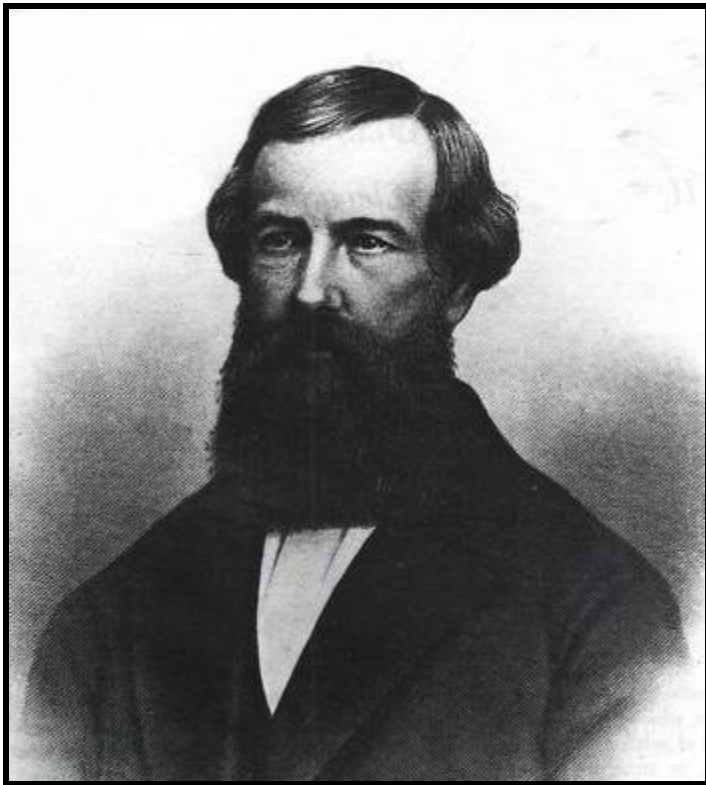


ELISHA GRAVES OTIS and the SAFETY ELEVATOR and AFTERWARDS

by Brian Roberts, CIBSE Heritage Group

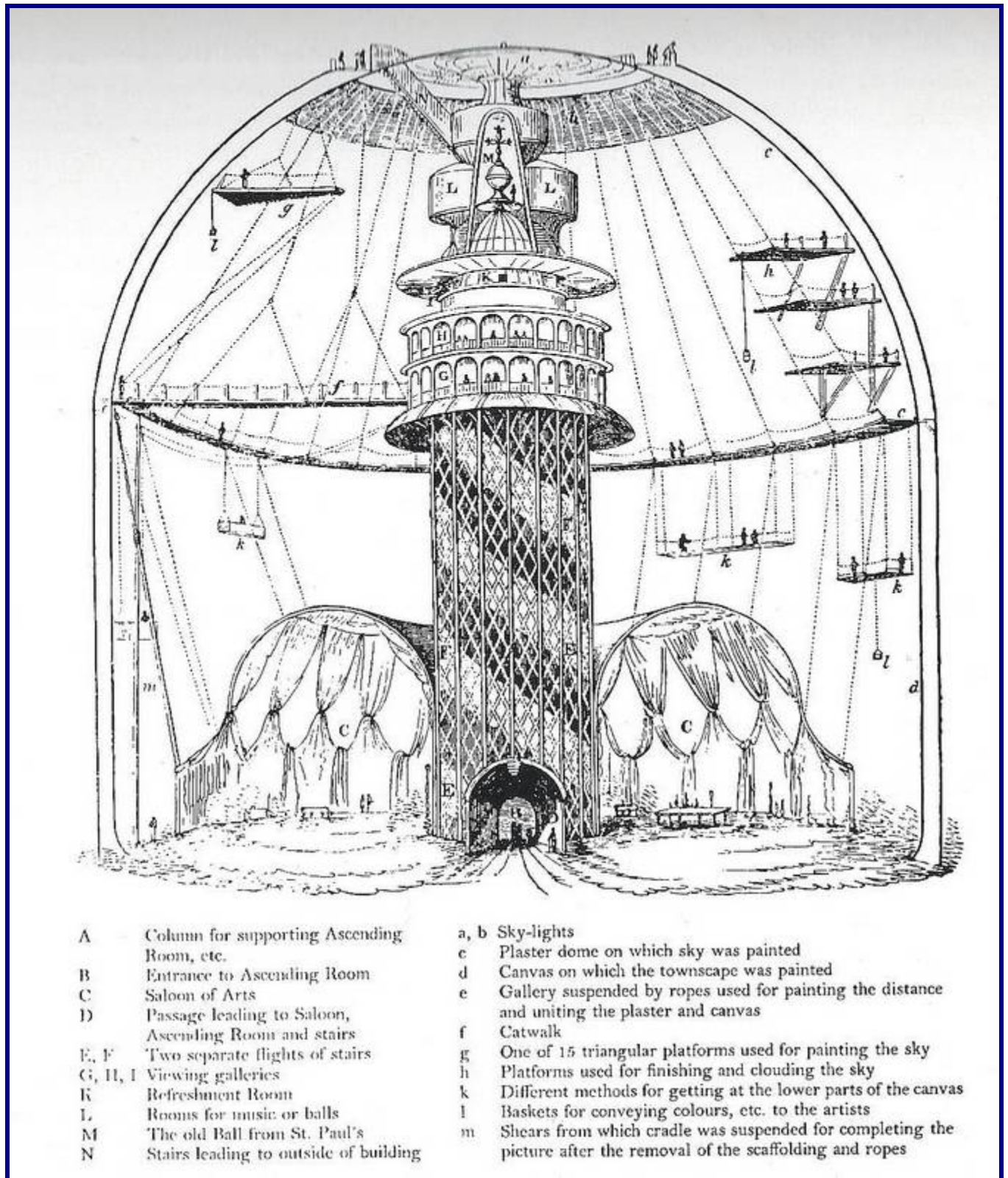


Elisha Graves Otis 1811-1861

Elisha Graves Otis was born on the 3rd August, 1811 in Halifax, Vermont, USA, to Stephen Otis and Phoebe Glynn. At the age of 20, he left home and settled in Troy, New York, where he was employed as a wagon driver. In 1834, he married Susan Houghton and they had two sons, Charles and Norton. Moving to Vermont Hills, he built and ran first a grain mill, which he later converted into a sawmill. Neither was a commercial success so he turned to building wagons and carriages.

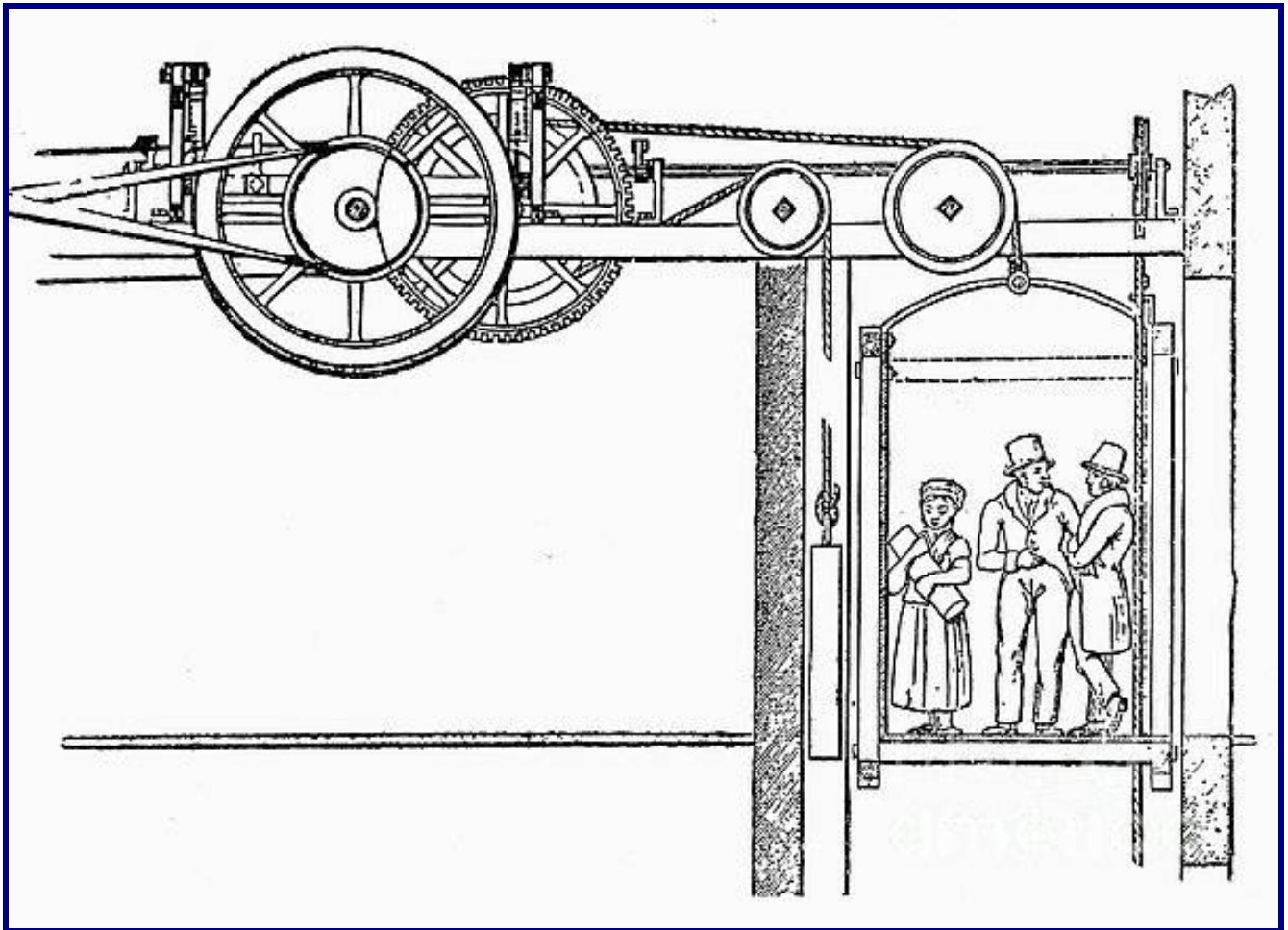
After the early death of his wife, and at the age of 34, he remarried and moved to Albany in New York State, where he was employed first making toys, then bedsteads. Later, he moved to Yonkers, New York, and while cleaning up an abandoned sawmill, he and his sons designed and tested a hoisting platform which was to become his “safety elevator,” Otis started his Union Elevator Works, but fame and success came only to him when he demonstrated his elevator’s safety features by “cutting the hoisting rope” at the 1854 New York World’s Fair.

BEFORE OTIS



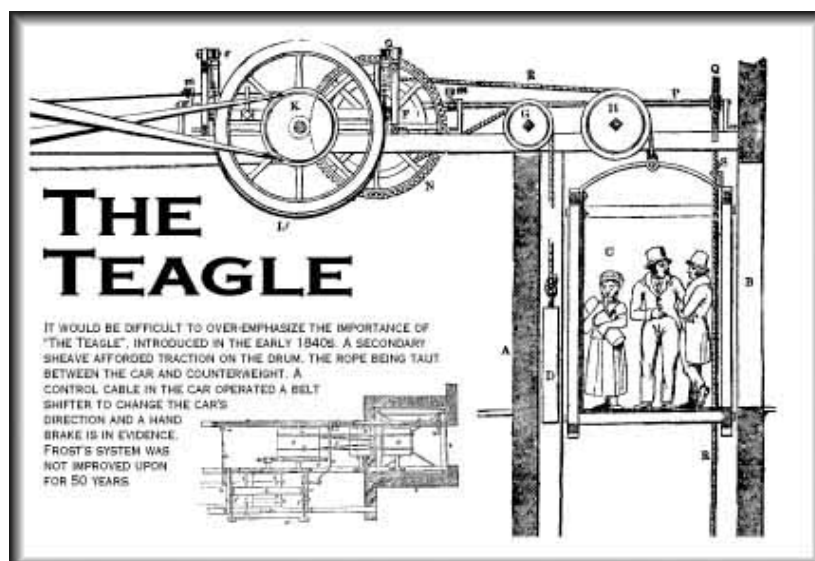
The Regent's Park Colosseum was completed in 1824 and opened later

The Colosseum, modelled on the Pantheon in Rome, was an ambitious panorama entertainment featuring an enormous painted view of "London from the Summit of St Paul's Cathedral." Visitors were transported up to the viewing-platform in the "Ascending Room"- London's first hydraulic elevator.



The Teagle Elevator of 1835

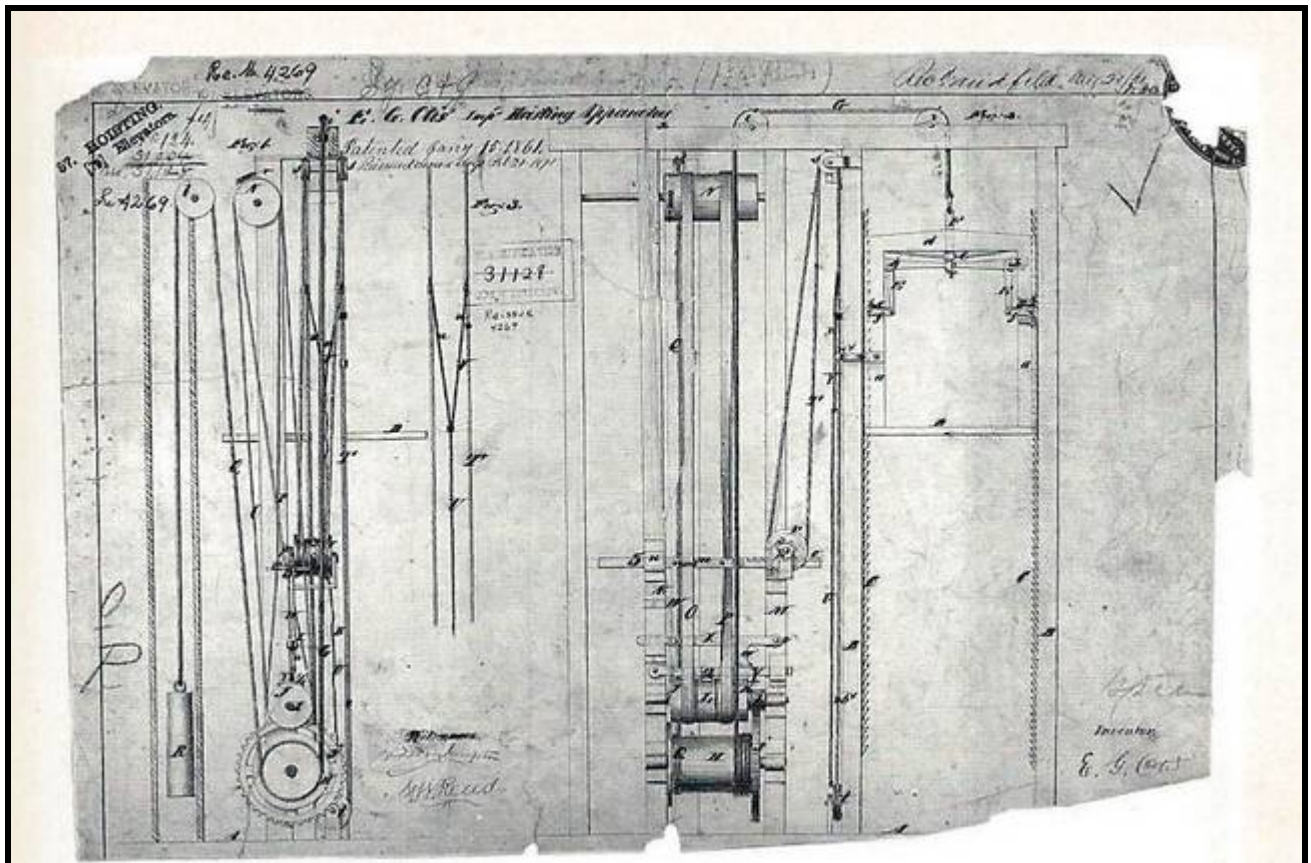
The so-called Teagle elevator was an English invention by Frost and Stutt, being belt-driven, counterweighted and operated by steam.



