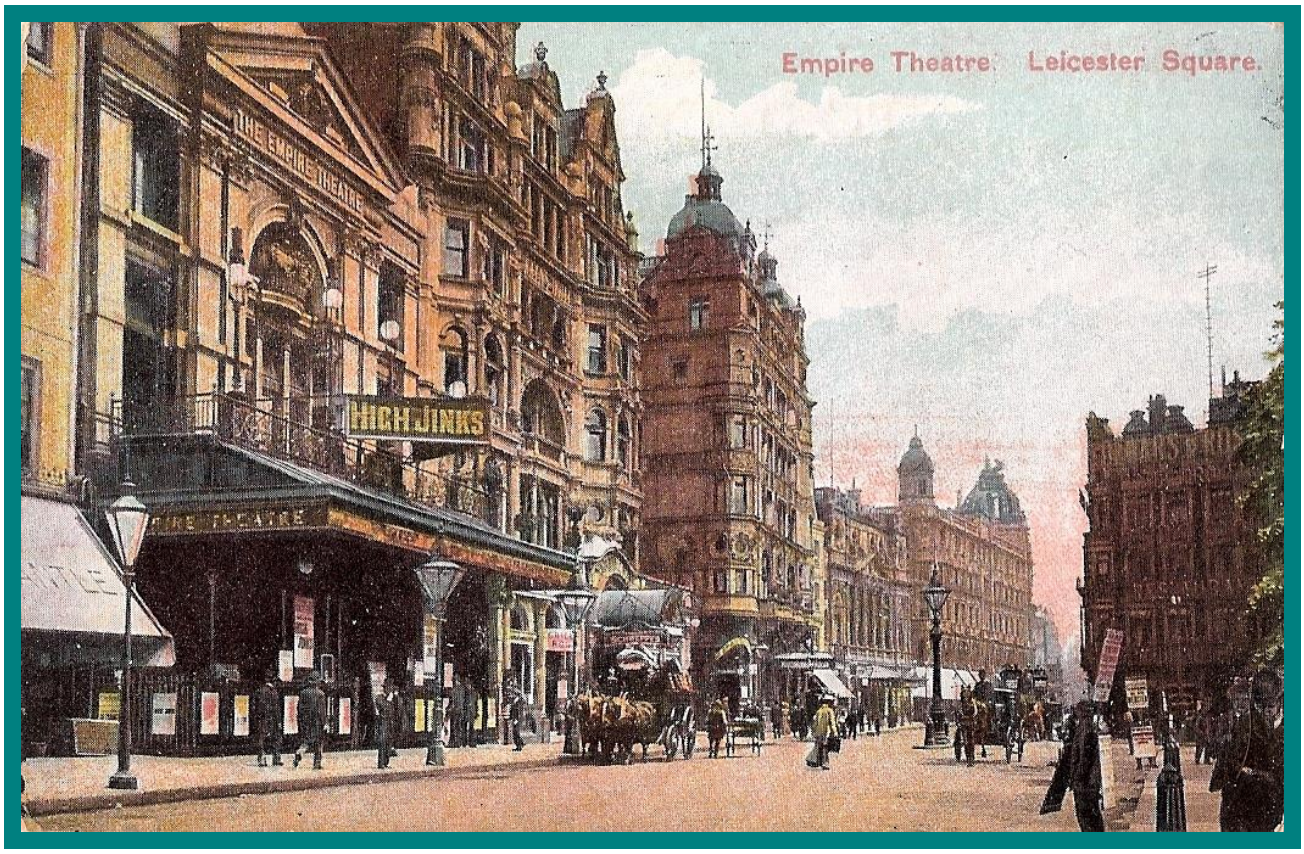
# Building Engineering Services
# HERITAGE REVISITED
## PART EIGHT

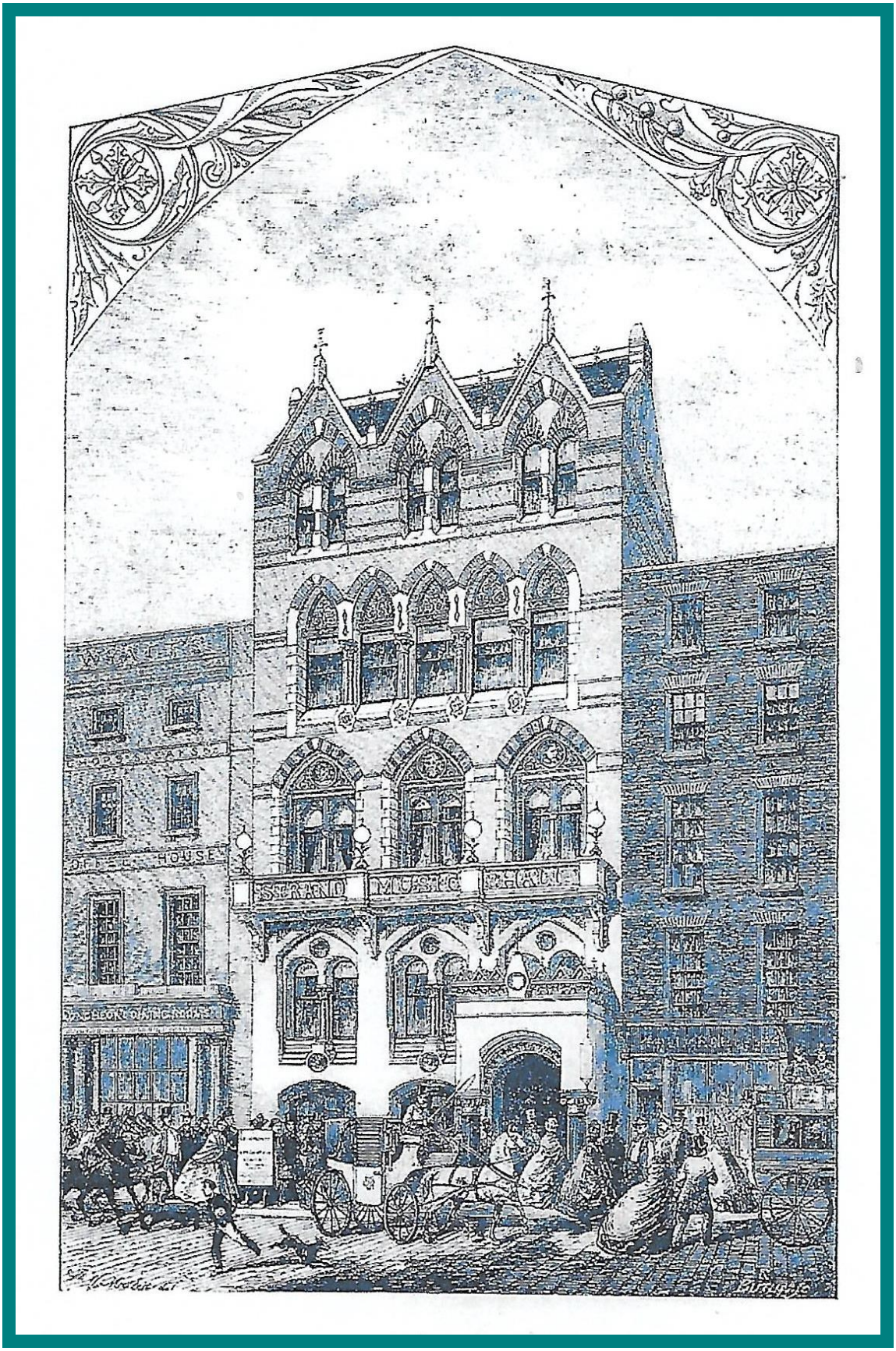
Second Edition 2021


## BRIAN ROBERTS
CIBSE Heritage Group


**The Empire in Leicester Square, London, a theatre in 1890 (now a cinema) was heated and ventilated by Wilson Weatherley Phipson, the system having a gas-engine-driven fan and gearing with a large ventilating gas light in the foyer.**

# STRAND MUSIC HALL, LONDON




**Opened in 1864, heating and ventilation by W.W. Phipson: "The power of regulating the heat without interference with the ventilation.....provides perfect ventilation and genial warmth."**

# OHIO THEATRE, TOLEDO, OHIO


**Air conditioned by Carrier Engineering Corporation in 1927.**

# INTRODUCTION

**Part-8: 2nd Edition reviews the early seventy years of progress in the heating, ventilating and air conditioning of British and American theatres; from ice-block cooling to centrifugal refrigeration, including important patents and examples of the work of manufacturers and installers. Extracts from technical papers, copies of patents, advertisements, photographs and drawings are all taken from the CIBSE Heritage Group website and Archives.**

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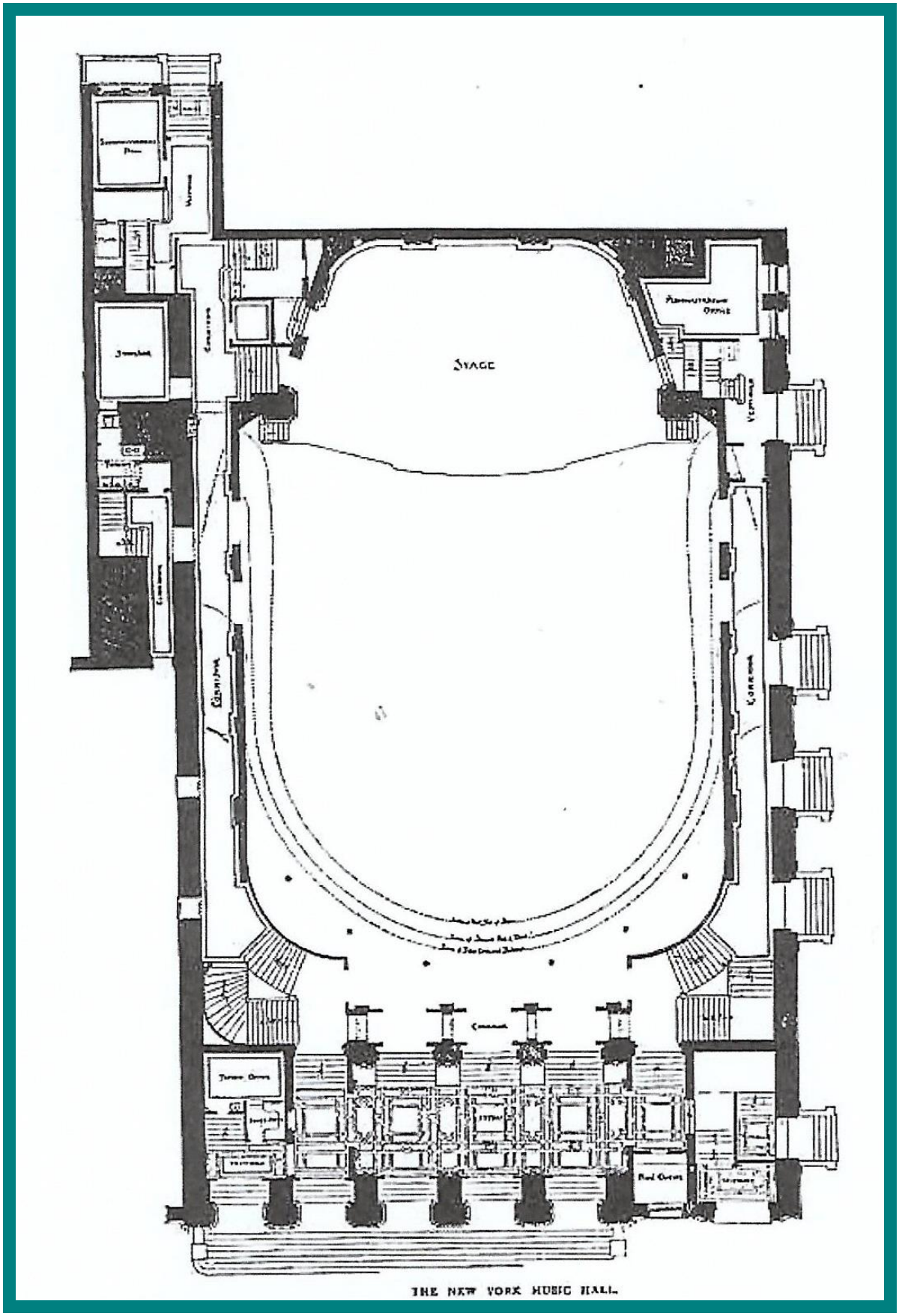
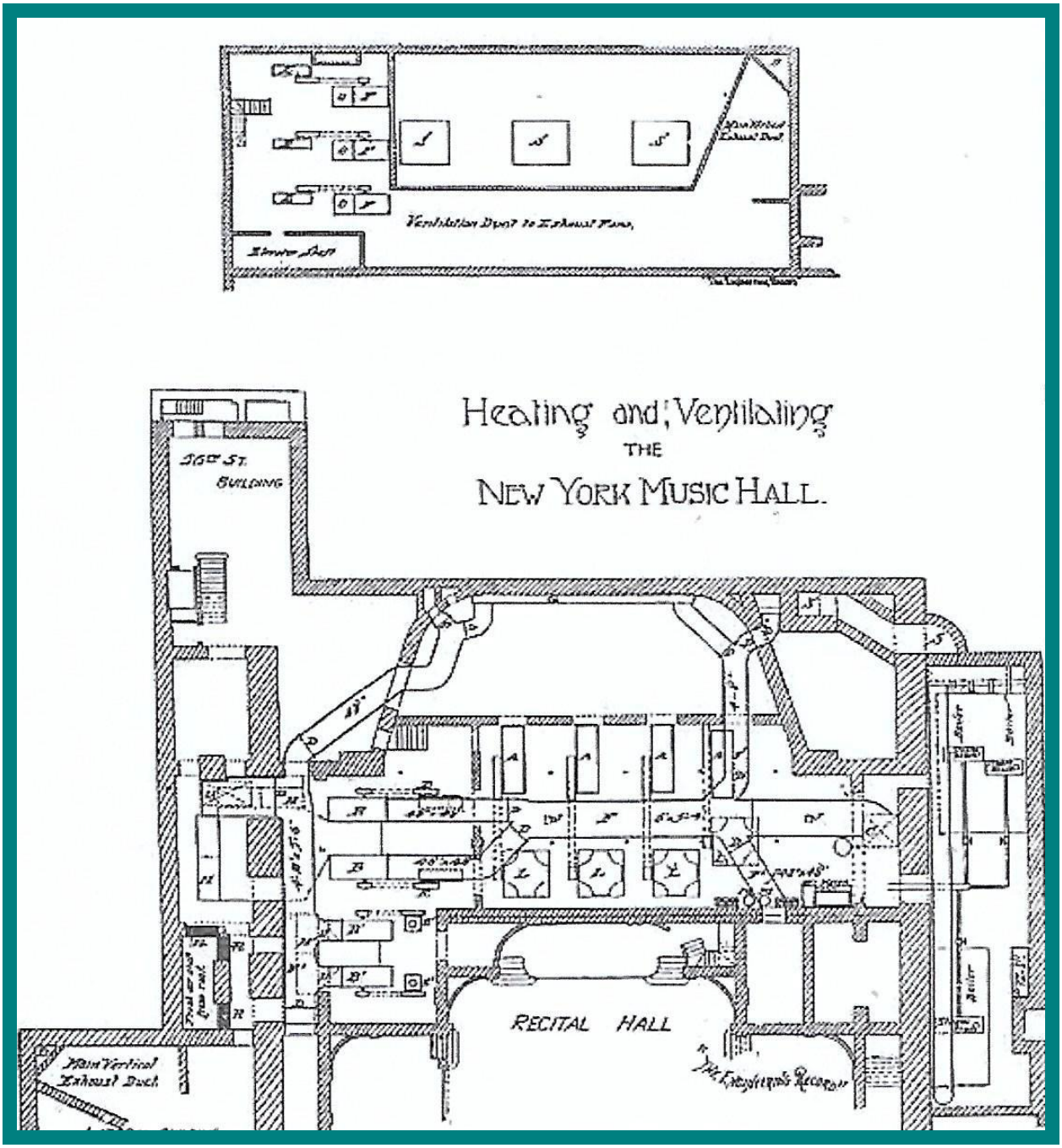
# NEW YORK MUSIC HALL




**(Drawings on pages 4 to 11 inclusive from Engineering Record, 1891)**

# NEW YORK MUSIC HALL
# LATER CARNEGIE HALL



# NEW YORK MUSIC HALL



With this amphitheater may be compared the New York Music Hall founded by Andrew Carnegie, a full description of which, with plans, is given in *The Engineering Record* of July 4, 1891, and February 6, 1892. The main concert hall has a seating capacity of 3,000, the recital hall beneath this seats 1,200. The fresh warmed air enters the music hall through numerous perforations in or near the ceiling,

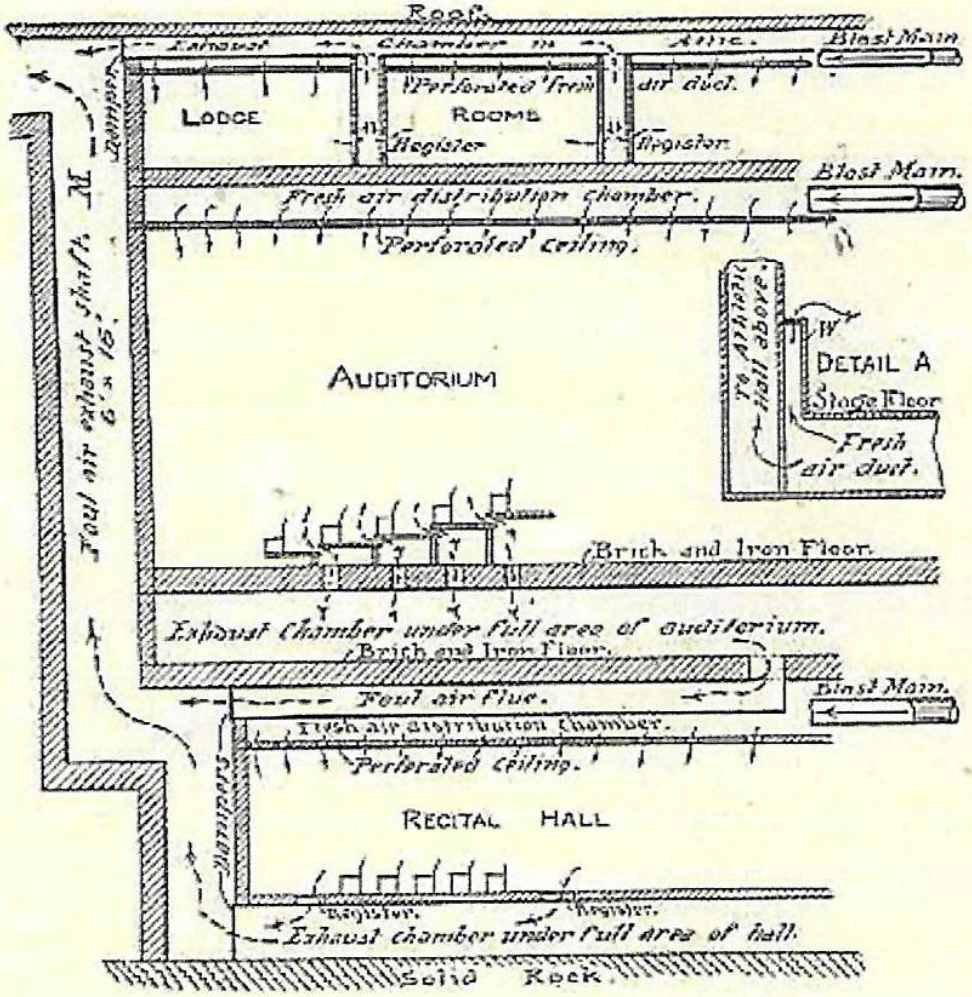



FIG. 129.

being forced in by two 7-foot Sturtevant blowers which draw it through heaters of 1¼-inch pipe containing 6,600 square feet of heating surface.

Figure 129 is a general vertical section of the main building, not to scale or accurate position, but intended as a diagram to show the distribution of fresh air and the withdrawal of foul air in the principal

# NEW YORK MUSIC HALL



rooms. Detail A shows the method of supplying extra heat and air to the stage through perforations in the horizontal top of the 6-foot wainscoting *W*, around the walls.

