Chicago skyline with early skyscrapers in the 1920s.

SKYSCRAPERS
THE FIRST CENTURY
AND THE INTRODUCTION OF AIR CONDITIONING

BRIAN ROBERTS
NEW YORK

Postcard view of Lower Manhattan, looking north from Fulton Street, c.1919.
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New York skyline with early skyscrapers in the 1920s.

_A wealth of information and illustrations on skyscrapers and air conditioning over the century from 1885 is available on the Heritage Group website and in the References and Further Reading listed on page 44._

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Buildings with names in bold have been visited by me.

BMR, Budleigh Salterton, 2021.
Before the first skyscrapers, the tallest buildings were the Cathedrals, with Lincoln the world’s tallest (1311-1548) at 525 feet until it collapsed in a storm, leaving two smaller spires, as shown in this 17th century print, now removed.
ST BOTOLPHS, BOSTON, LINCOLNSHIRE

1520: 272 ft, Highest tower (exclusive of spire) of any English Parish Church. Popularly known as the 'Boston Stump'.
SALISBURY CATHEDRAL, WILTSHIRE

ULM CATHEDRAL, GERMANY

1890: 520 ft, The tallest church building in the world,
The Basilica de la Sagrada Familia in Barcelona, commenced in 1882 is scheduled when finished to reach a height of 566 ft.
ENGINEERING USA STYLE

Brian Roberts' personal view of American services engineering.

This article looks at American building services engineering, particularly air conditioning, as seen through the eyes of the author in more than a dozen trips to the USA over the past ten years. The impressions, opinions and conclusions (and any factual errors) are his alone. They are based on visits to many buildings and installations. They also reflect tours of exhibitions and factories, participation in ASHRAE Committees, and discussions with owners, consultants, contractors, manufacturers and maintenance engineers — ranging from the Eastern Seaboard to the deep South, Texas and the West Coast.

It is perhaps first appropriate to briefly recap on some of the contributions made to building services by the USA. The work of Edison in lighting and later electrical generation and distribution, the invention by Otis of the lift, and the developments due largely to Willis Carrier, air conditioning, psychrometrics, the centrifugal refrigerating machine and the induction system, are generally well known.
HOME INSURANCE BUILDING, CHICAGO

1885: 180 ft, 12 floors. Regarded as the First Skyscraper. Demolished 1931.
WAINWRIGHT BUILDING, ST LOUIS

FLATIRON BUILDING, NEW YORK

1909: 700 ft, 50 floors. Architect: Napoleon Le Brun & Sons. Not air conditioned. By the late 1920s, the clock tower and its annexes were too small. The Company approved the design for a 100-storey tower, but the Great Depression in 1929 led to only the 28-story base being built. Said to have been fully air conditioned, but no confirmation or details of refrigeration (?) discovered.
SINGER TOWER, NEW YORK

WOOLWORTH BUILDING, NEW YORK

Mechanical ventilation with plant rooms up to 46th floor. Some specialist rooms at lower levels served by Kinealy air washer cooling systems. Tallest building in the world 1909-1913.
When built the tallest building in Chicago. Once offices, now partly student accommodation.
WRIGLEY BUILDING, CHICAGO

1924: 438 ft (spire), 30 floors (North Tower), 21 floors (South Tower).
Architect: Graham, Anderson, Probst & White. Air conditioning in a few areas,
View north on South LaSalle Street, early 1920s (from Willis).
Right: Illinois Merchants Bank, Rookery Building.
NEW YORK SKYSCRAPERS

View north on Broadway, c.1915 (from Willis)- narrow facades and tall towers.
Left to right: Trinity, U.S. Realty, Singer, City Investing and Woolworth Buildings.
Regarded as first air conditioned office block in the USA, installation by Carrier.
Refrigeration 300 TR with overnight chilled water storage, condenser cooling water
from adjacent river. (ASME Book No. HH9106).
PSFS BUILDING, PHILADELPHIA

EMPIRE STATE BUILDING, NEW YORK

Air conditioning progressively added from 1950s.
Completed in 1940, 850 ft, 70 floors. Architect: Raymond Hood.
Not originally air conditioned except for a number of radio broadcasting studios
Radio City Music Hall movie theatre (6000 seats) air conditioned 1933 (600 TR, 240,000 cfm).
UNITED NATIONS, NEW YORK

Air conditioned by perimeter induction units and interior high velocity all-air systems.
HVAC Consultant: Jaros, Baum & Bolles.
GATEWAY CENTRE, PITTSBURGH

ALCOA BUILDING, PITTSBURGH

External wall cladding is thin lightweight aluminium.
Offices provided with radiant ceiling panel heating and cooling systems.
SEAGRAM BUILDING, NEW YORK

MARINA CITY, CHICAGO

LAKE POINT, CHICAGO

1968: 645 ft, 70 floors. Architect: Schipporeit-Heinrich Associates. When completed it was then the tallest Apartment Block in the world. "Air conditioning provided by wall units".
JOHN HANCOCK BUILDING, CHICAGO

WORLD TRADE CENTRE, NEW YORK

1972-73: 1368 ft, 110 floors. Architect: Minoru Yamasaki and Emery Roth & Sons. Both towers destroyed in the terrorist attack of 2001 (referred to as 9/11). Tallest building in the world 1972-1974. Fully heated and air conditioned with 2-pipe under-window induction units and an all-air constant volume system throughout, having seven York 1000 TR chillers (49,000 TR total) and a condenser system employing water from the nearby River Hudson.
WORLD TRADE CENTRE, NEW YORK (1973)

The World Trade Centre is a six-building complex totalling nearly 1 000 000 m² of floor area, next to the Hudson River. The twin towers, each of 110 storeys and 412 m high (475 m if you count the TV masts), contain some 43 600 windows employing around 60 000 m² of glass. Below ground are six levels that house the Port Authority Trans Hudson rail rapid transit system, parking space for 2000 cars, and the central air conditioning and refrigeration plant. The working population of the Centre is some 50 000; business and other visitors can amount to a further 80 000 daily.