ELISHA GRAVES OTIS



Otis demonstrating his safety lift "by cutting the rope" at the 1854 New York World's Fair



Part of the Otis Elevator (Hoisting Apparatus) Patent of 1861

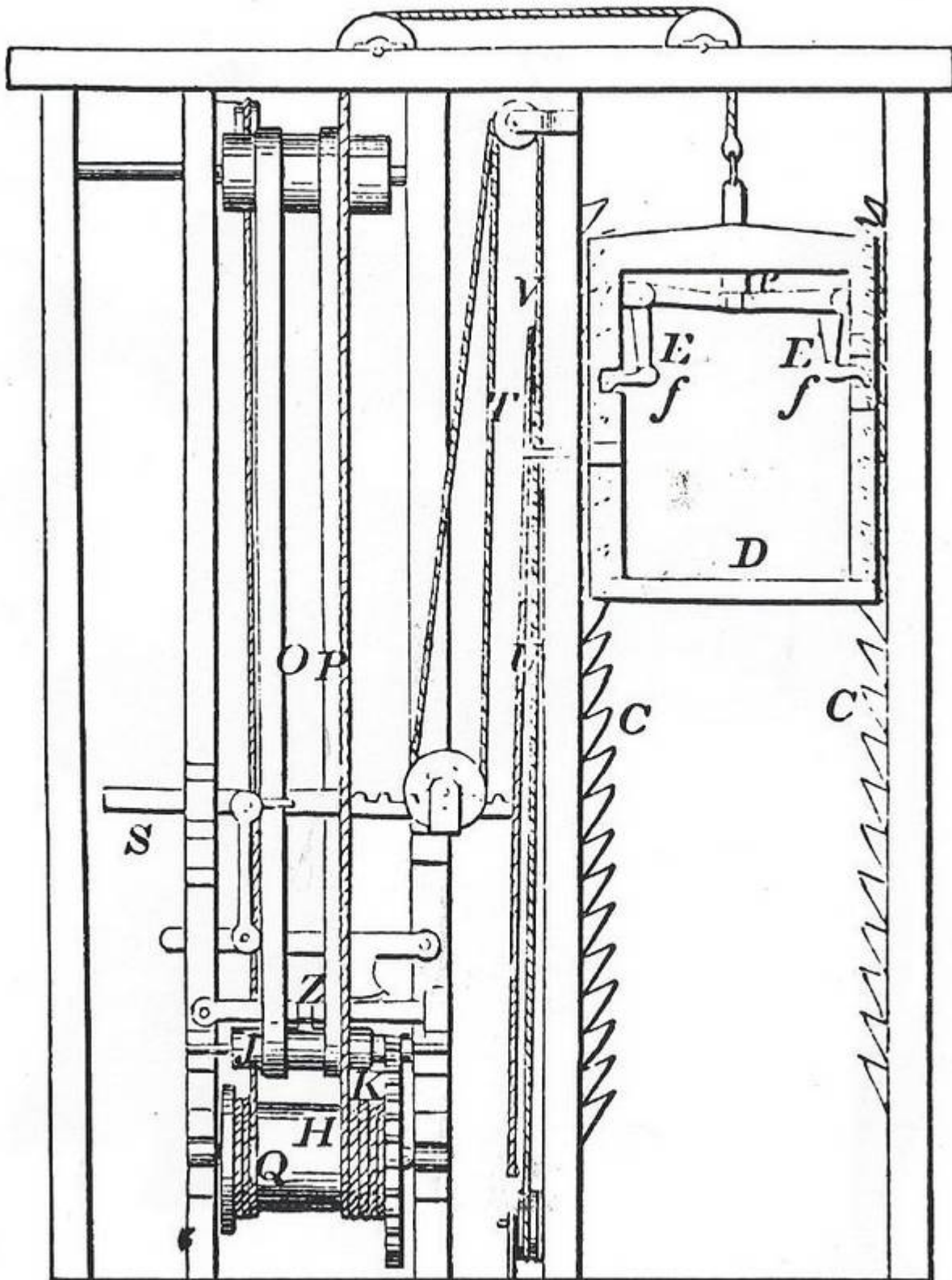
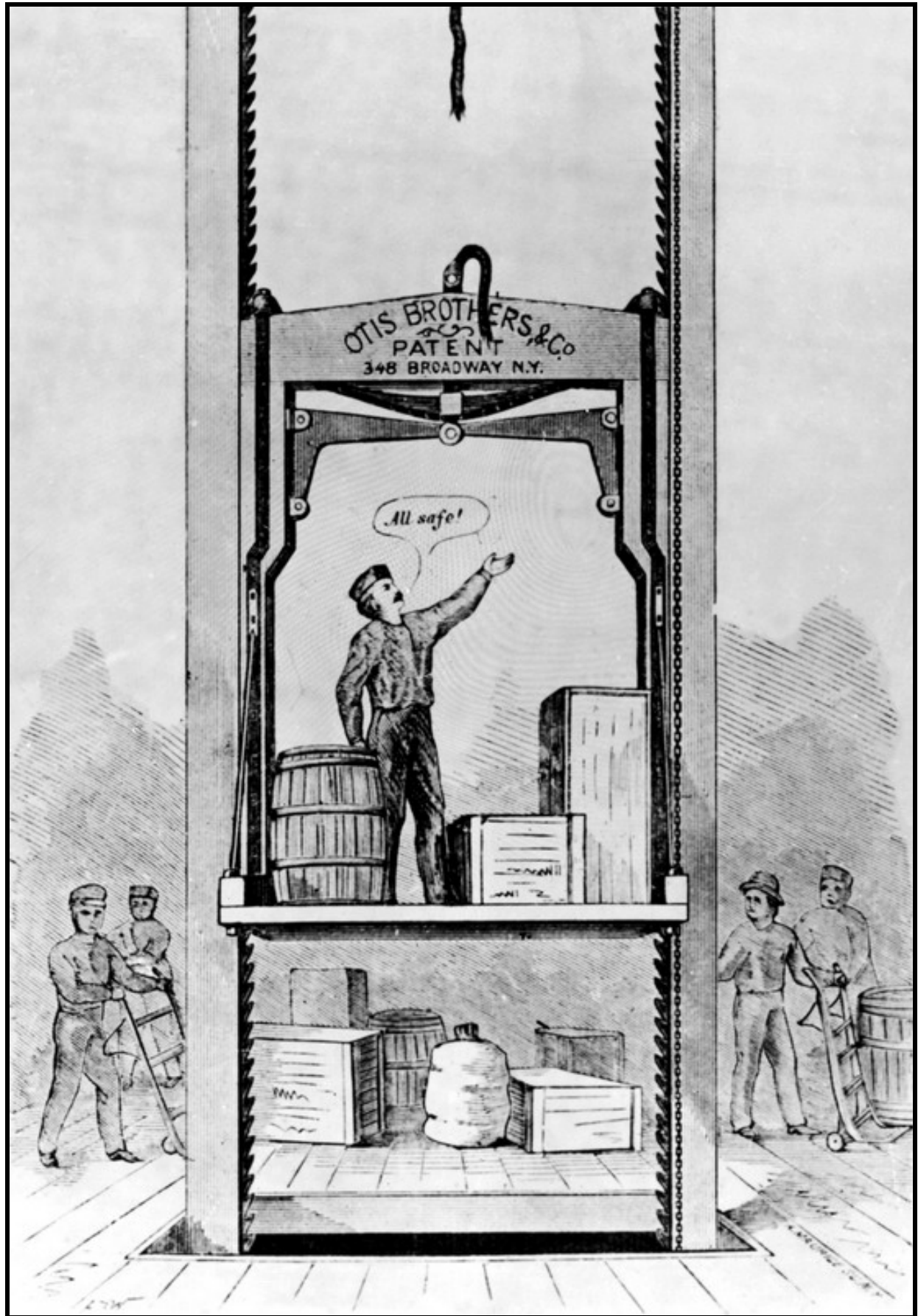
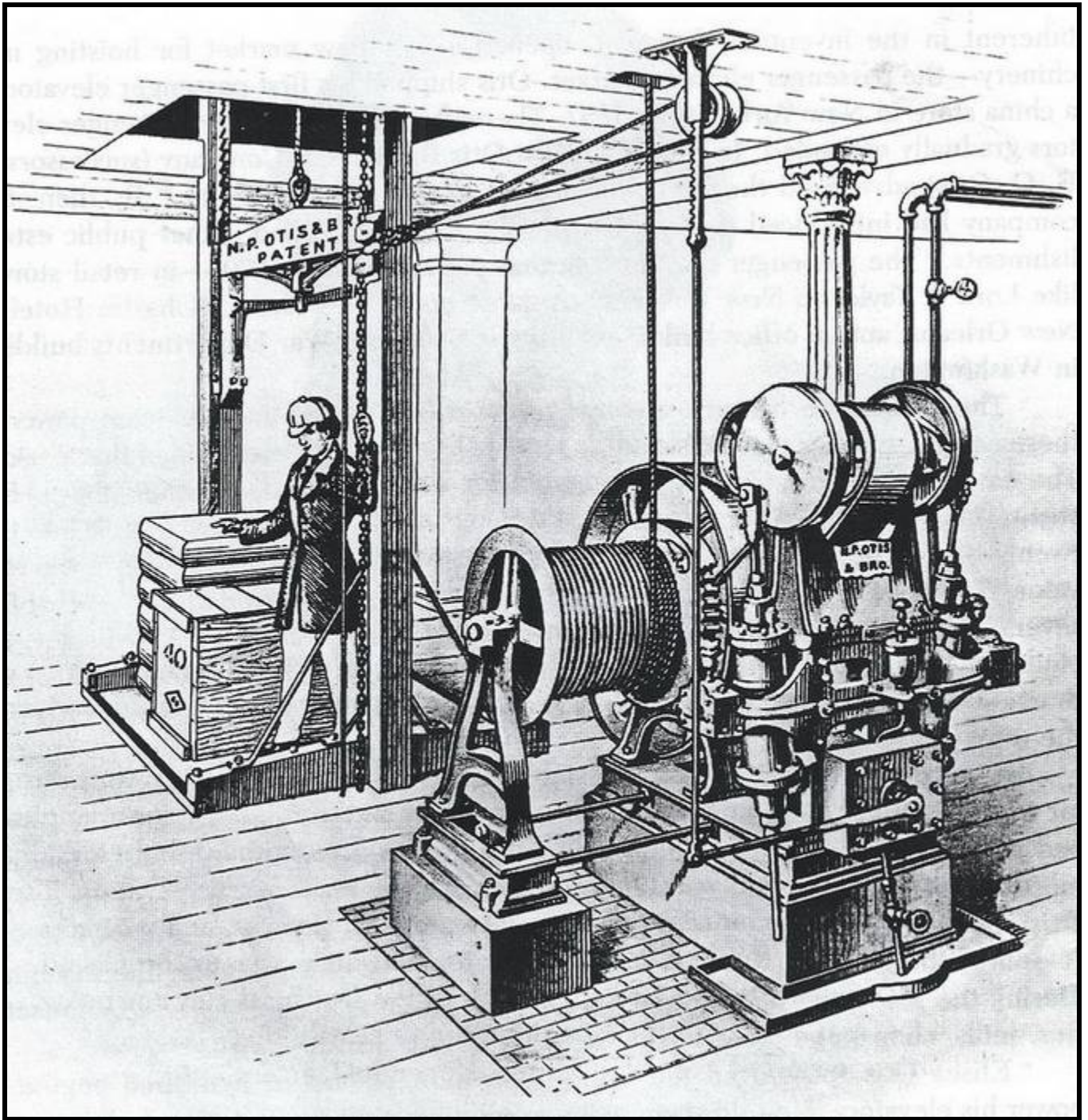


Diagram of the Otis Safety Elevator

Saw-toothed ratchet bars are attached to each of the four side vertical guide rails with a spring at the top of the elevator car [D] and the lifting cable, part of a pulley and winding drum system, is attached to the upper bar of the spring, itself kept taut by the weight of the car. If the cable snaps, the spring is released and sturdy bars (pawls) lock solidly into the saw-teeth [C] clamping the elevator car safely in place



Elisha Otis' invention- the Safety Elevator, c.1861



Elisha Otis and his sons began by selling steam-powered freight elevators and their associated steam engines, like this 1861 model



In 1873, Otis provided a steam-operated elevator with a manually controlled rope system for starting and stopping to serve the new Lord & Taylor Department Store in New York City

OTIS, BROTHERS & CO.,

Sole Manufacturers of

OTIS' PATENT LIFE AND LABOR SAVING HOISTING MACHINERY

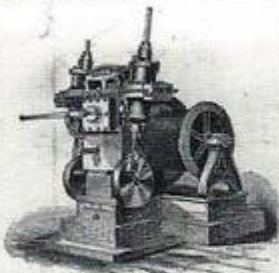
MANUFACTORY AT YONKERS, N. Y.

OFFICE, 307-9 BROADWAY, New York.

Office Hours, from 11 to 2 o'clock.

For the use of Stores, Hotels, Commission Houses, Storage Warehouses,
Sugar Refineries, Packing Houses, Livery Stables, Factories,
Bakeries, Mills, Shipping Docks, Mines, &c.

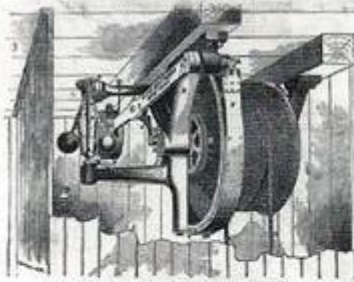
A GREAT VARIETY OF SUPERIOR HOISTING MACHINERY, ADAPTED TO EVERY CLASS OF BUSINESS,
AND POWER, CONSTANTLY ON HAND AND IN PROCESS OF MANUFACTURE.



Union Hoisting Engine. Cut A.
Old Patent Double-line Hoisting Engine, adapted for use in connection with Safety Platforms for Storage Warehouses, Packing Houses, Shipping Docks, Mines, &c. Motion of Platform of well of standard, up to 100 feet per minute.



Union Hoisting Engine. Cut B.
Old Patent Double-line Hoisting Engine, showing application of Patent Automatic Stop Mechanism, by which the engine is automatically stopped after making any desired number of revolutions. Motion of Platform of well of standard, up to 100 feet per minute.



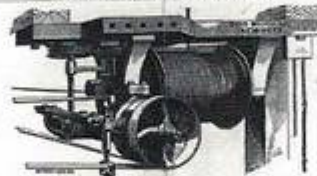
Automatic Safety Drum. Cut C.
Old New Patent Safety Mechanism for stores and high buildings where the excessive weight of the 5 ton Lifting Screw tends to prevent the safety spring from setting at the critical moment, thereby rendering a safety device indispensable between the Hoisting Engine and Safety Platform necessary. This "Safety Drum" is arranged directly over the hoistway, and acts as a monitor in the entire motion, instantly stopping the Platform upon any approach to an unsafe position.

DEALERS in all kinds of Machinery required in the application of
Steam for Hoisting Purposes.

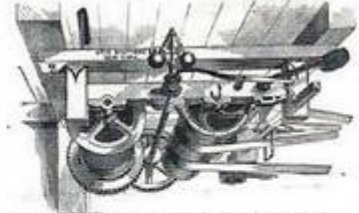
STEAM BOILERS, STEAM PUMPS, STEAM & WATER GAUGES, STEAM & WATER
PIPES, DAMPER REGULATORS, SHAFTING, IRON CASTINGS, PULLEYS, &c.

WIRE ROPE

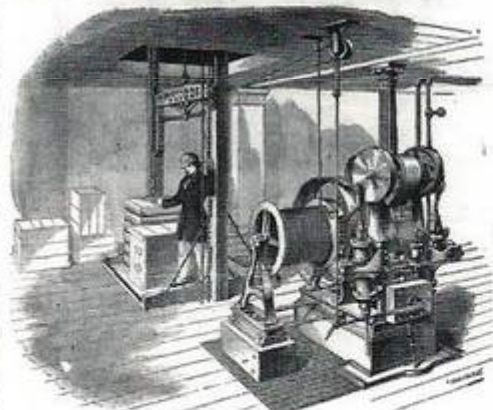
Of the best quality, manufactured expressly for Hoisting, constantly
on hand and supplied to Order.



Lifting Power-screw combination. Cut D.
For Manufacture and all general purposes of hoisting by belts. A strong, compact machine, simple in construction, and readily attached to any well or without Safety Platform.



Lifting Power-gear combination. Cut E.
Old Patent Universal Hoisting Machine, as illustrated below, showing "The Self Attachment," by which the machine is instantly stopped in case the hoisting motion is made motion from any cause, or in the breaking of a belt while the machine is in motion.



Metropolitan Hoisting Engine. Cut F.
Old Patent Non-revolving Belt and Gear Hoisting Engine, Safety Platform and connection, for Hotels, Mercantile Houses, &c. Platform of Cut moves any speed, at will of standard, up to 100 feet per minute.

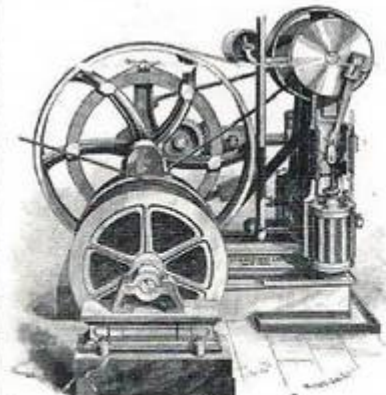
DESCRIPTIVE CIRCULARS
Of our Machinery, with any information
required, will be furnished on application by
Mail or in person.



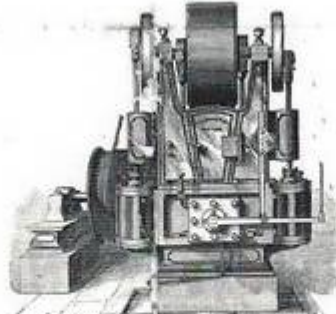
Relief Hoisting Engine. Cut G.
Old Patent Non-revolving Screw Hoisting Engine, adapted for use in connection with Safety Platform, also especially fitted and readily adapted for working the ordinary screw-hoisting Machine, giving 90 feet per minute motion of Platform.



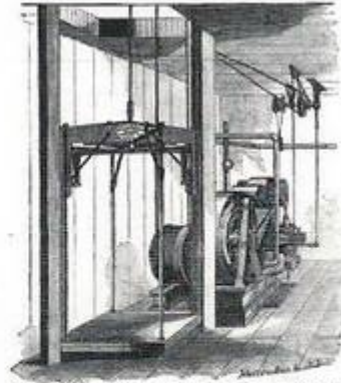
Universal Hoisting Machine. Cut H.
Old Patent Lifting Power, Safety Platform and connection, for Factories, Mills, Shops, Bakeries, and all general business purposes where steam, water or gas power is at constant use. Motion of Platform 50 feet per minute.



Cut I.
Otis' National Stationary Cylinder Hoisting Engine.
Side View. See Cut J.



National Hoisting Engine, Front View. Cut J.
In this Hoisting Engine are combined heavy steel and cast-iron frames, which will contain it in such a rigid stationary position. It is very strong, and especially built for a neat and beautiful appearance, and runs without noise. The mechanism is constructed upon an entirely new principle, by which a direct-acting and very simple motion is obtained with less loss by friction than in any other mechanism for the purpose in use.



Metropolitan Hoisting Machine, showing Corner Platform. Cut K.
The "Corner Platform" is adapted to buildings where it is necessary to hoist goods to and from the platform on all sides or on any two sides at right angles at any of the different floors.

STANDARD HYDRAULIC ELEVATOR

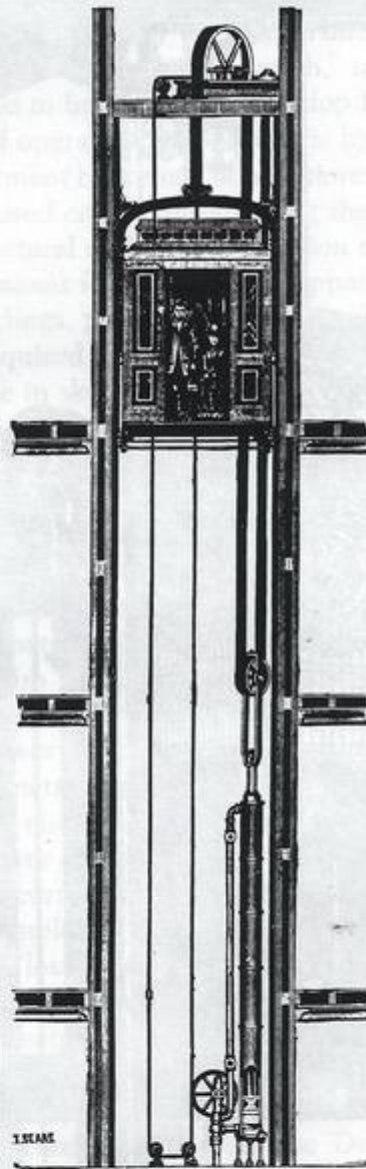
For Passengers and Freight.

ADOPTED BY U. S. GOVERNMENT.

Upon Report of Eminent Experts appointed by the Secretary
of the Treasury.