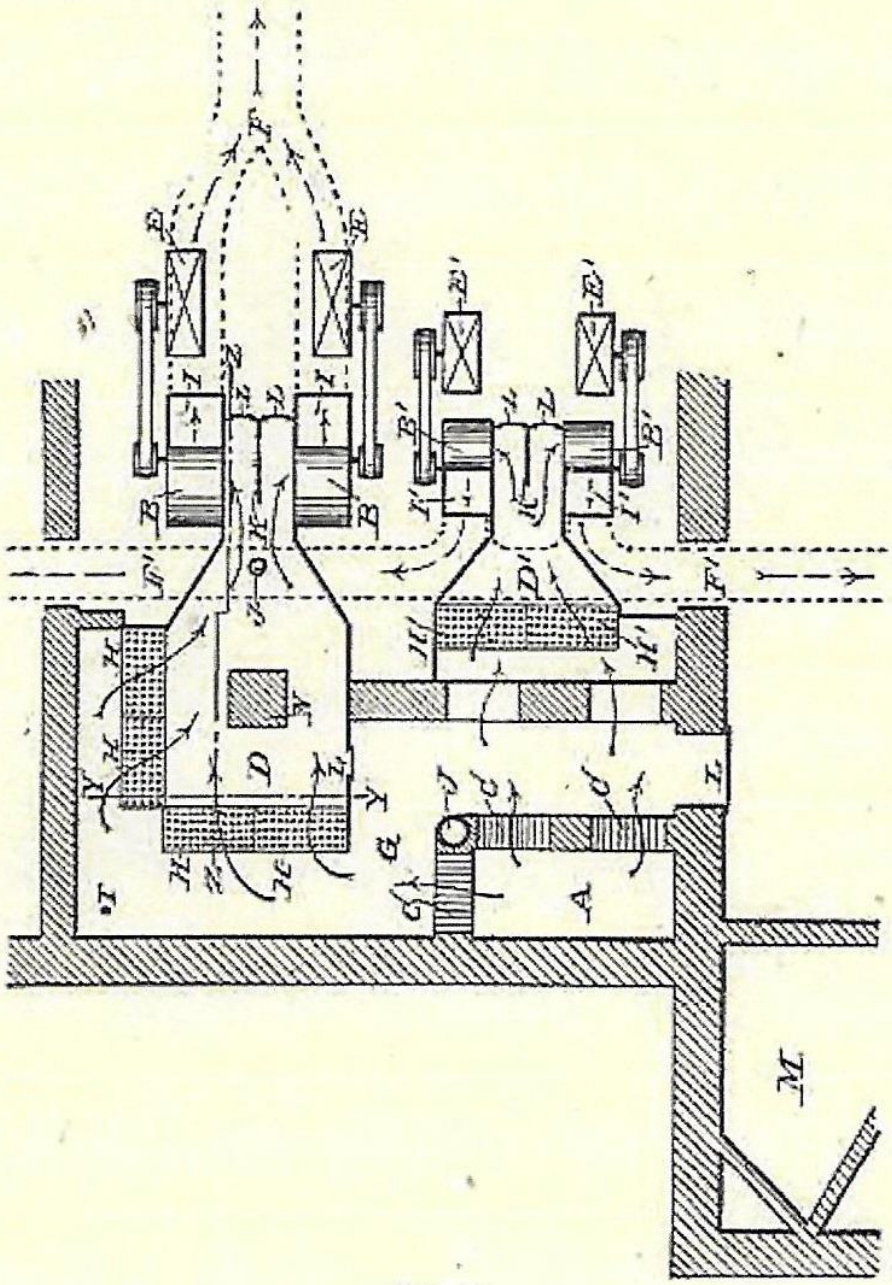


FIG. 130.

Figure 130 shows the heating, cooling and blowing plant. *A* is the fresh-air shaft from the roof, 6x12 feet, supplying the distributing

# NEW YORK MUSIC HALL



chamber *G*. In warm weather ice may be placed in the racks *C C* to cool the air. The blowers *B B* draw the air into the chambers *D D* through the steam radiators *H H*. *E E* are the engines driving the blowers, and *F* is the main air duct having a cross-section of 30 square feet.

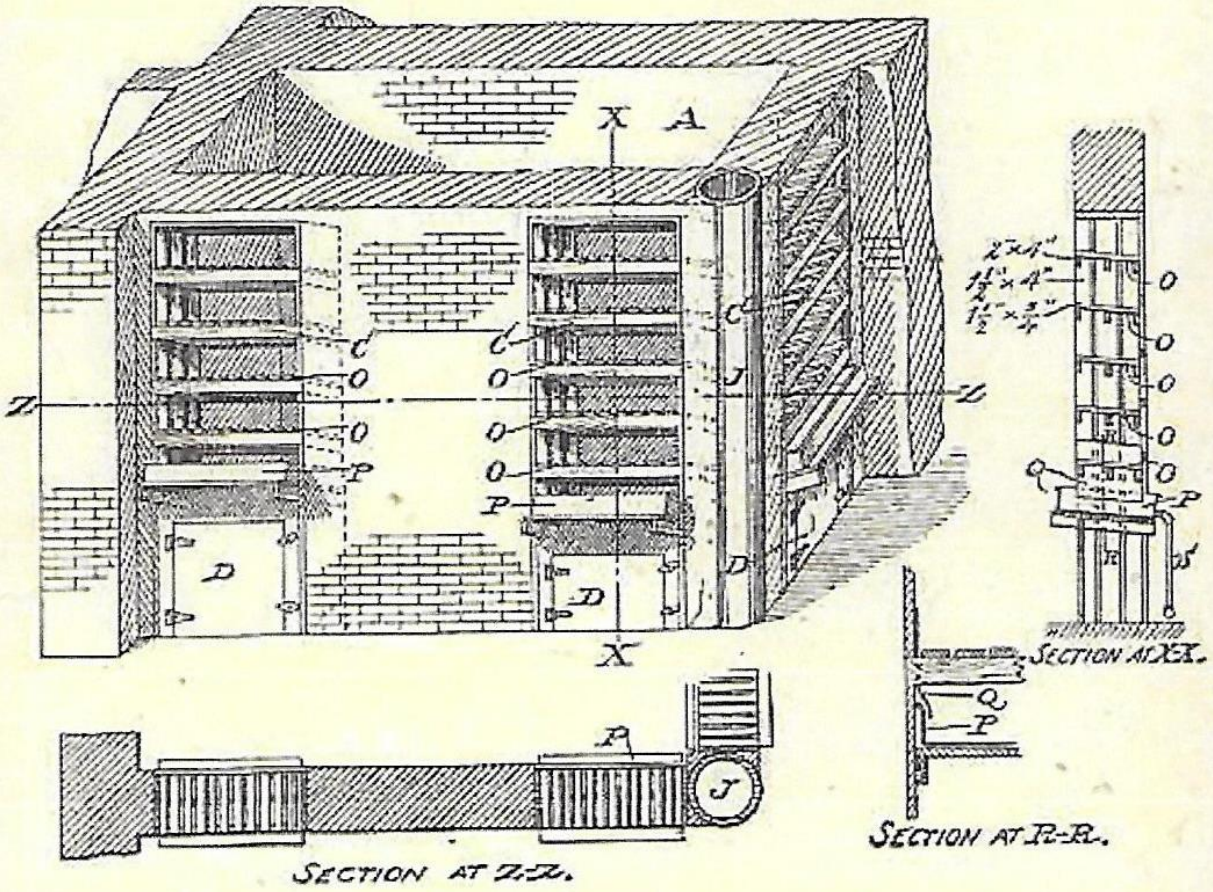



FIG. 131.

Figure 131 shows the bottom of the fresh-air shaft *A*, with its outlets. *O O* are the ice-racks; *P P*, iron drip-pans. *S S* are waste-pipes; *D D*, doors.

Figure 132 is a perspective view from *Y*, Fig. 130, of the chamber *D*, two sides of which are composed of radiators *H H*. *U* is the steam supply and *V* the drip pipe.

Figure 133 is a section at *z z* Fig. 130 showing the inlet to the blower and the check valve *F*, which opens with the blast but closes against

# NEW YORK MUSIC HALL



back pressure. The air is drawn out from the hall by a separate fan system, being taken from or near the floor levels, and carried in a shaft to the roof where the exhaust fans are located. It will be seen that this

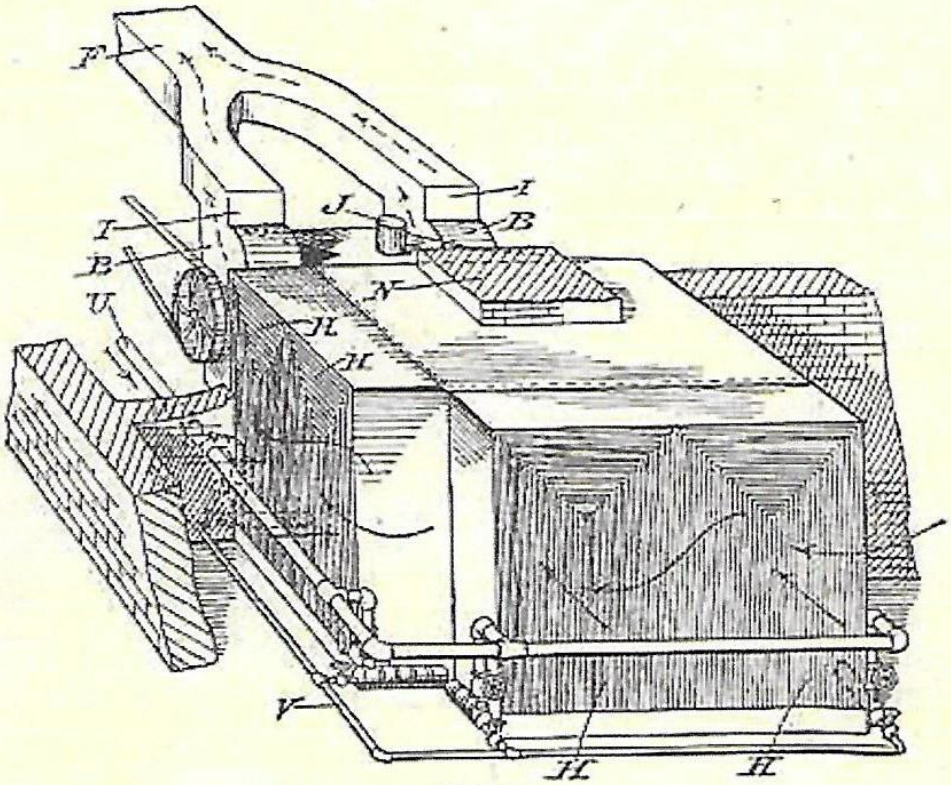



FIG. 132.

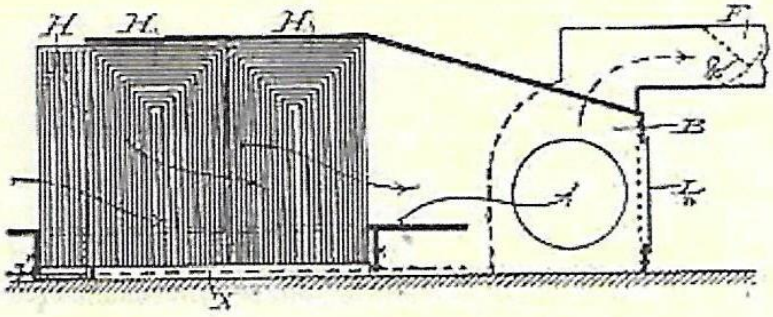
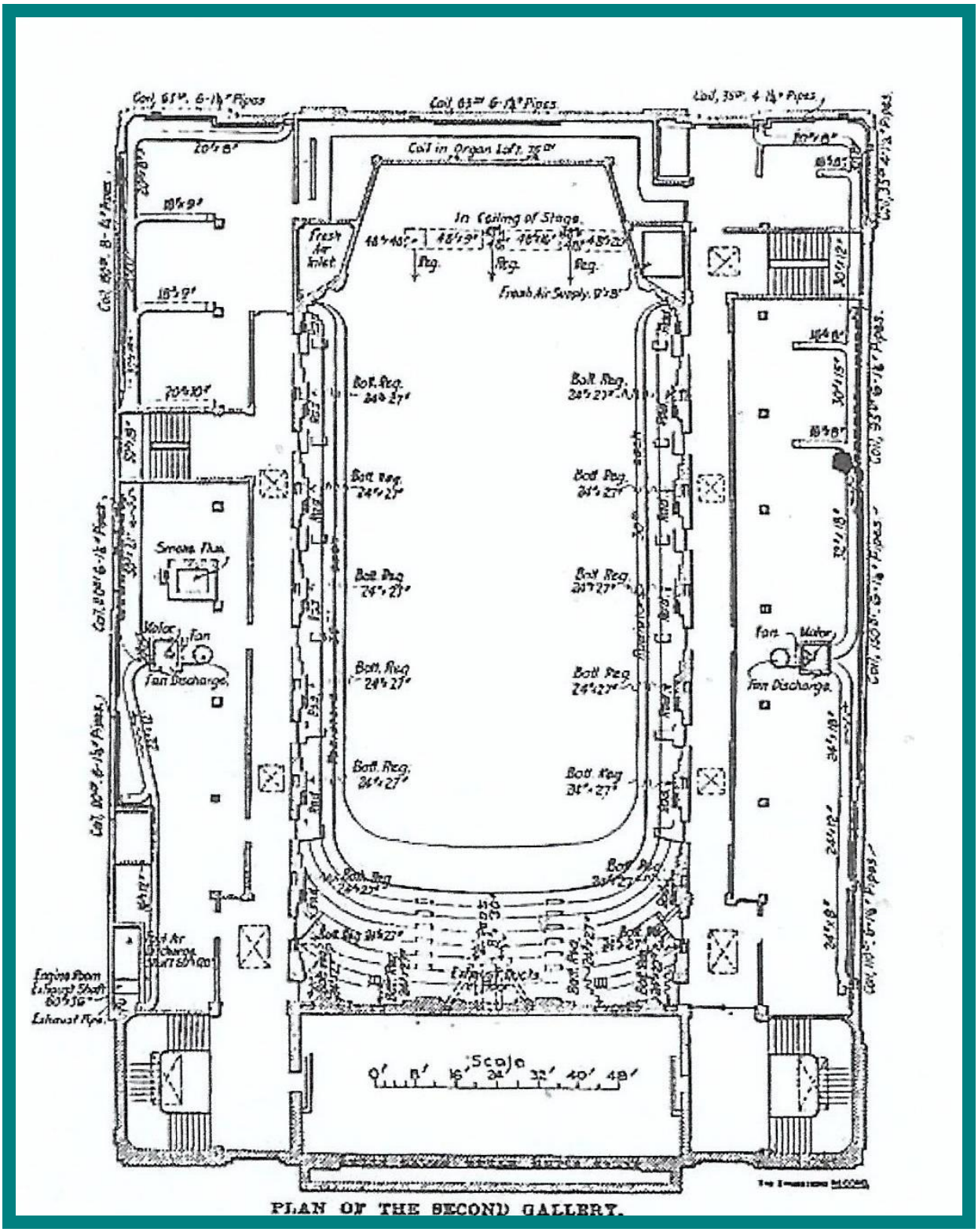



FIG. 133.

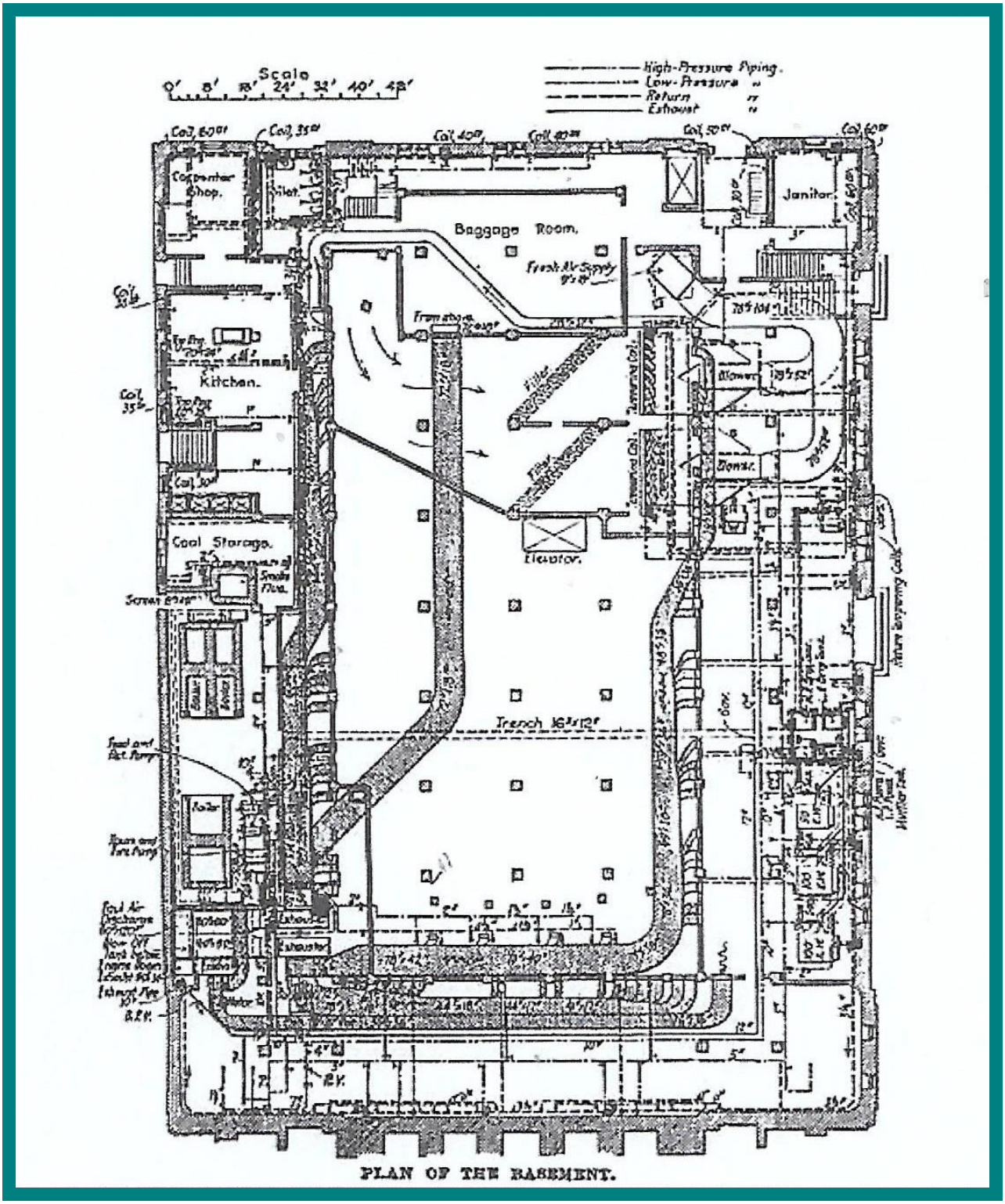
is a system of downward ventilation, the efficiency of which can only be maintained by a considerable expenditure for power.

# SYMPHONY HALL, BOSTON



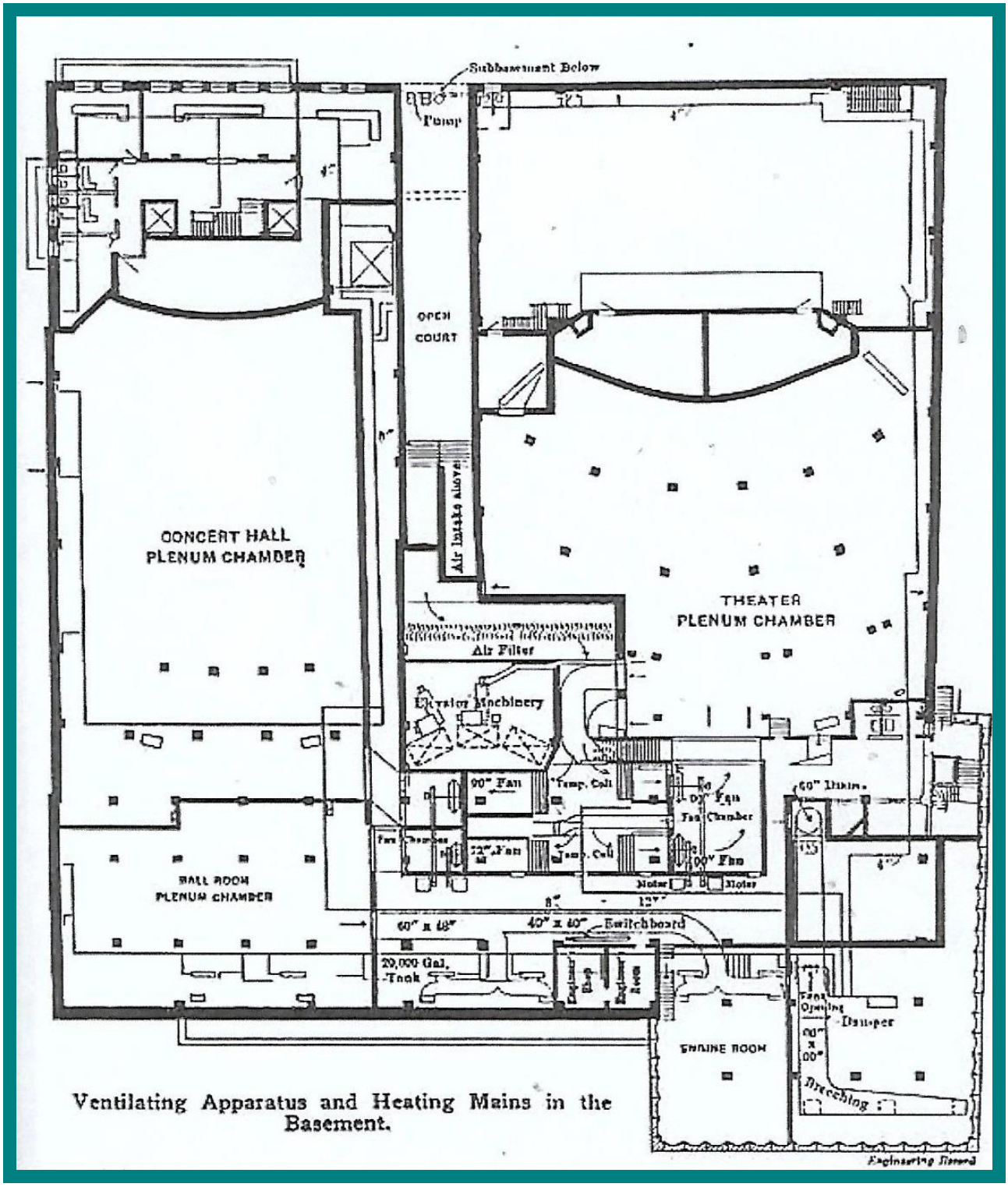

PLAN OF THE SECOND GALLERY.

