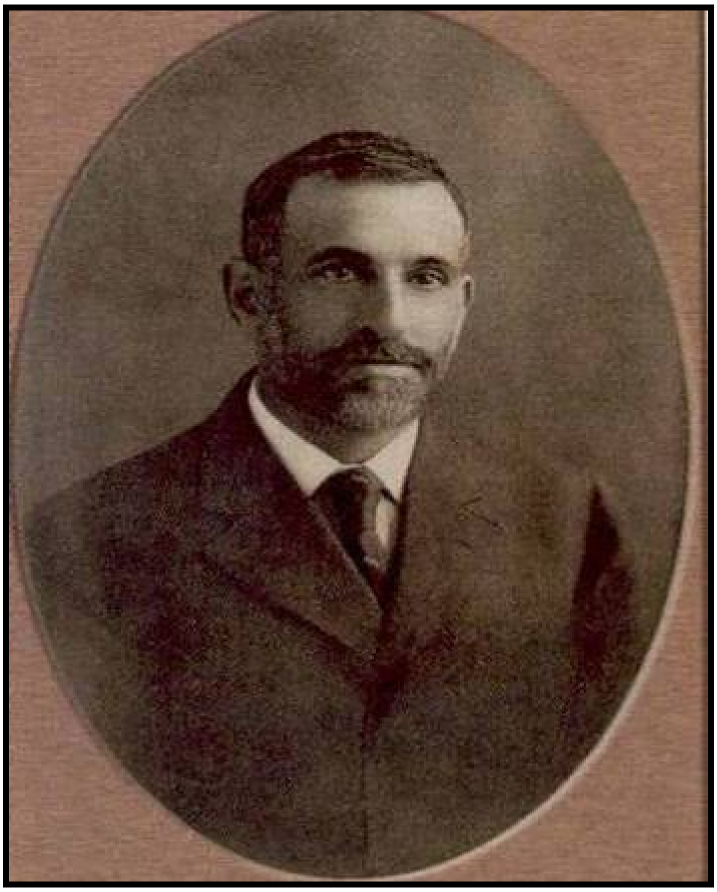
# ALFRED WOLFF
# AIR CONDITIONING PIONEER

**by Brian Roberts, CIBSE Heritage Group**



*Alfred R Wolff 1859-1909*

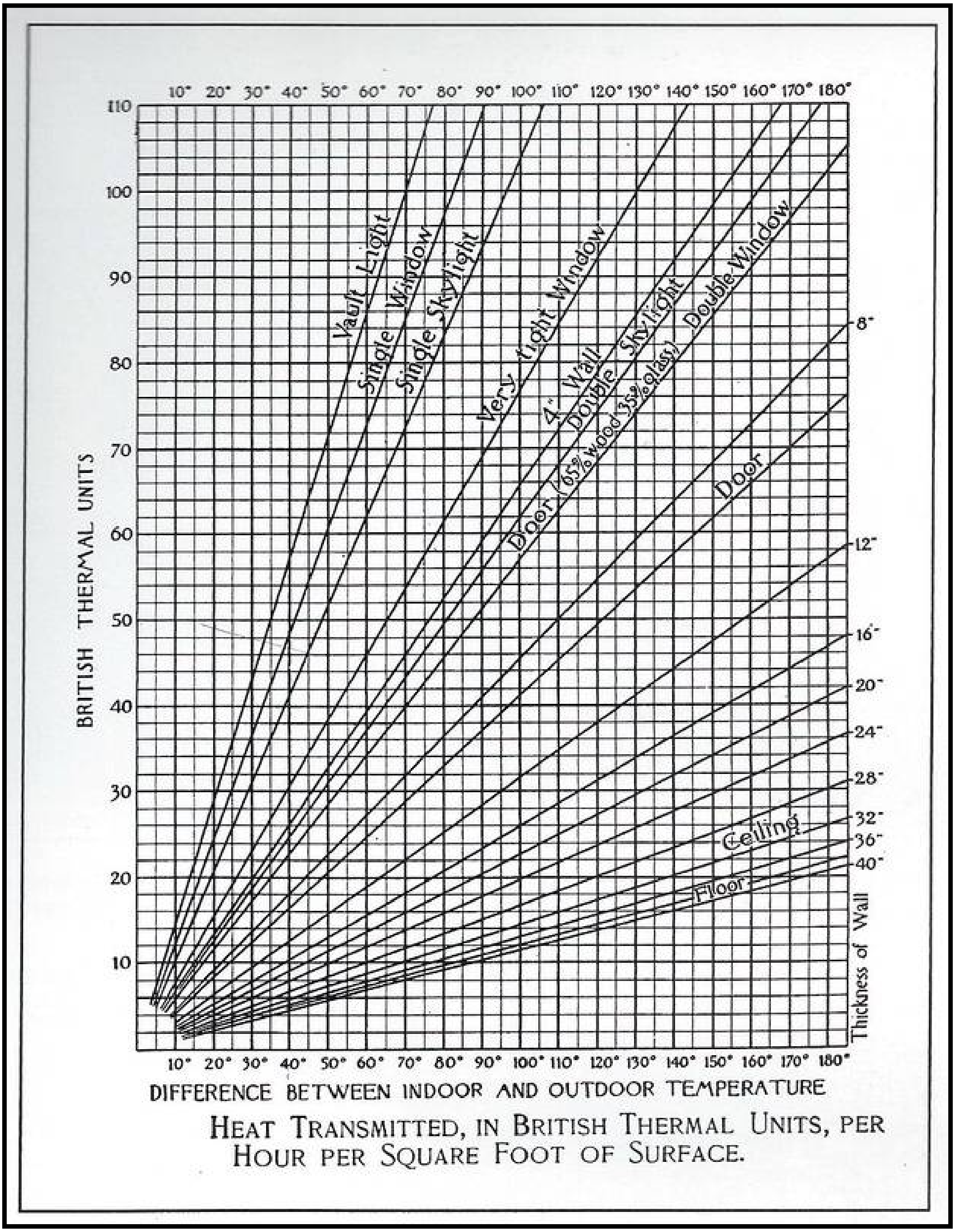
**ALFRED WOLFF**

Wolff was born on 16 March 1859 in Hoboken, New Jersey. At age 13 he entered the Stevens Institute of Technology receiving his Degree in Mechanical Engineering at the age of 17. He then became an apprentice (without pay) at the New York office of Charles Emery, a renowned consulting steam engineer. Later, he formed a consulting engineering partnership with W Weightman. Several years later, Wolff set up his own practice and gave increasing attention to the heating and ventilating of large buildings.

Wolff was considered an eccentric. He refused to get involved with any organisation that advocated secrecy. He refused to join the American Society of Heating and Ventilating Engineers because salesmen were permitted to join. It is said he always impressed upon potential clients that the costs of system operation and maintenance should receive greater consideration than first costs and frequently politely and firmly declined desirable commissions when his view was not accepted

Wolff refused to write letters (except in extreme cases), refused to issue work progress reports and avoided using the telephone, leaving such matters to others. He followed a strict moral code and practised business ethics which forbade bribes or kickbacks.

Wolff developed heat loss calculations from German methods using what is now termed *U-values*. He also recognised that internal heat gains, from people and gas or electric lighting contributed to cooling loads and he pioneered the use of air filters.




*Alfred Wolff's Design Chart for Determining Heat Transfer Rates for Various Building Materials*

Wolff believed in using the latest available design information. Electricity was coming into widespread use in the 1890's but it was often more economical to produce on site using steam-engine-driven generators with the large quantity of exhaust steam available to heat the building (co-generation). He also supported the change from steam-driven fans to DC electric drive and was a believer in the use of thermostatic controls favouring the Johnson pneumatic system.

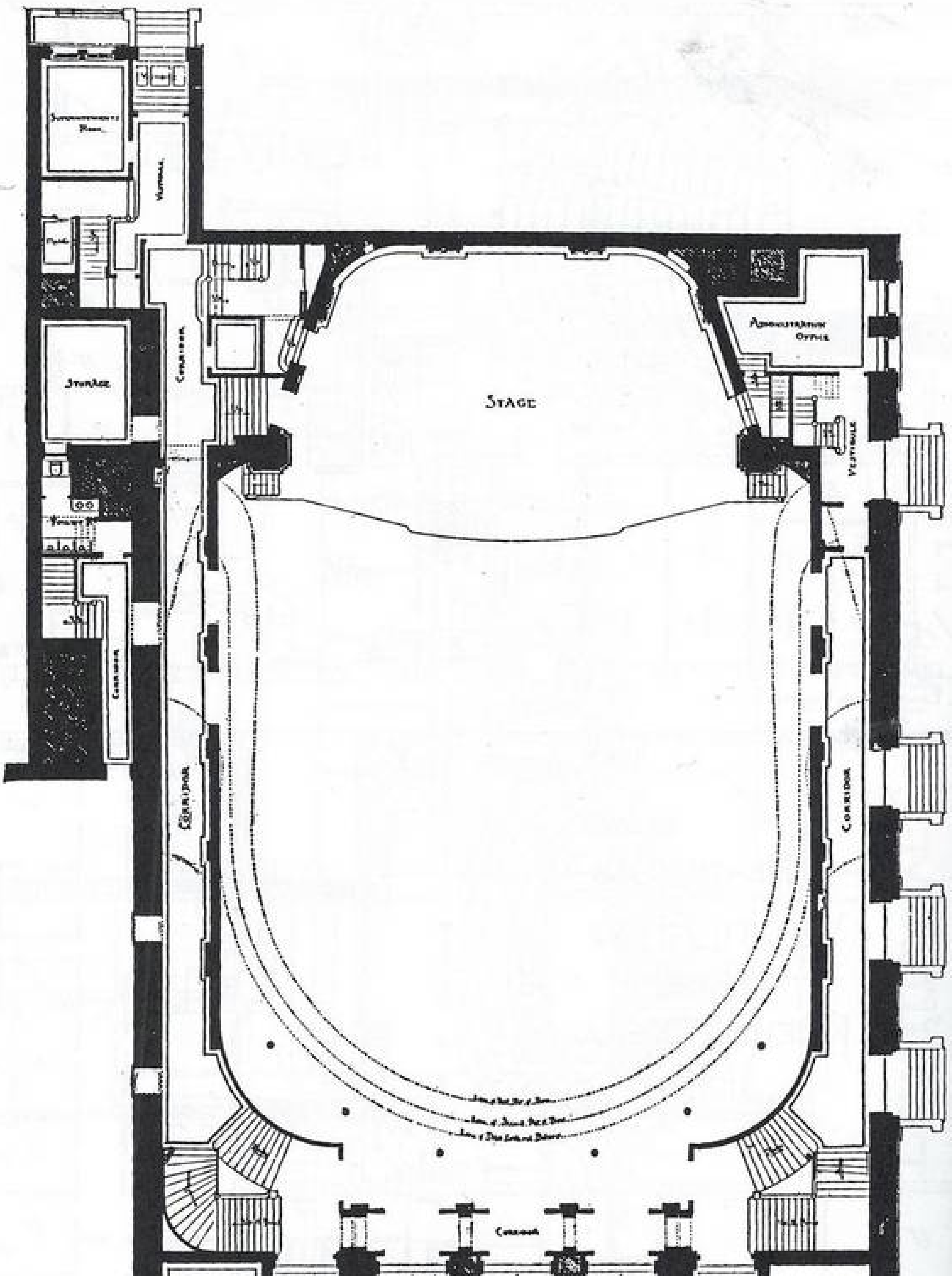
He employed cooling methods on his projects of this time including Carnegie Music Hall in 1889 (ice block cooling) and Cornell Medical College in 1902 (refrigeration by the Carbondale Company).