SAFE, SIMPLE,
ECONOMICAL.

ADAPTED TO USE IN
HOTELS,
PUBLIC
BUILDINGS,
STORES,
OFFICE
BUILDINGS,
FLATS,
PRIVATE
HOUSES,
AND FOR
DUMB
WAITERS,
ALSO IN
WAREHOUSES
AND
FACTORIES.



OPERATED BY
Water Pressure

FROM
STREET MAINS,
OR FROM
A TANK in Upper Story,
or on Roof of Building,
OR
PRESSURE TANK IN BASEMENT

Always Ready for Use,
NIGHT OR DAY.

COSTS NOTHING

WHEN
NOT IN USE.
CAN BE MANAGED
BY ANY

LADY OR YOUTH.

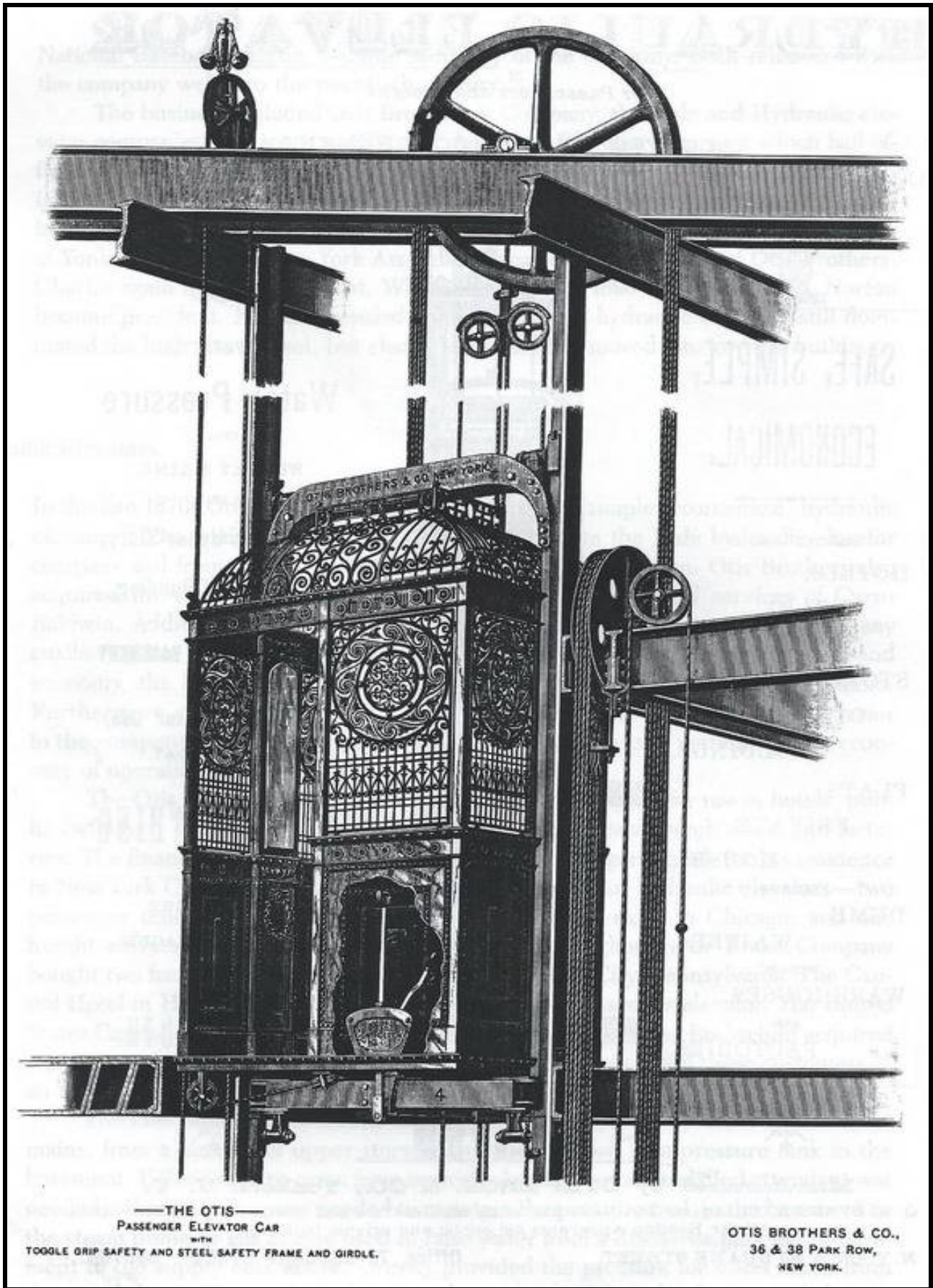
Manufactured by OTIS BROS. & CO., Yonkers, N. Y.

Q. N. EVANS & CO., Agents for New England; also, makers and designers of Steam and
Water Heating Apparatus for public and private buildings.

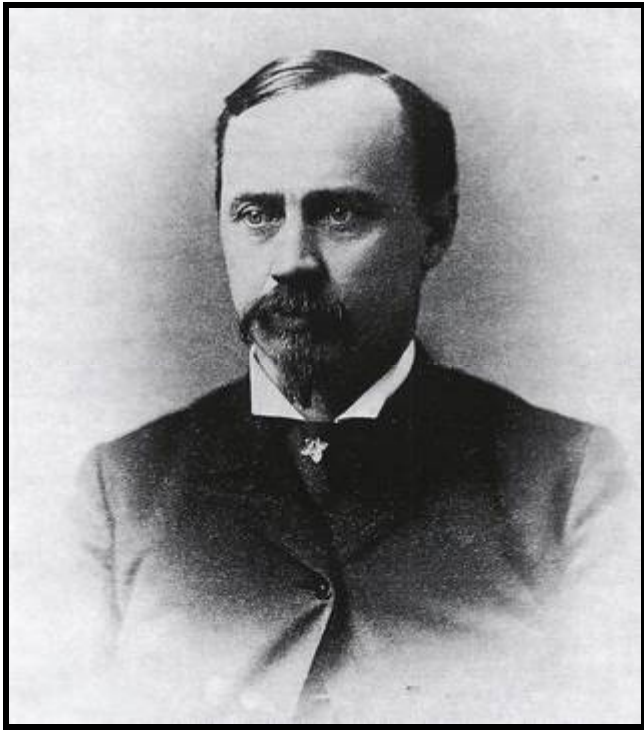
N. Y. Office, 60 DUANE STREET.

Office, 72 SUDBURY STREET, BOSTON.

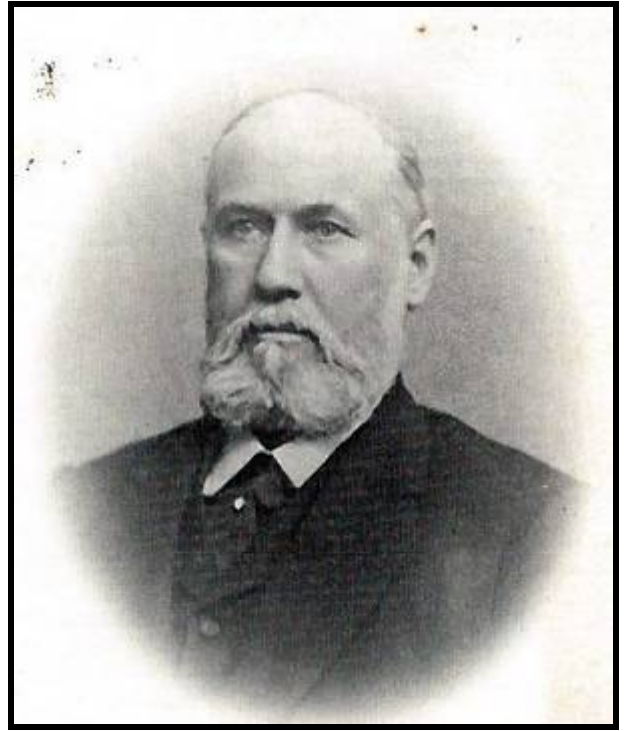
Advertisement of 1882 for the Otis Bros Standard Hydraulic Elevator, which operated by water pressure, and was first introduced in the 1870's



The Otis Passenger Elevator Car with the cutaway portion showing the Otis Controller, a lever connected to the rope control



Norton Prentiss Otis 1840-1905



*Charles Rollin Otis
Born between 1834 & 36, died 1927*



*William E Baldwin 1856-1930, who with
Norton Otis led the Otis Elevator Trust*

OTIS AUTOMATIC ELECTRIC ELEVATOR FOR USE IN RESIDENCES

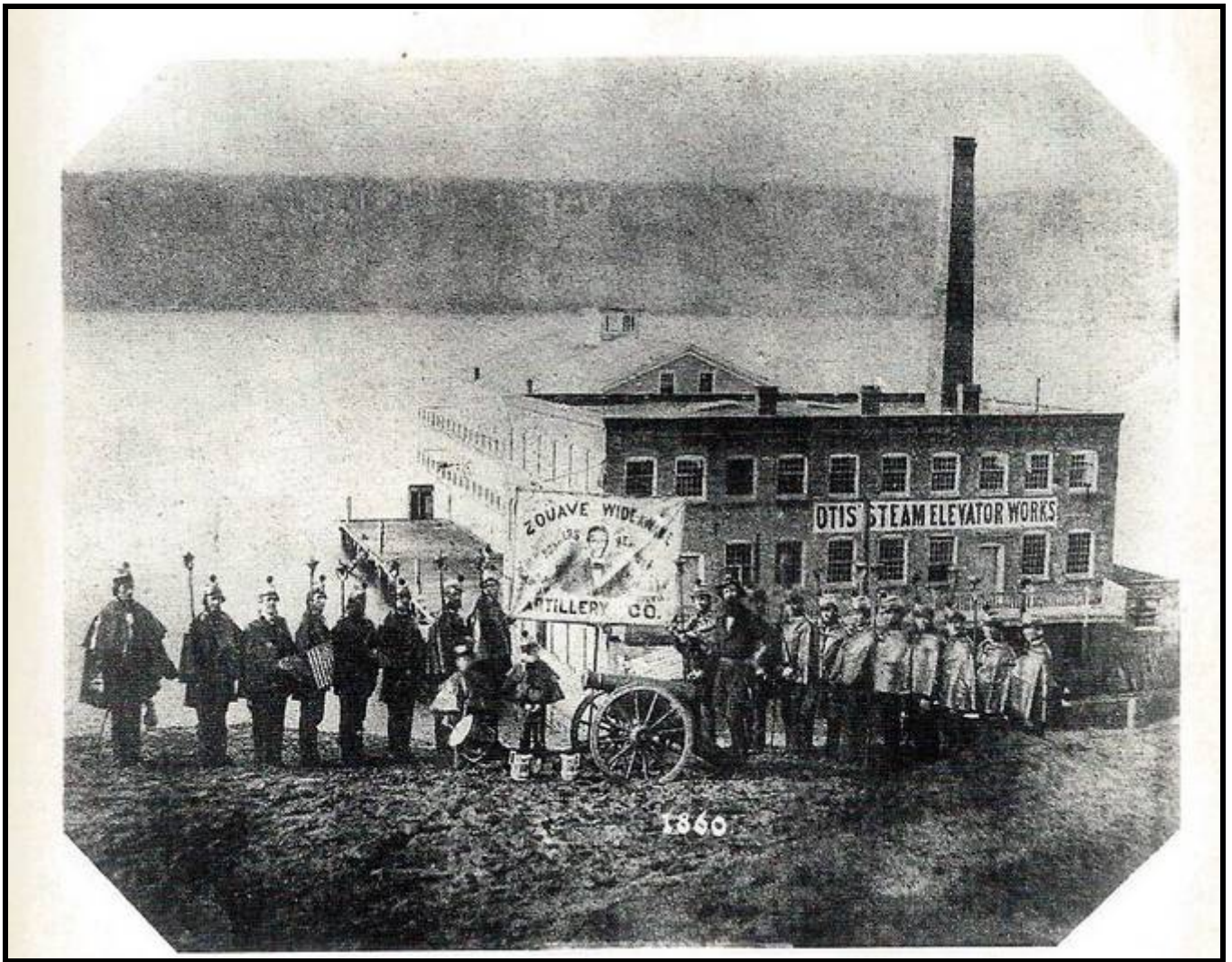
is an addition to the comfort of every member of the household; and at the same time increases the value and salability of property more than cost of installation. No house of pretension should be without one. We frequently install elevators in houses already built. It is not as much of an undertaking as one might think to thus bring an old house up-to-date. Write for blanks and specifications.

OTIS ELEVATOR COMPANY,
New York Office, 17 Battery Place

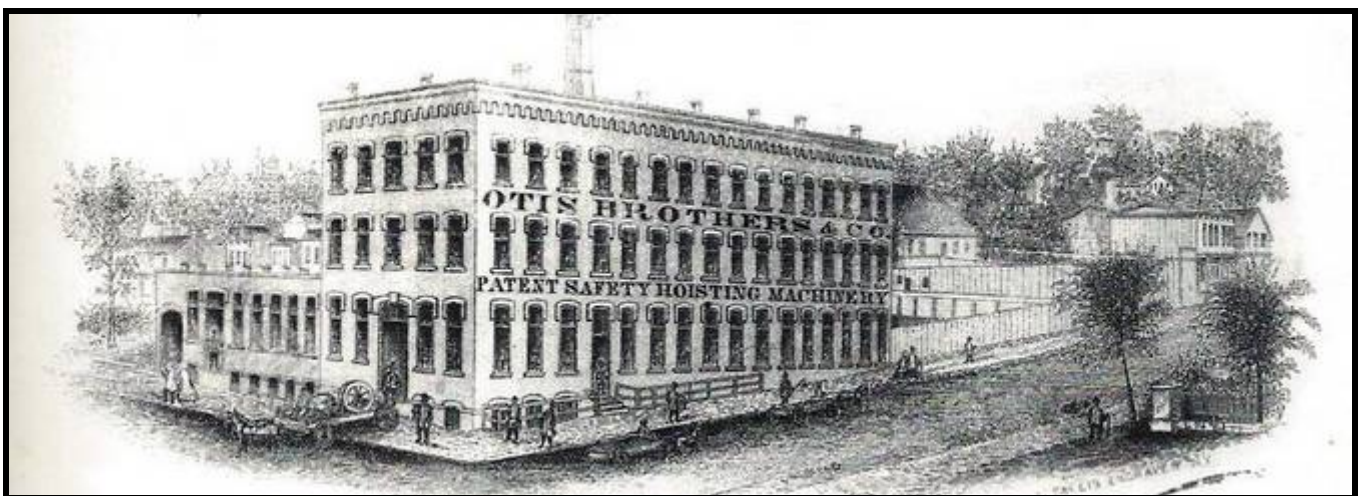
Branch Offices throughout the Country



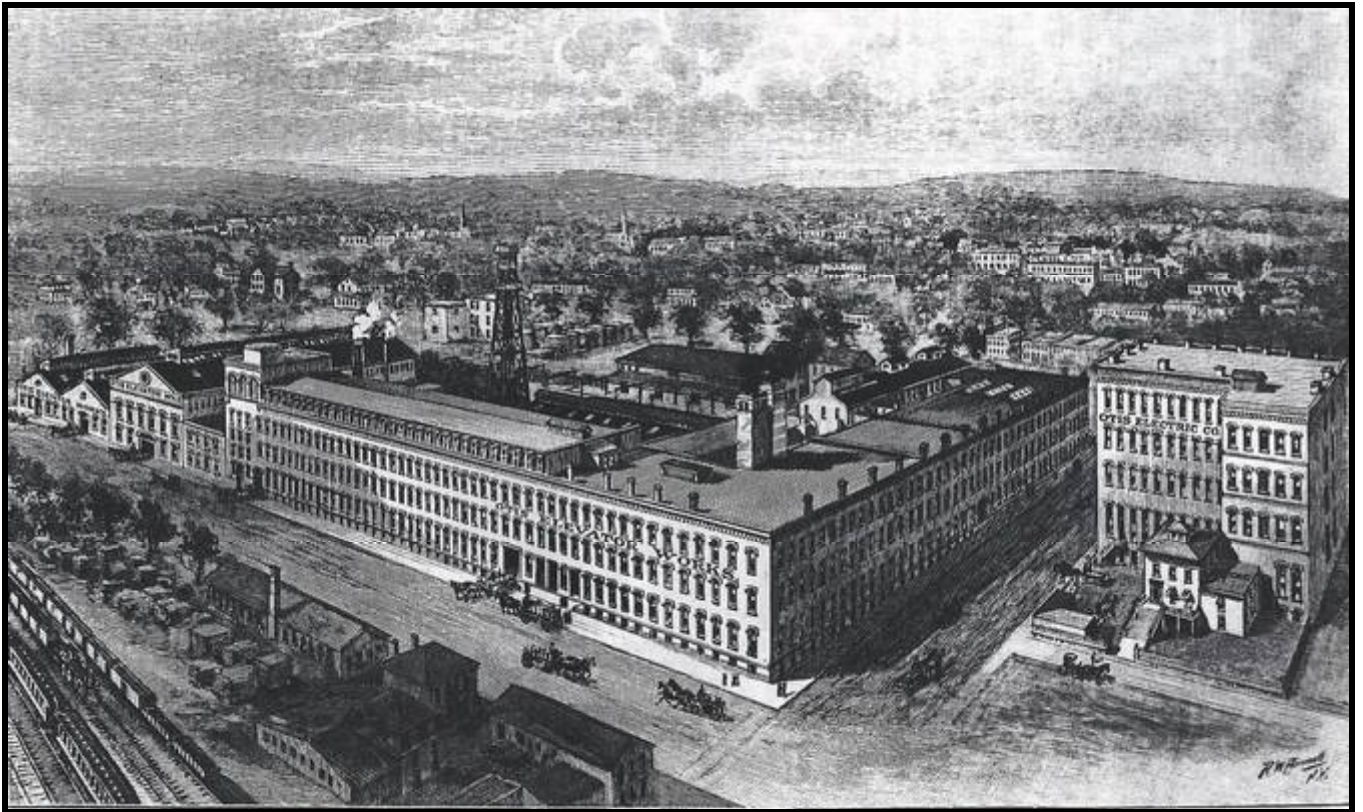
Around the year 1900, Otis advertised its popular Automatic Electric Elevator for use in residences (Automatic meant pushbutton control)