# SYMPHONY HALL, BOSTON



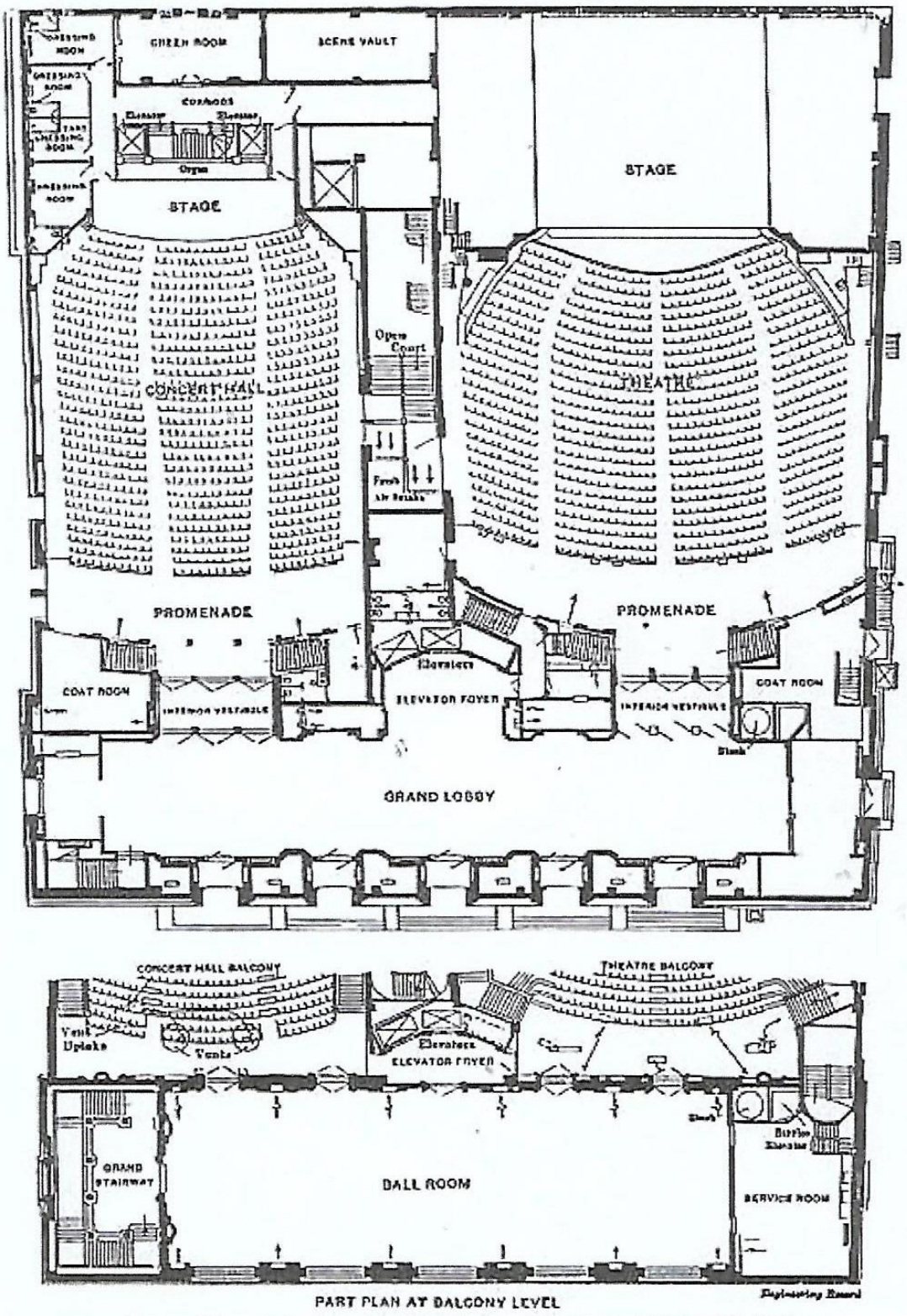

PLAN OF THE BASEMENT.

# NEW YORK ACADEMY OF MUSIC




**(Drawings on pages 12 & 13 from Engineering Record, 1908)**

# NEW YORK ACADEMY OF MUSIC




Ground Floor Plan of the Brooklyn Academy of Music and Plan of Ball Room.

# DAVIDSON PATENT 681,389
# FAN 1901

No. 681,389. Patented Aug. 27, 1901.

S. C. DAVIDSON.

CENTRIFUGAL FAN.

(Application filed Dec. 10, 1900.)

(No Model.)

FIG. 2.

FIG. 1.

WITNESSES:
Jno. White
Thomas F. Wallace

INVENTOR:
Samuel Cleland Davidson,
By Attorneys,
Dustin & Fraser & Co

# CARRIER PATENT 854,270
# HUMIDIFIER 1907

No. 854,270. PATENTED MAY 21, 1907.

W. H. CARRIER.

METHOD OF HEATING AND HUMIDIFYING AIR.

APPLICATION FILED JULY 16, 1906.

2 SHEETS—SHEET 1.

Fig. 1.

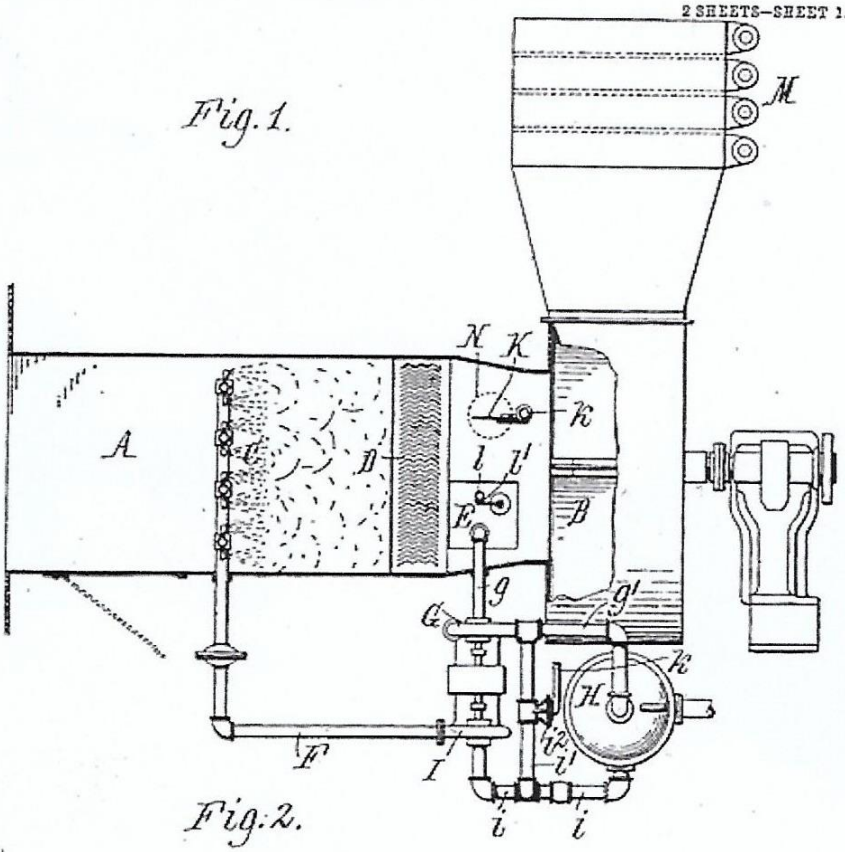
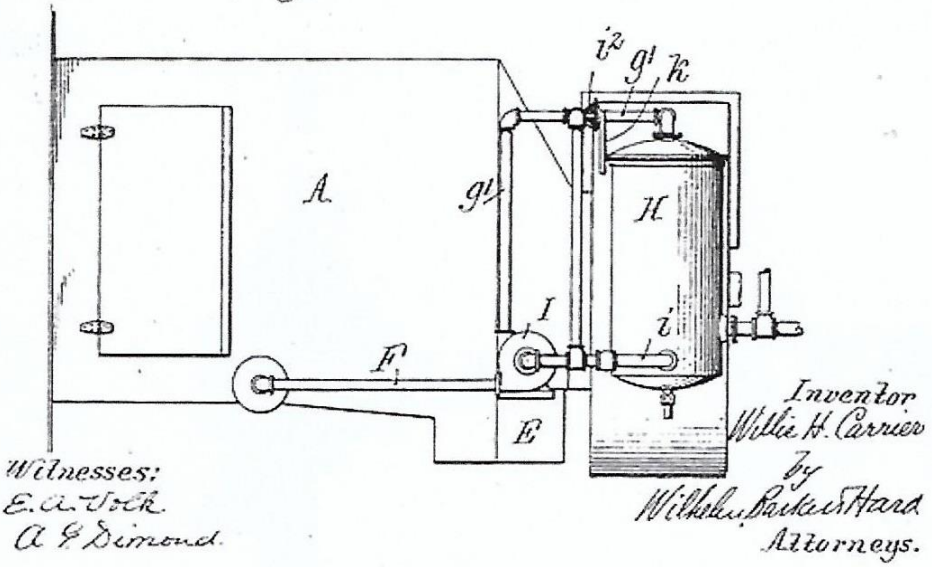


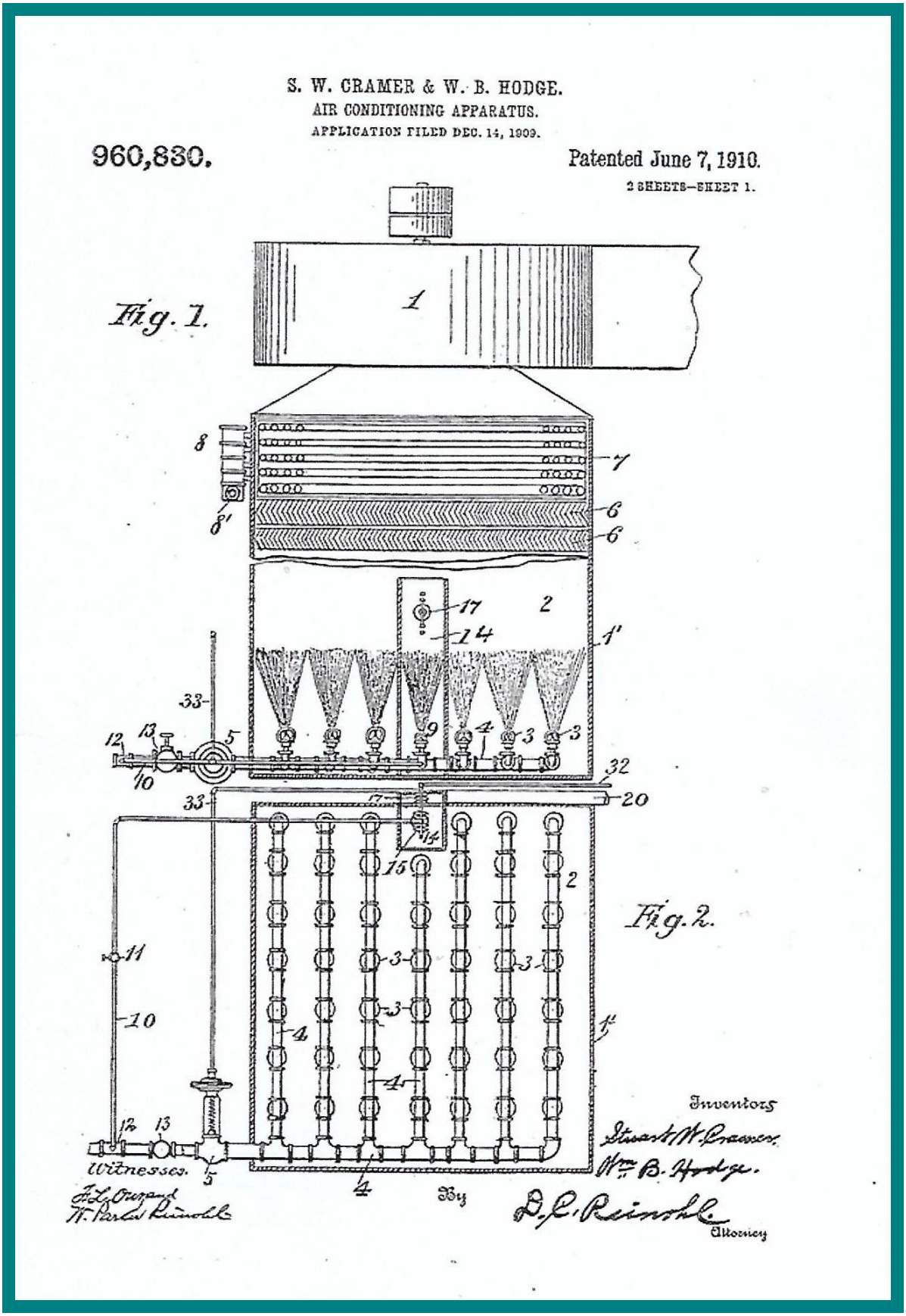

Fig. 2.




Witnesses:
E. A. Tock.
A. F. Dimond.

Inventor
Willis H. Carrier
by
Wilkes, Packard & Hard
Attorneys.

# CRAMER & HODGE PATENT 960,830 AIR CONDITIONING APPARATUS 1910



S. W. CRAMER & W. B. HODGE.
AIR CONDITIONING APPARATUS.
APPLICATION FILED DEC. 14, 1909.

960,830. Patented June 7, 1910.

2 SHEETS—SHEET 1.

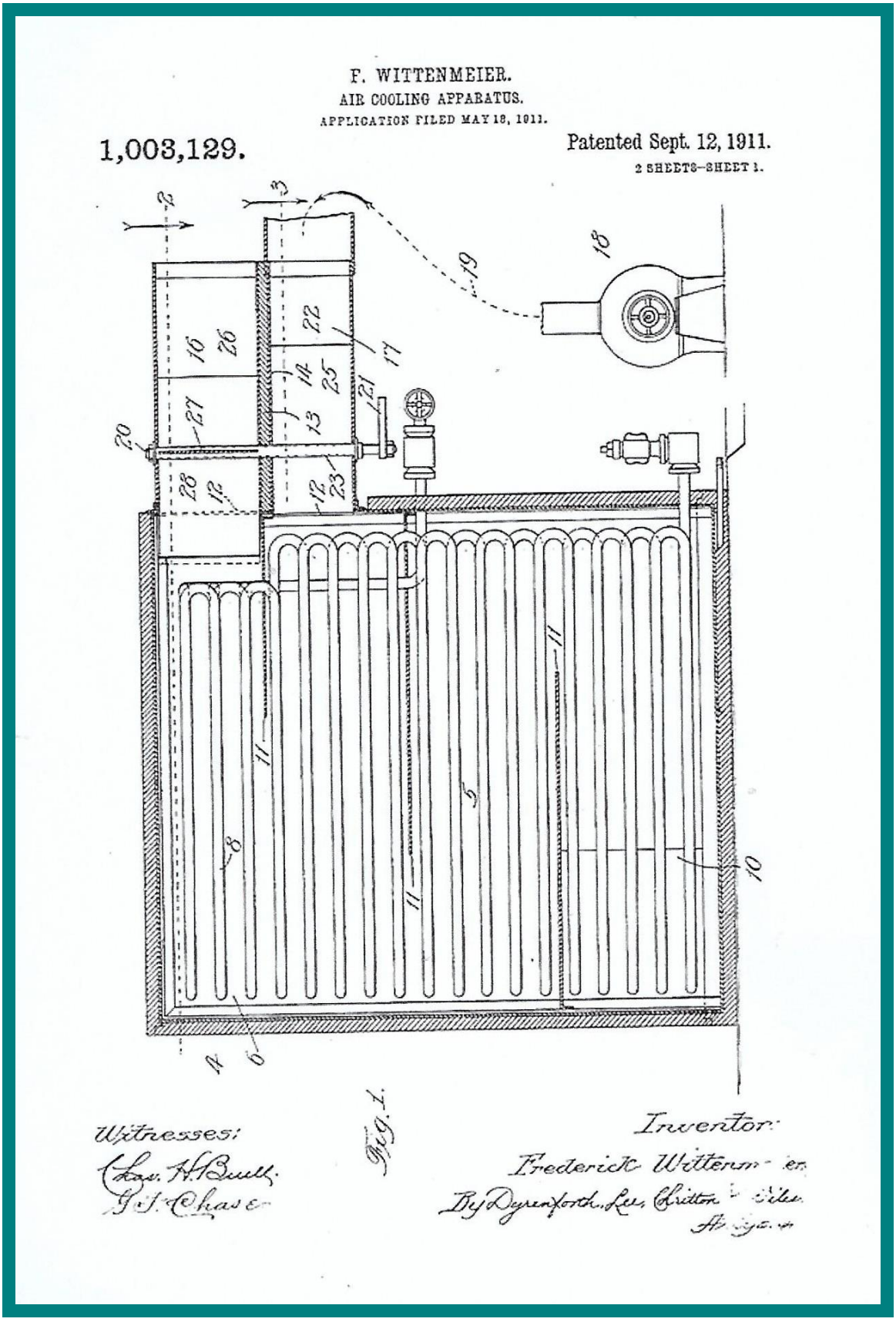
Fig. 1.

Fig. 2.

Witnesses.
F. L. Ouyard
H. Parker Reinhold

Inventors
Stuart W. Cramer.
Wm. B. Hodge.
By D. P. Reinhold
Attorney

# WITTENMEIER PATENT 1,003,129
# AIR CONDITIONING APPARATUS 1911



F. WITTENMEIER.
AIR COOLING APPARATUS.
APPLICATION FILED MAY 18, 1911.

1,003,129. Patented Sept. 12, 1911.

2 SHEETS—SHEET 1.

Fig. 1.

Witnesses:
Chas. H. Bull.
G. F. Chase

Inventor:
Frederick Wittenmeier
By Dyrenforth, Lee, Chritton & Giles
Attys.

# CARRIER PATENT 1,059,976
# PURIFIER & HUMIDIFIER 1913

W. H. CARRIER.

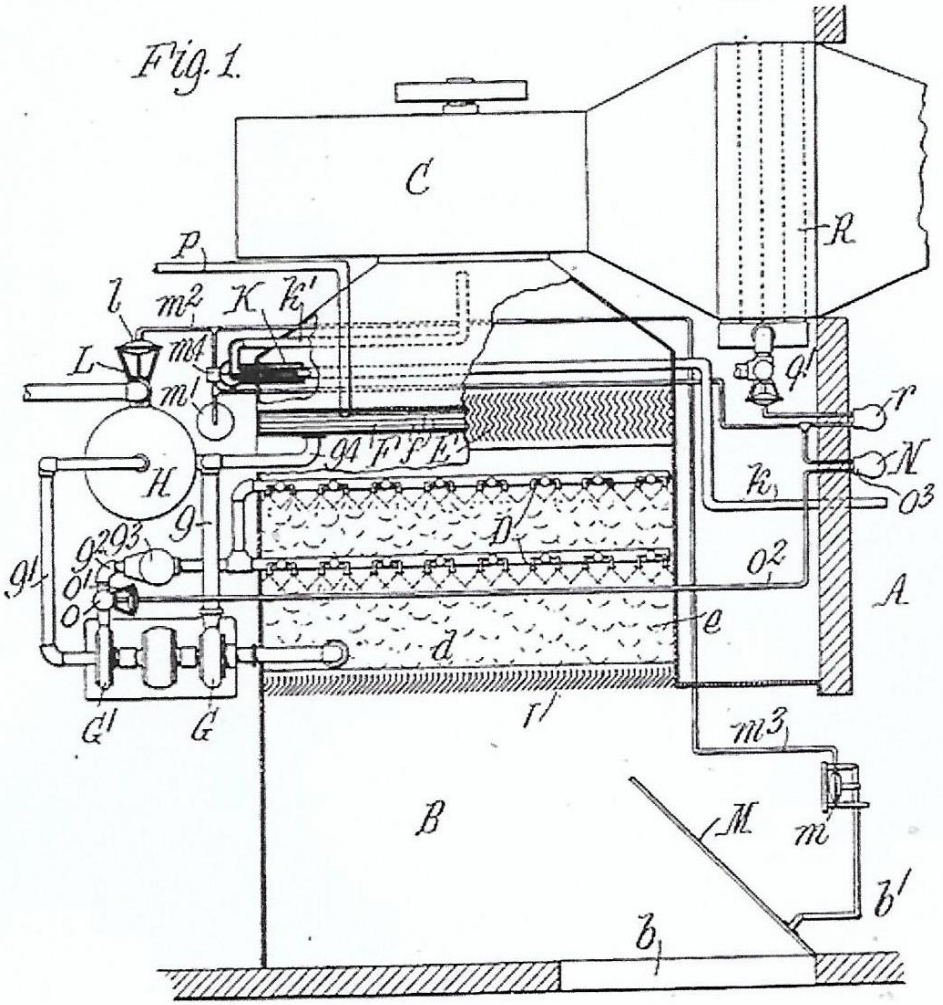
SYSTEM FOR PURIFYING, HUMIDIFYING, AND CONTROLLING THE HUMIDITY OF AIR.