**CARNEGIE MUSIC HALL, NEW YORK**

*Carnegie Hall in 1899*

Carnegie Hall (known as the New York Music Hall until 1894) was founded by Andrew Carnegie and opened officially on 1st May 1891. The main concert hall was provided with a seating capacity of 3000, the recital hall beneath this seated 1200. The architect was William B Tuthill. His design was widely praised for "its acoustical excellence").

In 1986 the Hall underwent a major renovation and restoration.




THE NEW YORK MUSIC HALL.

**Figure 45b(10).** Carnegie Hall (1891).

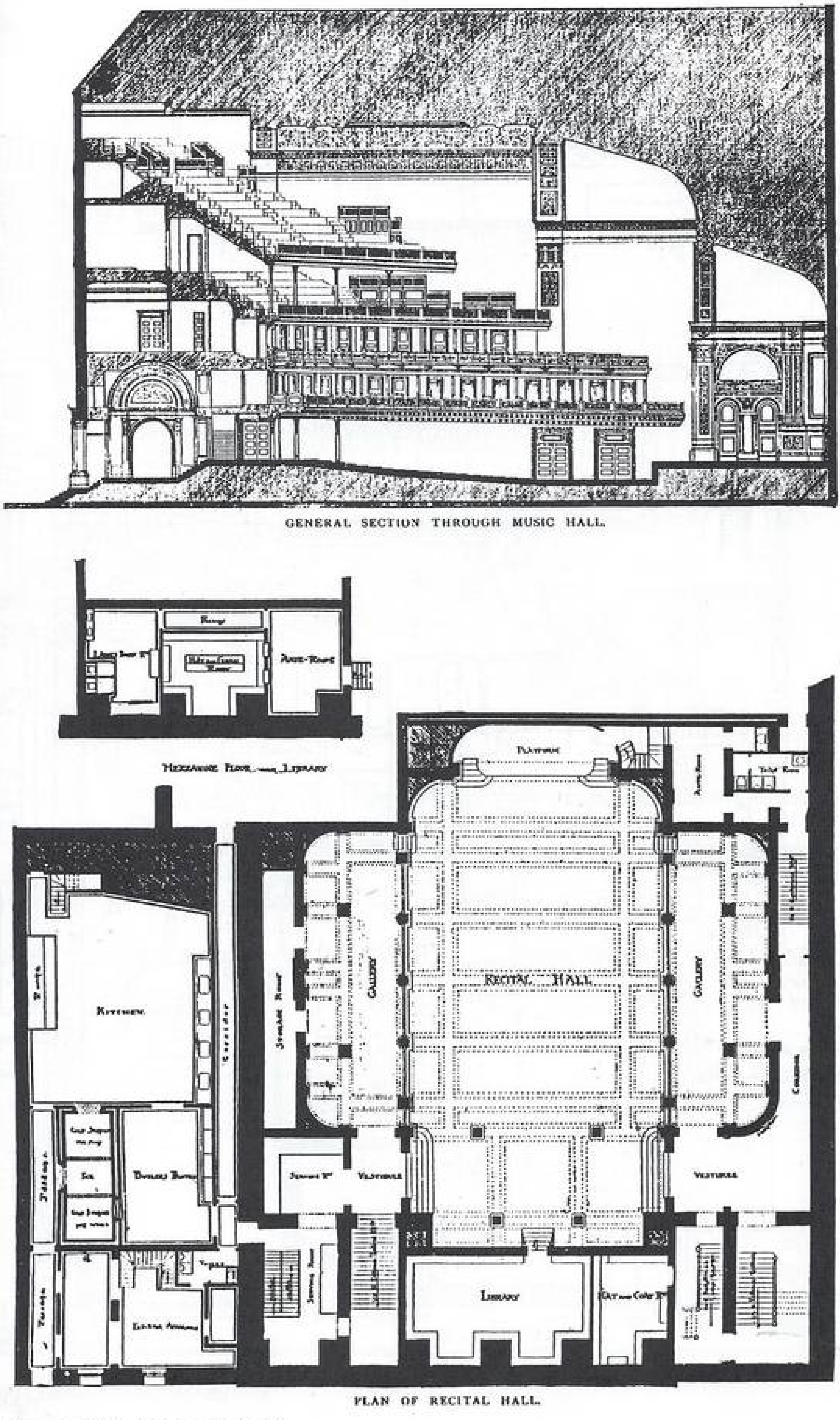



**Figure 45b(11).** Carnegie Hall (1891).

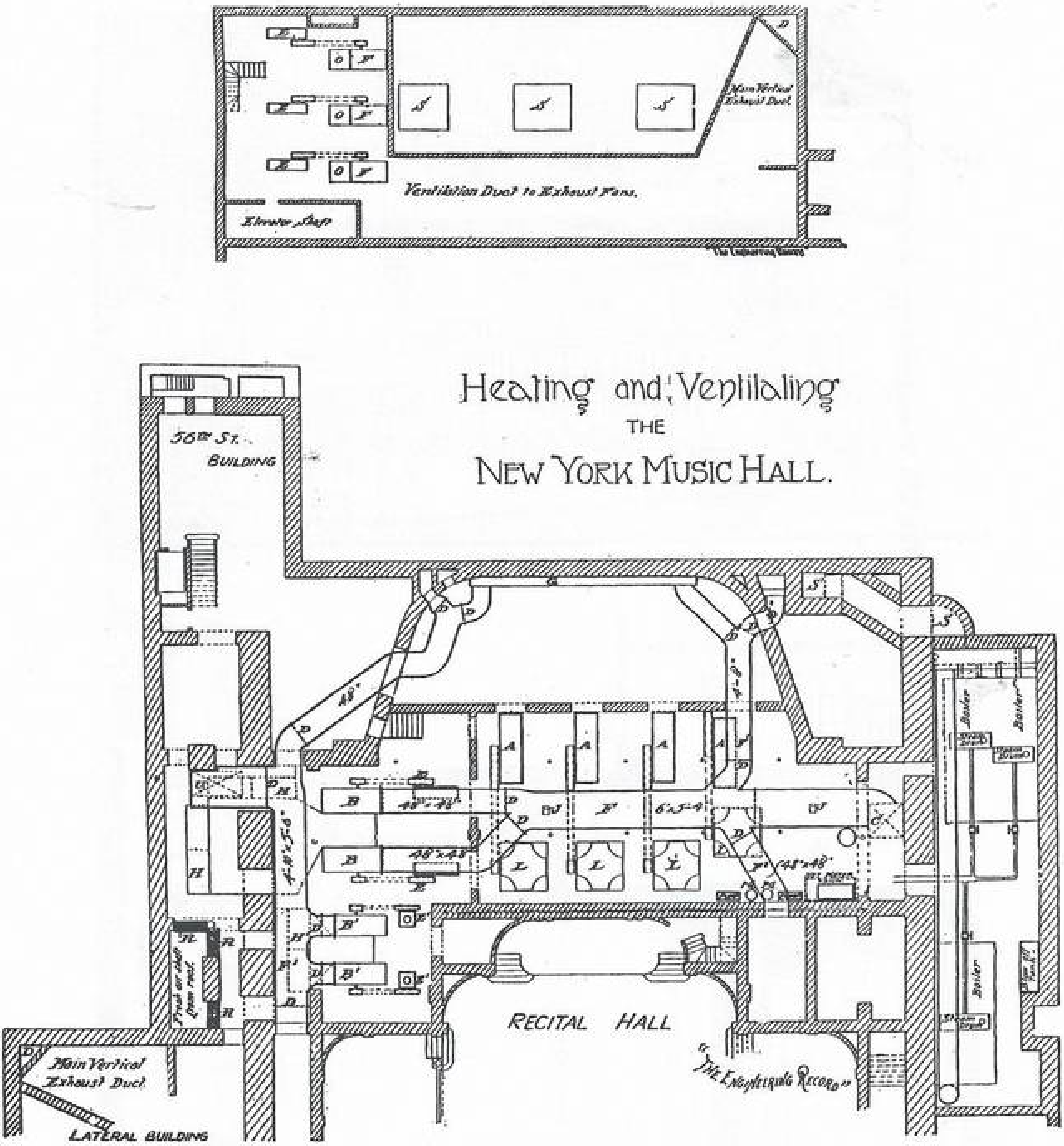
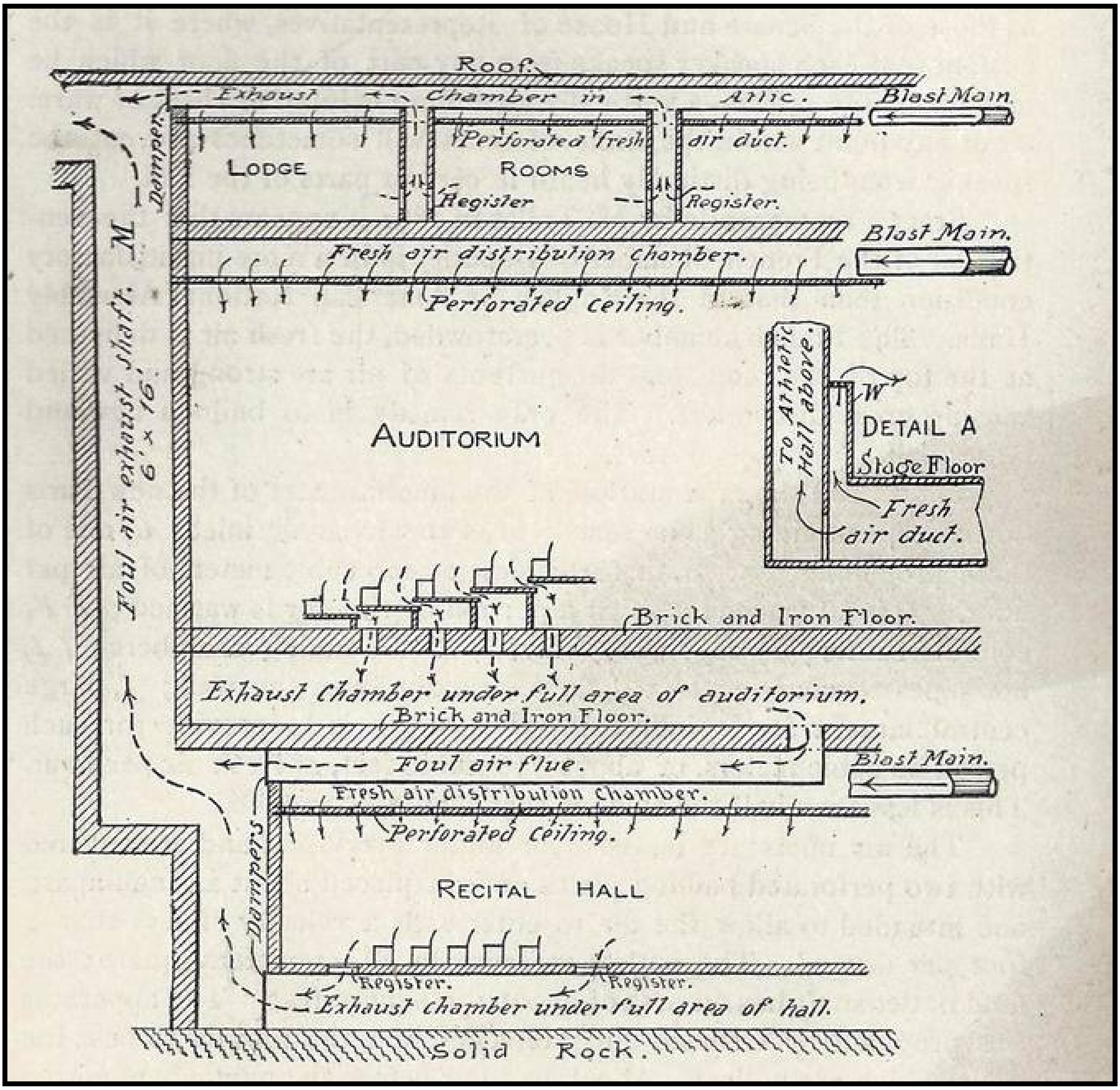