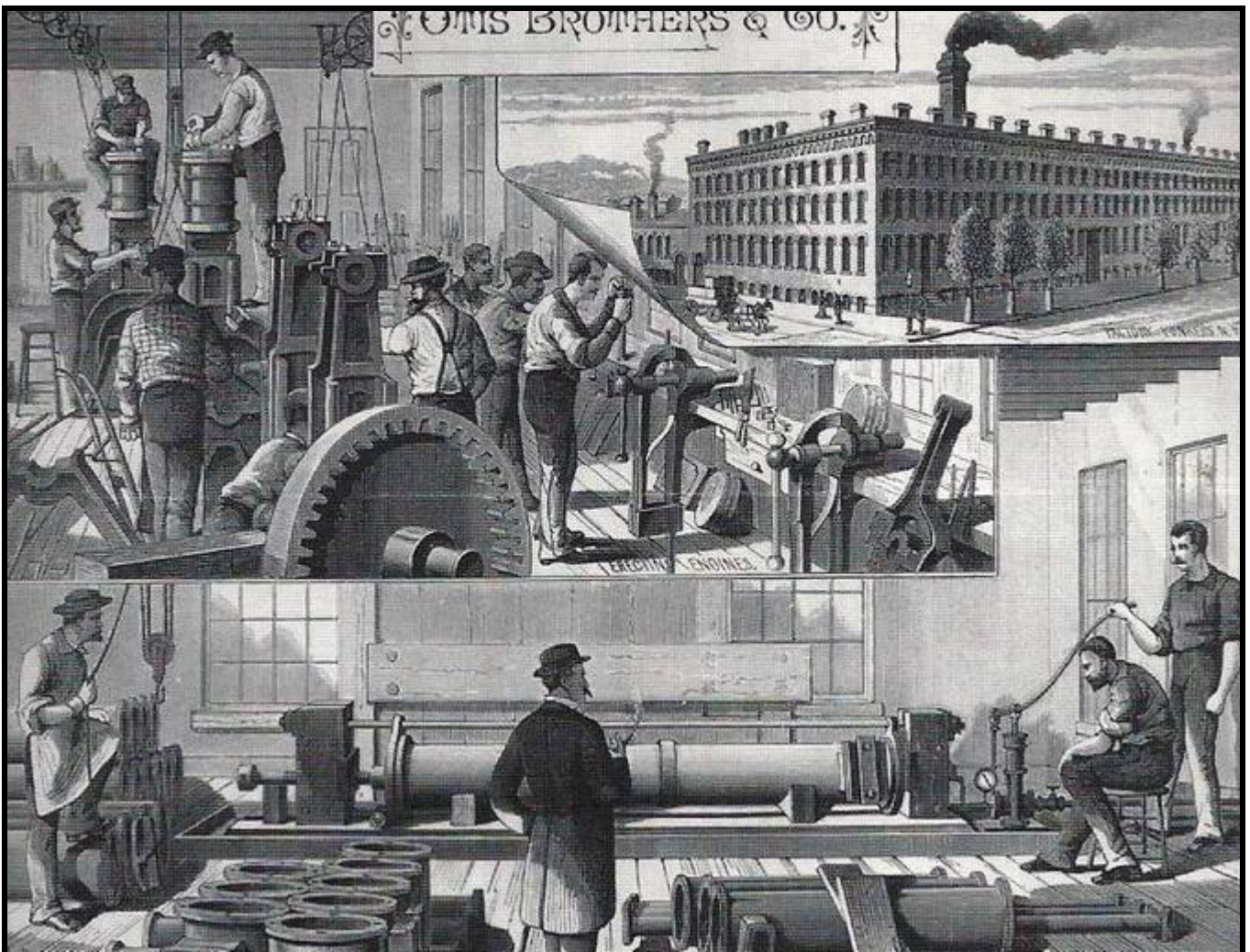
The Otis Steam Elevator Works in 1860. Elisha, with hand on artillery piece, was a supporter of Lincoln



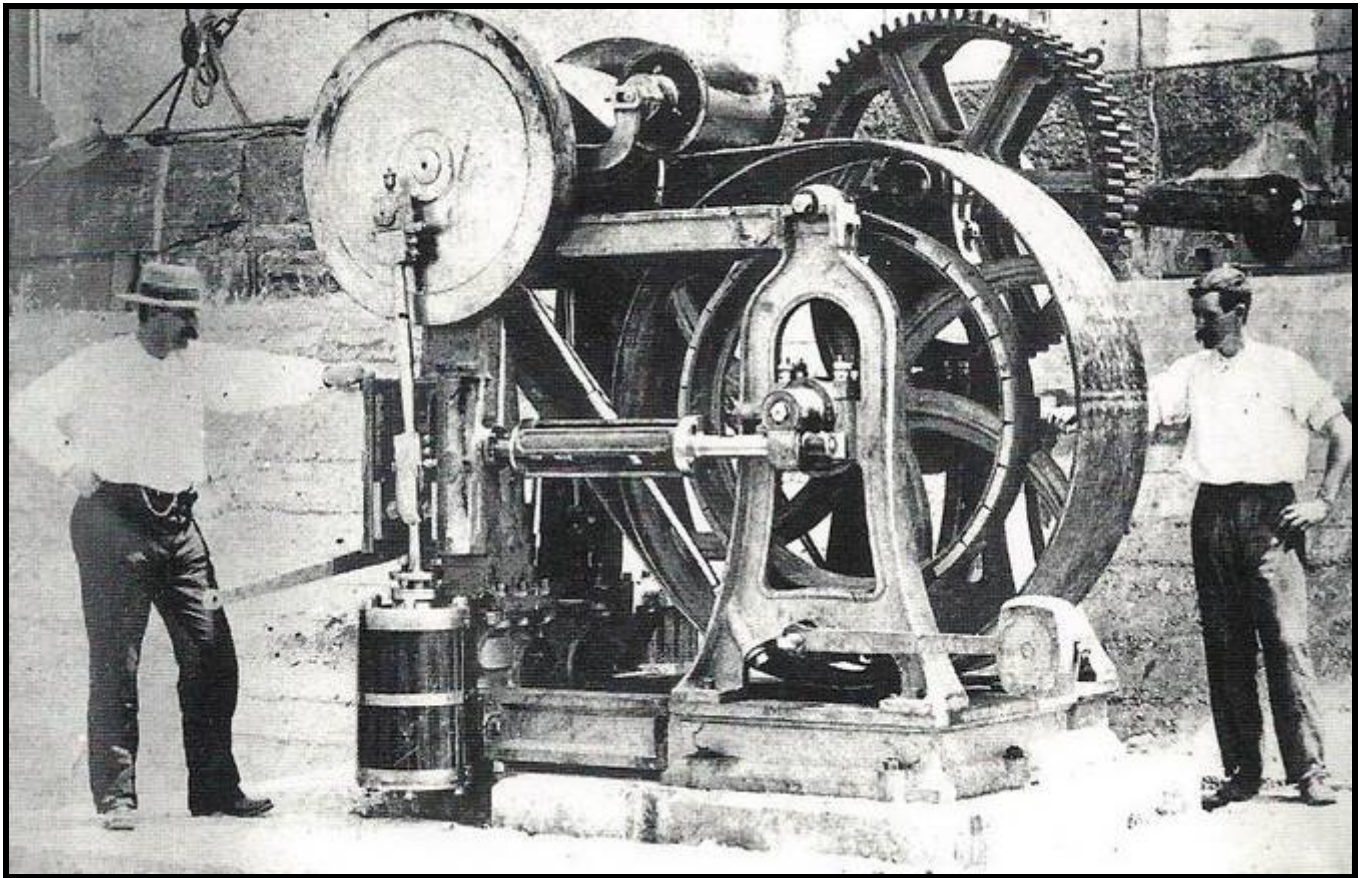
The Otis Bros Factory in Yonkers, New York, about 1870



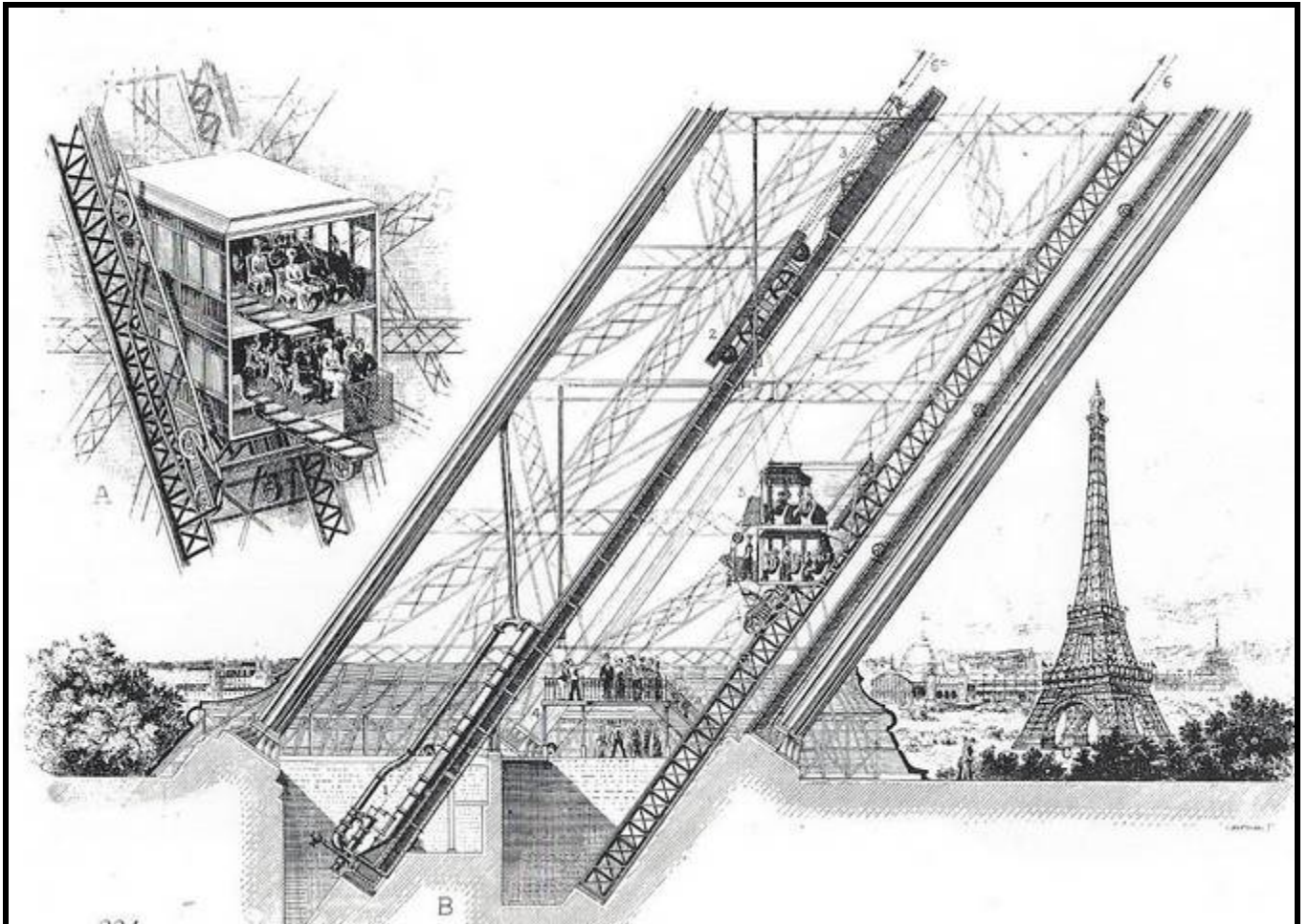
The Otis Elevator Works and the Otis Electric Company (right) in Yonkers, New York, 1896



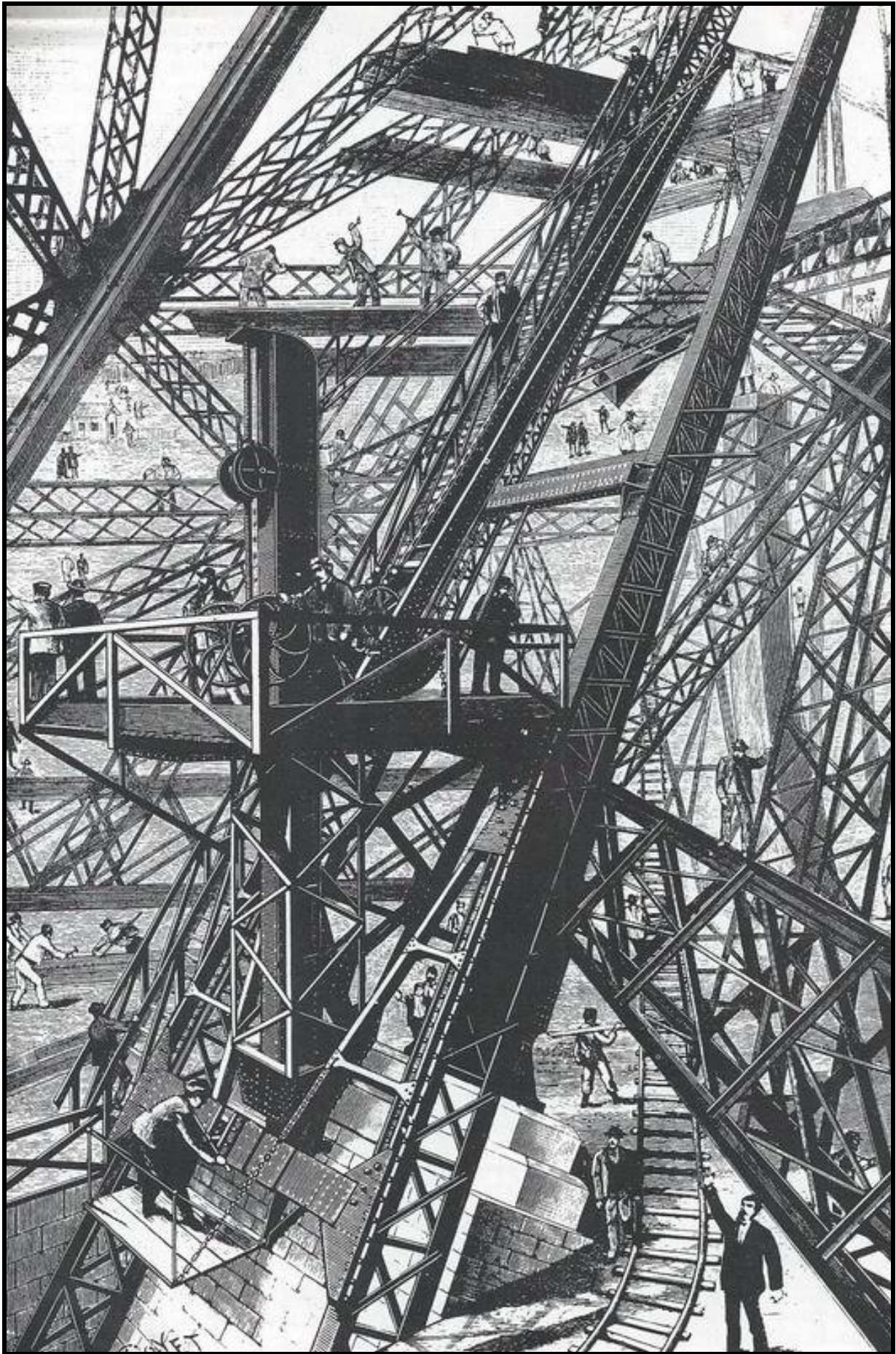
Engine construction at Edison Bros Yonkers Works in 1878



The Washington Monument Elevator Engine, Washington D.C., 1880



Drawing of the double-deck Otis hydraulic cars which ran up an inclined leg of the Eiffel Tower to the Second Platform level at 380 feet, 1889



Building the 984 feet tall Eiffel Tower for the Paris Exposition of 1889

EIFFEL VERSUS OTIS

Eiffel faced a problem with the provision of an elevator to climb the tower's sloping legs because no French company was willing to quote and the Exposition's Charter prohibited the use of foreign equipment. (The contract for the vertical elevators to serve the upper parts of the tower had already been awarded to French firms). That left Eiffel with only Otis Ascenseur Cie and in due course they were awarded the contract.

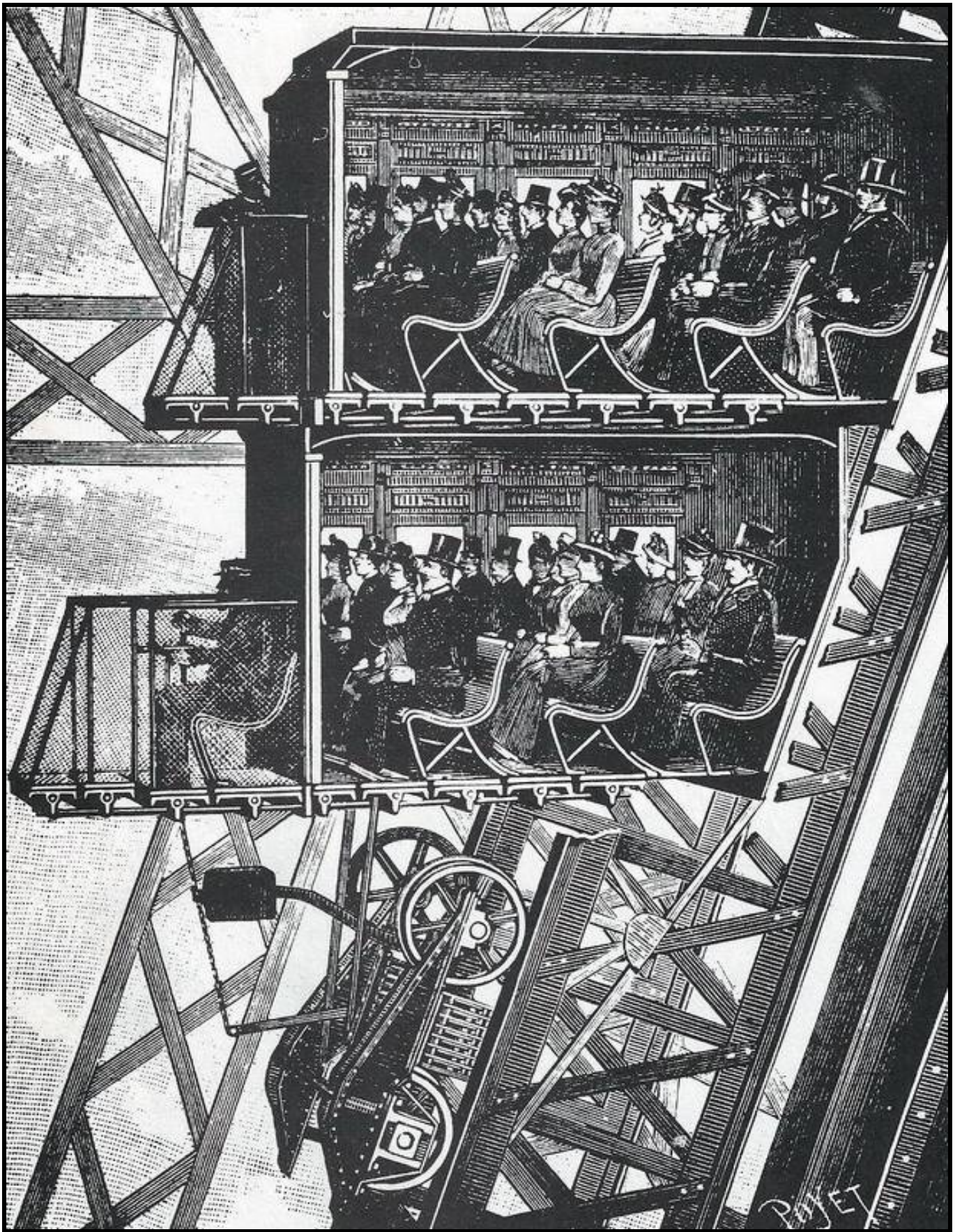
The Otis system employed a hydraulic, rope-gear unit that had become standard since about 1880. It used a "thirty-six-foot-long cylinder (which) was inclined at an angle parallel to the car's initial run. It incorporated a piston thirty-eight inches in diameter attached to cables running through a huge tackle composed of five fixed and six movable pulleys..." The necessary water reservoir was sited on the tower's second platform as it could not be located at ground level where it would interfere with the tower's foundation.