APPLICATION FILED APR. 23, 1908.

1,059,976. Patented Apr. 29, 1913.

2 SHEETS—SHEET 1.

Fig. 1.




Witnesses:
E. A. Volk.
A. J. Dimond.

Inventor.
Willis H. Carrier,
By Wallace Barnes & Hazel
Attorneys.

# CARRIER PATENT 1,078,608
# AIR COOLING APPARATUS 1913

W. H. CARRIER.
AIR COOLING APPARATUS.
APPLICATION FILED JAN. 19, 1912.

1,078,608. Patented Nov. 18, 1913.

2 SHEETS—SHEET 1.

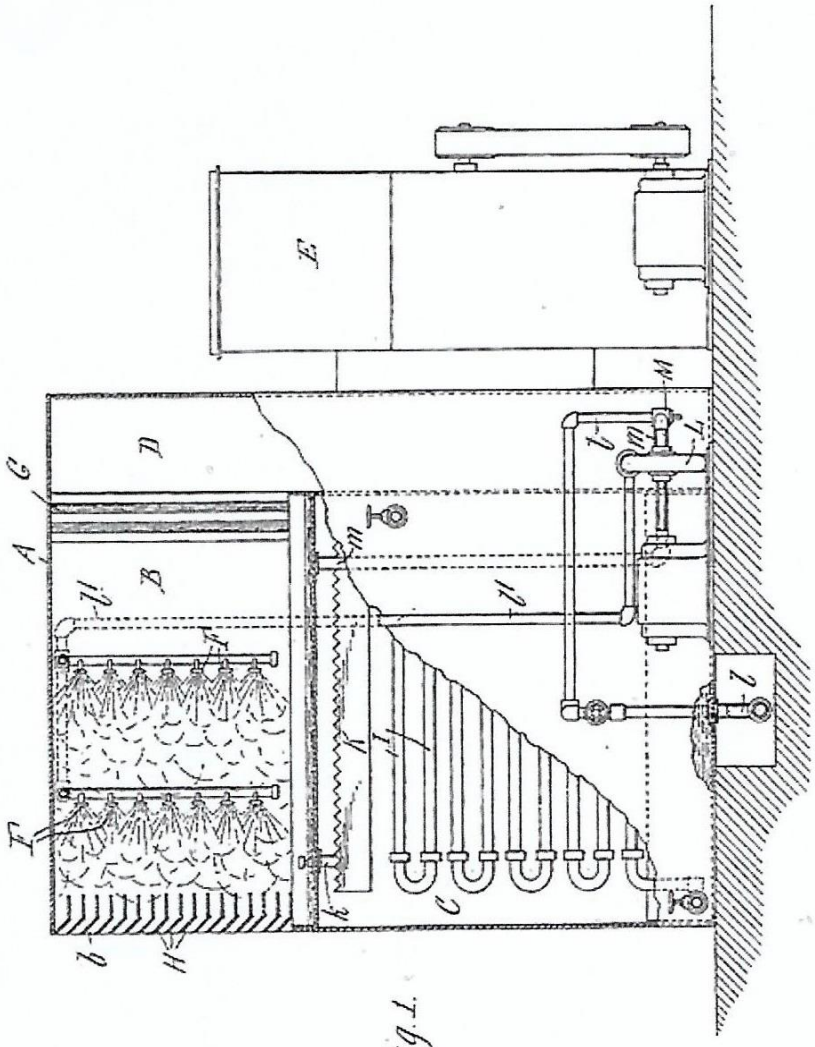
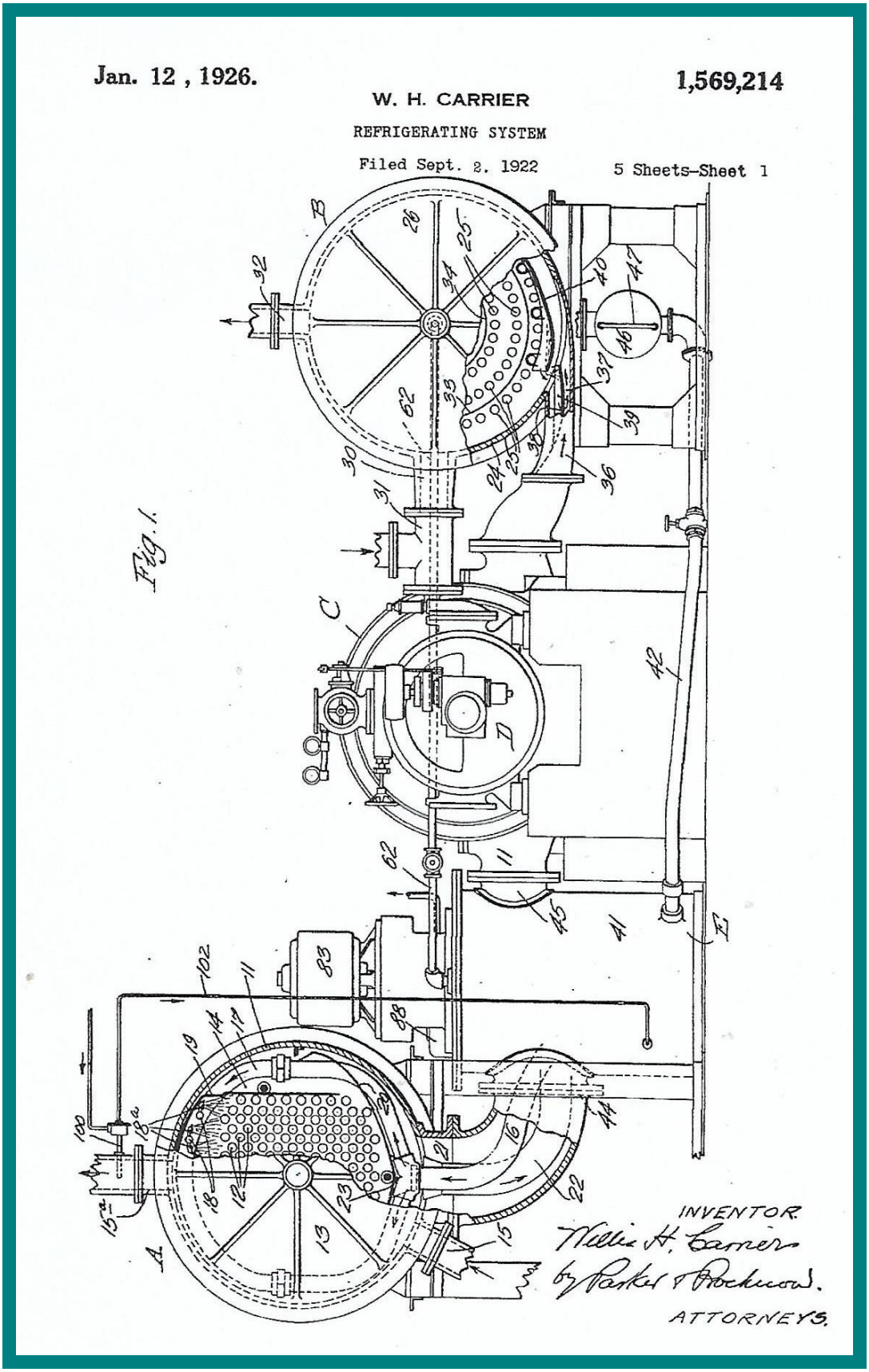



Fig. 1.

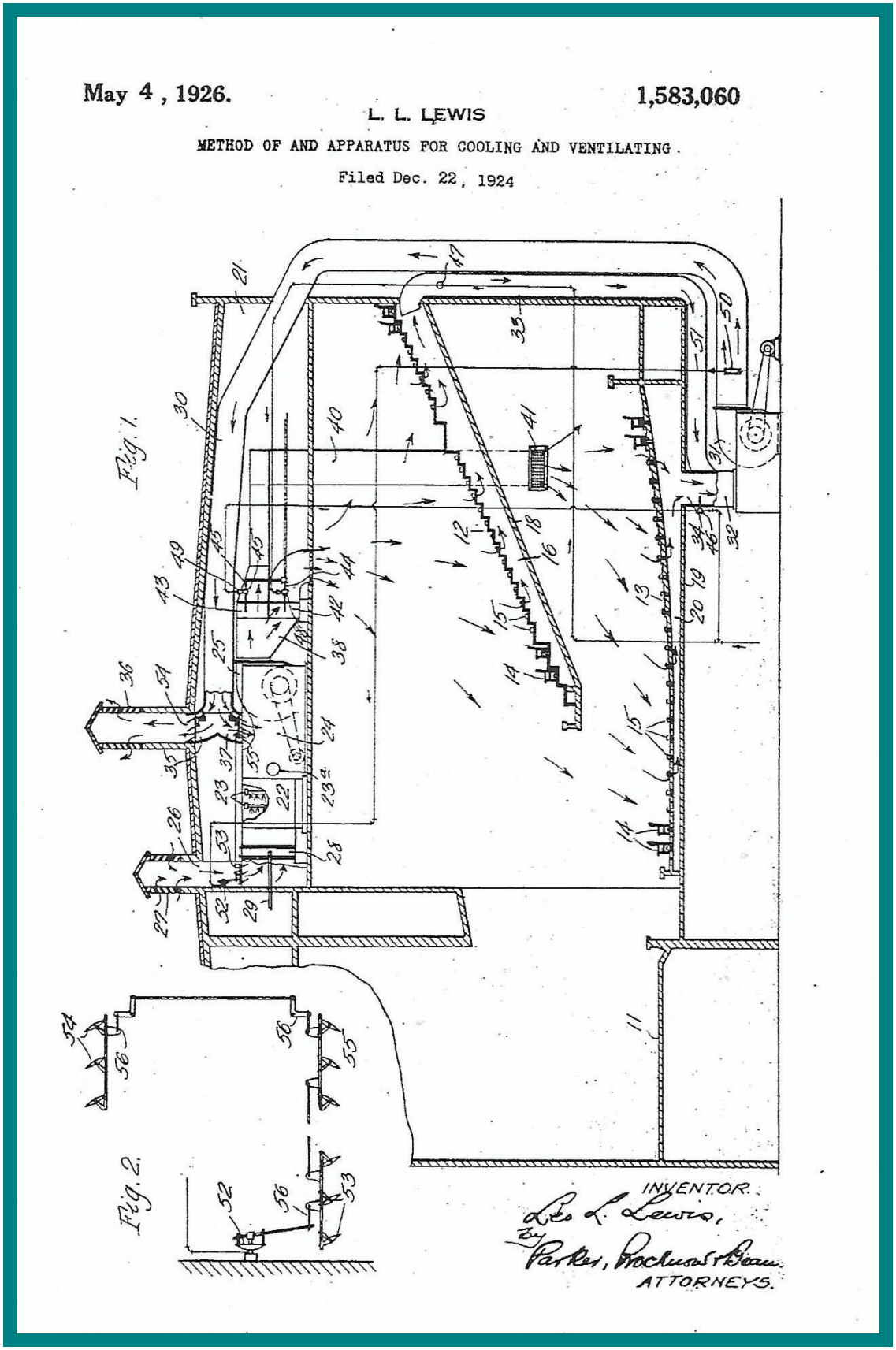
Witnesses
A. E. Dimond.
A. Borkenhagen

Inventor.
Willis H. Carrier.
By Wilhelm, Parker & Hardy
Attorneys.

# CARRIER PATENT 1,569,214
# REFRIGERATING SYSTEM 1926



# LEWIS PATENT 1,583,060
# COOLING & VENTILATING METHOD 1926



May 4, 1926. 1,583,060

L. L. LEWIS

METHOD OF AND APPARATUS FOR COOLING AND VENTILATING

Filed Dec. 22, 1924

Fig. 1.

Fig. 2.

INVENTOR.
Leo L. Lewis,
By Parker, Prochnow & Beam.
ATTORNEYS.

# CARBON DIOXIDE REFRIGERATION

## It was adopted as a SAFE refrigerant for COMFORT COOLING in occupied spaces as Ammonia, the refrigerant then in common use for ice-making and cold stores, was toxic and unsuitable.

**It began in the Chicago Movie Theatres of Balaban & Katz. Other theatre chains and other manufacturers followed- The York Ice Machinery Company using carbon dioxide machines and then the Carrier Engineering Corporation with their large cooling capacity, centrifugal water chiller, using safe refrigerants, first dielene, then trichloroethylene, and finally "Freon."**

The idea of carbon dioxide (also known as carbonic acid gas and carbonic anhydride) refrigeration systems can be traced back to the American civil engineer and professor Alexander Catlin Twining (who advanced the earlier work of Evans, Perkins and Hague) by building a vapour-compression ice-making plant in 1853, based on his US Patent 10,221 of 1853. The claim in his earlier British Patent, BP 13,167: 1850, that he invented the vapour-compression process itself proved to be insupportable. The American Civil War prevented Twining's efforts to make ice in the South.

During the 1850s, James Harrison, a Scotsman working in Australia, also obtained a number of British Patents for his machines, though he first used ether as a refrigerant.

Another early pioneer was Carl von Linde who experimented with carbon dioxide when in 1882 he designed a machine for Krupps in Essen, Germany. (Linde preferred and developed ammonia machines).

Raydt received BP 15475:1884 for a compression ice-making system using carbon dioxide.

The breakthrough came when Franz Windhausen of Germany designed a carbon dioxide compressor and obtained BP 2864: 1866 which was purchased and improved upon by J & E Hall and found widespread application for refrigerated cargo ships.

### THE KROESCHELL BROS ICE MACHINE COMPANY

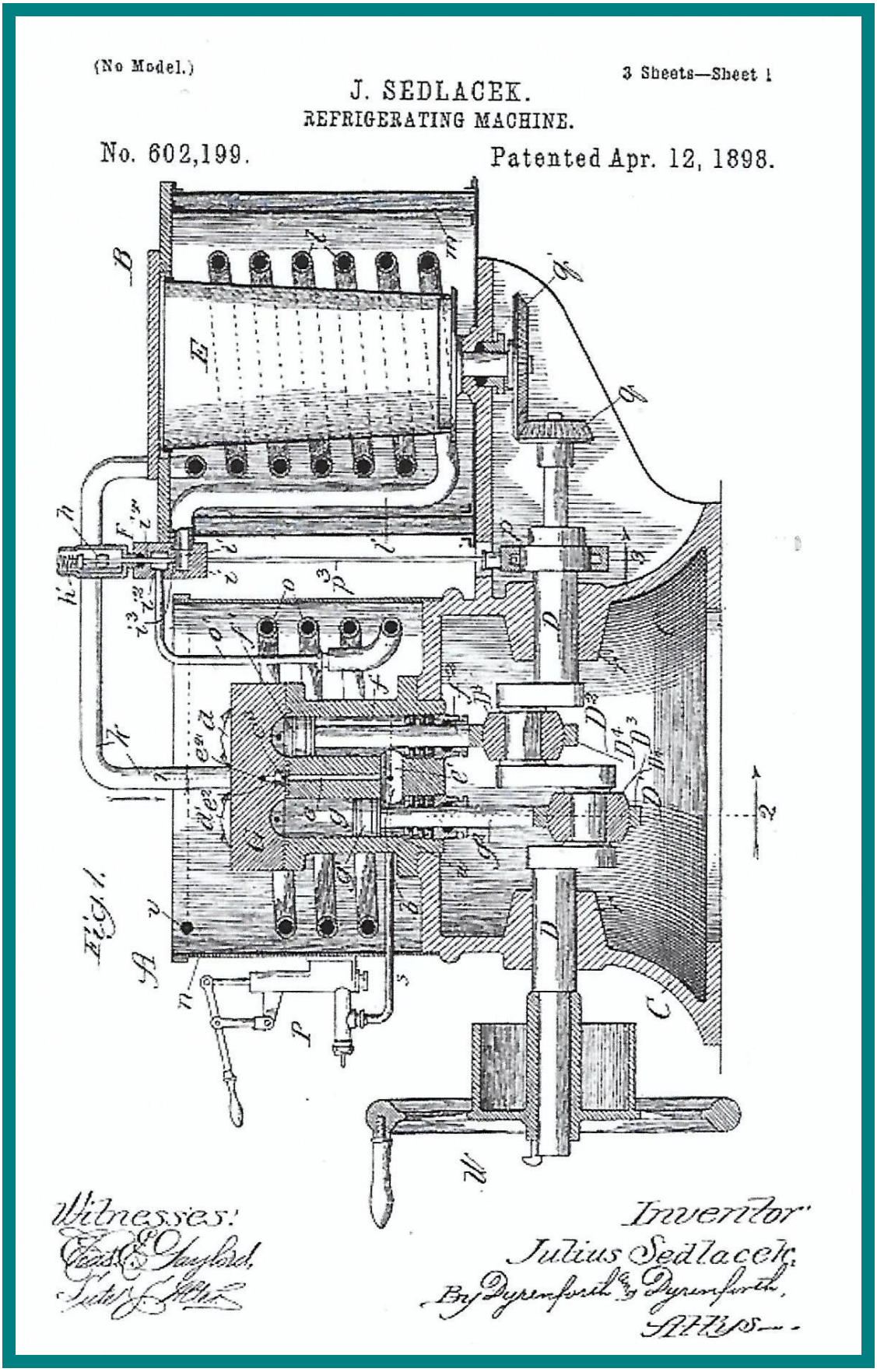
In 1896, Frederick Wittenmeier joined Kroeschell Bros who, at the time, were in the boiler manufacturing and steam-fitting business. .

It was in Chicago that carbon dioxide refrigeration was developed by Wittenmeier and the Kroeschell Bros using patents purchased from the Hungarian Julius Sedlacek. Wittenmeier experimented with $CO_2$ ice machines and this developed into a successful business leading to the formation of the Kroeschell Bros Ice Machinery Company in 1897 with Wittenmeier as Chief Engineer, leading in turn to the application of air conditioning for movie theatres.

"At that time (1900) the carbonic machine was commercially unknown in this country (USA) and much of the credit for its successful development to the present time must be given to him (Wittenmeier)."

**Brunswick-Kroeschell, in their advertising, list as "cooled" by them, a number of Chicago theatres. These listings include movie theatres where the air conditioning is said to have been provided by the Wittenmeier Machine Company but it possible that Kroeschell Brothers (before forming the joint company with Brunswick in 1924) supplied the $CO_2$ refrigerating plant. Fred Wittenmeier was the Chief Engineer for Kroeschell before setting up his own company in 1917. Wittenmeier is credited with providing the first ever air conditioning (a spray washer with an integral direct expansion refrigerant coil) for a theatre, this being the Central Park Theatre in Chicago in 1917. The Central Park was part of the Balaban & Katz chain who became pioneers in adopting air conditioning for the theatres which they owned.**

# SEDLACECK PATENT 602,199
# CARBON DIOXIDE MACHINE 1898


(No Model.) 3 Sheets—Sheet 1.