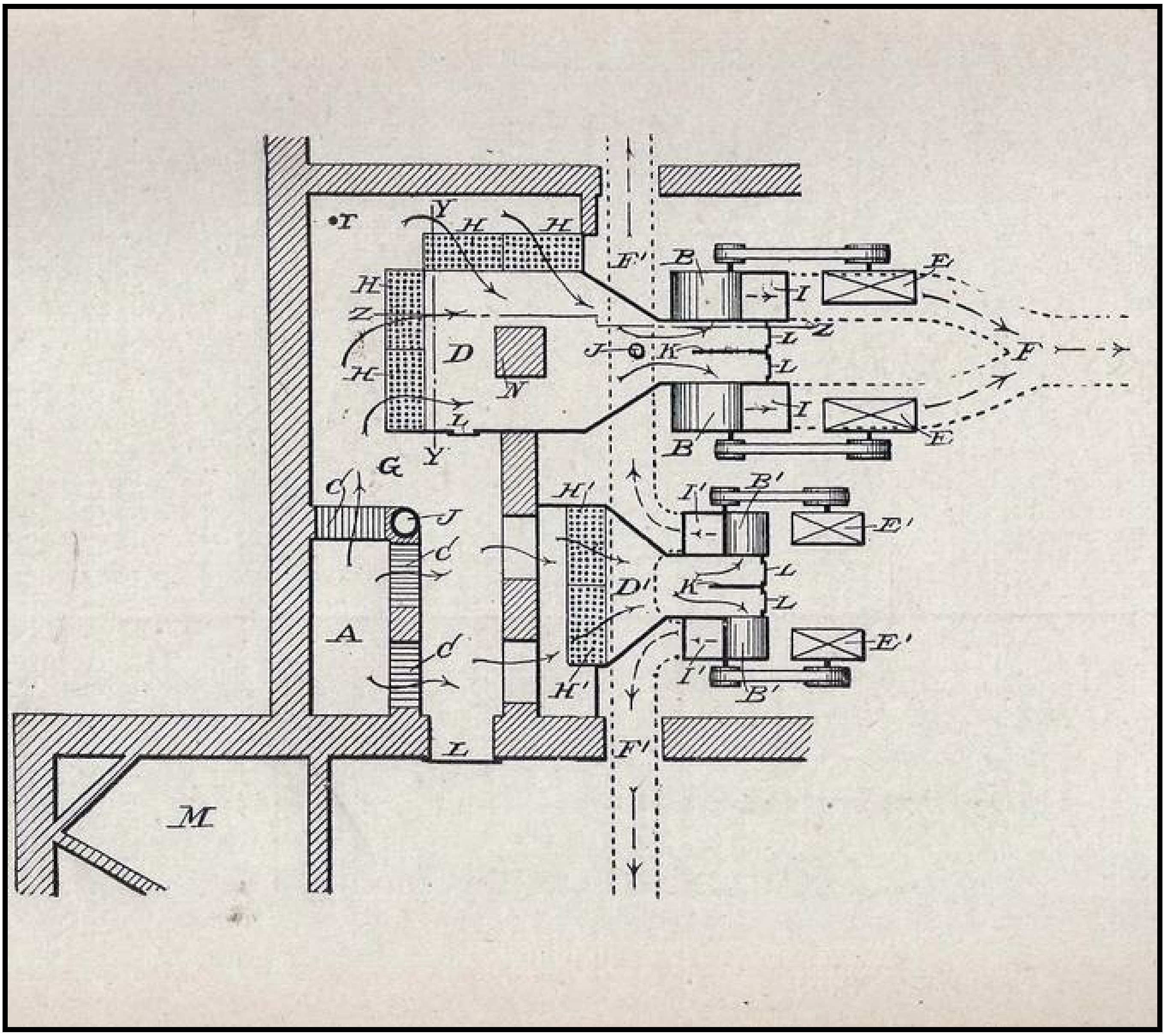

**Figure 45b(12).** Carnegie Hall (1891).

*The ice-block cooling and ventilating system*




*Carnegie Hall Air Distribution System*

“The fresh warmed air enters the music hall through numerous perforations in or near the ceiling, being forced by two 7-foot Sturtevant blowers which draw it through heaters of 1.25-inch pipe containing 6600 square feet of heating surface.”




*Carnegie Hall "Heating, cooling and blowing plant"*

A is the fresh air shaft from the roof (6 x 12 feet supplying distributing chamber G)

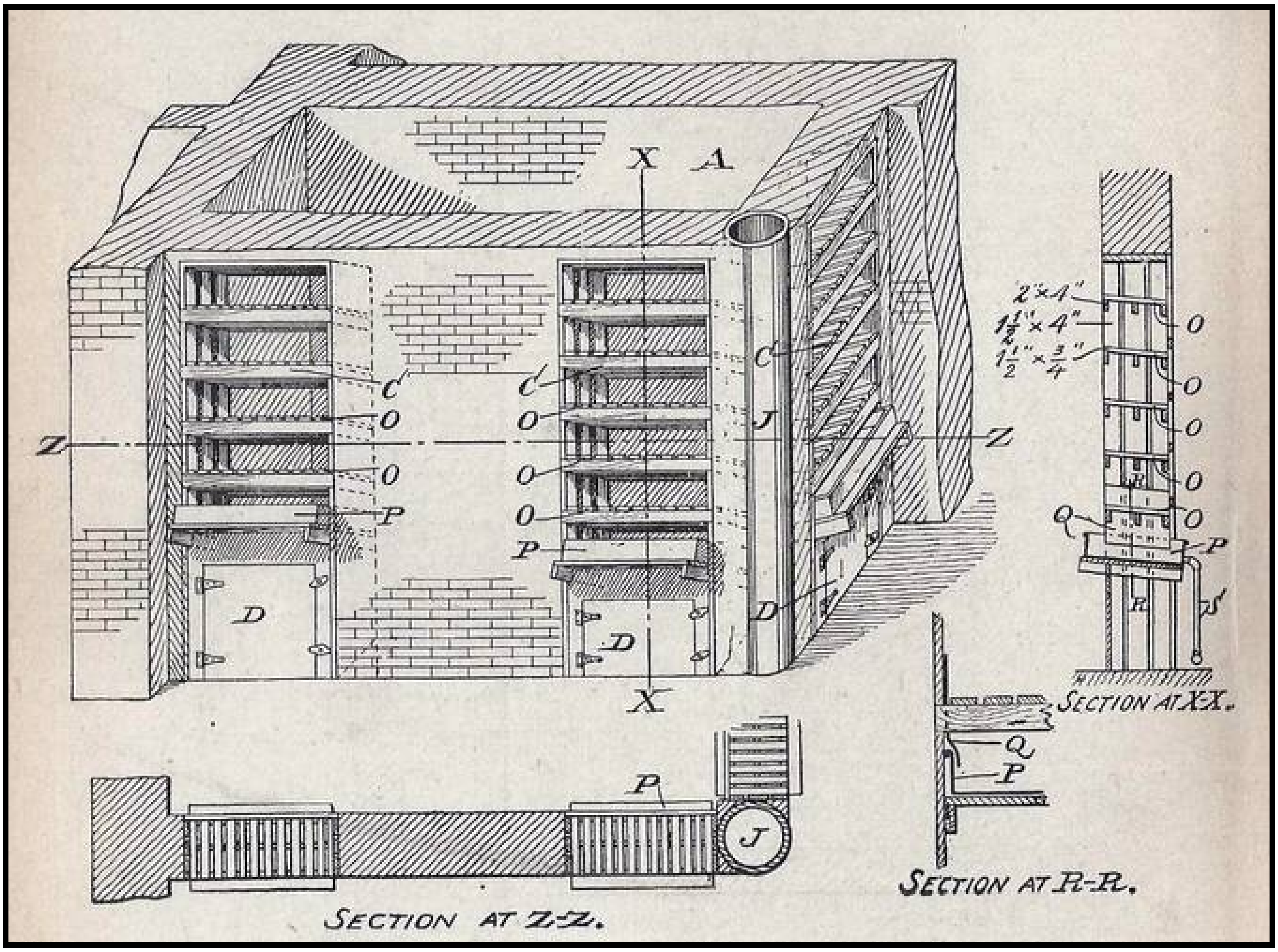
B is a fan which draws air into the chambers D through the steam radiators H

C is an ice rack for use in warm weather

E is an engine driving a fan

F is the main air duct (area 30 square feet)

P is an iron drip pan, S is a waste pipe: D is a door




*Carnegie Hall air inlet chamber detailing the racks for holding ice-blocks for cooling*