However, trouble was yet to come. Eiffel insisted that Otis use a rack and pinion safety system, but rather than compromise their design Otis refused. The argument persisted until Otis threatened to withdraw from the project and the suggested French changes were quietly dropped.

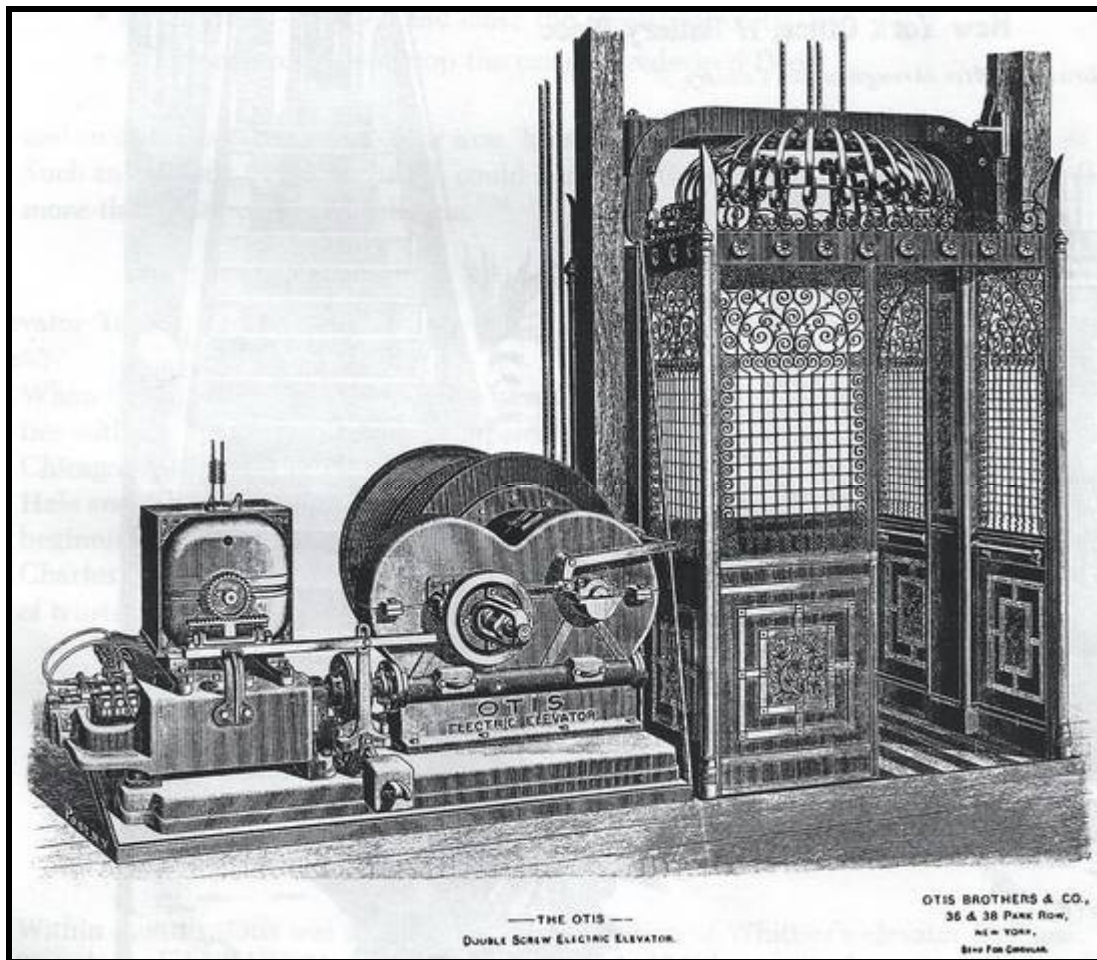
Eiffel then started another argument with Otis as the original contract required the elevators to be in operation by 1st January, 1889. Otis could not meet this date because of the numerous modifications made during installation, but guaranteed the elevators would be functioning by 1st May. Eiffel then said he would refuse to pay for the work, so Otis again threatened to quit. Eiffel duly paid up, though the elevators were not both in operation until mid-June. However, they worked so well they were one of the hits of the show. [From Harriss]



Visitors to the Paris Exposition of 1889 with an Otis elevator just visible (right) on the far tower's leg



Sectional view of the 1889 Otis double-deck elevator for the Eiffel Tower



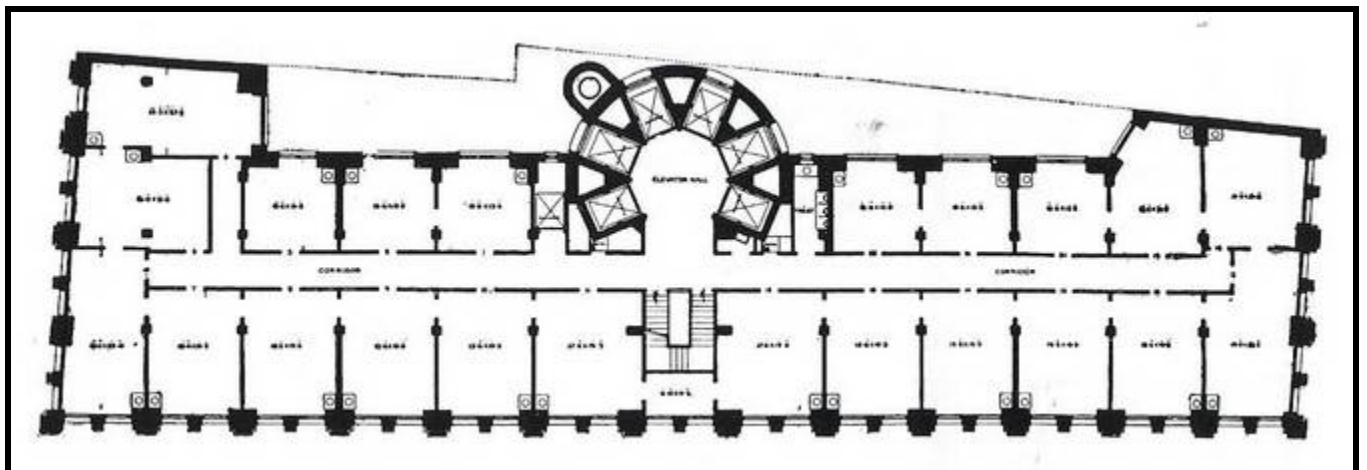
The Otis Bros Double-Screw Electric Elevator of the 1890's, having worm gears and a drum making it suitable for low-rise and low-use applications

In the late 1860's, Otis Brothers & Company advertised the "novel luxury" of the passenger elevator and had introduced the "Palace Elevator" for hotels and other public establishments.

The 19th century was the age of steam power and initially most freight elevators and many early passenger elevators were powered by steam. However, this changed with the introduction of the Otis hydraulic elevator, the firm having acquired the technology from Hydraulic Elevator of Chicago. Being powered by high pressure water this type became popular around the turn of the century with the rise of the skyscraper. The industry again changed dramatically with the availability of electric power. Otis Brothers sold their first electric elevators in 1889. Then in 1892, with the young General Electric Company, the Otis Electric Company was formed. Otis Bros went on to form relationships with many other elevator companies becoming a trust to limit competition and control prices. In 1906, the Federal Government charged them with violation of the Sherman Antitrust Law and as a result Otis had to agree not to hinder trade, not to fix prices and not to divide territory.

Around 1905, Otis had introduced the gearless traction electric elevator and a range of important controlling devices making their system ideal for the new higher buildings like the Singer and Woolworth towers. Otis went on to achieve world-wide dominance in the elevator business and in 1975 was acquired by the United Technologies Corporation becoming a wholly owned subsidiary.

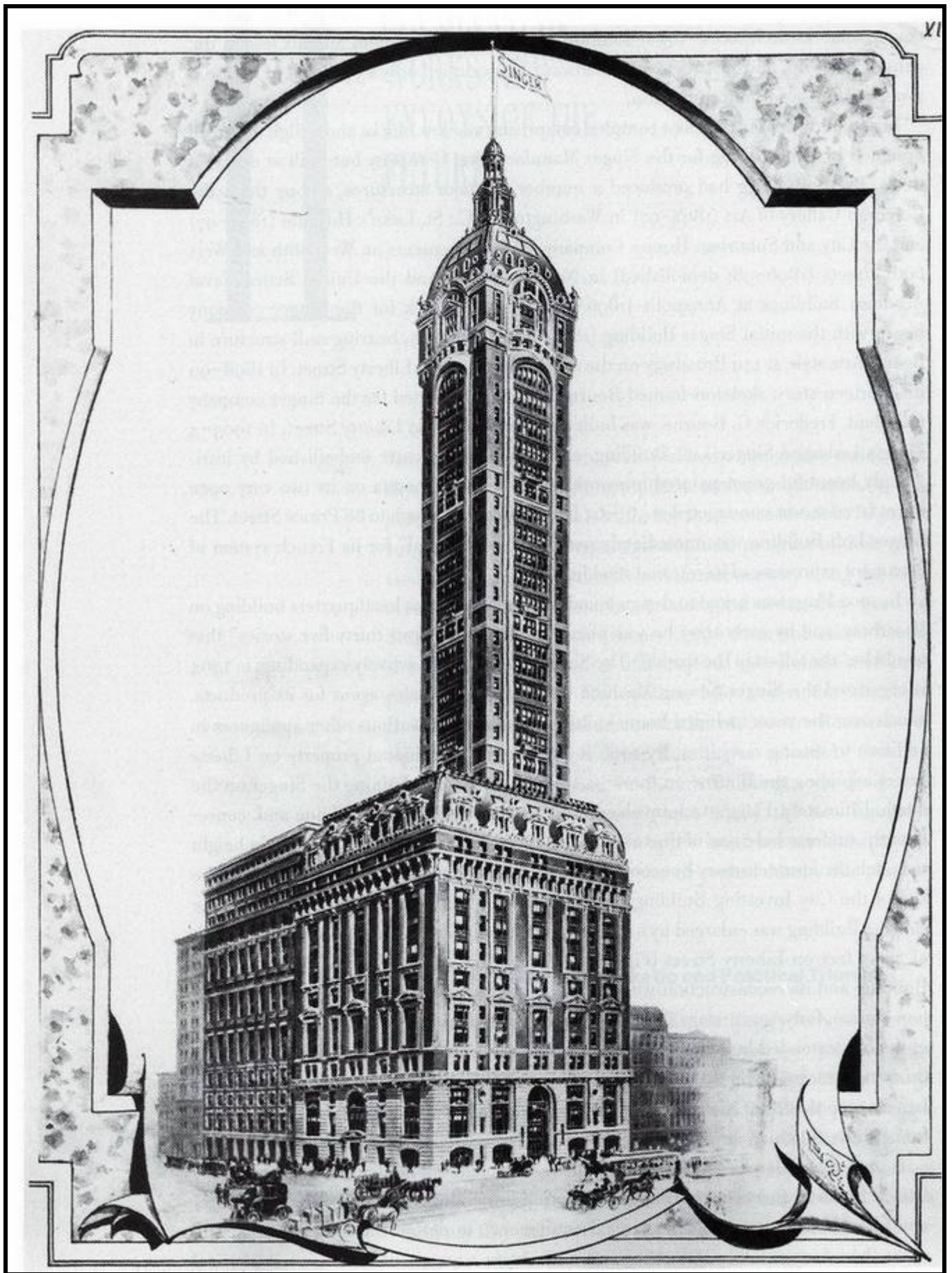
EARLY OTIS ELEVATOR INSTALLATIONS



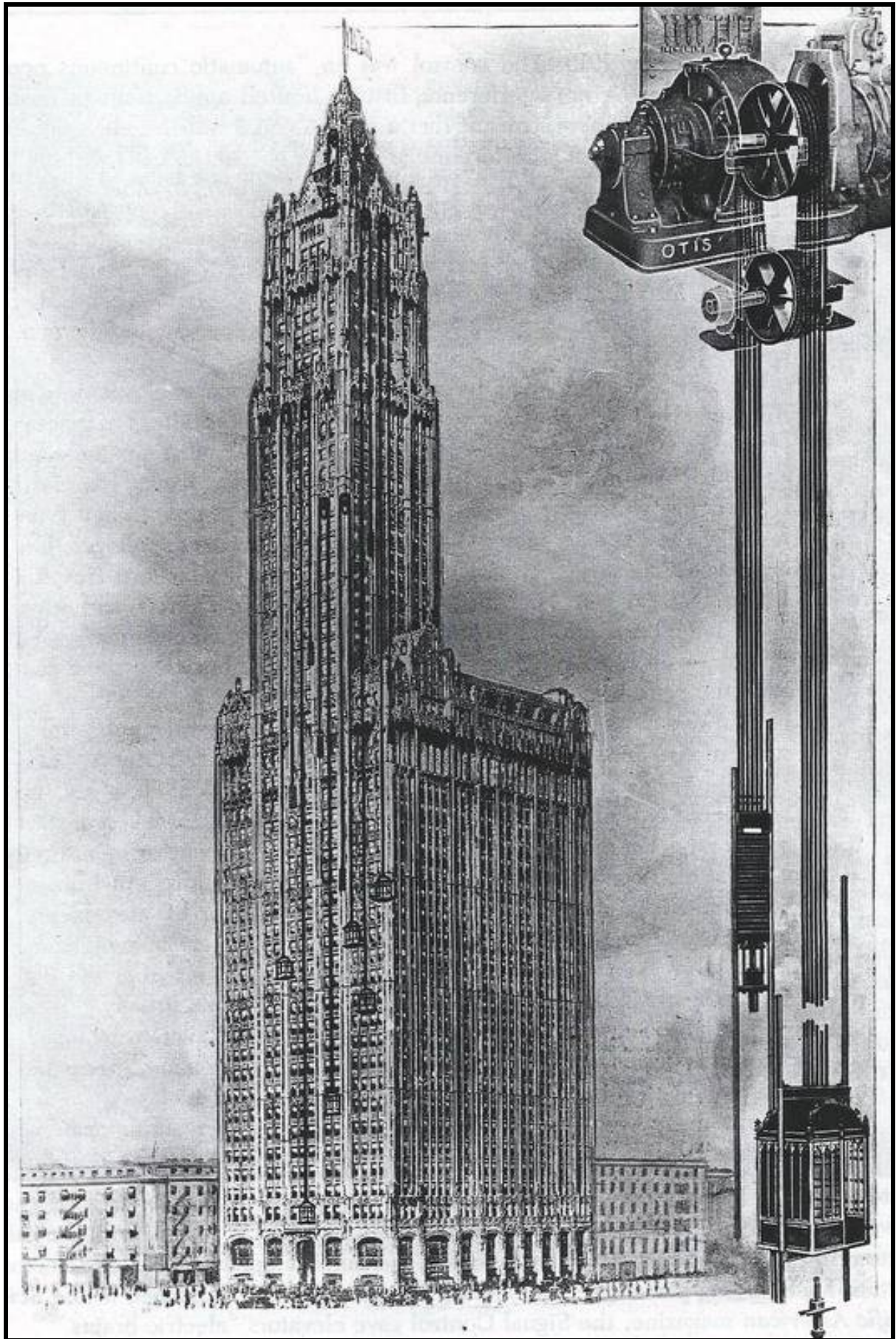
New York's Havemeyer Building of 1893 (now demolished) had 6 Otis hydraulic passenger elevators