J. SEDLACEK.

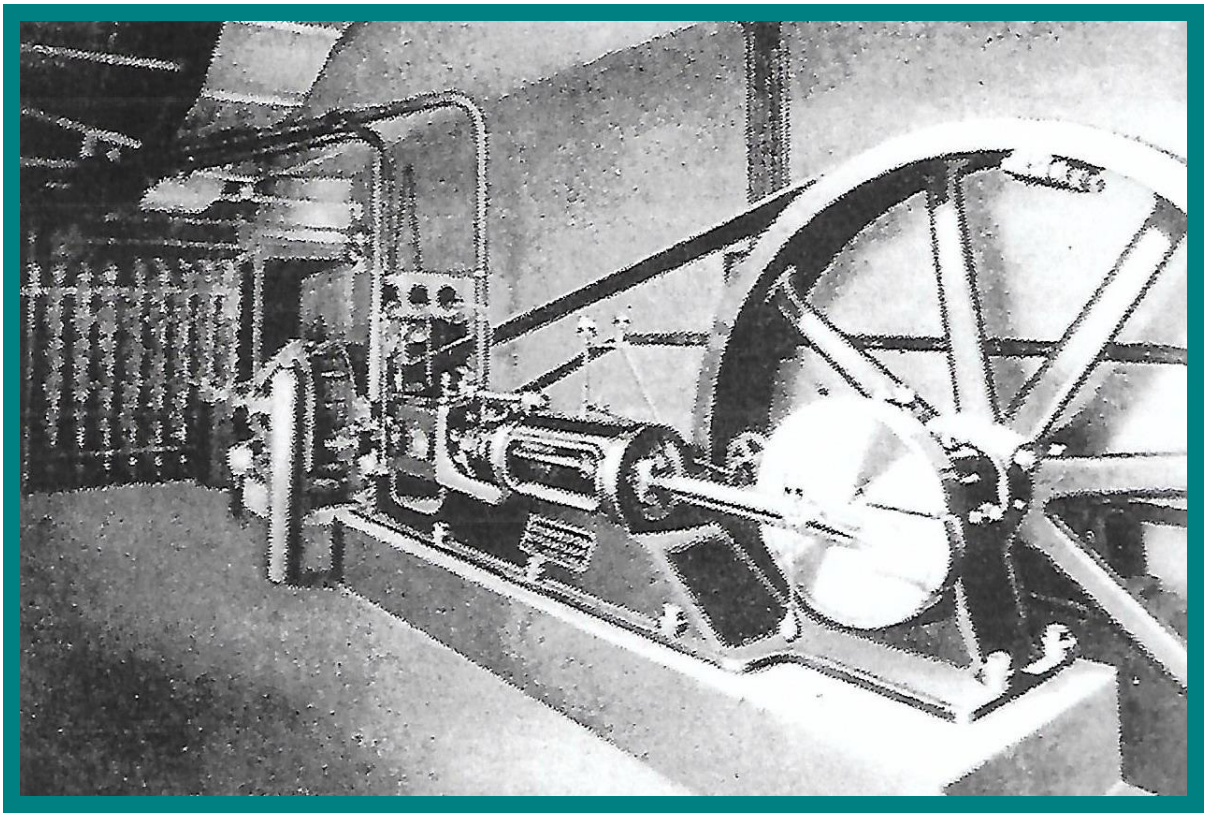
REFRIGERATING MACHINE.

No. 602,199. Patented Apr. 12, 1898.

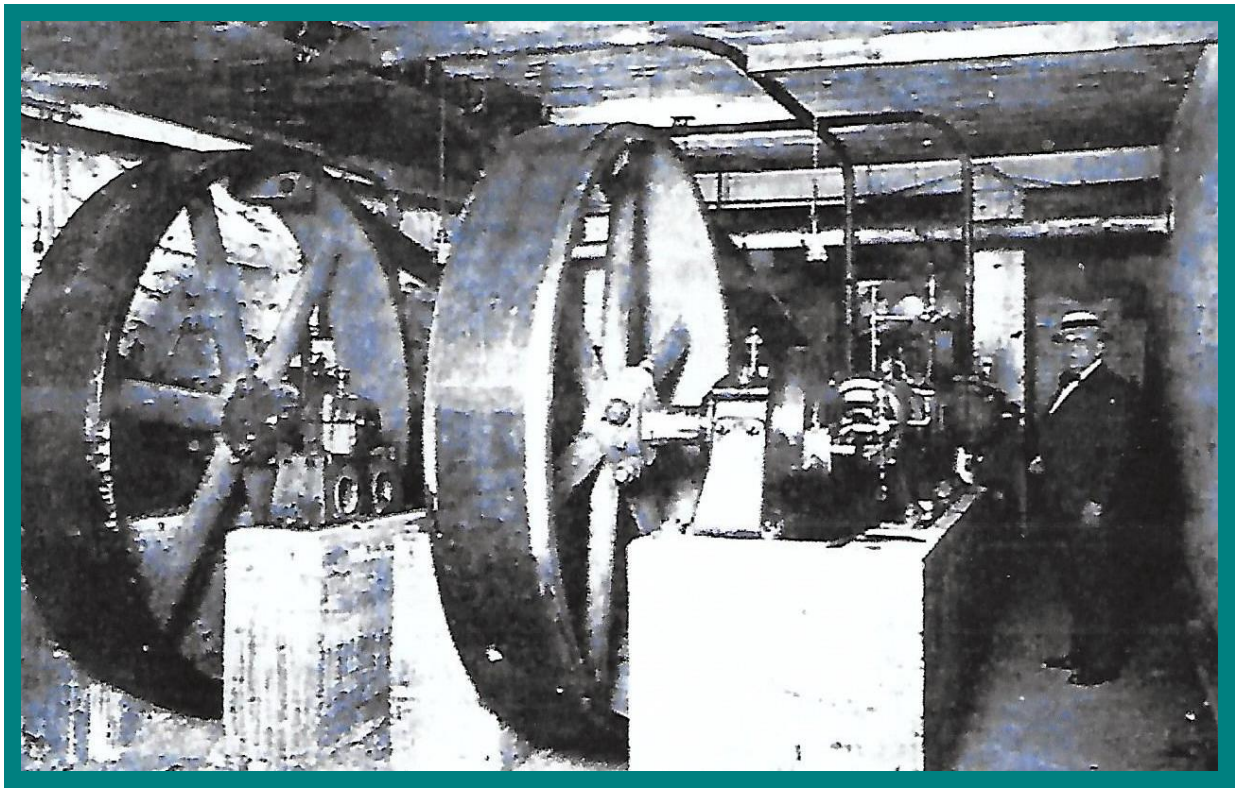
Fig. 1.

Witnesses:
Chas. E. Gaylord.
Inventor:
Julius Sedlacek,
By Dyrenforth & Dyrenforth,
Attys.

# KROESCHELL BROS. ICE MACHINE CO.
## AND SUCCESOR COMPANIES



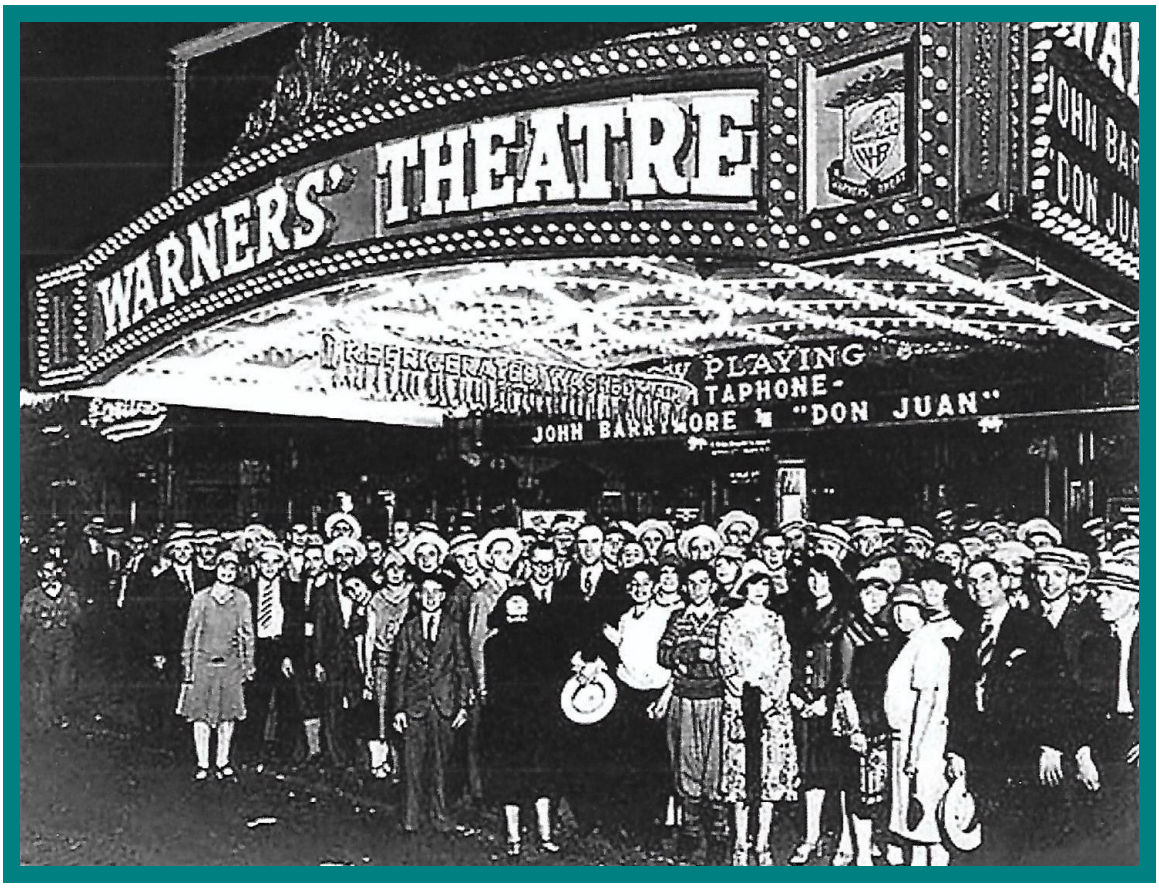
**$CO_2$ machine at the Central Park Theatre in Chicago (1780 seats) opened in 1917.**



**$CO_2$ machine at the Davis Theatre in Pittsburgh (2100 seats) opened in 1925.**
**Note the characteristic huge flywheels.**

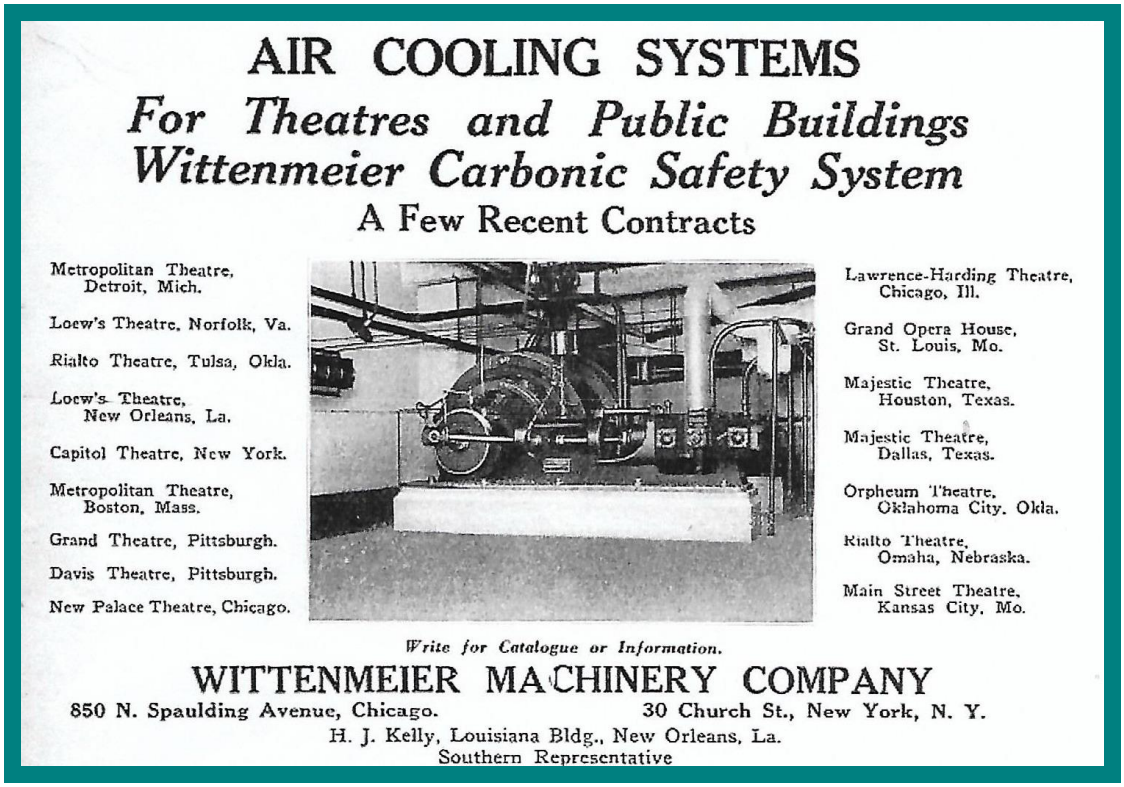
# KROESCHELL & WITTENMEIER


**Roosevelt Theatre (1535 seats), Chicago 1921 air conditioned with $CO_2$ refrigeration.**

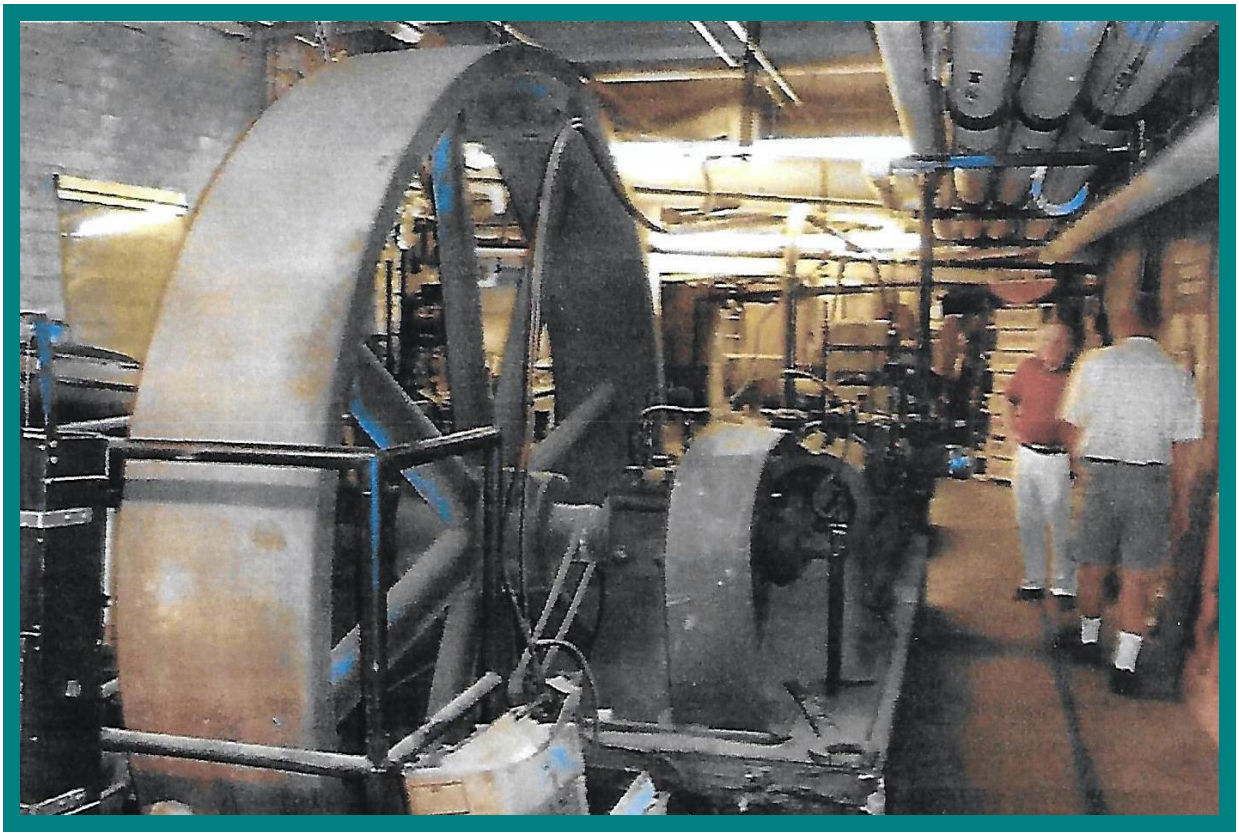



**Warner Theatre (1322 seats), New York in 1926, premiere of first film with pre-recorded musical soundtrack, with Wittenmeier "Refrigerated washed air" (sign under canopy, complete with icicles). The first talkie "The Jazz Singer" followed in 1927.**

# WITTENMEIER MACHINERY COMPANY

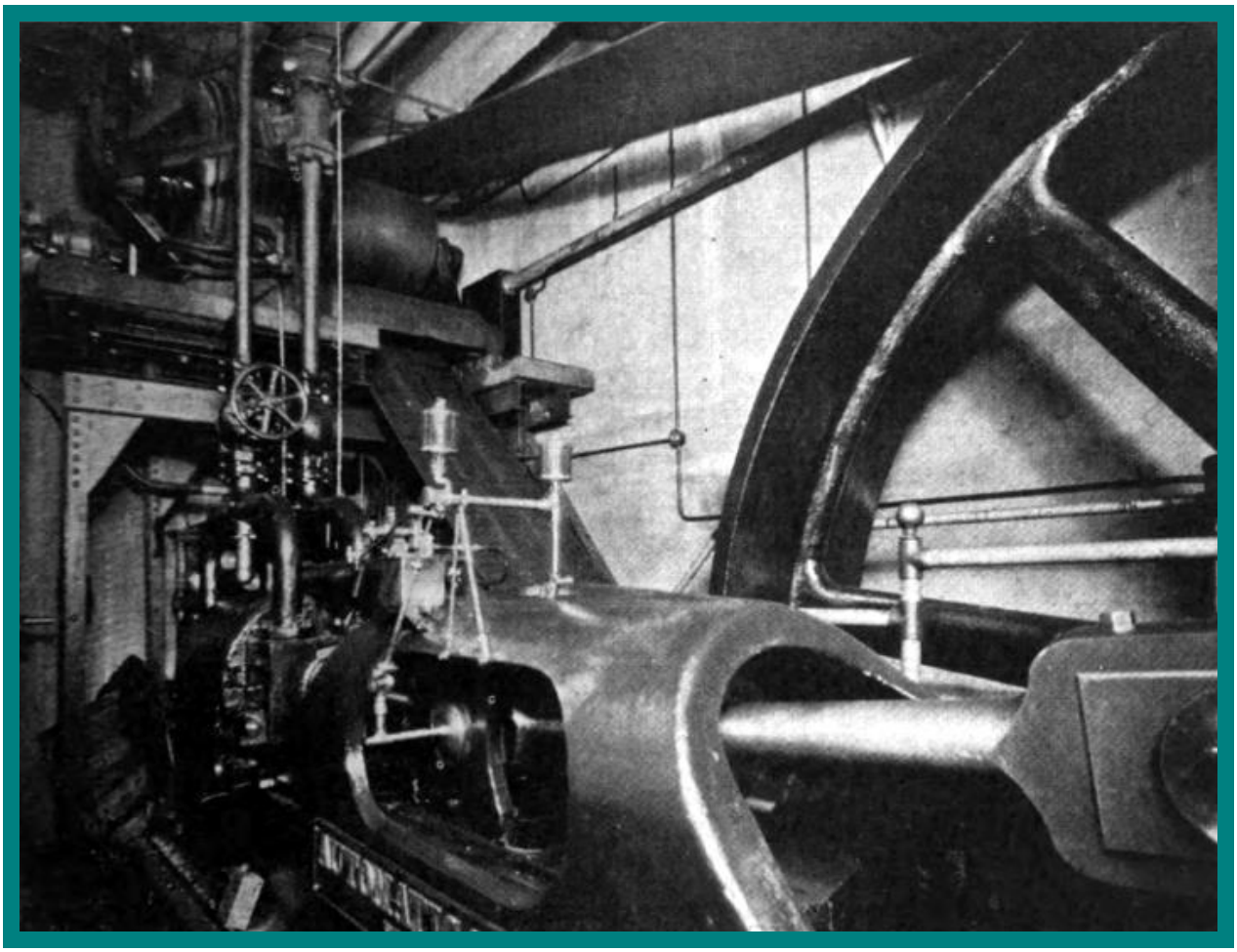



**Wittenmeier "Air Cooling" installations with carbon dioxide refrigeration.**



**Wittenmeier $CO_2$ compressor at the Orpheum Theatre in Minneapolis, installed in 1921.**
**A detailed survey with photographs was carried out by Bern Nagengast, ASHRAE Historical Committee in August 2006 and is available on the ASHRAE website.**

# KROESCHELL & WITTENMEIER



**150 TR $CO_2$ machine installed in Chicago's Tivoli Theatre (3520 seats) in 1921. The system had a large chilled water storage tank made up in off-peak hours.**