C & O form the ice-racks

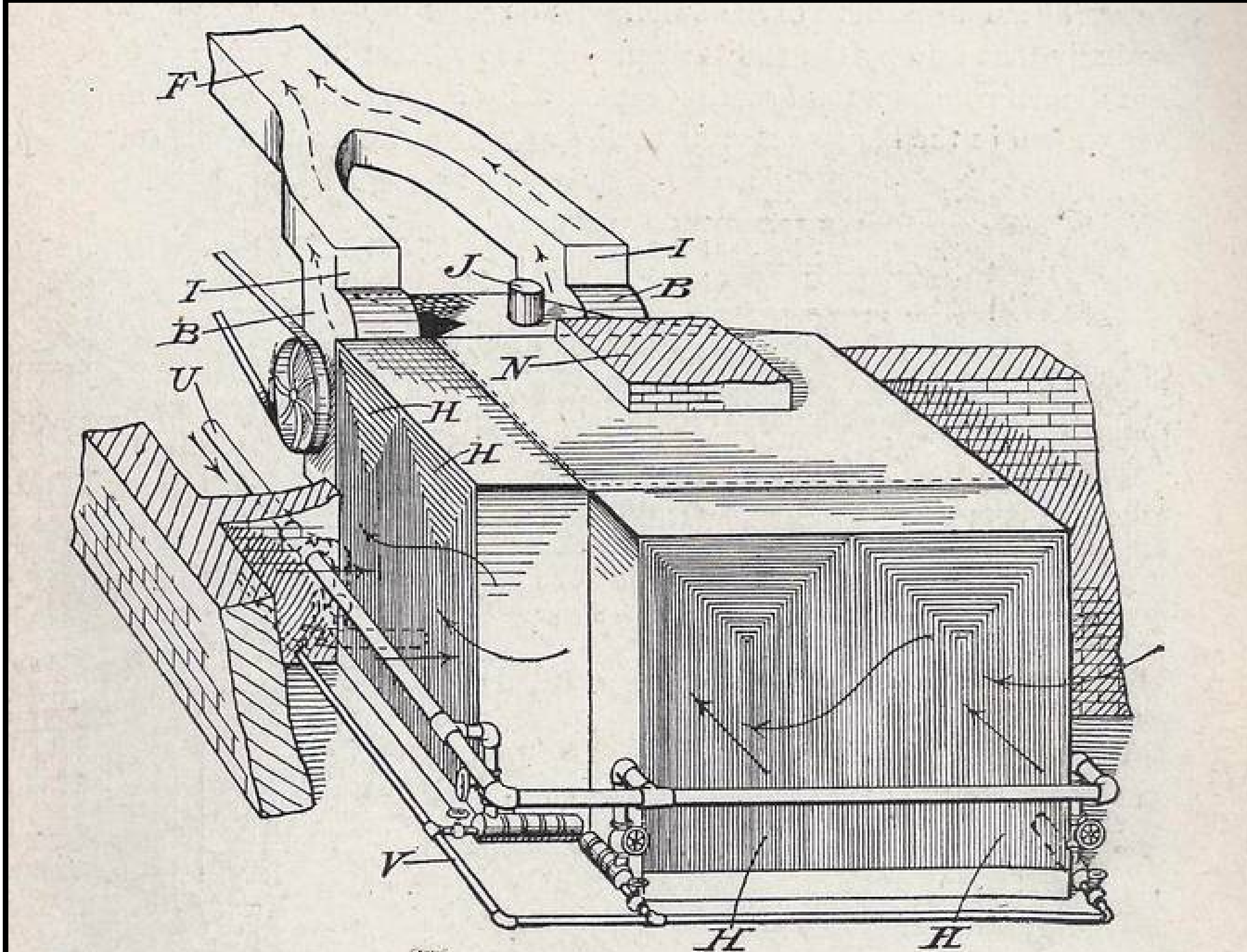
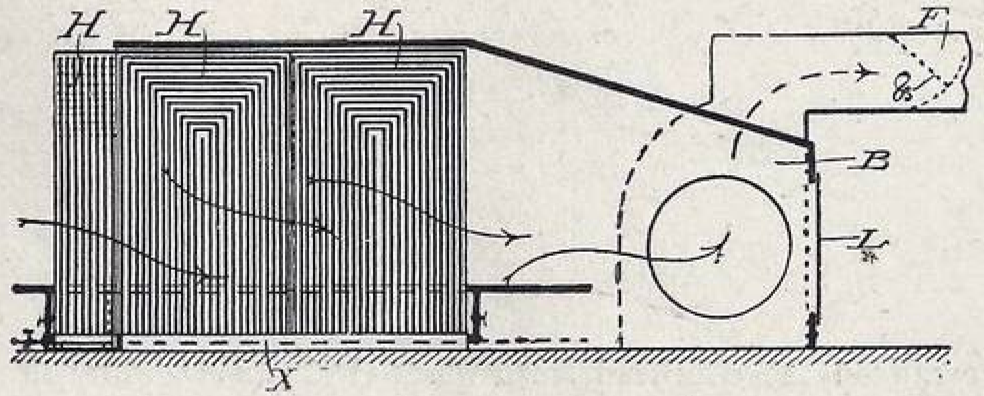



FIG. 132.




*Carnegie Hall: View of the fan system*

H is a steam heating coil

**THE NEW YORK STOCK EXCHANGE**

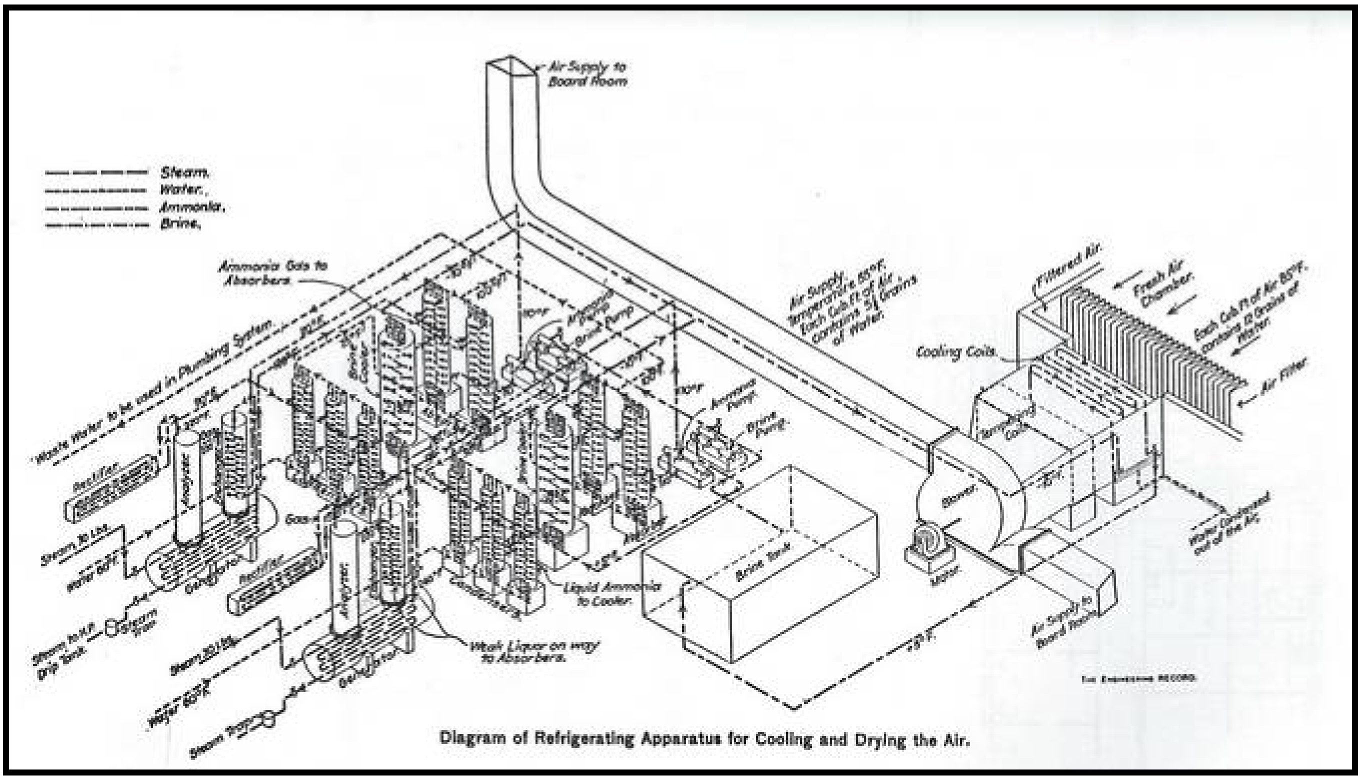
After the architect George Brown Post, who contributed to the origin and development of the early "skyscraper" in the 1870's, was appointed to design the New York Stock Exchange, it is said that he expected Wolff to complete all the ventilation drawings in two weeks. Wolff said that was impossible because the architect's plans were so complex and in the event it took almost a year. (It is not known how Post felt when Wolff refused to accept the normal custom that his fee would be a percentage of what the architect received and instead negotiated a separate agreement).

When Wolff received the plans for the New York Stock Exchange he was confronted with a design for one of the largest interior spaces (the Trading Floor) in the city "a block long room that would hold 1500 traders, with a skylighted ceiling 72 feet high and an entire wall of windows." Initially Wolff designed a thermostatically controlled heating and ventilating system but as he developed the scheme for the Trading Floor (also referred to as the Board Room) he concluded that ventilation alone would be unable to control either the temperature or the humidity.

Realising that some form of artificial cooling was necessary, Wolff consulted with Henry Torrance Jr, a well known refrigeration engineer, with whom he had worked before. They designed a mechanical cooling system that Wolff was able to convince the Building Committee was worth an extra cost of $130,000 dollars. The revised mechanical system design employed four high-pressure steam boilers feeding three steam-engine-driven direct current generators with an output of 750 kW for lighting and electric motors. The exhaust steam from the generator engines, supplemented by live steam, was used to supply "13,000 sq ft of direct and 5000 sq ft of indirect radiation," but perhaps more importantly exhaust steam was used to power the aqua-ammonia absorption refrigerating plant, chilling brine which was pumped to the cooling/dehumidifying coils of the Trading Floor air handling plants. The heating plant was provided with a pneumatic control system.


*New York Stock Exchange in 1904 (Library of Congress photograph)*

*New York Stock Exchange, interior of the main floor*

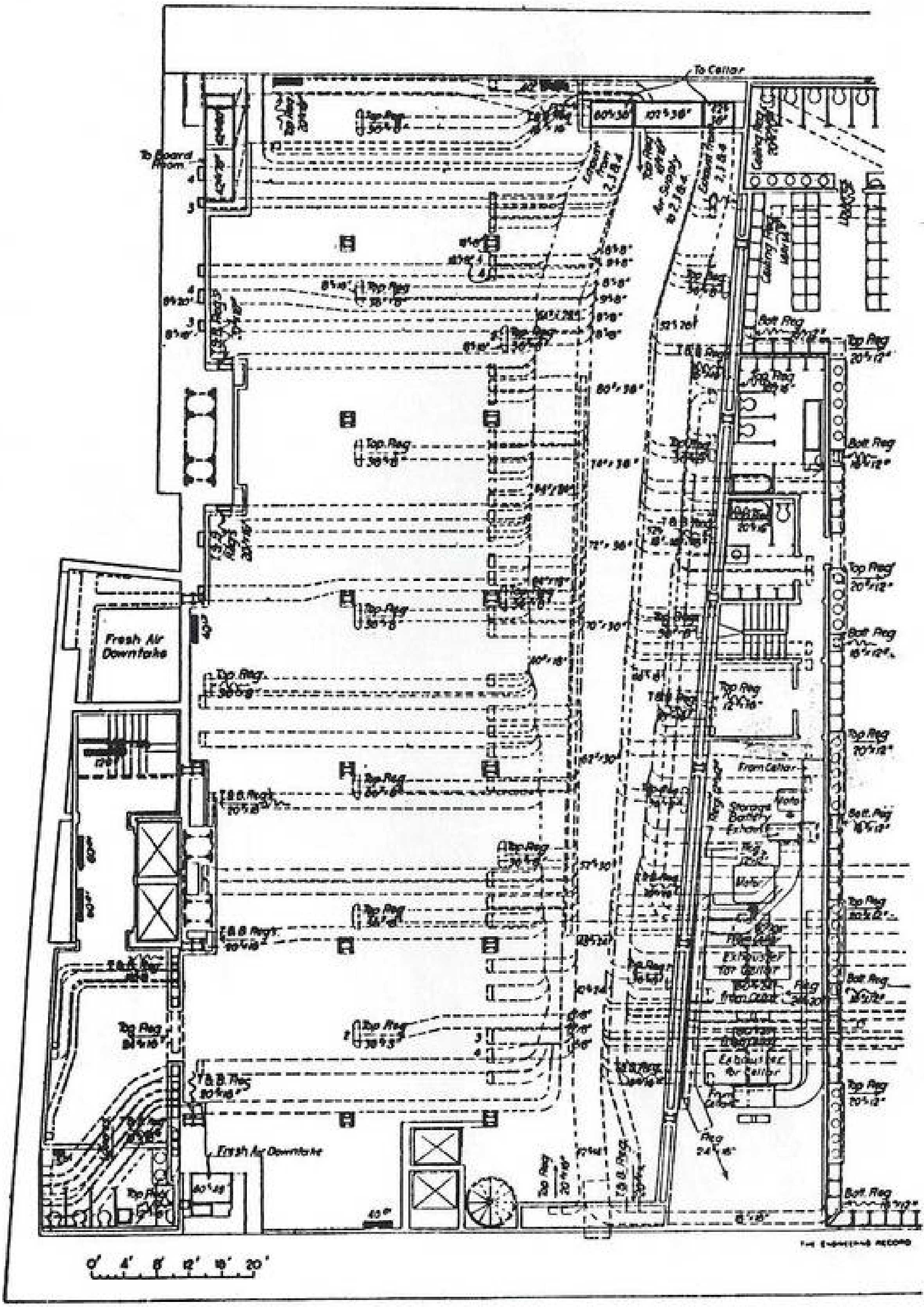



*New York Stock Exchange: Refrigerating & Air Conditioning, scheme drawing from 1904*