Each tower has mechanical equipment rooms on floors 7, 41, 75 and 108. There are over 100 000 supply and return air grilles and diffusers, 1000 fans circulating over 5000 m³/s of air, 250 steam humidifiers, 300 pumps, 100 heat exchangers, 30 000 underneath-the-window induction units and a central refrigerating plant with over 170 000 kW of cooling capacity.

There are seven centrifugal chillers, each of 24 400 kW cooling capacity, driven by 13·8 kW water-cooled synchronous motors rated at 5200 kW. Each machine uses 10 000 kg of R22. The evaporators take the full static head of the tower’s chilled water systems. Water for condenser cooling is taken at the rate of 5600 litre/s from the Hudson River. The chilled water pumps include “low pressure” zone pumps of 930 kW, delivering 630 litre/s at a head of 107 m and a working pressure of 3·2 MPa, while the “high pressure” pumps are 450 kW and handle 300 litre/s with a head of 100 m; however, in the latter case the working pressure is 5·6 MPa.
SEARS TOWER, CHICAGO

Originally had induction unit air conditioning now replaced with fan-coil units.
The refrigeration capacity was 17,000 TR with four 300 TR cooling towers.
Automatic control system has been upgraded.
UNITED CALIFORNIA BANK, LOS ANGELES (1974)

What was claimed at the time to be a "unique all air system" which conserved energy provides the air conditioning for the bank and office building for United California Bank. This 62 storey 261m high block has a floor area of 116 000 m² in the USA's tallest building west of Chicago. The 56 x 38 m tower has a steel frame with bronze curtain walling of solar control glass.

The hvac system, which at 1971 prices cost $38/m² of floor area, consists of an all electric and all air system, dual duct for exterior zones, vav for the centre of the building. There are fan room at floors 4, 5, 22, 42 and 61. The supply air volume is 8.3 m³/s per floor, each floor being 1670 m². Refrigeration plant consists of four 3.2 MW centrifugal chillers. These are located on the roof and mounted on an airbag system maintained at 560 kPa through a pneumatic system and air compressor.

The electricity supply enters at 34.5 kV and is transformed in the basement to 12.7 kV for distribution to floors 22, 42 and 61. 3 MVA lighting and 1 MVA power transformers at these levels feed 480/270 V and 208/120 V systems.

The fire protection system begins with a 375 000 litre basement reservoir. There are two 224 kW fire pumps, each 47 litre/s capacity at 370 m head.

The maintenance staff is 12. The Delta 2000 building automation system alone costs $30 000 per year for its maintenance contract, and one complete change of the filter bags costs $12 000 for the bags and the same again for labour (1977 prices).

Architects were Charles Luckman Associates, services consultants Syska & Hennessy.
PENZOIL PLACE, HOUSTON, TEXAS (1975)

Penzoil Place is a 36 storey office block, 120 m high. The floor area is 167 000 m² in twin towers which have curtain walls with solar glass. The towers are linked by an atrium lobby. Parking for 600 cars is provided on three levels.

The air conditioning is a dual duct type with two air plants per floor. The atrium is served by 16 air handlers. The central fresh air plant is on the roof. The main pipes runs are four 250 mm diameters pipes for chilled water and four 150 mm pipes for heating hot water. Refrigeration is supplied by four 5600 kW chillers linked to a single five-cell roof top cooling tower of 25 MW heat rejection capacity. The fans of the cooling towers have 5 m diameter blades.

The boiler plant consists of two 5 MW mthw boilers, with nitrogen pressurisation, generating hot water at 120°C primary, with heat exchangers having 82°C secondary. The two boiler flues are 800 mm diameter, discharging through a 10 m high stack at the pavement edge.

The electrical system has two 4 kW aluminium bus-duct risers in each tower. There are 23 000 lamps in each tower and the total power in 12.5 MVA. In 1977 electricity bills were $110 000 per month. Also in 1977, the bill for water treatment for the cooling tower was $25 000 per year. There is a maintenance staff of five.

Fire protection includes sprinklers in the lobby and at lower levels, fire detectors in the towers, and pressurised staircase ventilation for smoke control. The architects were Philip Johnson and John Burgee, services consultant I A Manan & Associates.
JOHN HANCOCK, BOSTON

PEACHTREE PLAZA, ATLANTA

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The Skyscraper Museum is an architecture museum located in Battery Park City, Manhattan,
New York City and founded in 1996. The museum focuses on high-rise buildings as "products of
technology, objects of design, sites of construction, investments in real estate, and places of work
and residence." The Skyscraper Museum also celebrates the architectural heritage of New York
and the forces and people who created New York's skyline. The Skyscraper Museum was
founded and is directed by Carol Willis, a professor of architectural history and author of "Form
Follows Finance" in 1995.