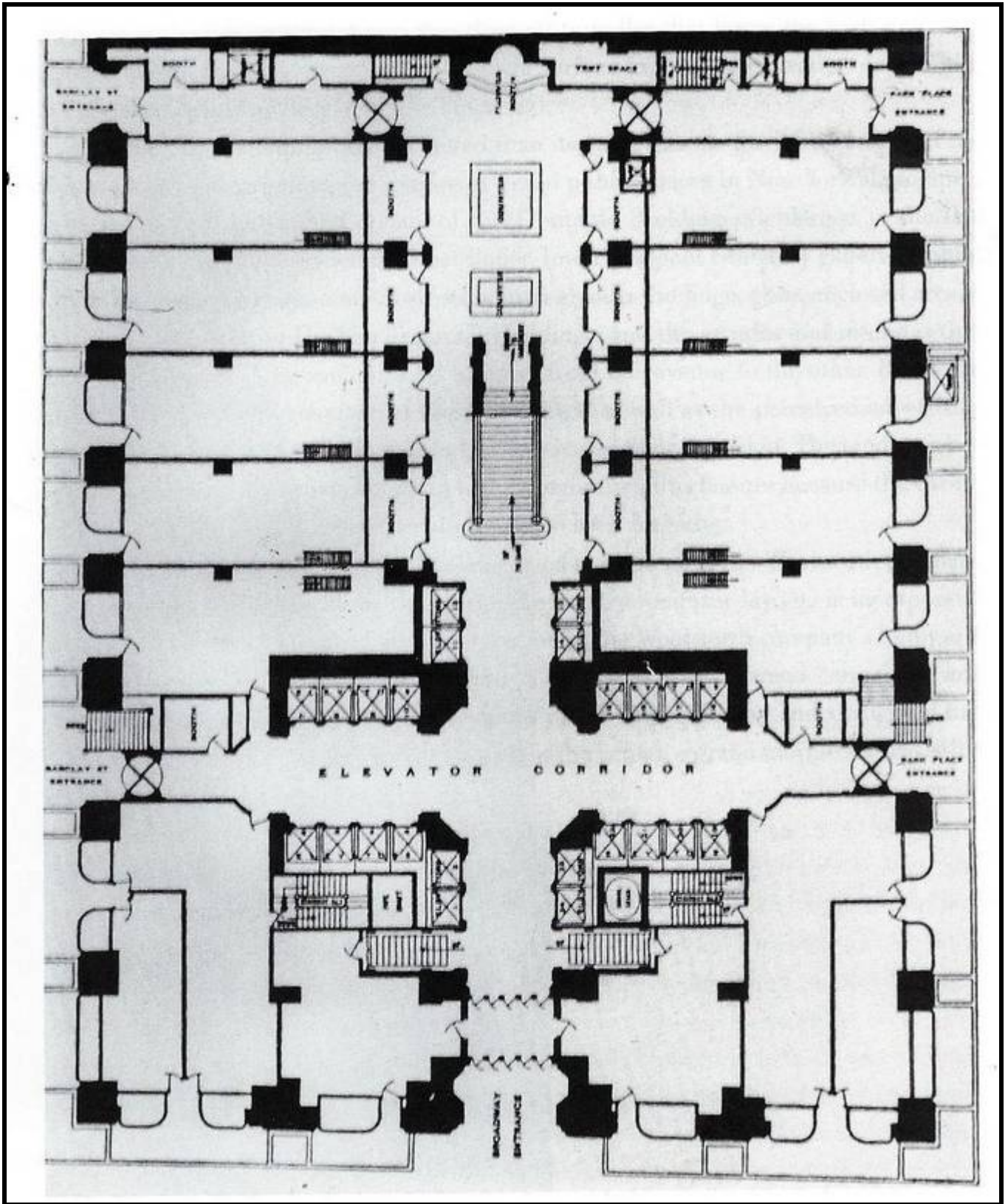
The twenty-storey Flatiron Building of 1902 in New York had 6 Otis rope-gearred hydraulic elevators



The Singer Tower of 1908 (later demolished) in New York was provided with 16 Otis Electric Passenger Elevators, possibly the first such installation on this scale



In 1913, the new sixty-storey Woolworth Building (dubbed “The Cathedral of Commerce”) was equipped with 26 Otis traction elevators for carrying passengers and freight



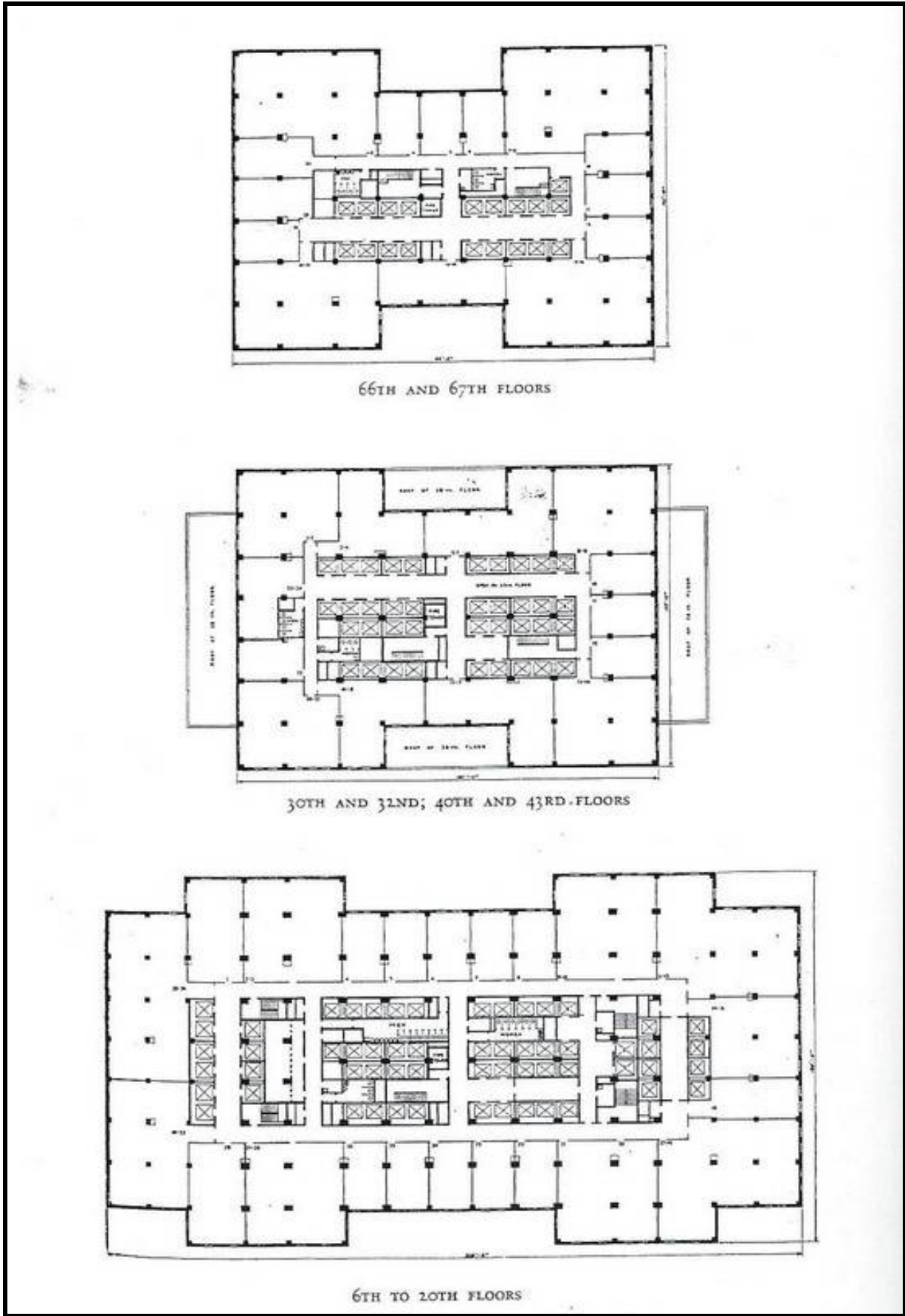
Plan of the Elevator Lobby of the Woolworth Building



Construction workers on the Empire State Building 1930 (a Lewis W Hine photograph)

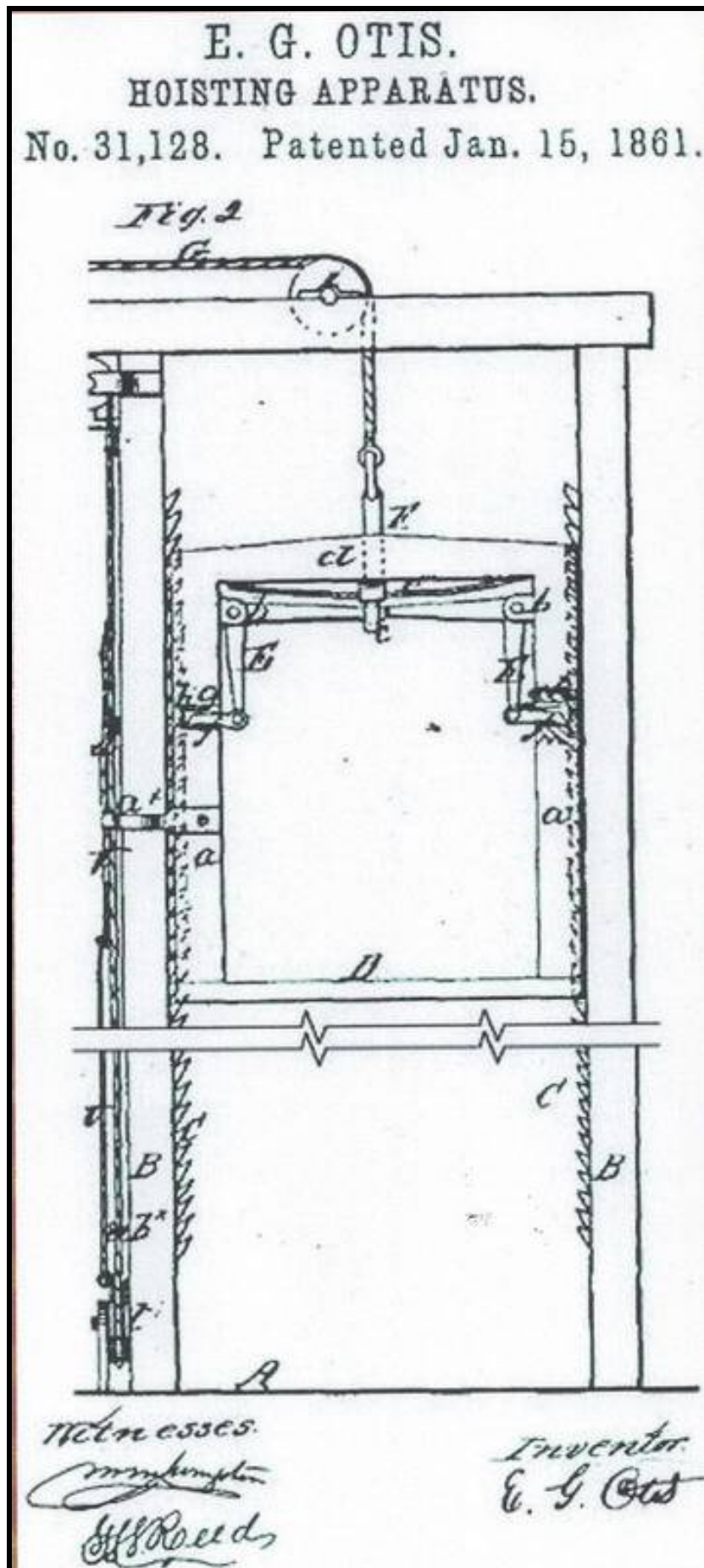


The Empire State Building in New York was completed in 1931 with 68 Otis elevators



Typical floor plans of the Empire State Building showing the arrangement of Otis elevators

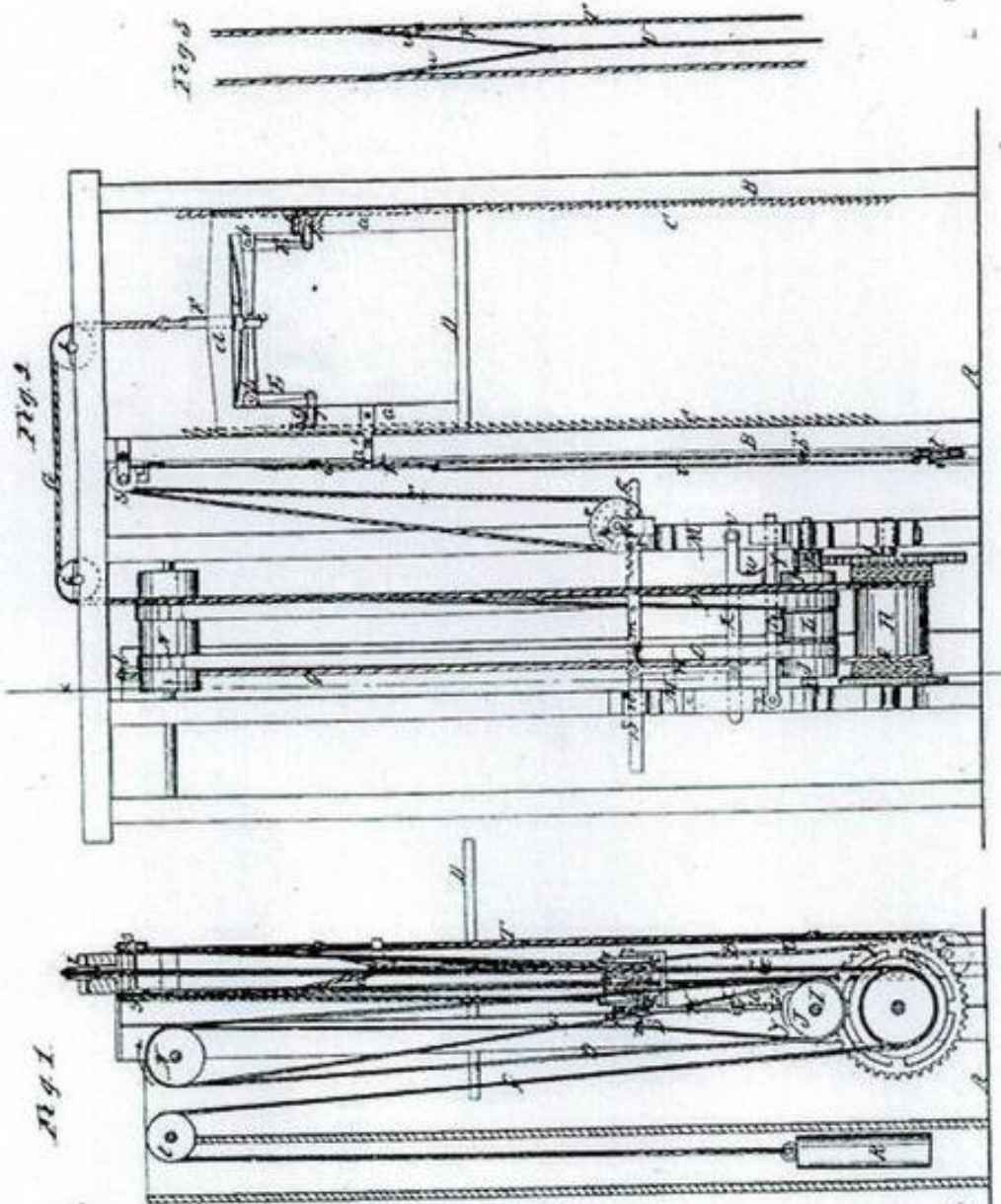
APPENDIX I: SOME EARLY AMERICAN OTIS PATENTS



E. G. OTIS.
HOISTING APPARATUS.

No. 31,128.

Patented Jan. 15, 1861.



Witnesses
[Signature]
[Signature]

Inventor
E. G. Otis

C. R. & N. P. Otis,

Elevator.

No 51,076.

Patented Nov. 21, 1865.

Fig. 3.

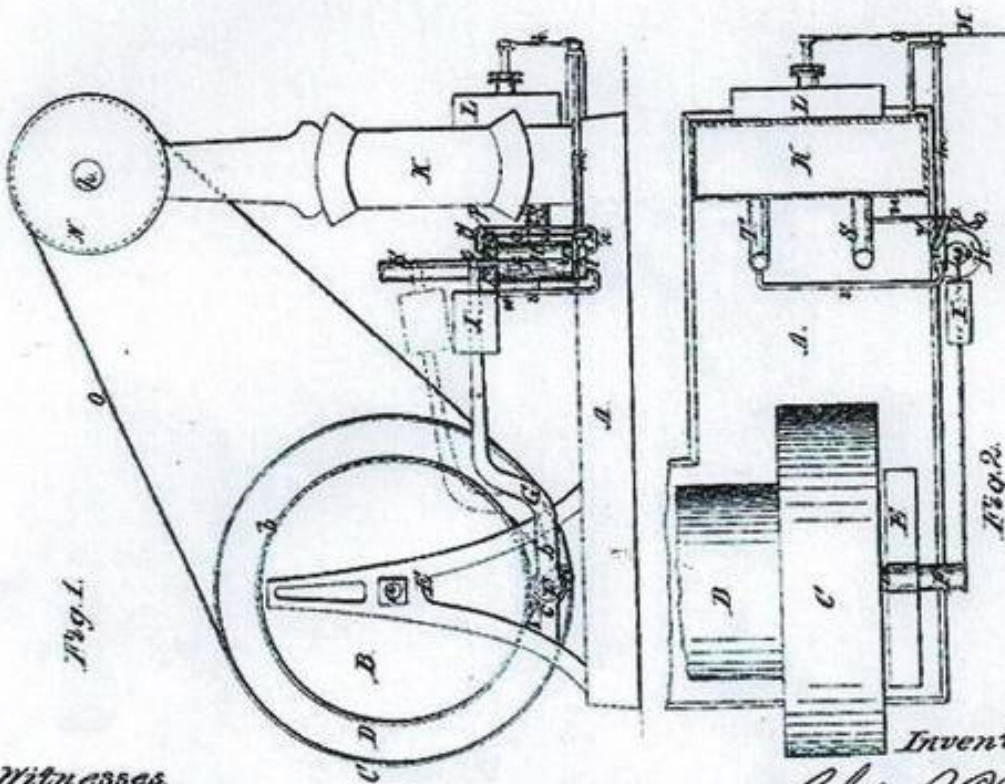
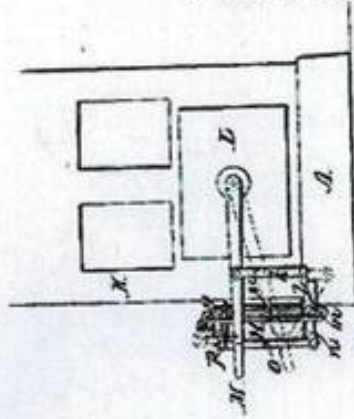


Fig. 1.

Fig. 2.

Witnesses
J. W. Coombs
G. W. Reed.