# BIG COOLING PLANT IN STOCK EXCHANGE.

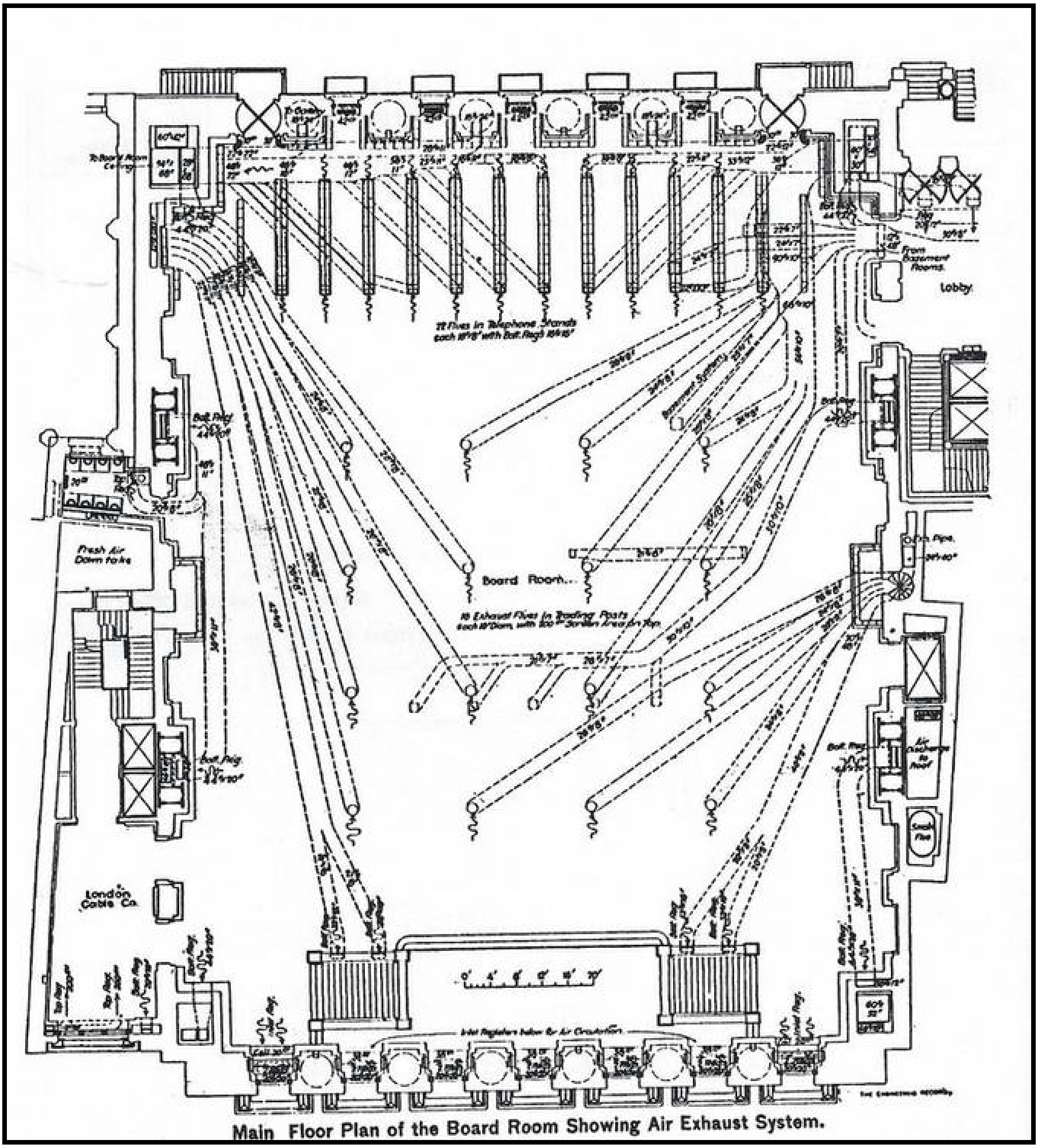
Three 150 Ton Machines Will Try to Keep the Brokers' Tempers Even—This Practically Marks the Opening of a New Era in Refrigeration.

INTERIOR OF THE BOARD ROOM OF THE NEW YORK STOCK EXCHANGE.

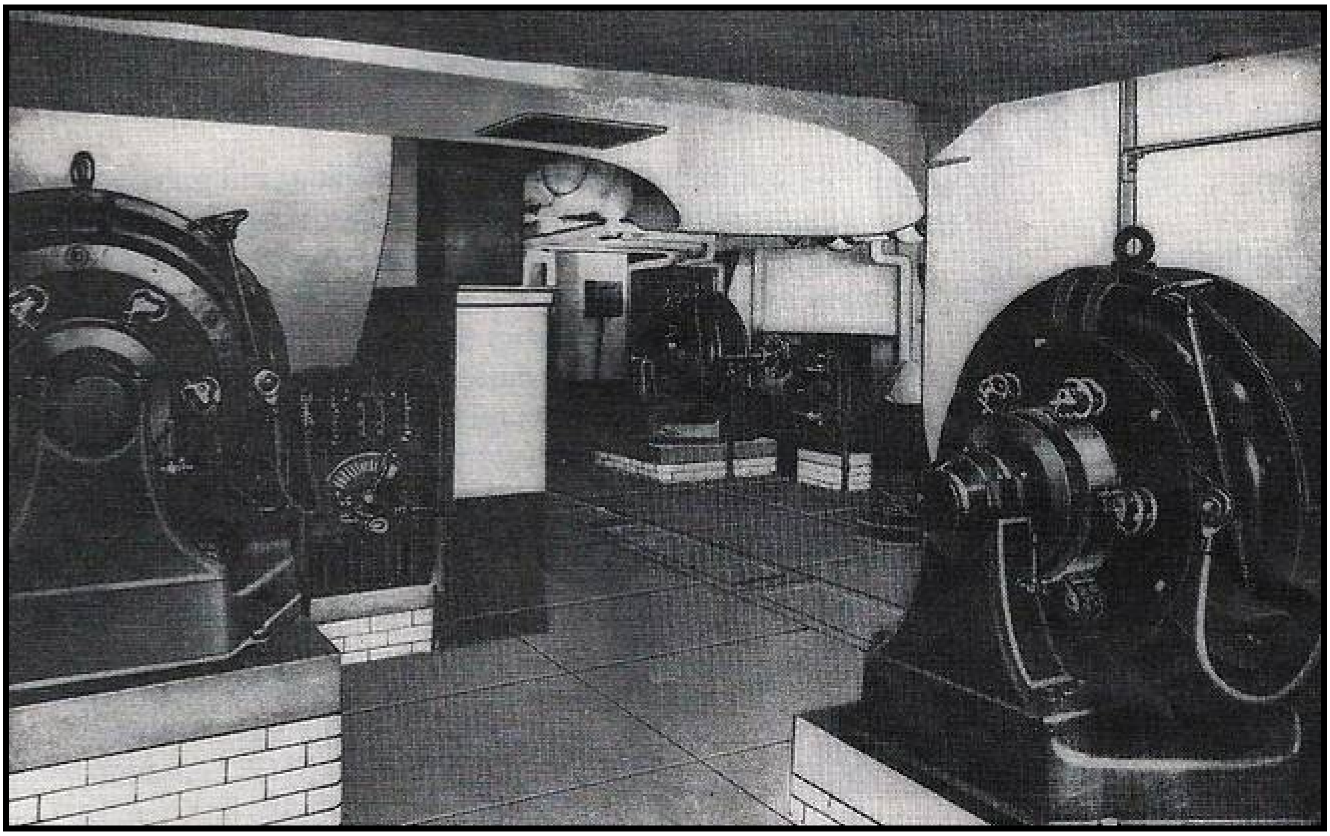



**Ducts over Ceiling of Sub-Basement No. 2.**

*New York Stock Exchange: Refrigerating & Air Conditioning, scheme drawing from 1904*




*New York Stock Exchange: Refrigerating & Air Conditioning, scheme drawing from 1904*



*Stock Exchange Basement with Sturtevant fans driven by DC electric motors*

Wolff's calculations of 1901 reveal that the plant was designed to lower the Trading Floor temperature "from 85 degF to 75 degF and the relative humidity from 85% to 75%" requiring a cooling plant capacity of 420 tons (1477 kW). He told the Building Committee:

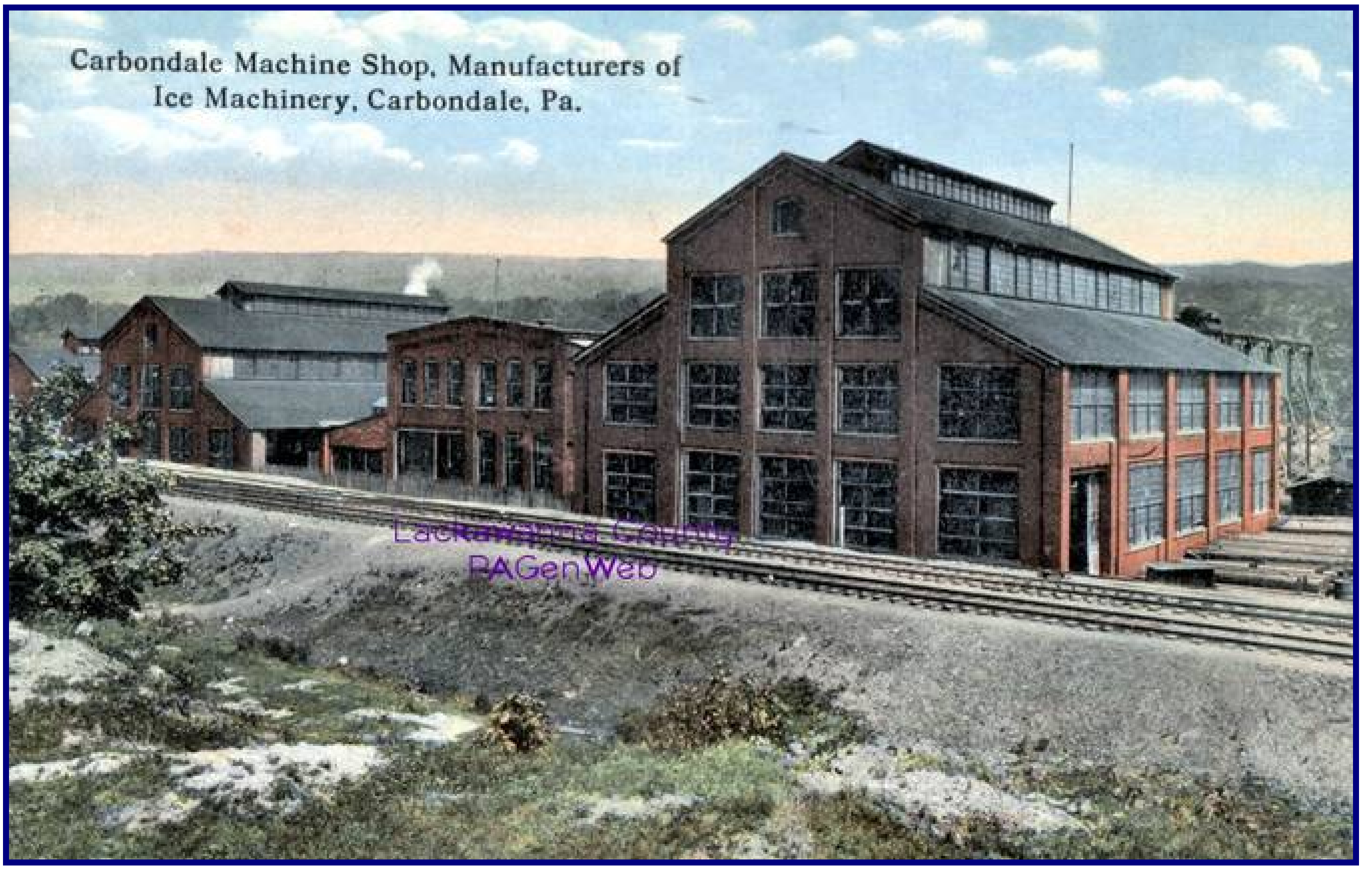
> "I would like to say the importance of this plan to the upper portion of the board room is the abstraction of the moisture and the reduction of humidity. I attach less importance to the reduction of the temperature than to the abstraction of the moisture."