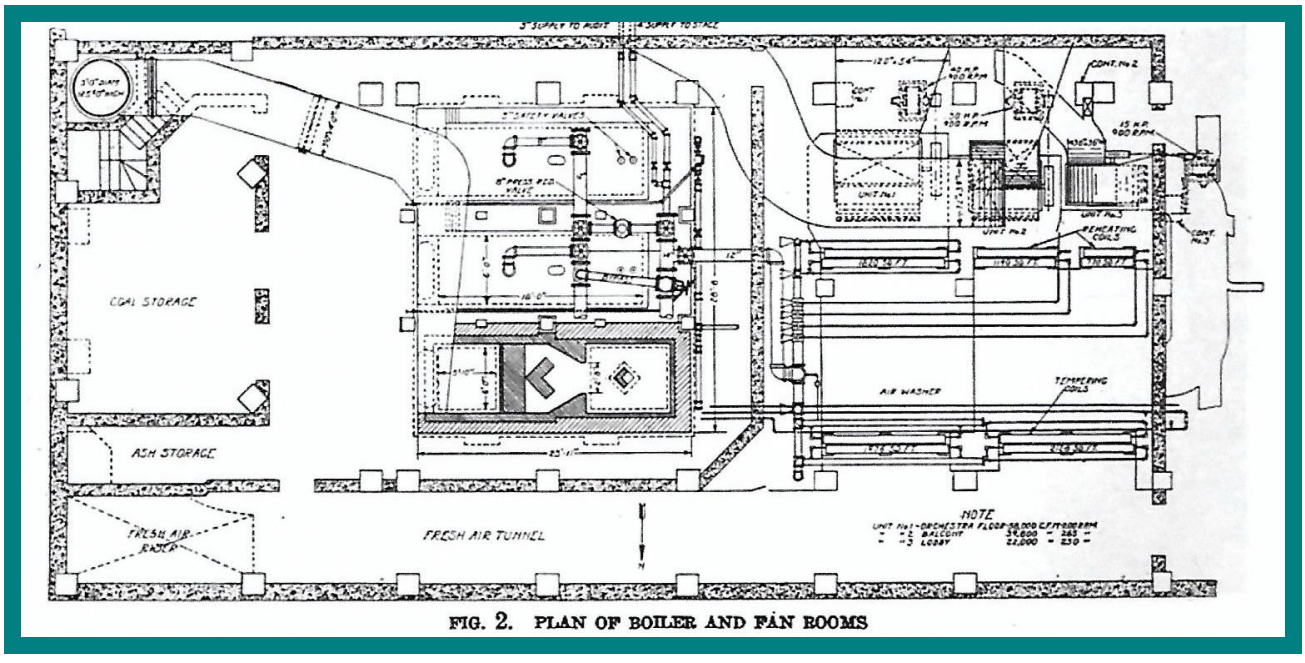
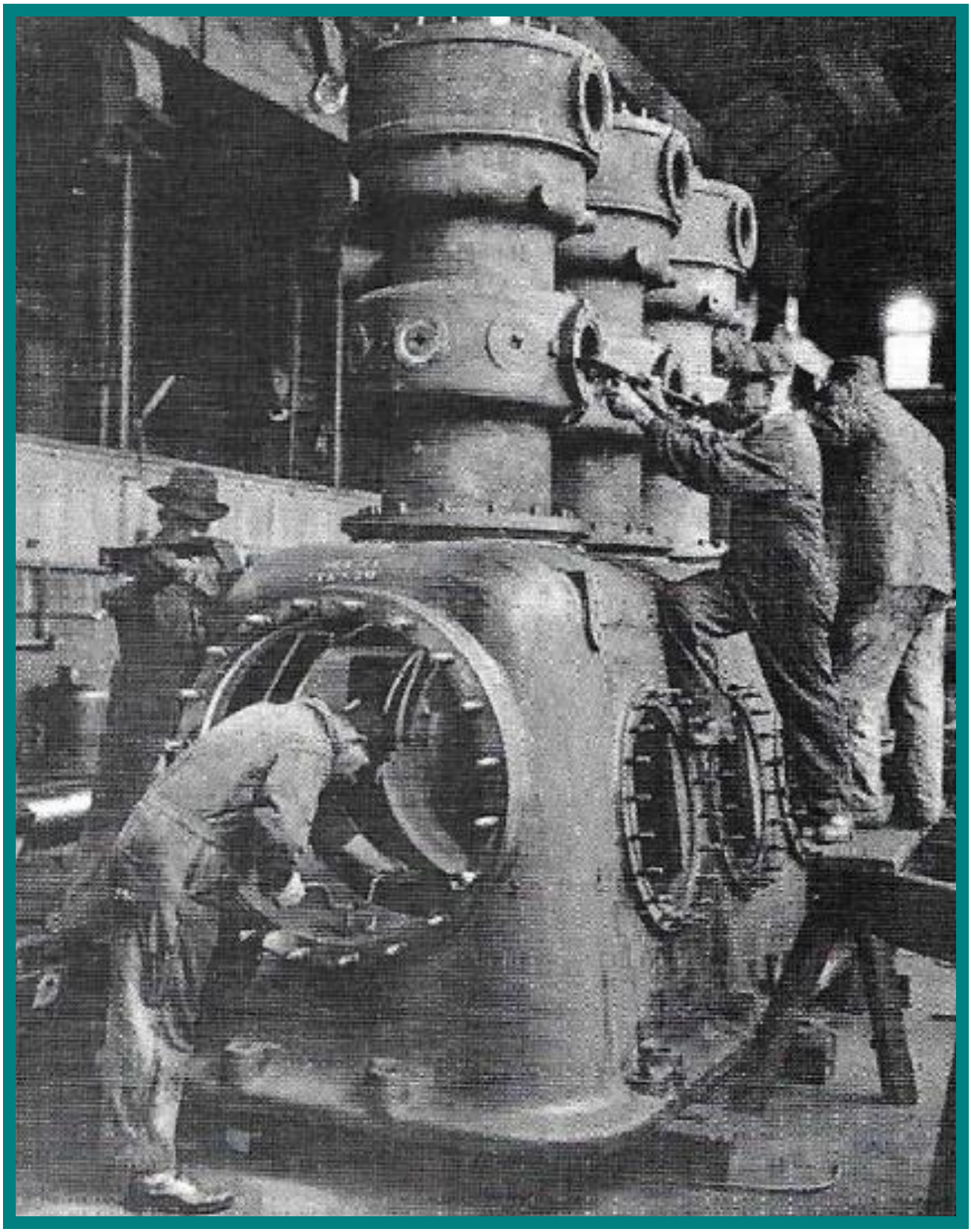



FIG. 2. PLAN OF BOILER AND FAN ROOMS

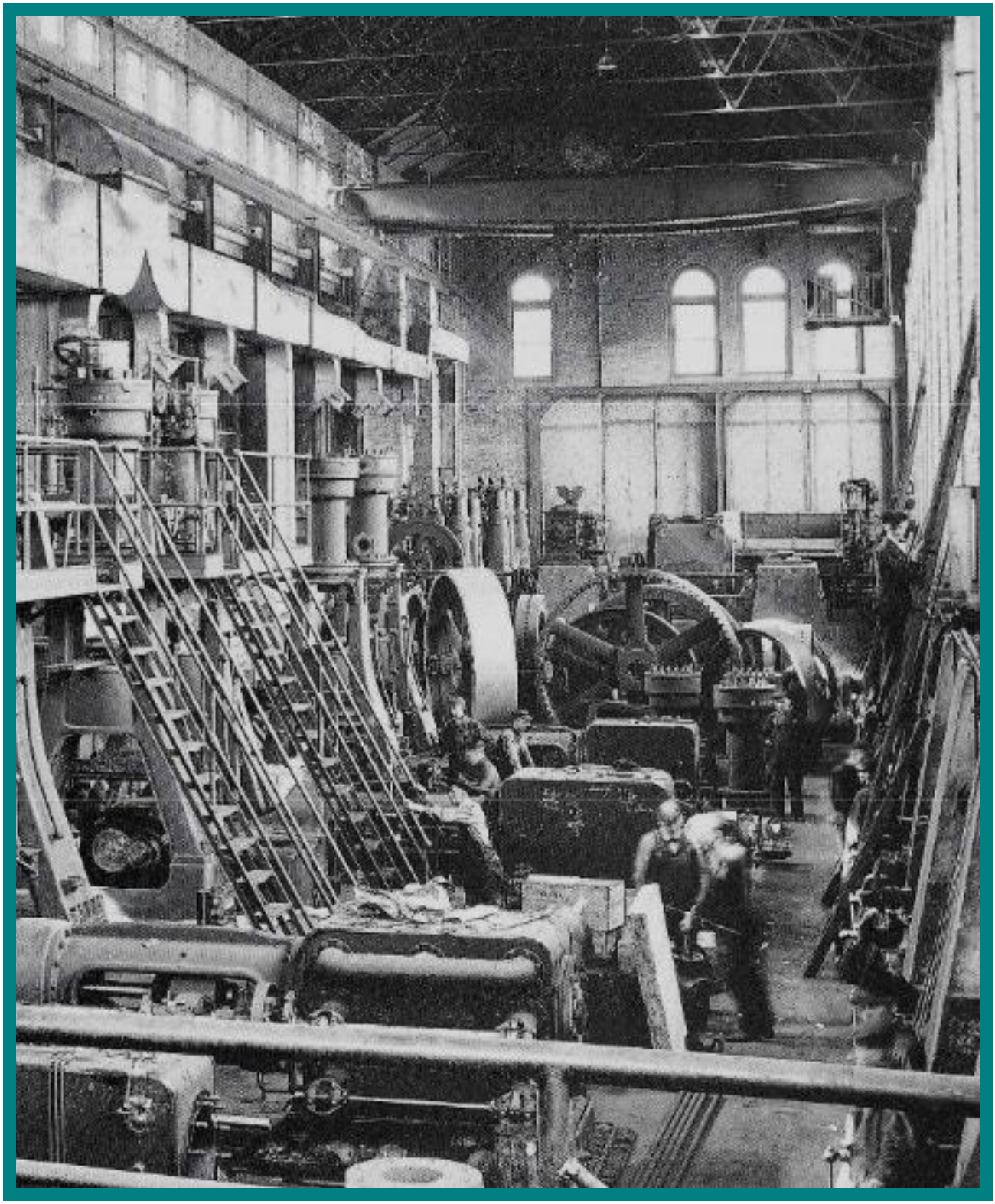
**Plan of Boiler and Fan Rooms showing Fresh Air Tunnel, Coal and Ash storage.**

# YORK ICE MACHINERY CORPORATION
## ALSO YORK MANUFACTURING COMPANY



**Building a giant ice-making machine at York.**

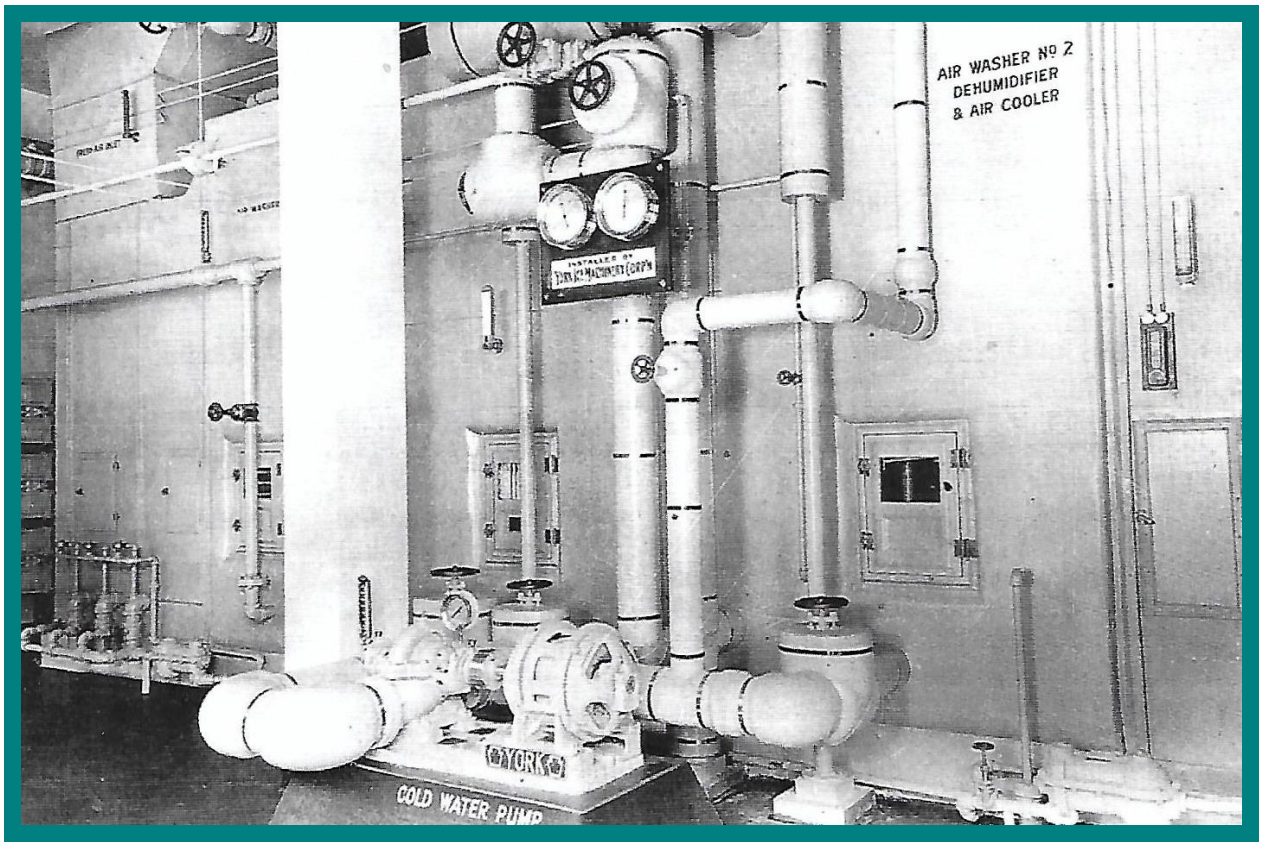
# YORK ICE MACHINERY CORPORATION



**The Engineering Department of the Large Machine Shop, c.1911.**

# YORK ICE MACHINERY CORPORATION

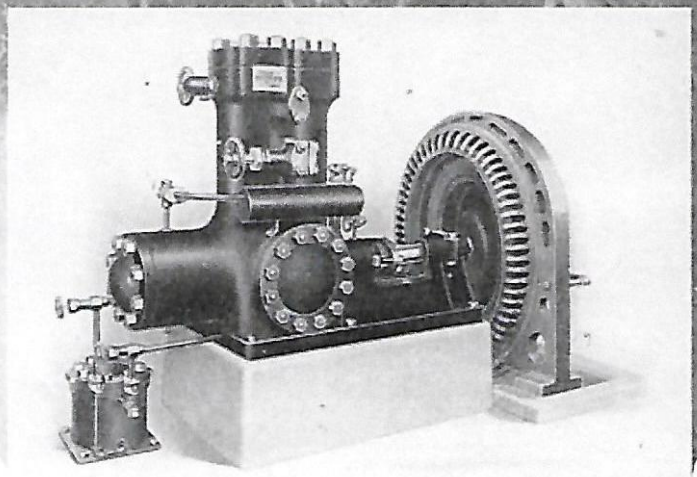
**The Engineering Department at York in 1902.**




**York chilled water spray washer in Fox Theatre, Spokane, Washington 1932.**

# YORK ICE MACHINERY CORPORATION





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### *Let the world's largest Organization of Refrigerating Engineers guarantee your results*

You can count on increased box-office receipts during those five months of torrid summer weather—more profitable business than during winter.

Your townfolks will flock to your theatre as a haven of relief—for a really enjoyable two or three hours. The World's Largest Organization of Refrigerating Engineers, specializing in all applications of mechanically produced refrigeration, stands ready to guarantee to make your theatre cool, comfortable and inviting during the hottest weather.

The York Manufacturing Company commands your confidence—backed by years of success in controlling temperature under every condition, the world over.

There is a service branch of the York Manufacturing Company in your territory. Mail the attached coupon and one of our engineers will gladly and without obligation on your part, consider your problems.

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YORK MFG. CO.,
York, Pa.

The subject of controlled temperatures for theatres is of interest to me. Please have one of your Engineers discuss this with me. There is no obligation on my part.

*Name of Theatre* .....

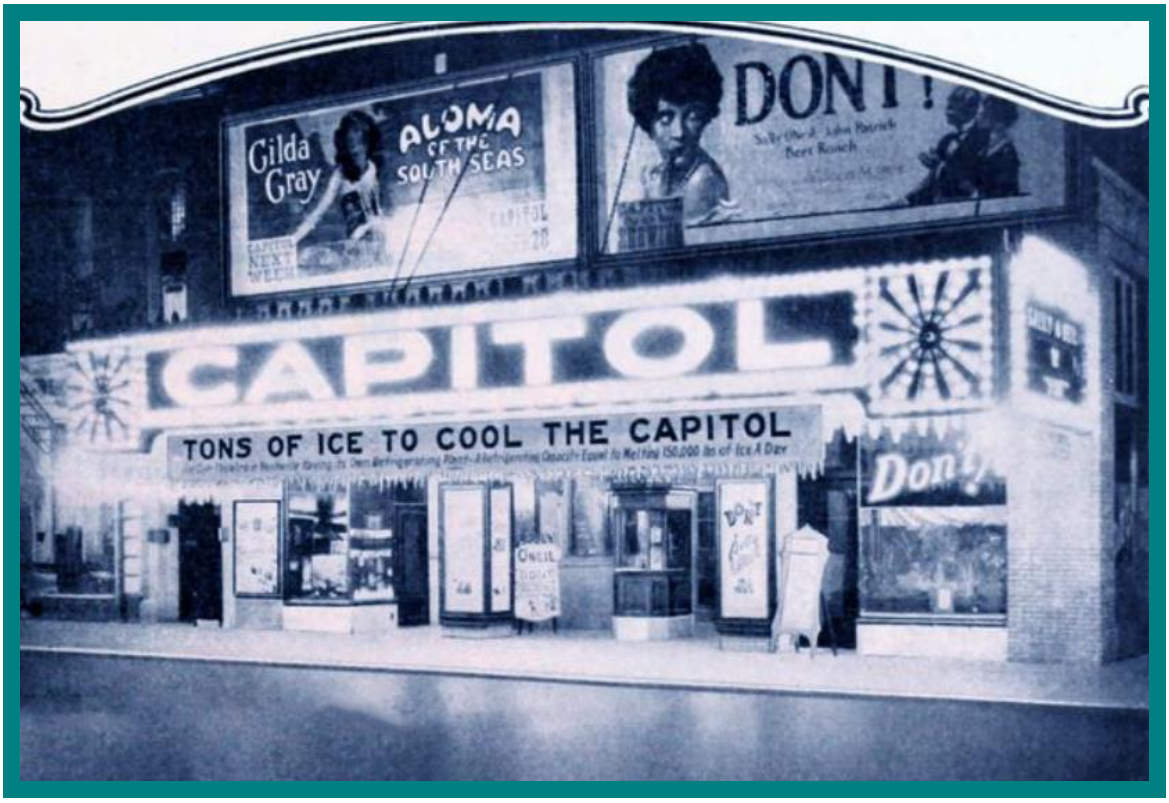
*Address* .....

*Signed by* .....

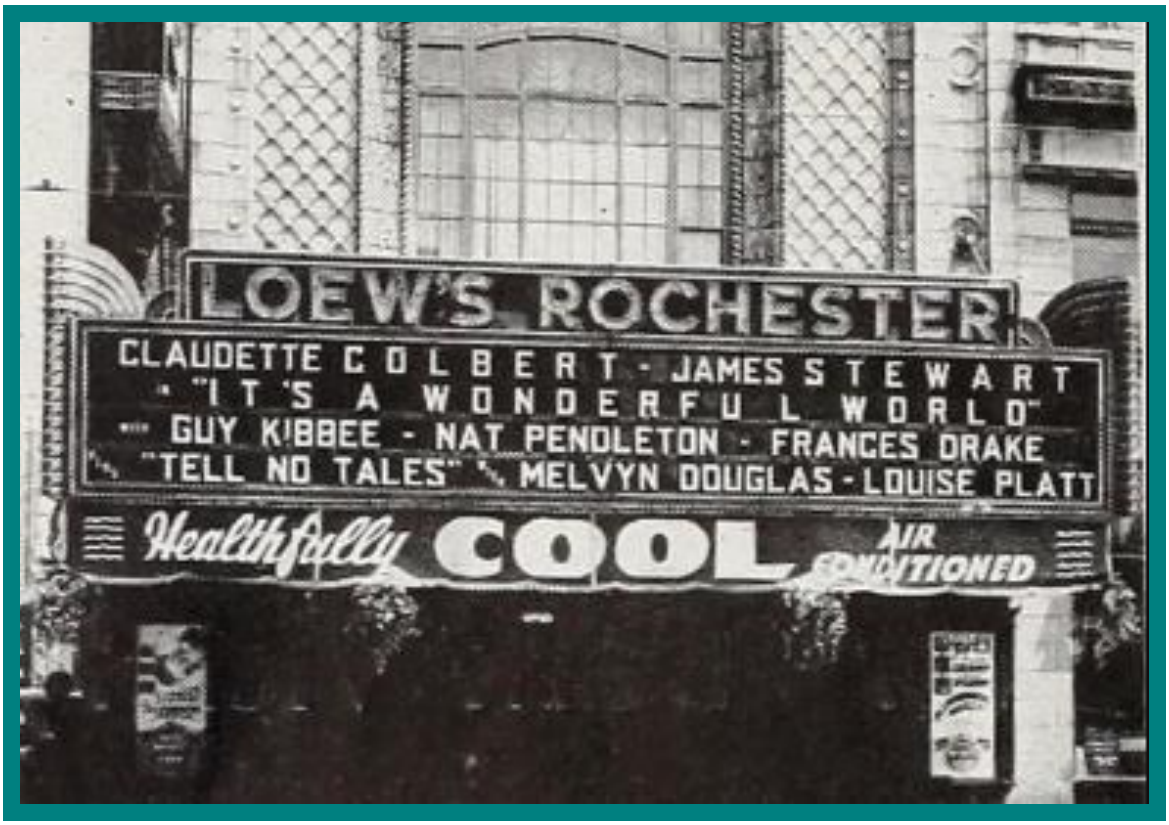
**YORK Manufacturing Company**
**York, Penna.**

**York Refrigeration 1926.**

# YORK ICE MACHINERY CORPORATION




**Capitol Theatre, Nashville, Tennessee (1151 seats) opened 1926, 75 TR York Refrigeration.**

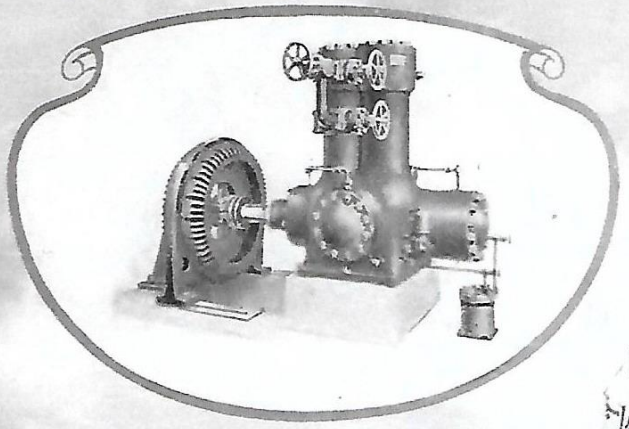



**Loew's Theatre, Rochester, New York (3581 seats) opened 1927.**

# YORK ICE MACHINERY CORPORATION

October 7, 1927

## Big Time "CHOOSES" YORK Refrigeration!




### The KEITH "PALACE"
### Cleveland, Ohio

is one of the finest theatres in America. Luxurious appointments, combined with the utmost in modern convenience, utility and harmonious proportions have stamped the "Palace" one of the show places in theatredom — a veritable palace in every sense.

