successful. The arches, also, besides carrying Sullivan's decorative lights, are used for the ventilation equipment, the air ducts being disguised as ornaments."

66. *Tidworth, pp. 177-180.*

[199] Louis Henri SULLIVAN 1856-1924

American architect. Pioneer in the design of metal-framed buildings and early skyscrapers of the Chicago School. Worked for a number of years with Adler [198]. Coined the dictum "Form Follows Function." Designed the Wainwright Building, St. Louis (1891), and the Guarantee Building, Buffalo (1895). He trained Frank Lloyd Wright [201] and has been termed the "Prophet of Modern Architecture."

62. *Frazier.*

[200] Charles Rennie MACKINTOSH 1868-1928

Scottish architect. Leader of the Art Nouveau movement in Great Britain. His leading work is considered to be the Glasgow School of Art, built in phases (1898-1909). He showed a willingness to utilize the new technologies of his time, including central heating and mechanical ventilation, and to integrate these in a decorative manner into his overall design. The building incorporates an air treatment plant (possibly a very early air-conditioning system) designed by William Key [98].

105. *Roberts, pp. 116-117.*

[201] Frank Lloyd WRIGHT 1869-1928

Generally considered America's greatest architect and ranked alongside Walter Gropius, Mies van der Rohe, and Le Corbusier [202] as one of the leading architects of the 20th century. Employed in his early years by Louis Sullivan [199]. Achieved renown for his domestic architecture, particularly in the Oak Park suburb of Chicago and later for his Prairie Houses. Designed many notable commercial and public buildings, including the Larkin Building, Buffalo (1904), the great Imperial Hotel in Tokyo (1922), the revolutionary Johnson Wax administration building in Racine, Wisconsin (1939), and New York's Guggenheim Museum (1959). For the Larkin offices (a mail-order business), the industrial nature of the site and the proximity of the New York Central Railroad, emitting fumes and noise, led Wright to design a large sealed inward-looking box, dependent on mechanical ventilation and overhead daylighting. He wrote, "The machinery of the various appurtenance systems, pipe shafts incidental thereto, the heating and ventilating intakes...are quartered in plan and placed outside the main building at the four outer corners...(with) the building practically sealed to dirt, odor, and noise." Later (1909), the Kroeschell Bros. Ice-Machine Company of Chicago added a CO_2 refrigerating plant to make the Larkin possibly the world's first air-conditioned office building.

57. *Pfeiffer, pp. 56-61. Portrait from* 119. *p. 689.*

[202] LE CORBUSIER 1887-1965

Charles Edouard Jeanneret. Swiss born, French architect, town planner, and artist. He designed and spoke of houses as "machines for living in." He sought unorthodox solutions to environmental control involving building orientation, structure, daylighting, and passive solar control; many of his buildings are not considered to be entirely successful in this respect. Le Corbusier claimed to have invented the external sunshade (*brise soleil*), and he developed the neutralizing wall (*mur neutralisant*), to offset the effects of outside conditions on the interior of a room. This involved circulating ventilating air, enclosed between twin walls or membranes, where "is blown scorching hot air, if in Moscow, iced air if in Dakar." Le Corbusier's most famous building is the Unité d'Habitation at Marseilles (1952), a massive housing project of 350 flats in eight double-storys, of which Reyner Banham wrote, "His heroic and sculptured air stacks on the roof...must be acknowledged as historically important if only as the first explicit sign for almost twenty years in his work that mechanical services are an expressible form of a building." Later, in his design for the Supreme Court in Chandigarh in the Punjab (1956), he provided an enormous canopy running the full length of the facade, to protect from wind and rain, combined with vertical wall screens providing natural ventilation of the courtrooms.

102. *Banham, Chap. 8.*