The ventilation systems, serving the Stock Exchange, employed eight centrifugal and three "disk" (propeller) fans, all driven by DC electric motors to deliver five air changes per hour or "200,000 cubic feet per minute of 100% outside air." The supply air was passed through "cheese cloth" filter racks, humidified in winter by steam coil water pans and tempered by steam heating coils. It is recorded that the exhaust air systems had an extract rate of "224,000 cubic feet per minute."

Few comfort cooling systems had been designed before 1901 and the proposed Wolff-Torrance plant was a giant of its time employing three ammonia absorption brine chillers with a cooling capacity of 450 tons of refrigeration (1582 kW). The Trading Floor cooling load was 300 tons (1055 kW). The additional 150 tons was designed to serve the underground basement areas removing machinery and boiler heat with a small amount used to cool drinking water. Waste water from condenser cooling was stored in roof cisterns and used to flush toilets. The Stock Exchange opened on 22 April 1903.

## THE CARBONDALE MACHINE COMPANY

The capacity of the refrigerating plant was reduced to 300 tons (1055 kW) prior to installation and arranged to serve only the Trading Floor. The refrigeration manufacturer was the Carbondale Machine Company of Pennsylvania using an improvement to the original English Pontifex patents which they had purchased in 1882.

The Carbondale Machine Company (From *Refrigerating Engineering*, December 1934)

## The Carbondale Machine Company

THE Carbondale Machine Company started operation in 1899 in a comparatively small plant located on Dundaff Street in the city of Carbondale, Pa., but in 1906 moved to a newly constructed plant in Simpson, a suburb of that city. The shops were modern in design at that time and equipped with up-to-date machine tools, providing first class facilities. Since then, the shops have been added to and improved, keeping the plant up-to-date.

The first president of the company was the late A. P. Trautwein, for many years a prominent figure in the industry. He was succeeded by N. H. Hiller, and the president at this time is Henry Torrance. Both of these men did much for the development of the refrigerating machine industry in general, and are, in a large measure, responsible for the important position of Carbondale in the industry today. Both men are members of The American Society of Refrigerating Engineers and have served as presidents of the Society.

Although 1899 is the date of founding of the present company, Carbondale really had its inception when the late E. E. Hendrick purchased the English Pontifex patents and commenced to build absorption refrigerating machines about the year 1882. Many machines were built and installed, but the design remained practically unchanged until 1899, when The Carbondale Machine Company was incorporated and the real development of the absorption refrigerating machine commenced.

Up to this time, practically all the machines were of the high pressure steam type, but shortly after the formation of Carbondale, the exhaust steam type of machine was developed. This type of machine using steam in the generator coils, at a pressure as low as one pound, or even less, made it possible to utilize exhaust steam for the production of refrigeration that otherwise would be wasted.

The absorption machine lent itself very easily to the production of distilled water ice and, following this, ice plants using the evaporator system were developed. These plants were economical in operation and produced ice of high quality. A great deal of money and effort was spent by Carbondale perfecting this type of machine, and for many years a test plant was maintained where new designs were thoroughly tested and perfected under actual running conditions, practically every part of the machine being improved in some way or other.

Up to the year 1919, The Carbondale Machine Company had installed comparatively few machines of the compression type, but with the development of the large central electric stations and raw water ice, Carbondale decided to enter the compression field actively. It was especially interested in the development of the two-stage compression machine, the high speed machine, making possible the use of direct-connected synchronous motors, internal combustion engines and the more economical types of steam engines, operating at relatively high rotative speeds. Types and designs of machines were constantly improved to keep pace with the progress of the industry.

The heat exchange apparatus in the beginning was largely of the shell and coil type. Among the first machines to use straight tube apparatus were the Carbondale absorbers, generators, coolers and other heat exchange apparatus. The vertical shell and tube ammonia condenser came into use and its many advantages made an unusual appeal to the trade, and the many improvements made by

Carbondale are still outstanding features of this type of condenser.

For many years, the Carbondale shell and coil type of cooler was recognized as almost standard in the industry, but later on straight tubes were developed and here, again, Carbondale was active in the development of the horizontal multipass brine cooler, which found much favor at that time, especially in the larger installations.

One of the early uses of refrigeration was in the refining of petroleum. Carbondale machines were probably the first used for this purpose, and subsequently were widely accepted in the industry. The particular requirements of the oil industry necessitated its own design of exchange equipment. The apparatus for the application of refrigeration to the oil refining processes was distinctly a Carbondale development and the original ideas embodied in the first Carbondale chilling machines are widely used in connection with the most modern methods of oil processing today.

PRESENT PLANT OF THE CARBONDALE MACHINE COMPANY, CARBONDALE, PA.

ORIGINAL SHOP OF THE CARBONDALE MACHINE COMPANY. PHOTOGRAPH TAKEN ABOUT 1899.

One phase of the industry in which Carbondale took a leading part was the development of the carbonic acid refrigeration machines, and also complete plants for the production of liquid $CO_2$, the company having made some of the largest installations of both refrigerating and $CO_2$ production plants now in use.

Air conditioning, considered by many the next great industrial development, is not a recent idea with the Carbondale Machine Company. More than 30 years ago, Carbondale machines were installed in the Hanover Bank and the New York Stock Exchange, New York, for this very purpose. At an even earlier date, Carbondale machines were used to condition the air in the dipping rooms of chocolate factories. Many of the present ideas in air conditioning are little more than refinements of apparatus or equipment installed in some of these early plants. For example, the unit cooler of today is simply a refinement of the coil bunker used in the larger plants thirty years ago.

The difficulties encountered in early installations of refrigerating machinery of the absorption type were probably less numerous than those encountered with compression type equipment. In the absorption system, the only moving part in the refrigerating cycle is the ammonia pump for transferring the strong ammonia liquor from the absorber to the generator, whereas with the compression system, the whole plant depended upon moving parts.

The developments in the metal industries were reflected in the design of refrigerating apparatus. The earlier pressure vessels were almost universally made of cast iron, but many years ago they were replaced with vessels of steel construction. Of course, many of the theories advanced in favor of the use of cast iron in preference to steel have since been discarded. The use of alloy steels has made breakage of crankshafts, connecting rods, and valves almost unknown in the compressors of today and is doubtless responsible, in great measure, for the success of the high speed machine.

In recent years the absorption system seems to have been eclipsed by the compression system, but this has been largely due to the development of the smaller compression machines. However, the absorption machine is still an up-to-date machine, as evidenced by the fact that some of the most successful household machines now in use are of the absorption type. Some of the most modern installations embody the combination of absorption and compression machines, where the use of exhaust steam from the engines driving the compressors can be most economically utilized in the operation of the absorption units in this type of combination plant.

For a number of years the Carbondale Machine Company was rather closely affiliated with the Worthington Pump & Machinery. Recently they merged their interests in the refrigerating line and the operations of the company were transferred to Harrison, N. J., under the name of the Carbondale Machine Corporation, where even better manufacturing facilities are available.

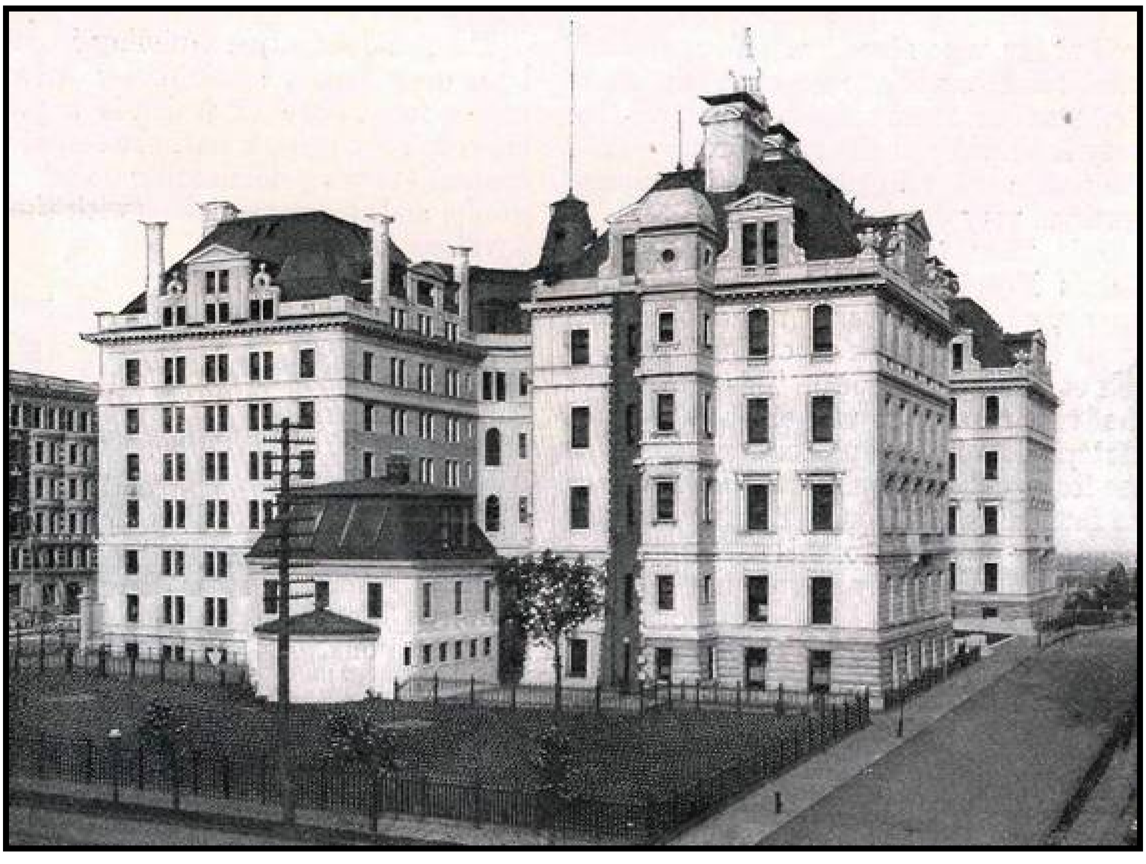
Wolff was also involved in other projects in New York. He was a consulting engineer for the design and installation of power plants for the New York Steam Company (later Con-Edison) a pioneer in the provision of district heating networks. He also designed many important projects of the time, including the Siegel-Cooper Department Store, the Hotel Astoria (which later merged with the Waldorf Hotel to form the Waldorf Astoria), St Luke's Hospital, the New York Life Insurance Building and the Metropolitan Life Building.