It is significant that this 'big time' 3200 seat house has installed York carbon dioxide system of air cooling and conditioning—a system which enables it to GUARANTEE the theatre-goer entertainment PLUS COMFORT.

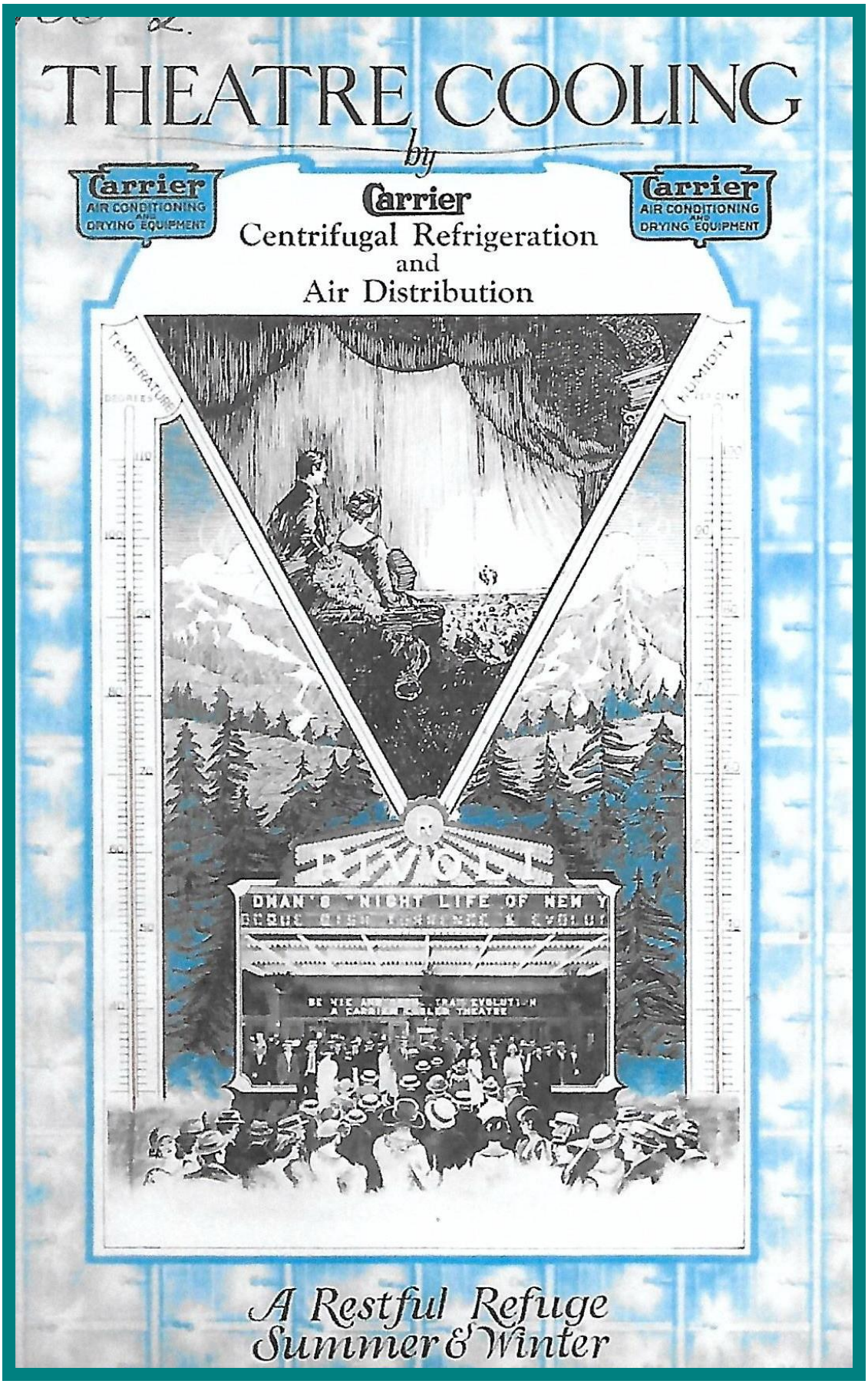
York air cooling and conditioning systems are designed for any size house, small or large.

Let us send you a list of York equipped theatres. No obligation on your part.

**YORK**
**ICE MACHINERY CORPORATION**
YORK PENNA

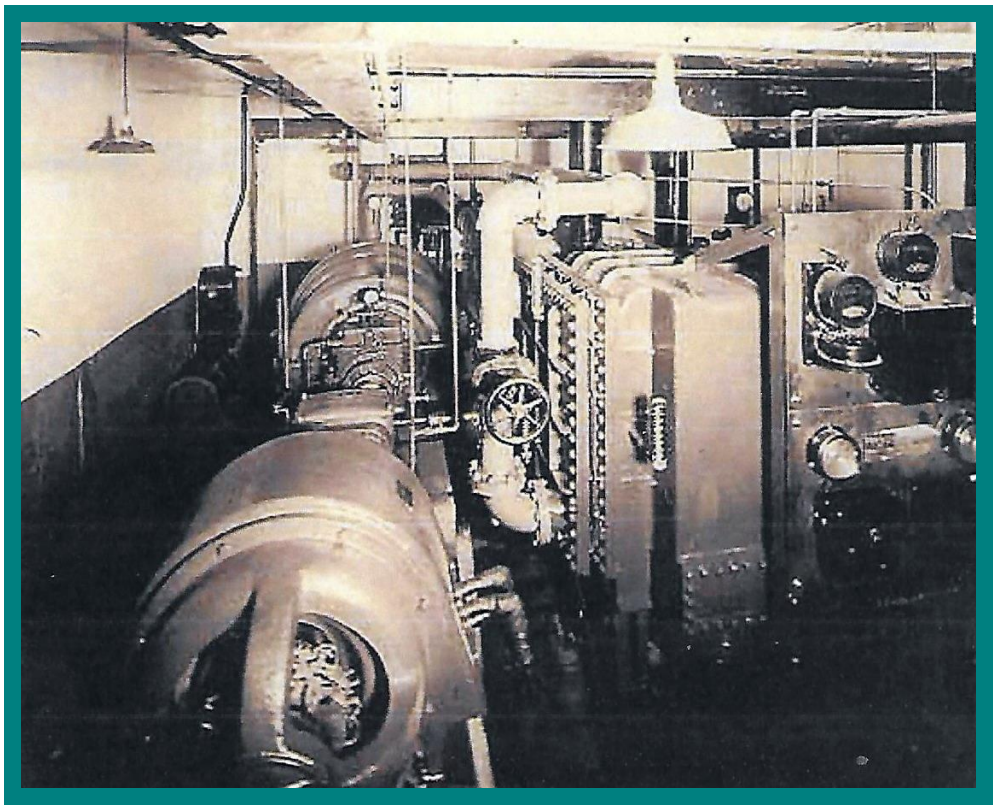
**The Keith Palace in Cleveland, Ohio with York "air cooling and refrigeration" opened in 1922.**