Inventor
Chas. R. Otis
Boston, P. O. Otis

APPENDIX II: DETAILED DRAWINGS FROM 1889 OF PARTS OF THE OTIS LIFTS FOR THE EIFFEL TOWER [FROM ANSALONI]

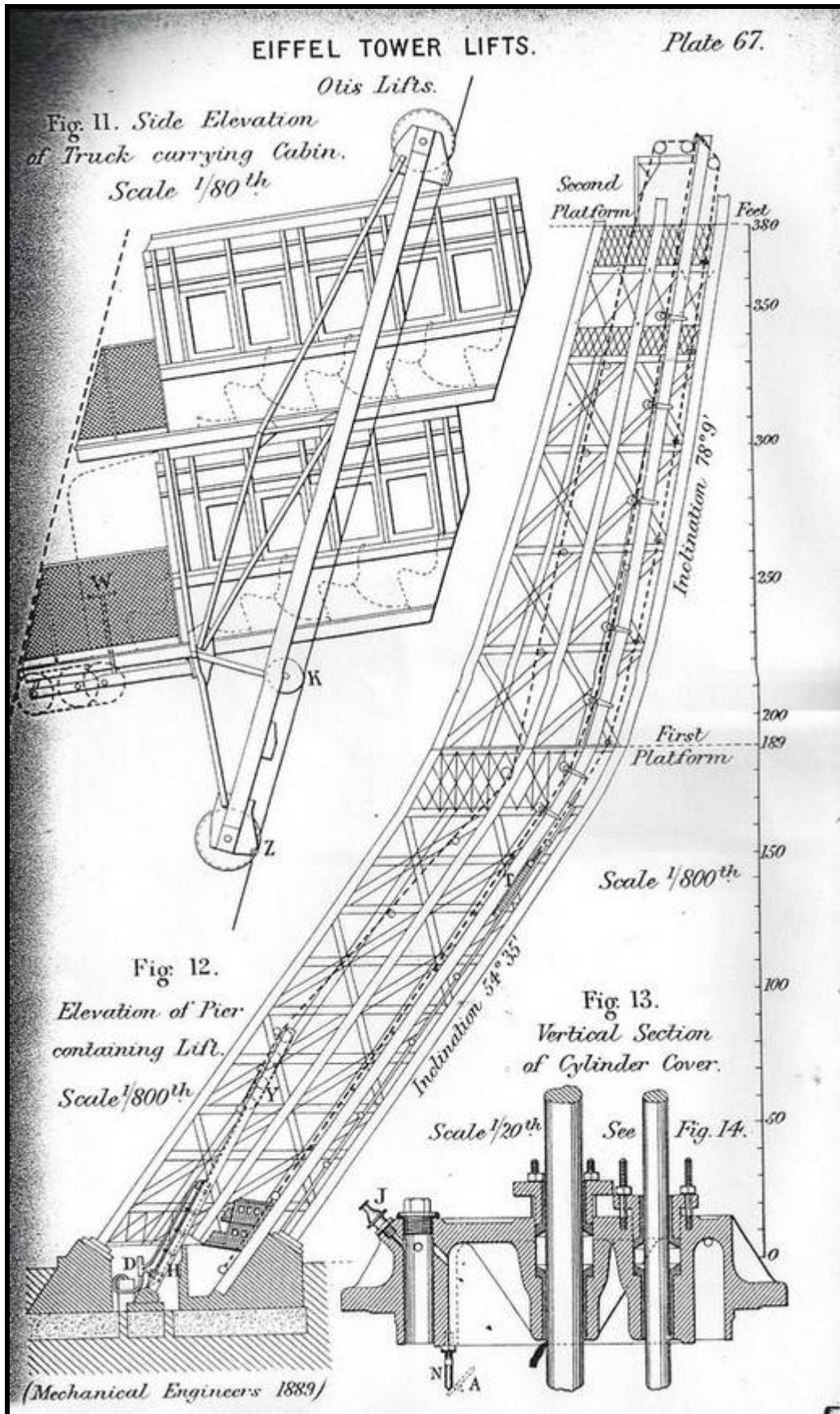


Plate 67: Otis Lifts Details

EIFFEL TOWER LIFTS.

Otis Lifts.
Hydraulic
Cylinder.

Fig. 15.
Plan of Dummy Piston.

Scale $\frac{1}{20}^{th}$

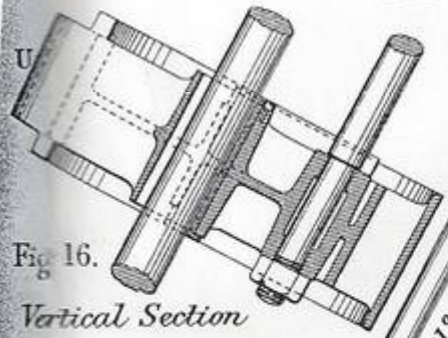
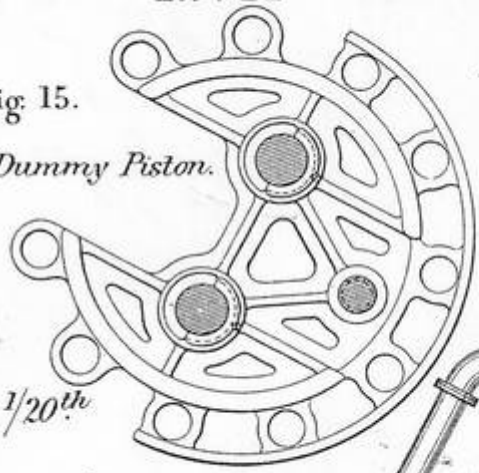


Fig. 16.
Vertical Section
of Dummy Piston.

Fig. 14.
Vertical Section
of Hydraulic Cylinder.
Scale $\frac{1}{100}^{th}$

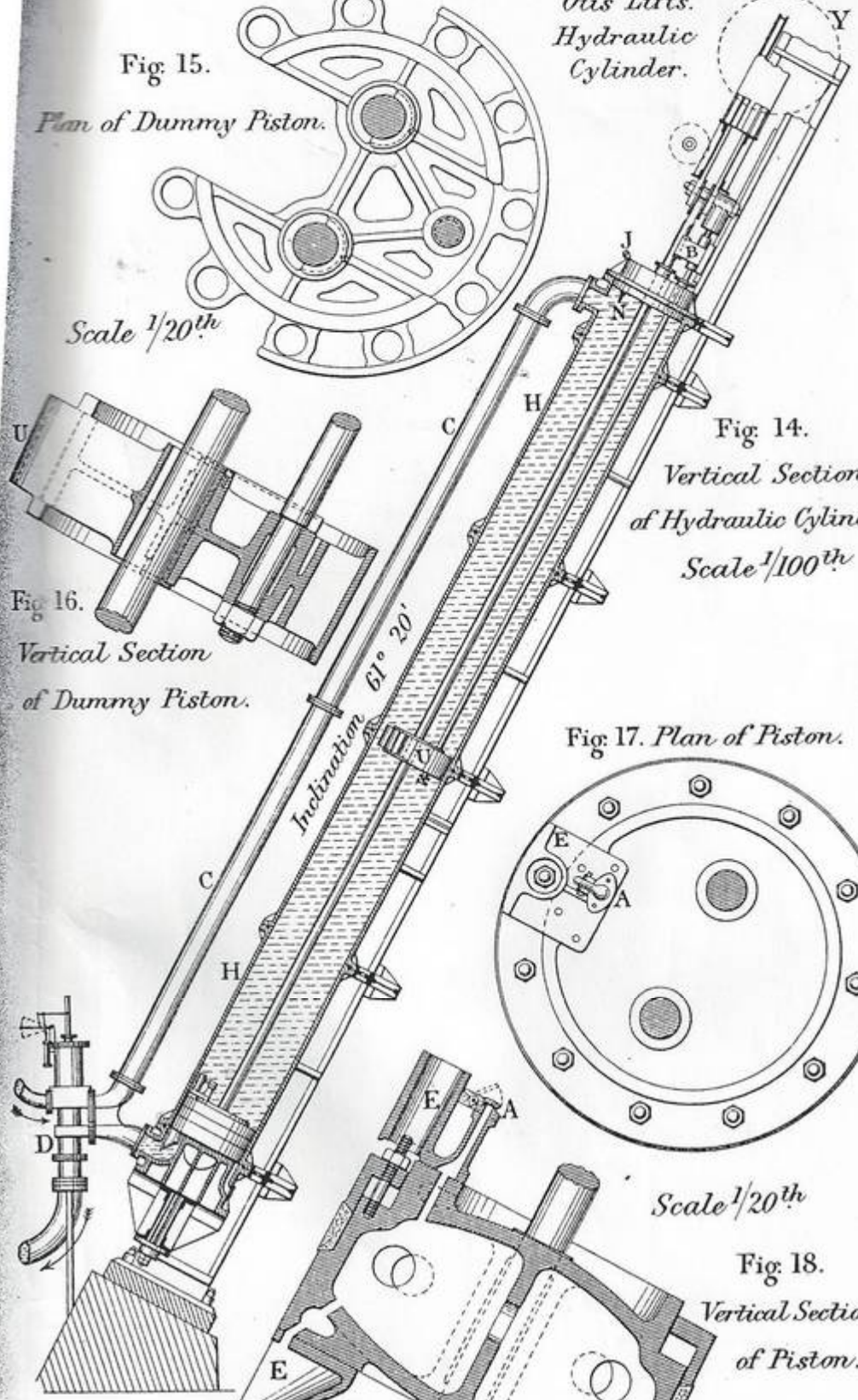
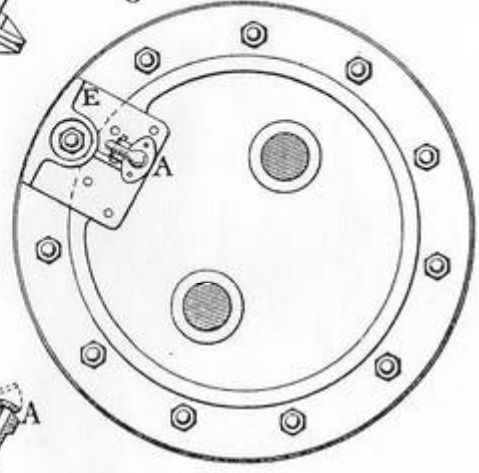
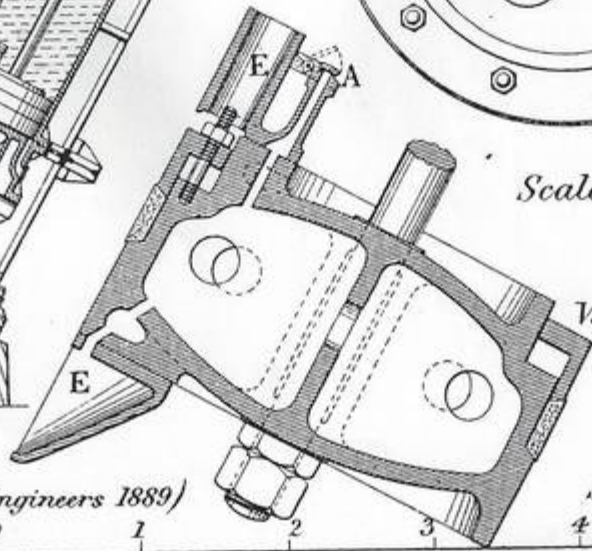


Fig. 17. Plan of Piston.



Scale $\frac{1}{20}^{th}$

Fig. 18.
Vertical Section
of Piston.



Scale $\frac{1}{20}^{th}$

(Mechanical Engineers 1889)

12 Ins. 6 0 1 2 3 4 5 Feet

EIFFEL TOWER LIFTS.

Plate 69.

Otis Lifts. Water Distributor.

Cabin Stationary.

Fig. 19.

Vertical Section.

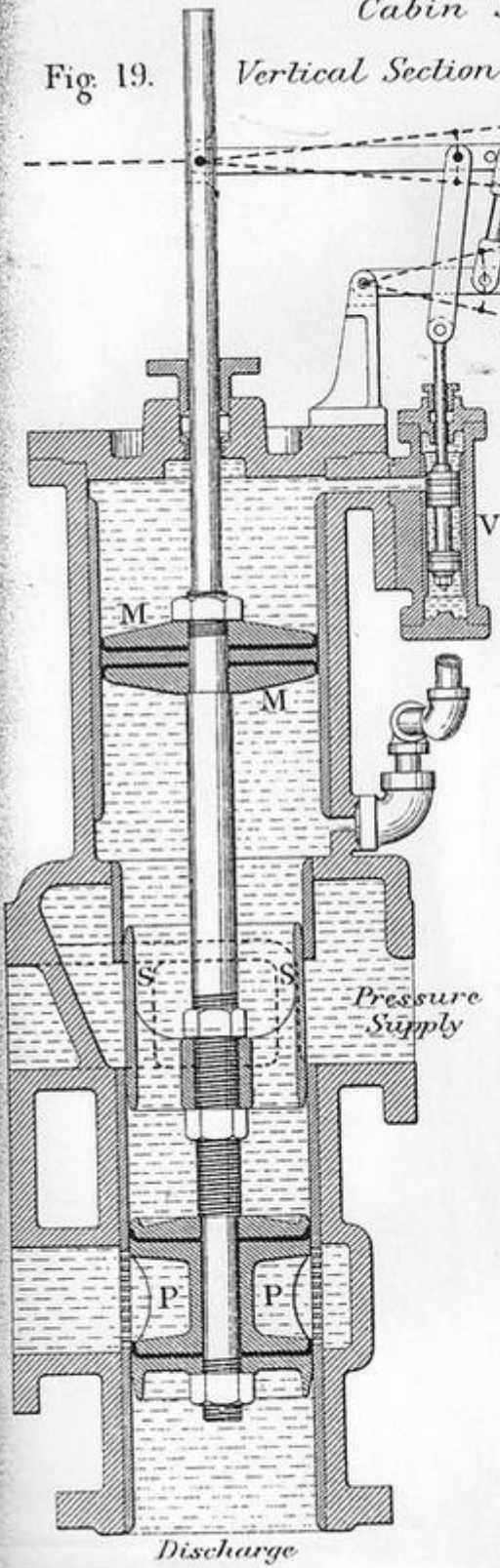
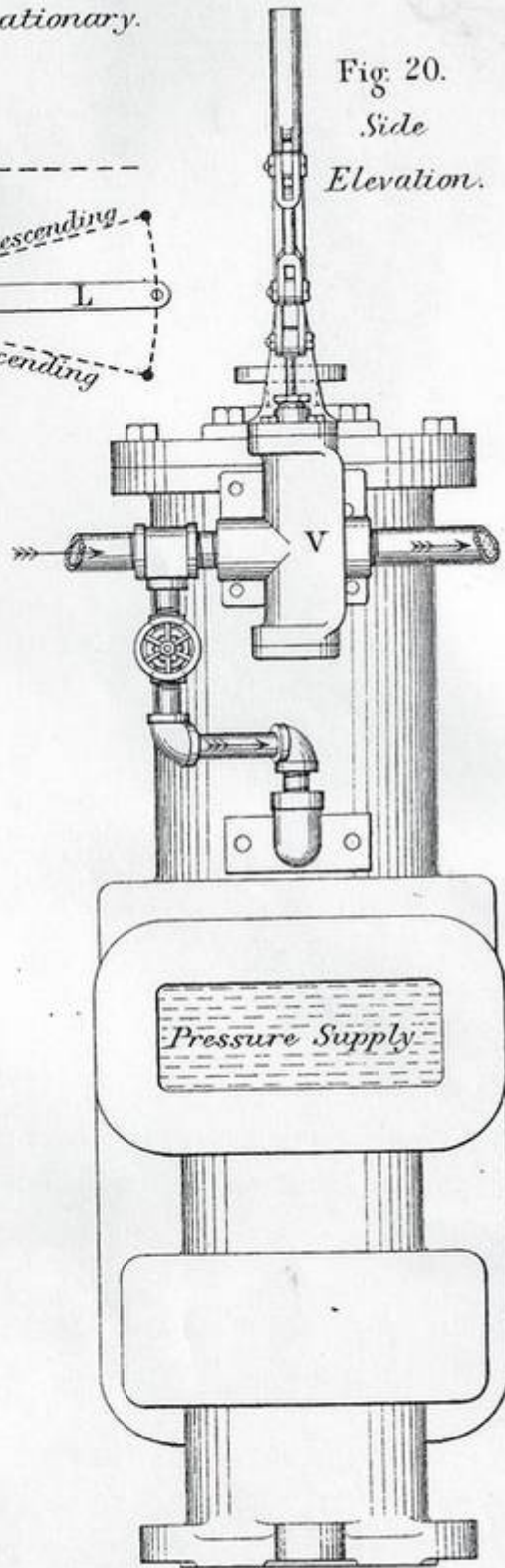


Fig. 20.

Side Elevation.



Inches 12 9 6 3 0 1
(Mechanical Engineers 1889)

Scale $\frac{1}{12}$ th Feet. 2 3

Plate 69: Otis Lifts- Water Distributor Cabin Stationary

EIFFEL TOWER LIFTS.

Plate 70.

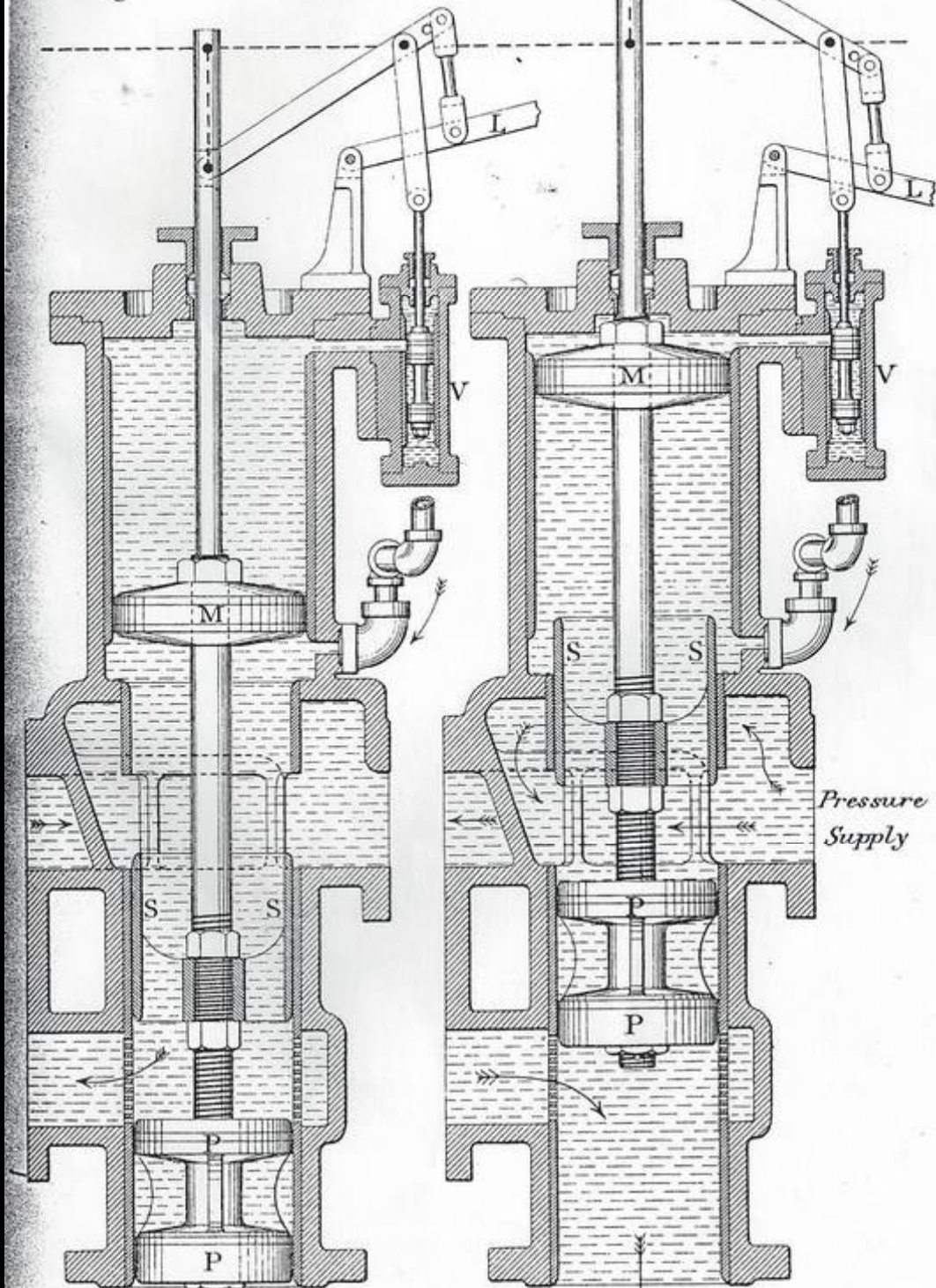
Otis Lifts.