The New York Life Insurance Building "was heated by steam from four water-tube boilers distributed through direct and indirect radiation. The system was controlled by thermostats from the Johnson Electric Service Co. The first seven floors were heated by indirect radiation to 70 in zero weather with a pressure of not more than five pounds by means of two central heating stacks and two of B F Sturtevant's 7-foot ventilating fans. Air filters clean all entering air from soot and dust……. For indirect radiation Bundy loop radiators and coils are used (A A Griffing Iron Co, Jersey City). Radiators are placed in halls, vestibules and toilets.

Around 1904, Wolff "adopted a different device for ventilating tall buildings … (for) the Hotel St Regis (New York), fifteen storeys high and pretty thorough ventilation was wanted. Fresh air ducts equal to the requirements of the various floors would be so large on the lower floors that a wholly impracticable proportion of floor space throughout the building would be sacrificed to air ducts if the plant was in the basement. Mr Wolff, therefore, divided his ventilating plant into batteries of four, placing one unit each in the basement, third, seventh and twelfth floors, with indirect stacks supplied with steam by pipes from the boiler in the cellar."

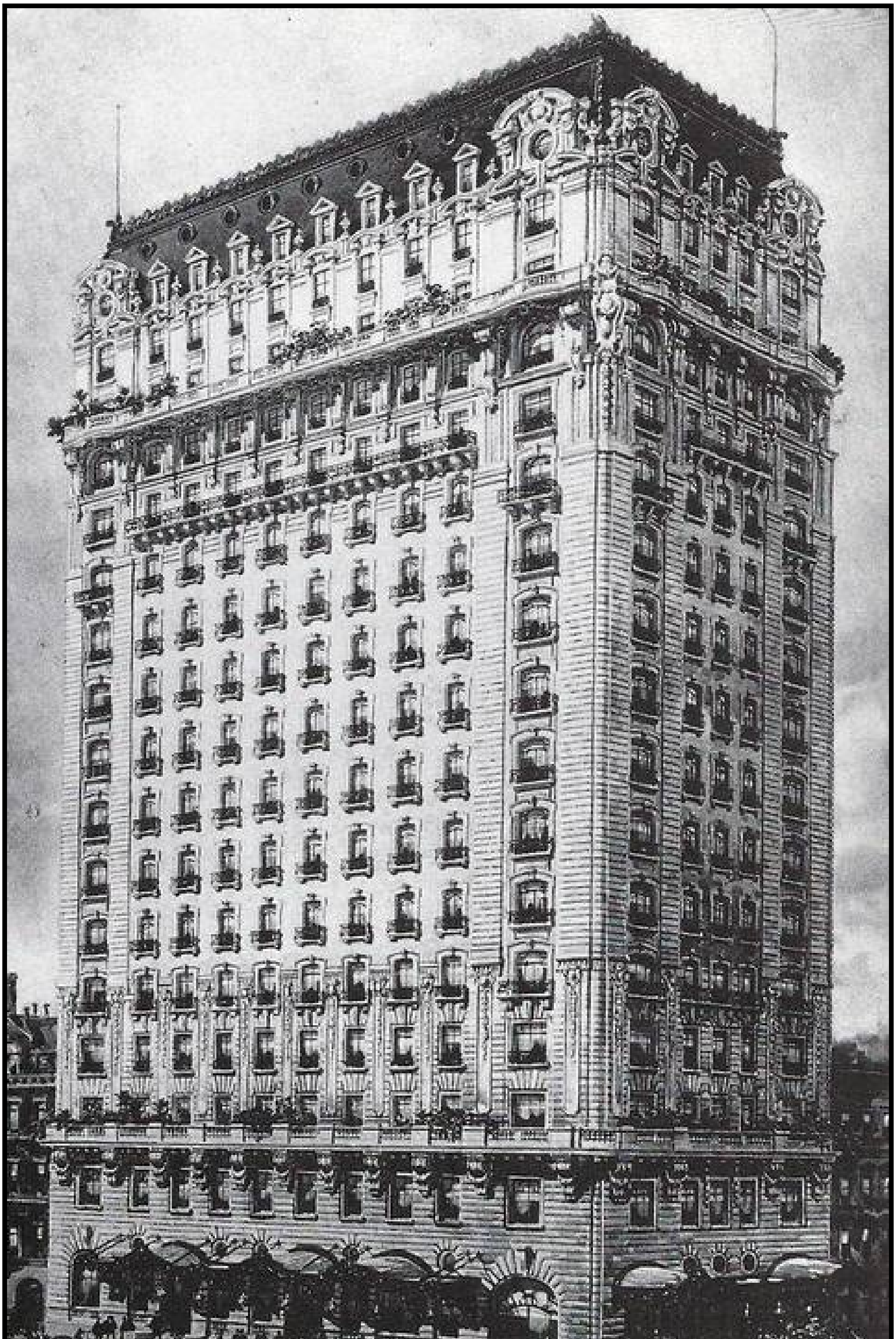
Wolff was also the consultant for a number of large residences, including the Cornelius Vanderbilt II house and the John Jacob Astor IV house. In Vanderbilt's house, the heating and ventilation was provided entirely by a gravity-type ducted air distribution, fans being used only for exhaust, with hot water boilers as the heating source. A similar system was employed in the Astor House.


*The Siegel-Cooper Department Store in New York 1896*



*St Luke's Hospital, New York*

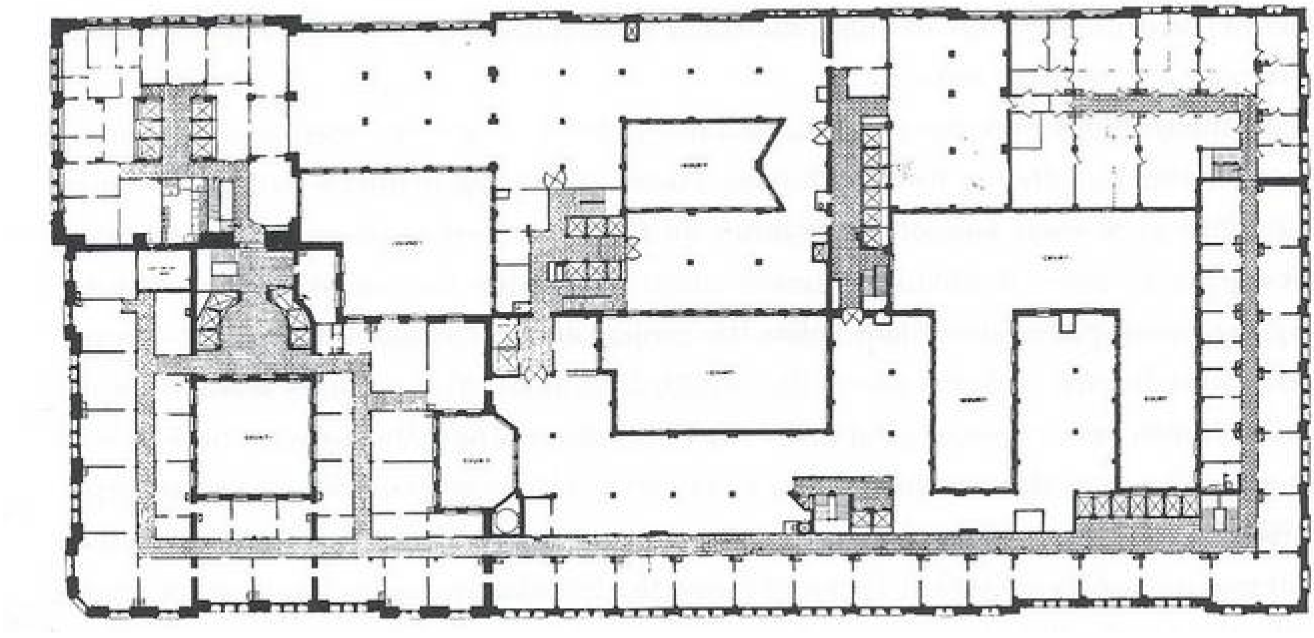
*The New York Life Insurance Building 1894-98*



*St Regis Hotel, New York, 1904*

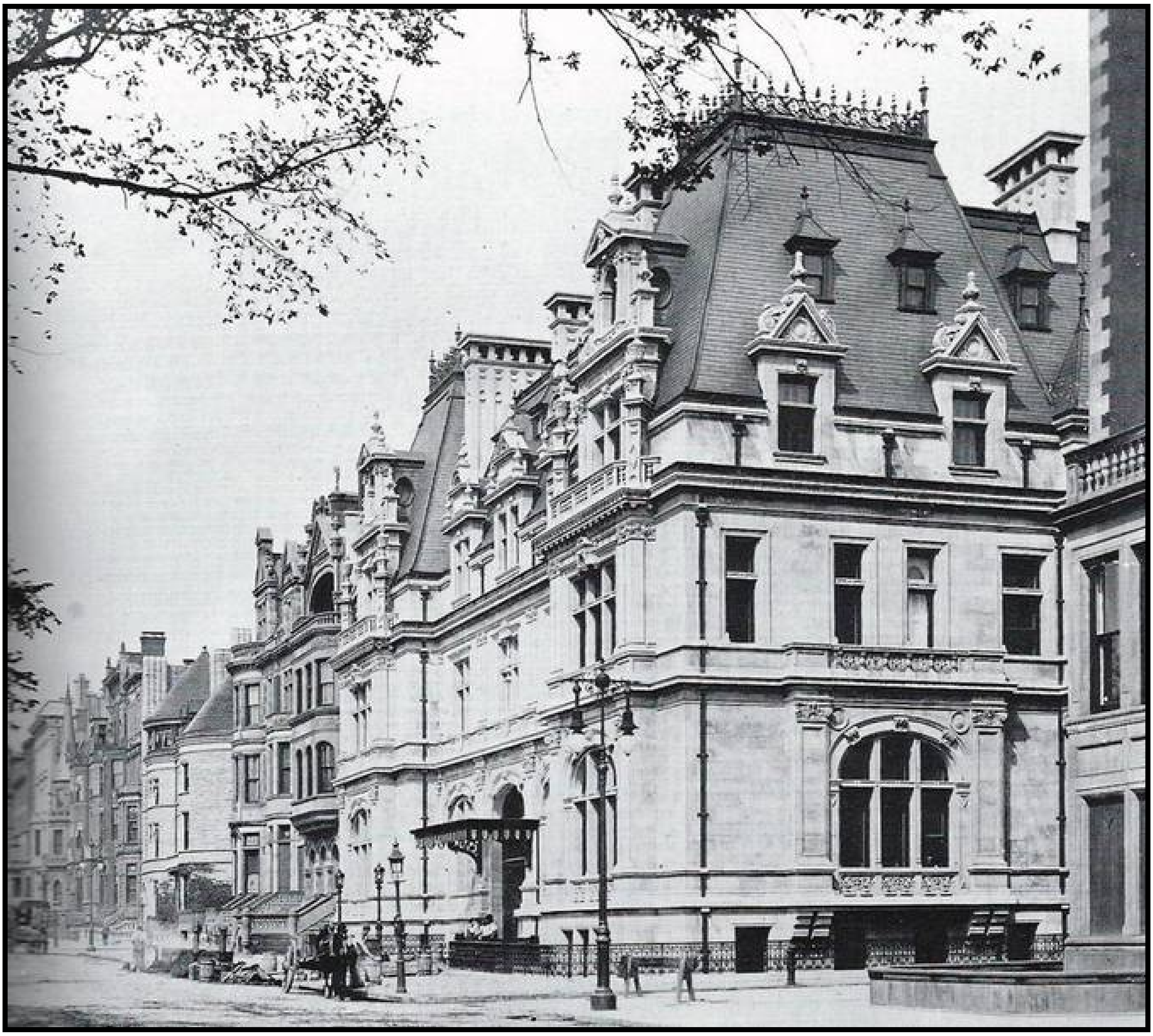
*Metropolitan Life Insurance Building & Tower (left), New York 1909*