# CARRIER CORPORATION

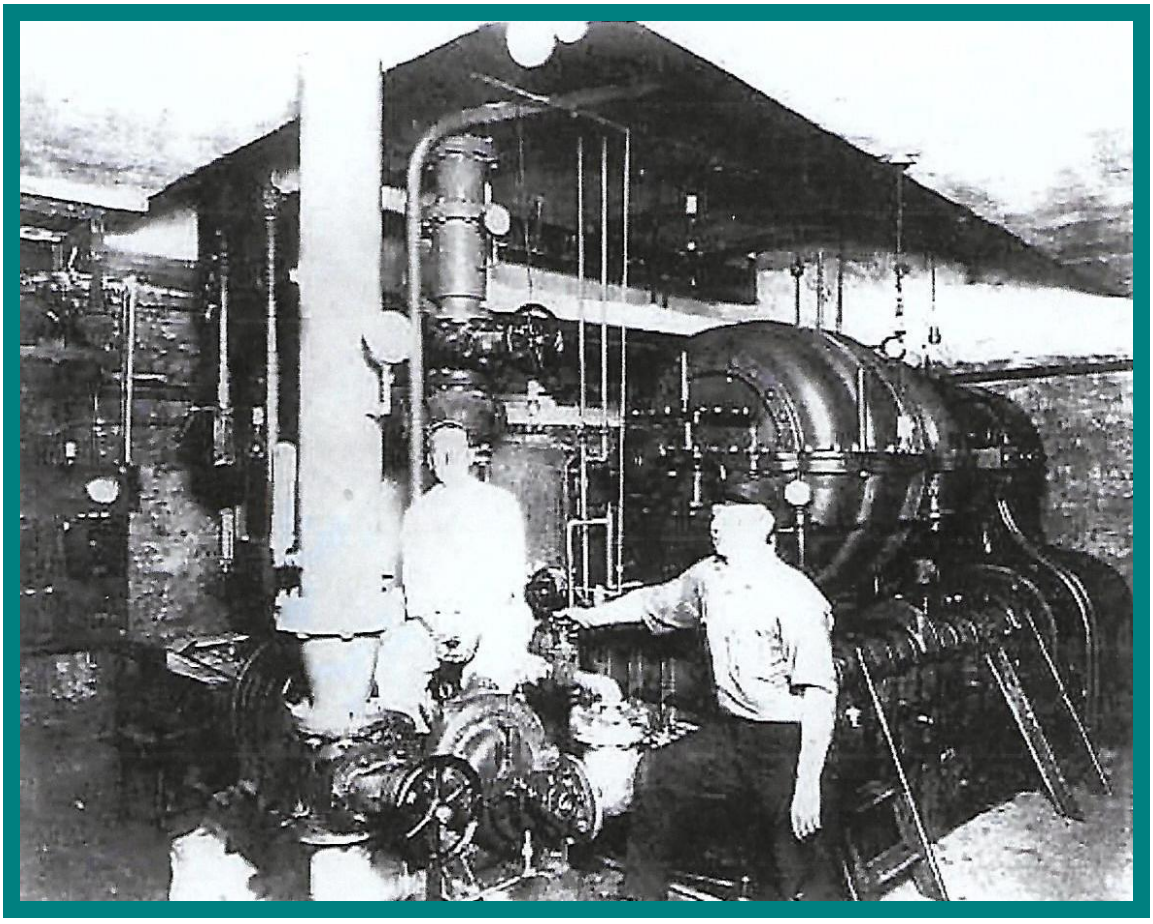



1925

# CARRIER CORPORATION

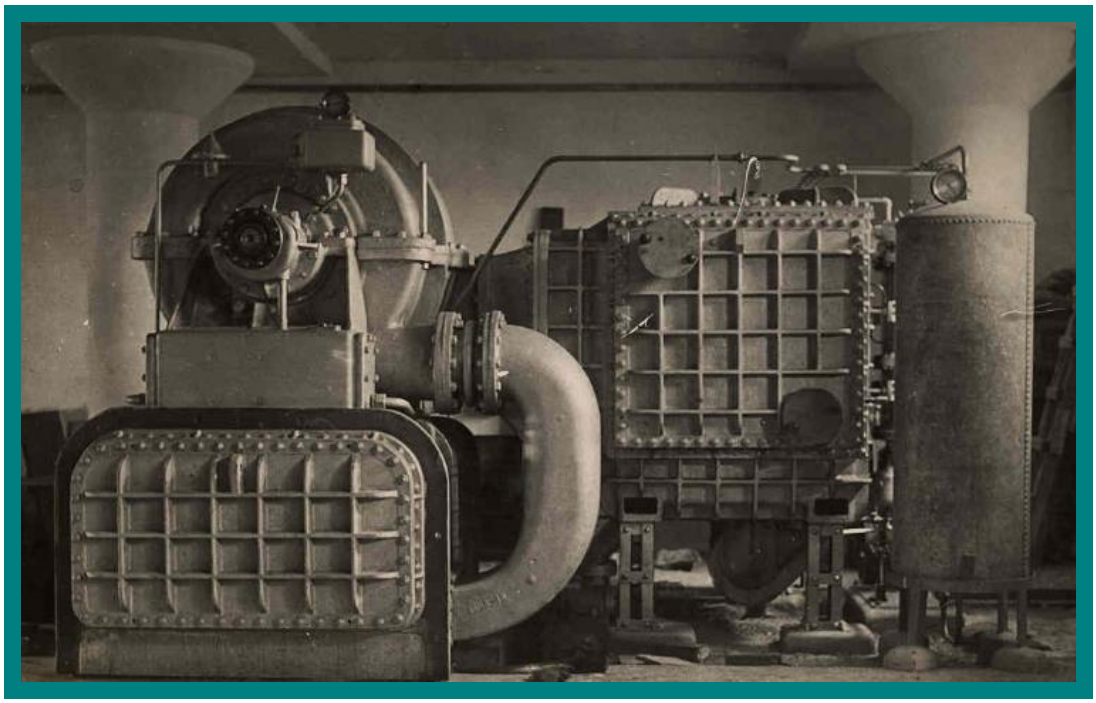


**Centrifugal chiller in the Palace Theatre, Dallas 1924.**

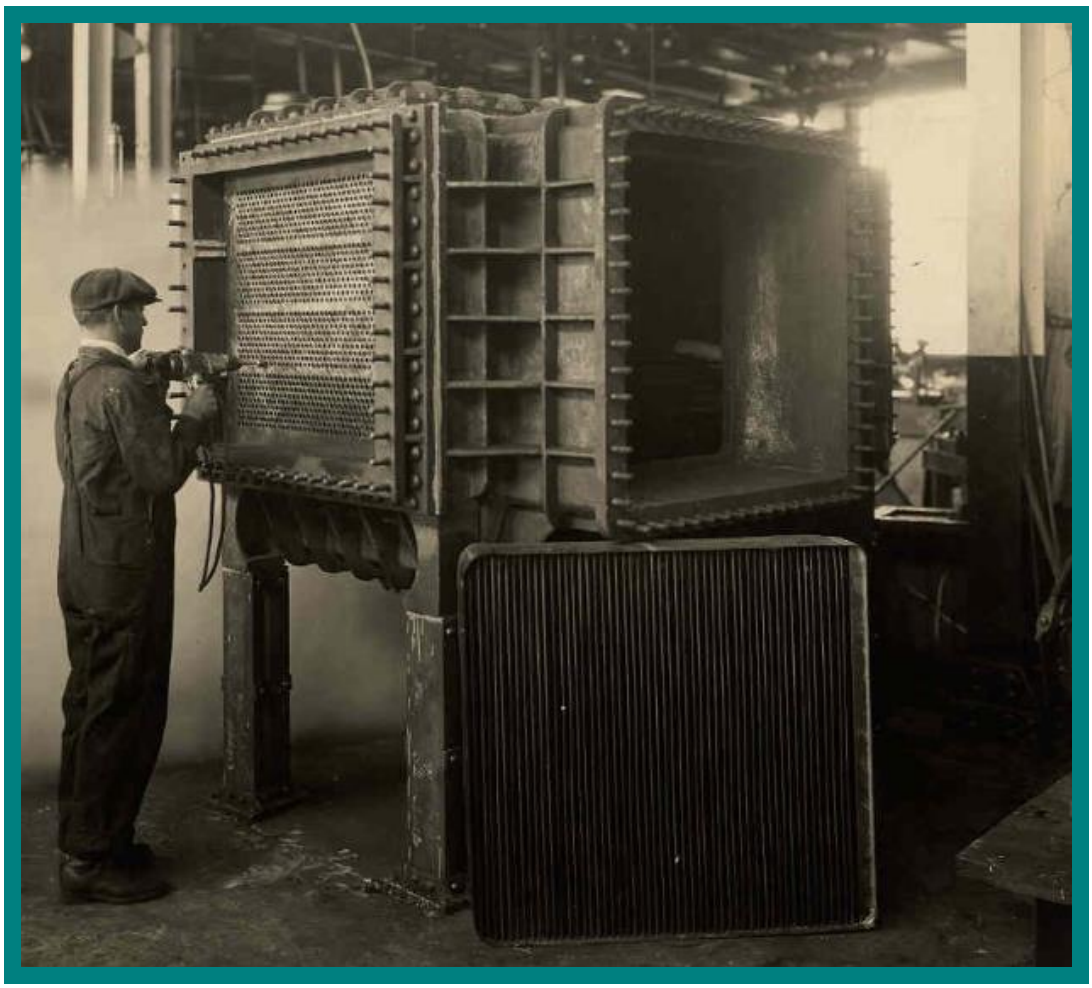


**Centrifugal chiller in the Missouri Theatre (3600 seats) St Louis, mid-1920s.**

# CARRIER CORPORATION

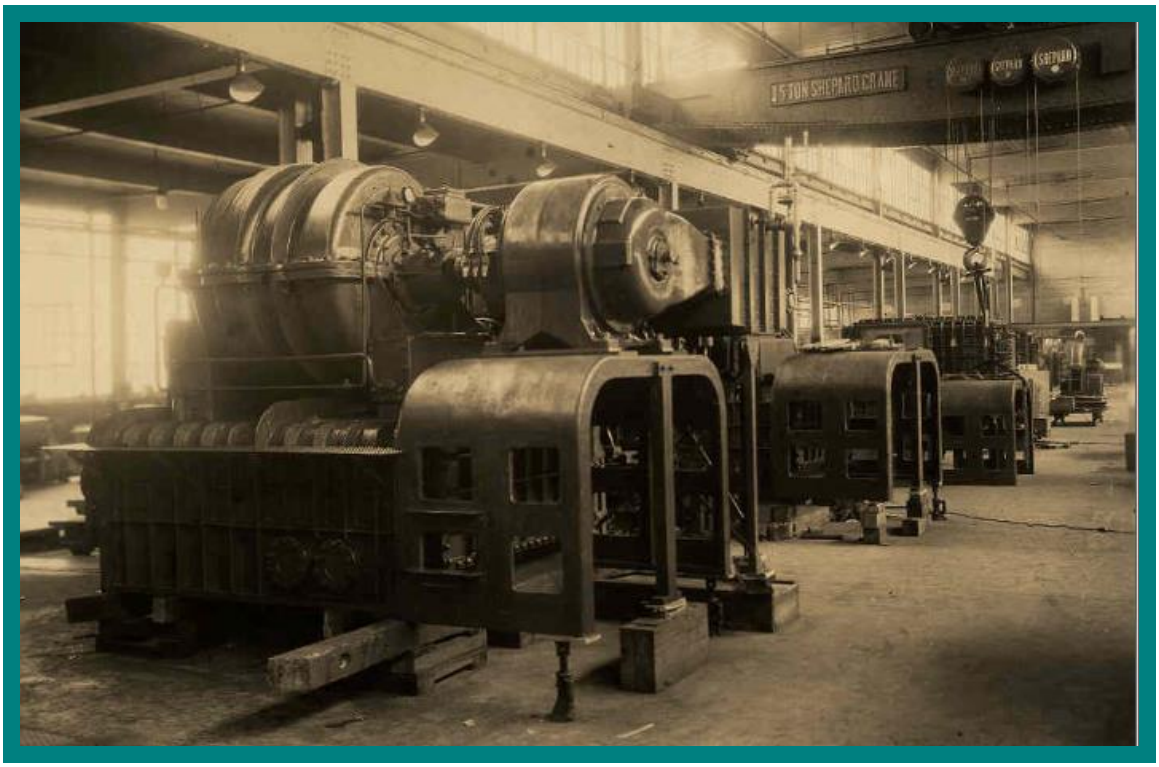


**Early centrifugal with rectangular heat exchangers (evaporator & condenser) c.1926.**



**Expanding heat exchanger tubes into end-plate at Newark Factory.**

# CARRIER CORPORATION

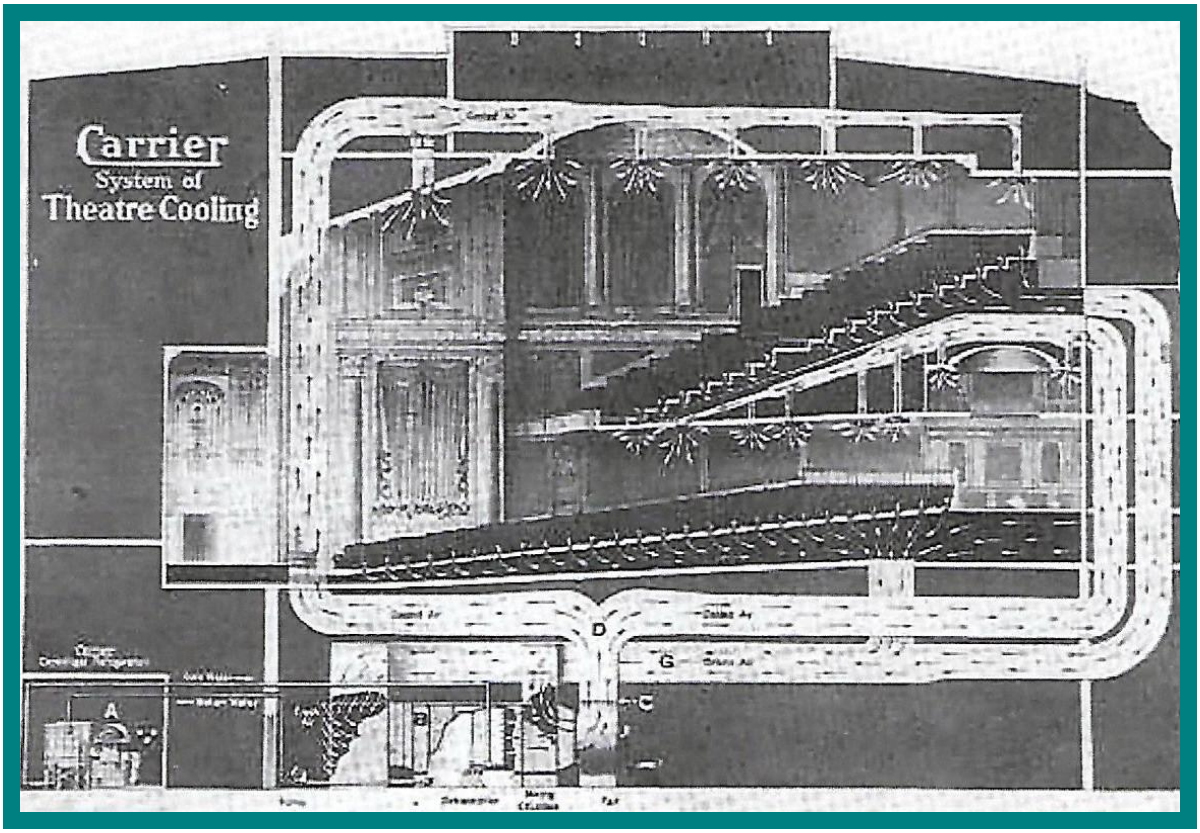



**Centrifugal compressor-motor assemblies at Newark 1926.**

**Heat Exchanger production line.**

# CARRIER CORPORATION

**Metropolitan Theatre (3485 seats) 1921-22, first Carrier "upside-down" air distribution.**




**Schematic of Carrier air distribution at the Metropolitan Theatre, Los Angeles.**
**Shows Carrier centrifugal (bottom left) not then in production, actual refrigeration probably Carbondale $CO_2$ machine.**

# CARRIER CORPORATION

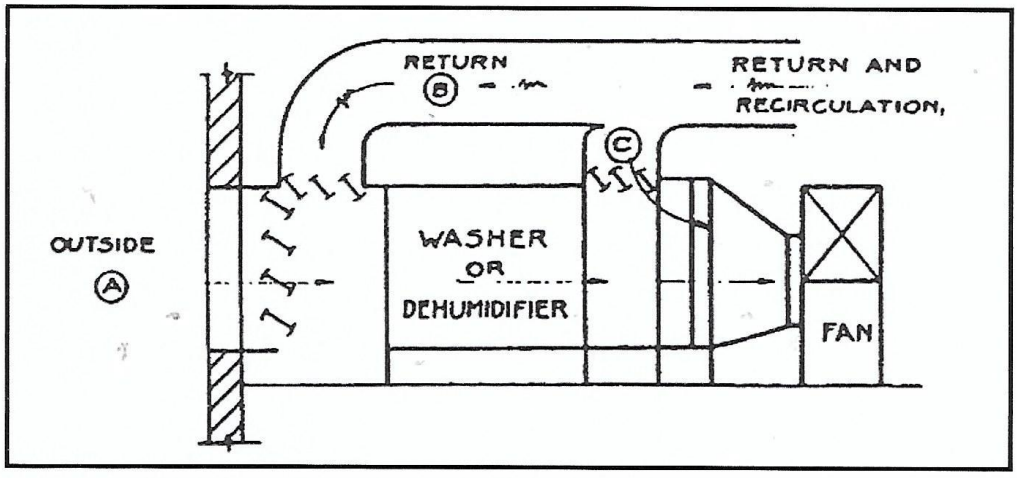
## THE CARRIER RETURN AIR BYPASS SYSTEM

There were three possible solutions to the high relative humidity and cold supply air problem resulting from Wittenmeier's pioneering designs in Chicago for the first air conditioned theatres. He had made some improvement by limiting the design dry bulb temperature between inside and outside to 10 degF.

The first option was to reheat the chilled air leaving the direct-expansion coil. Carrier had considerable experience of this method from their design of industrial systems with humidity control requirements. However, the additional capital and running costs made it expensive.

The second option was to reduce the air circulation to about 10 to 15 cfm (cubic feet per minute) per person allowing the audience body heat to raise the temperature and lower the humidity (a possibility with a full audience). However, it was a requirement of the Chicago Health Department that 25 cfm of outside fresh air had to be provided.

A third option was provide 25 cfm per person but mix 50% fresh air with 50% recirculated air which violated regulations but was, in fact, used by Wittenmeier at the Riviera Theatre (and possibly others). Carrier rejected this solution as unacceptable as the desired humidity was not guaranteed. Their proposal was therefore to use a *return air bypass system** (see following diagram) but Wittenmeier continued to provide the air conditioning for Balaban & Katz theatres until his death in 1928.

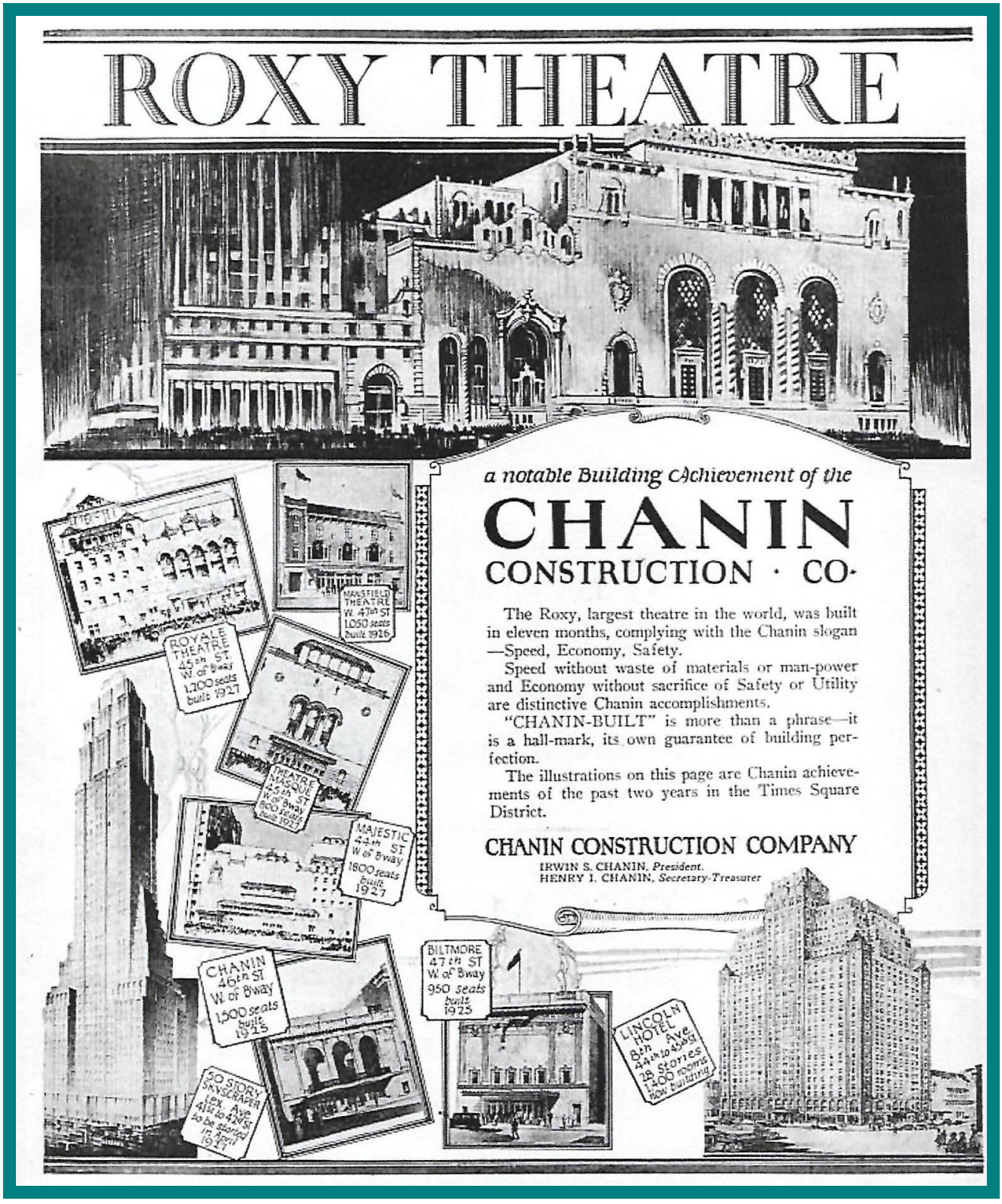



*The Return Air Bypass System*

*Carrier's first bypass system was not installed until 1921 in the Los Angeles Metropolitan Theatre. In December 1924, Logan Lewis of Carrier made a patent application for the return air bypass system (and upside-down air distribution, i.e. ceiling supply with floor return), but the pioneering air conditioning engineer Walter Fleisher held a patent for a similar design. So he and Carrier joined forces and in 1927 formed the Auditorium Conditioning Corporation which by 1946 had licensed an estimated 90 percent of the comfort air conditioning installations in the USA.

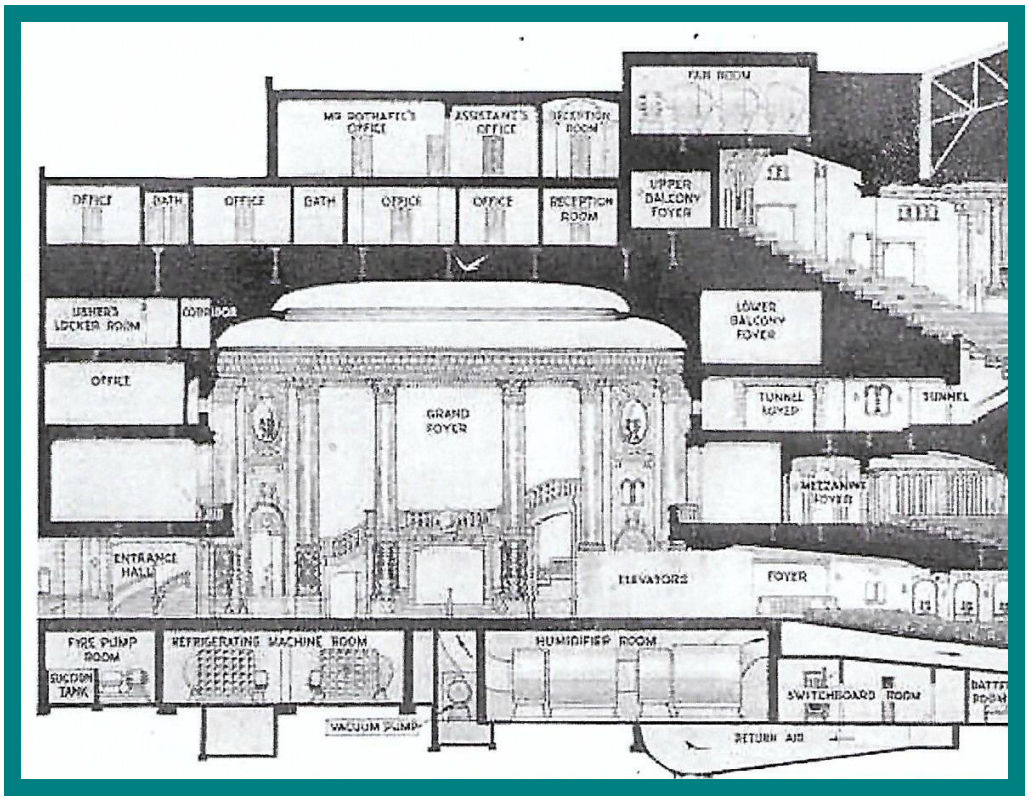
**The Return Air Bypass System patented by the Auditorium Conditioning Corporation.**

# CARRIER CORPORATION

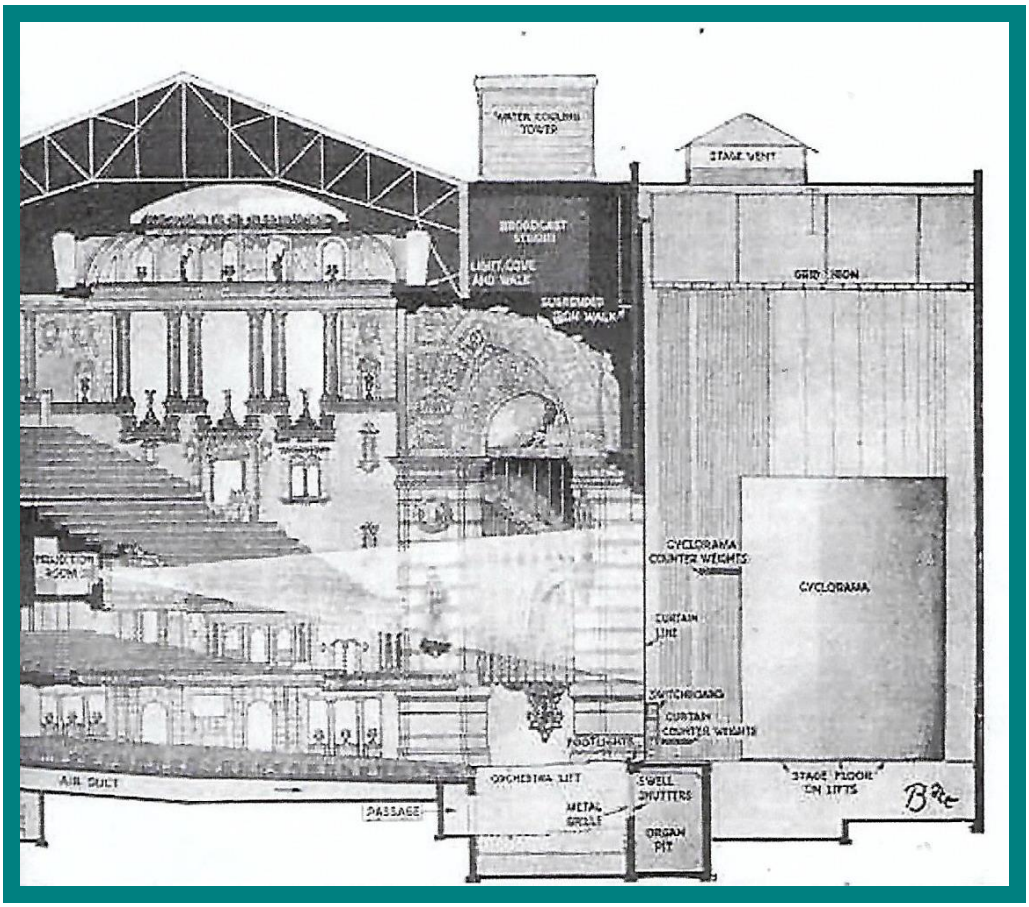



**The giant Roxy Theatre (nearly 6000 seats), then the world's largest, opened in New York City in 1927, fully air conditioned with Carrier centrifugal refrigeration (2 by 250 TR machines).**

# CARRIER CORPORATION

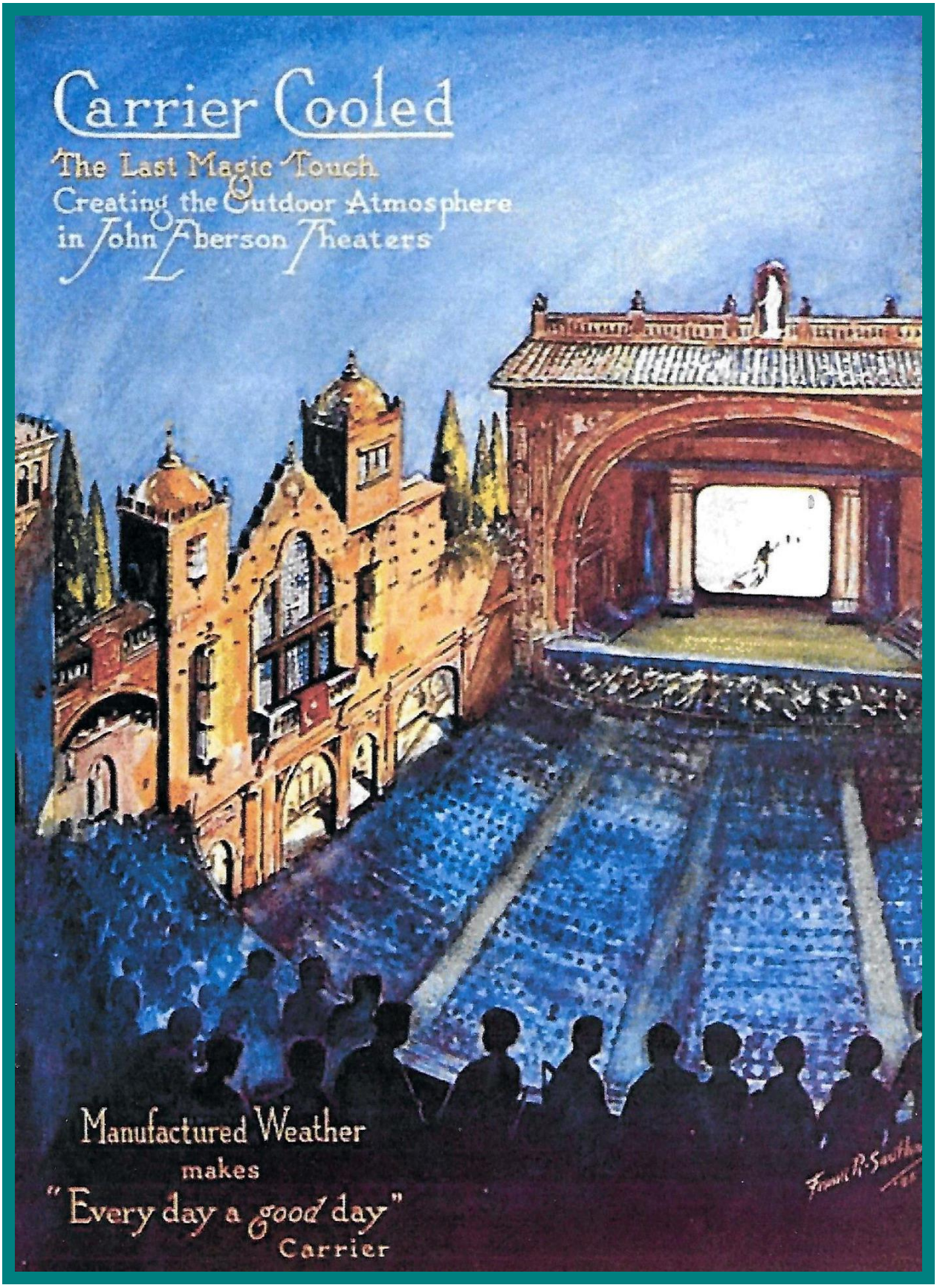



**Schematic showing the refrigeration machine room and fan/humidifier rooms.**




**Schematic showing basement air duct and roof cooling tower.**

# CARRIER CORPORATION




**The air conditioned Tampa Theatre, Florida (1252 seats), 1926 designed by John Eberson in the "atmospheric style" to look as if outdoors at night.**

# CARRIER CORPORATION


**The original centrifugal chiller installed in the Fox Theatre, Atlanta in 1929. Replaced in 1960.**

# CARRIER ENGINEERING COMPANY LTD

**The Carlton Theatre (1159 seats) in the Haymarket in London, opened in 1927. Said to be the first fully air-conditioned theatre (i.e., with refrigeration) in Britain and with only the country's 4th Carrier centrifugal installation.**