*Workers in the former Metropolitan Life Insurance Building in 1896 (note lamps at each station) Replaced by the New Building & Tower of 1909 on the same site*



*Typical floor plan of the entire complex, Metropolitan Life Building 1909*
*The tower is the small square in the upper left-hand corner*

*Cornelius Vanderbilt II house in New York 1892*



*The John Jacob Astor house in New York 1892*

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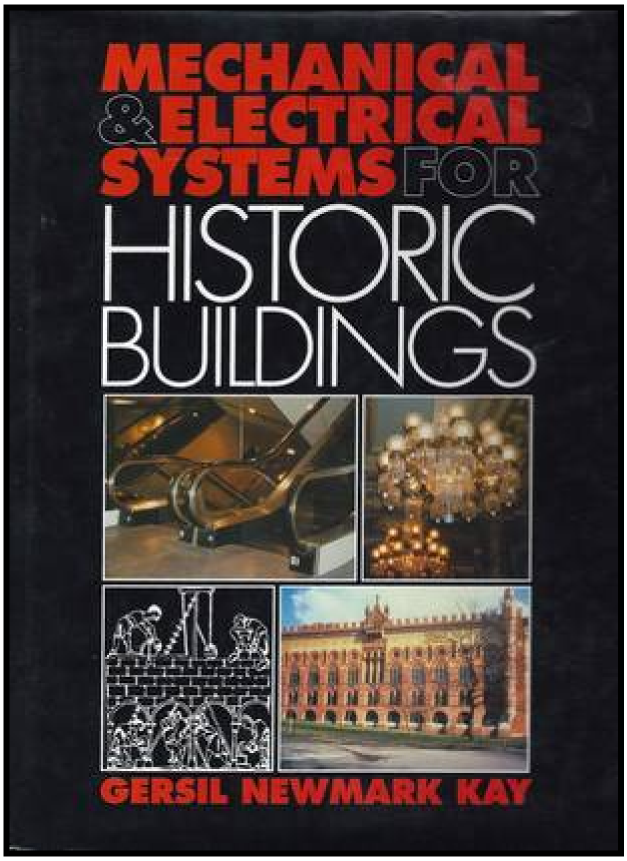
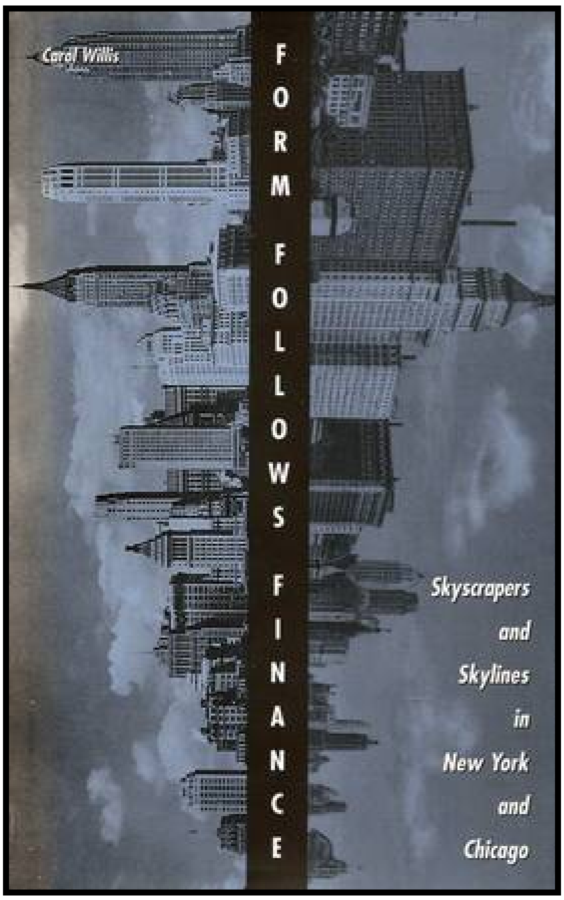
**POSTSCRIPT: FUTHER READING**




*1991*

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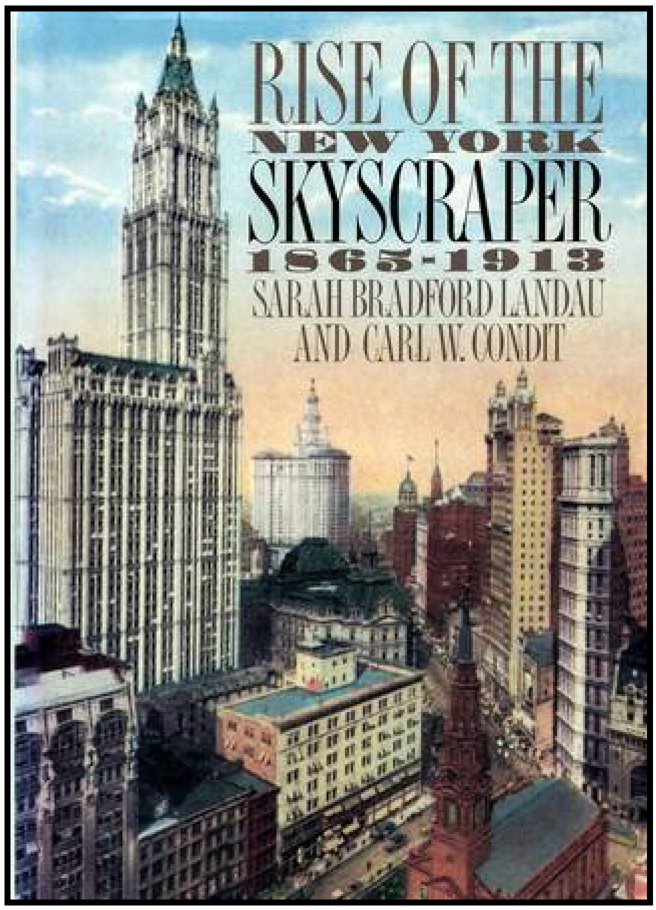


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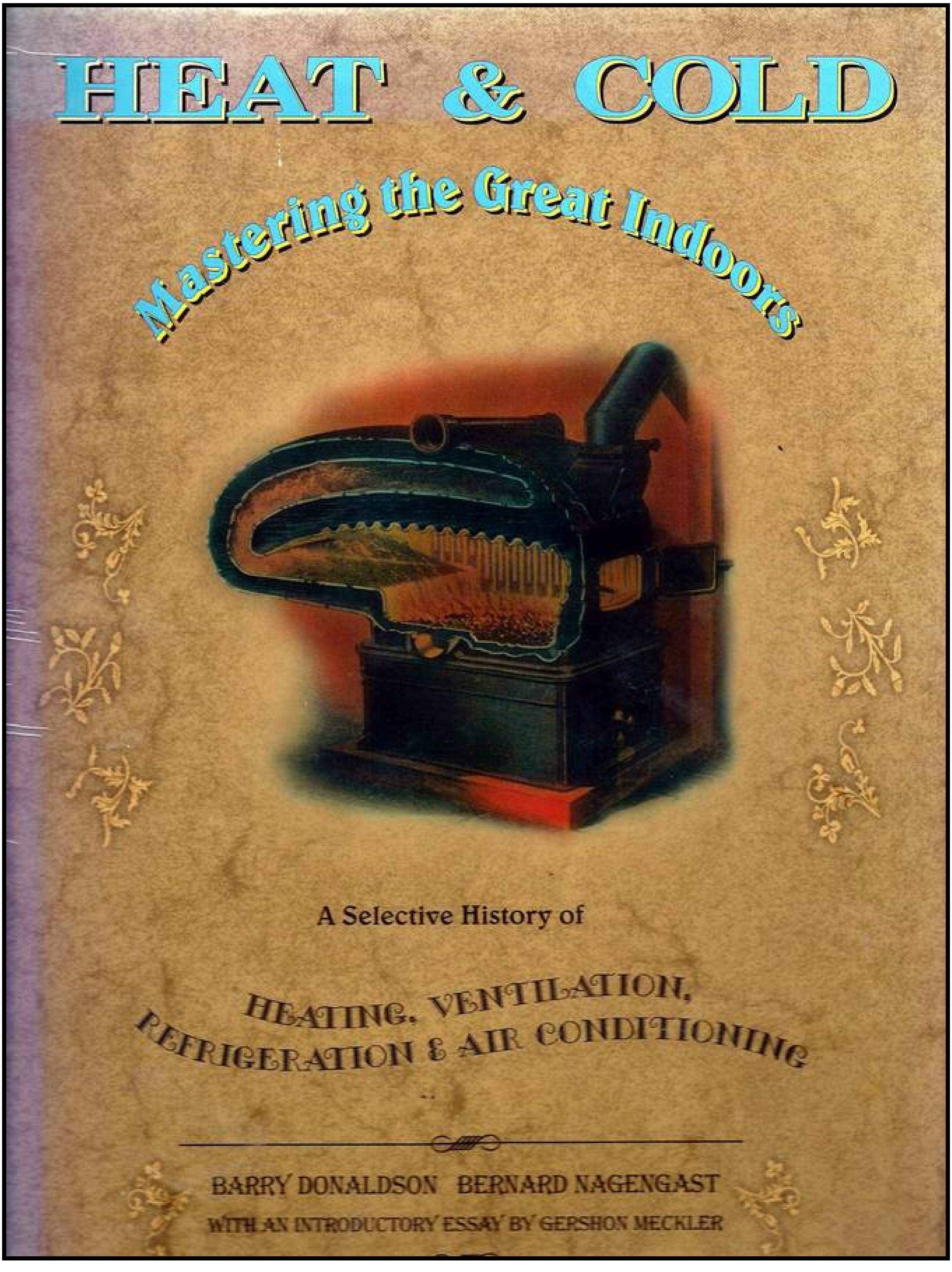
HEAT & COLD
Mastering the Great Indoors
A Selective History of
HEATING, VENTILATION,
REFRIGERATION & AIR CONDITIONING
BARRY DONALDSON BERNARD NAGENGAST
WITH AN INTRODUCTORY ESSAY BY GERSHON MECKLER

1994

## EPILOGUE

At the height of his career, Alfred Wolff became ill and died suddenly on 7 January 1909 at the age of 49. Wolff's design for the New York Stock Exchange air conditioning system operated successfully for nearly 20 years before it was modernised. It has greater claim to be the first scientifically designed air conditioning system than Carrier's Sackett-Wilhelms plant of 1902 which was not entirely successful being removed after a few years,