Fig. 22.

Vertical Sections of Water Distributor.

Cabin Ascending.

Fig. 21. Cabin Descending.



Inches (Mechanical Engineers 1889) 12 9 6 3 0 1
Discharge 2 Scale 1/12th Feet 3

Plate 70: Otis Lifts- Vertical Sections of Water Distributor

EIFFEL TOWER LIFTS.

Otis Lifts.

Hand Controlling-Gear.

To Water Distributor

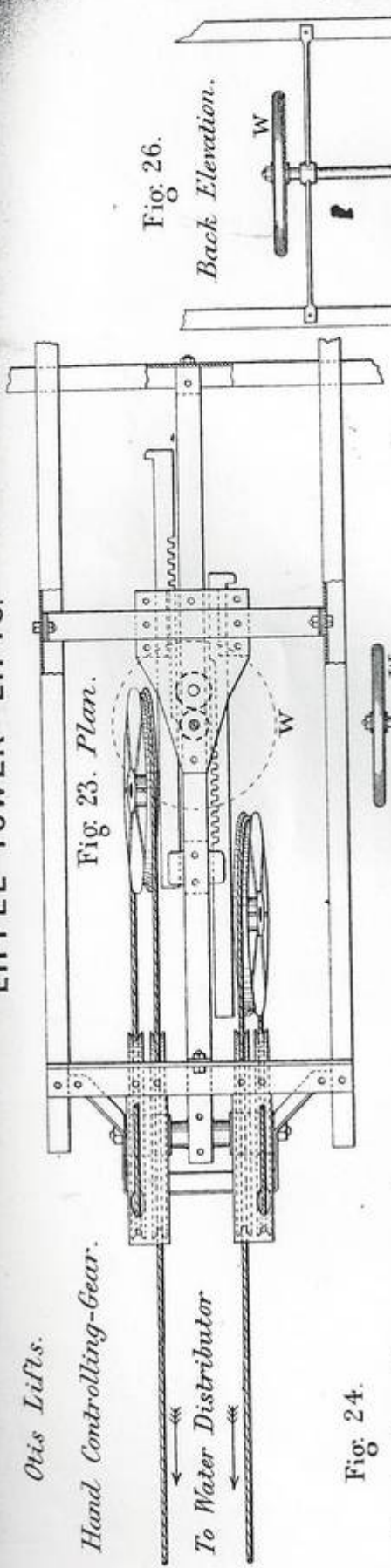


Fig. 23. Plan.

Fig. 24.

Front Elevation.

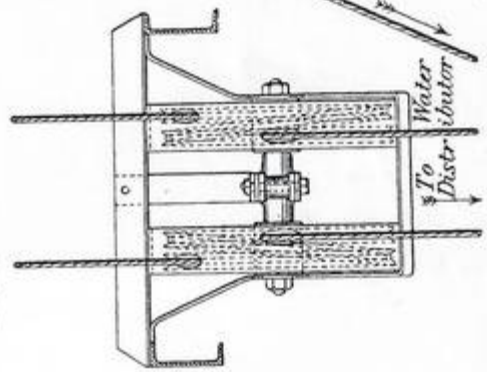


Fig. 25. Side Elevation.

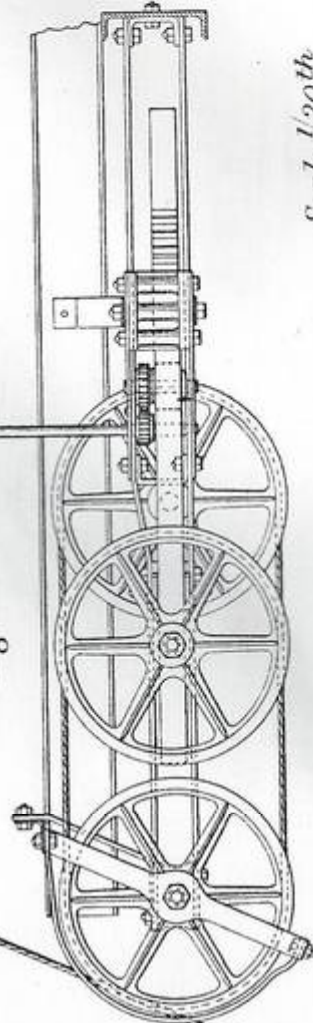
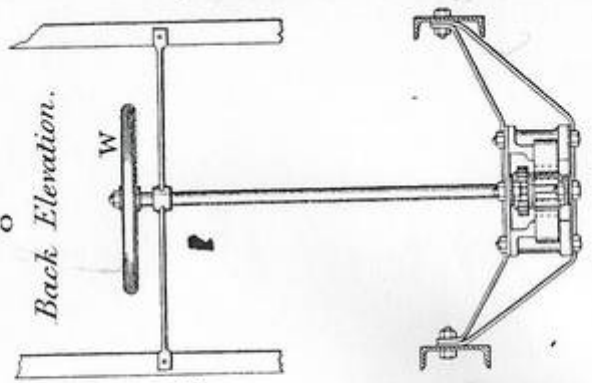


Fig. 26.

Back Elevation.



Scale 1/20th



(Mechanical Engineers 1889)

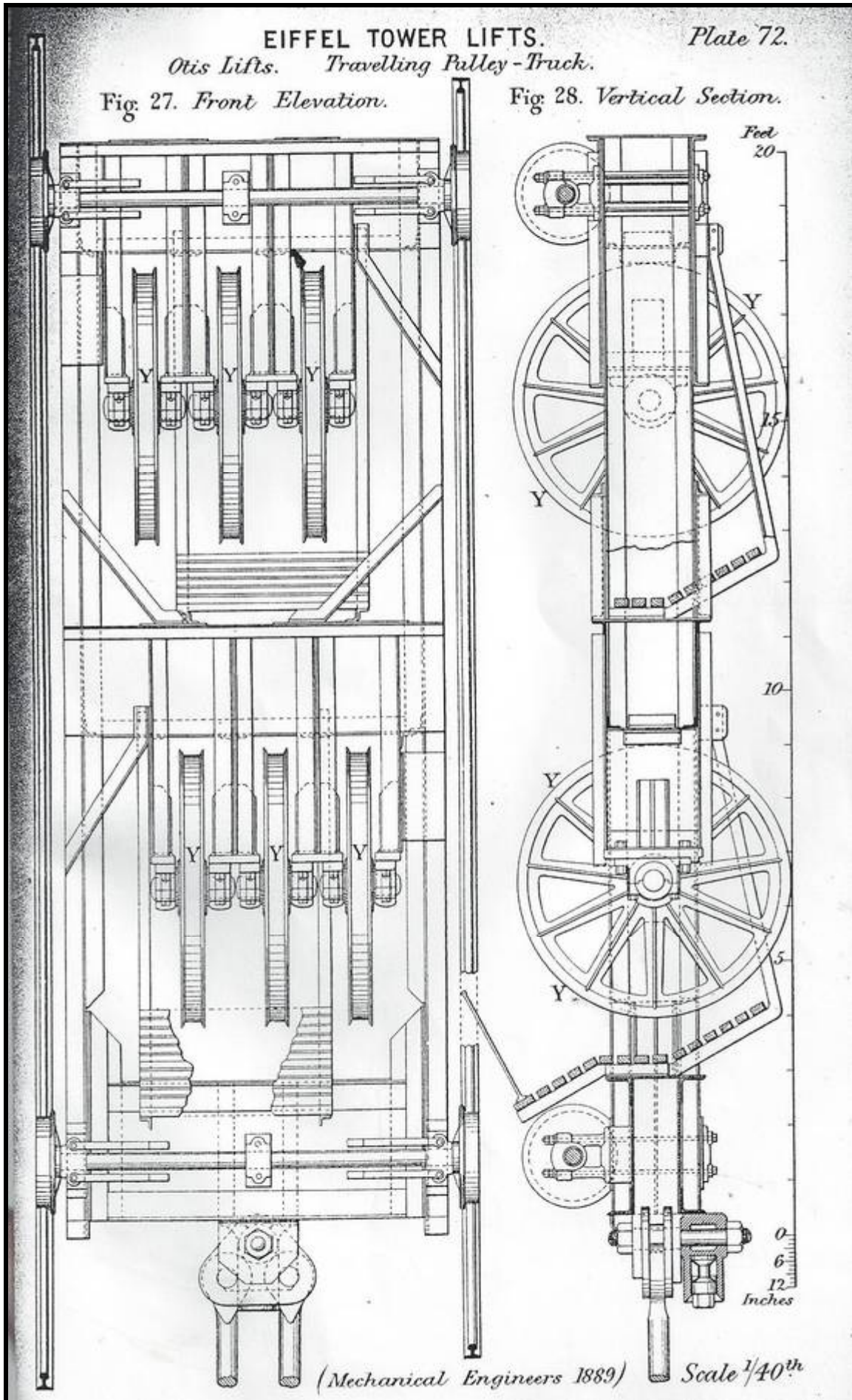
EIFFEL TOWER LIFTS.

Plate 72.

Otis Lifts. Travelling Pulley-Track.

Fig. 27. Front Elevation.

Fig. 28. Vertical Section.



EIFFEL TOWER LIFTS. *Plate 73.*

Otis Lifts. Cabin Safety-Brake.

Fig. 29. *Front Elevation.*

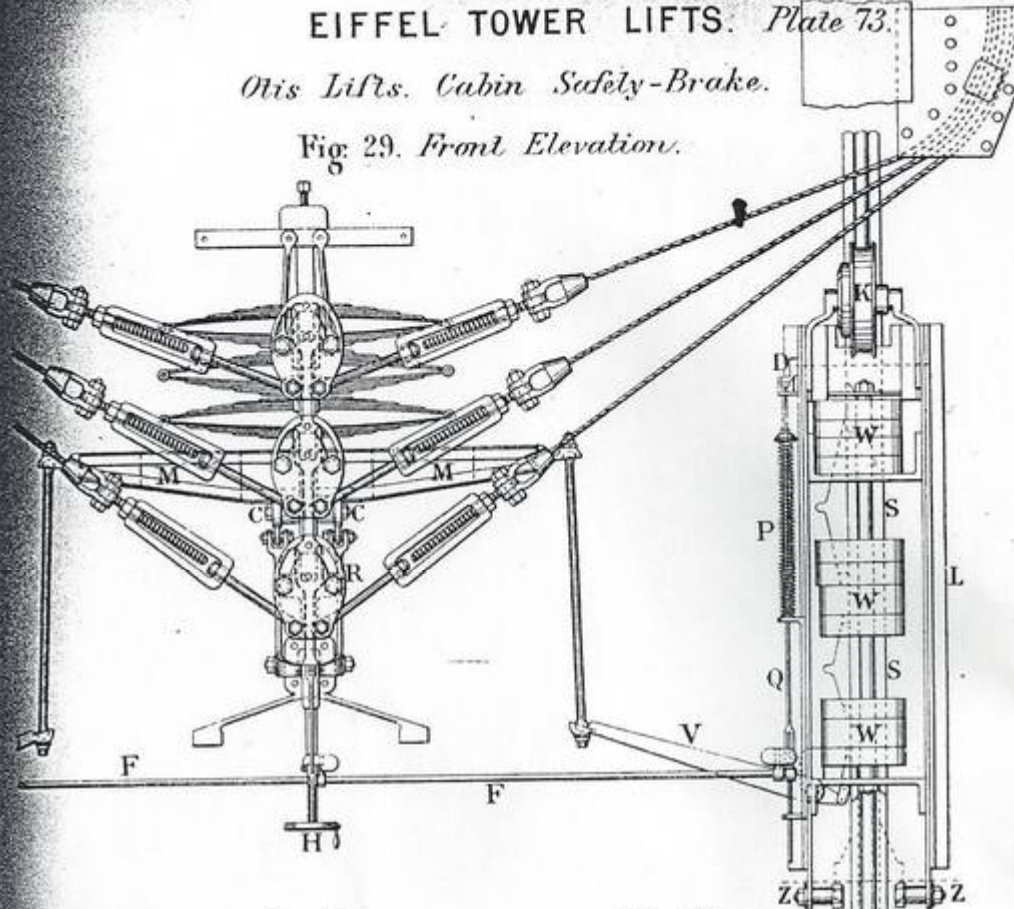


Fig. 30.

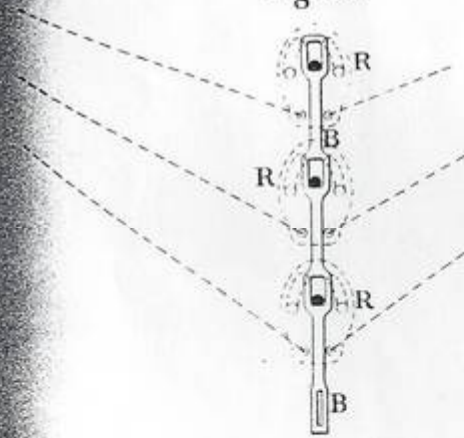


Fig. 31.

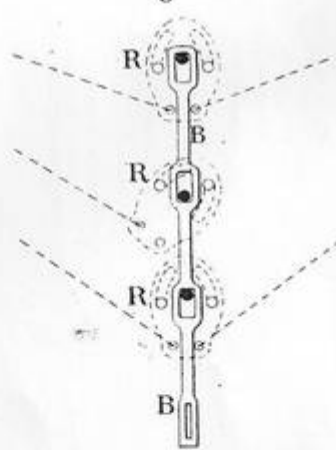


Fig. 32.

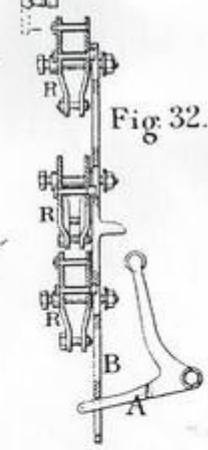
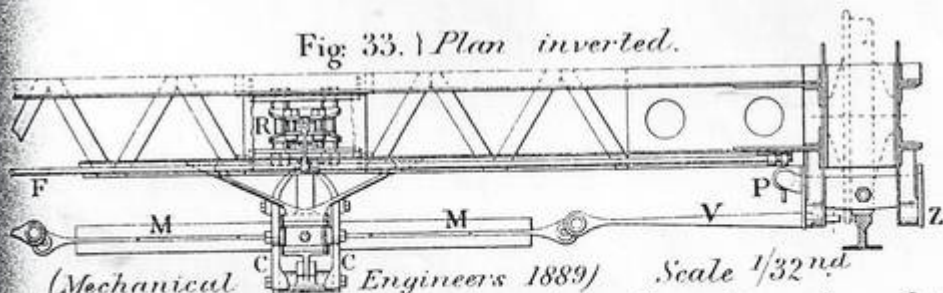


Fig. 33. *Plan inverted.*



(Mechanical Engineers 1889)

Scale $\frac{1}{32}$ in.

0 1 2 3 4 5 6 7 8 9 Feet 10

EIFFEL TOWER LIFTS. Plate 74.

Otis Lifts.

Lorry of Cabin Safety-Brake.

Fig. 34.

Front Elevation.

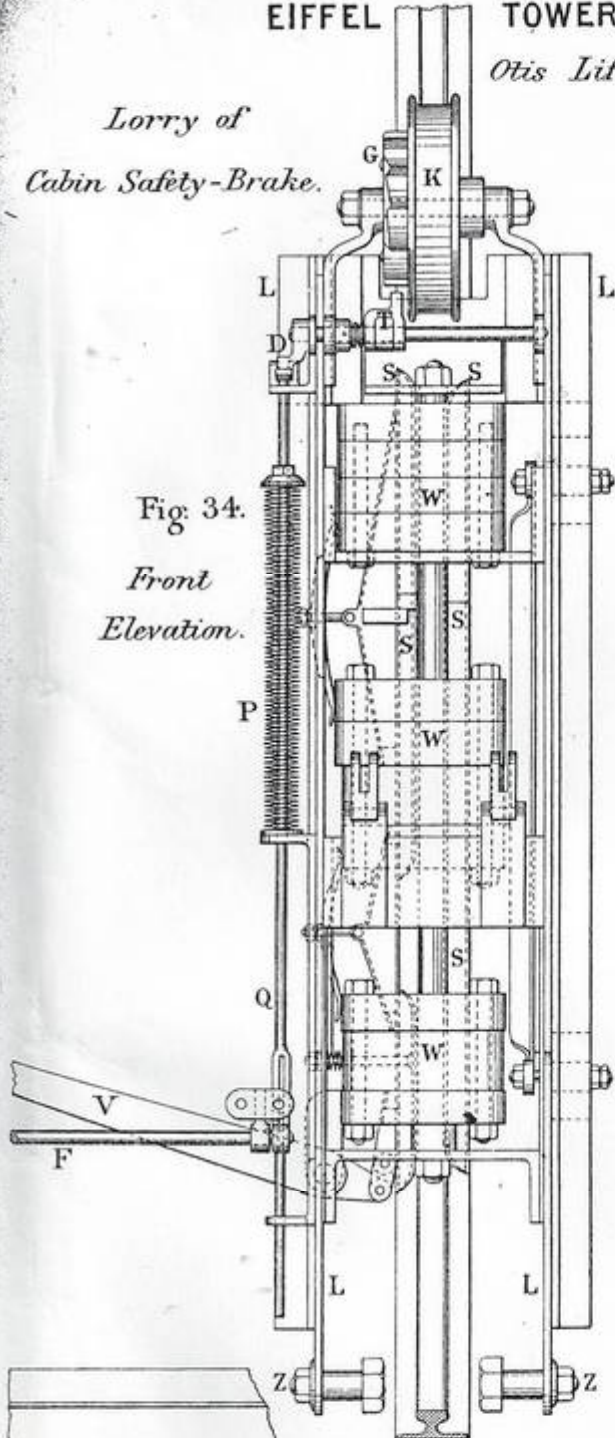


Fig. 35.

Side Elevation.

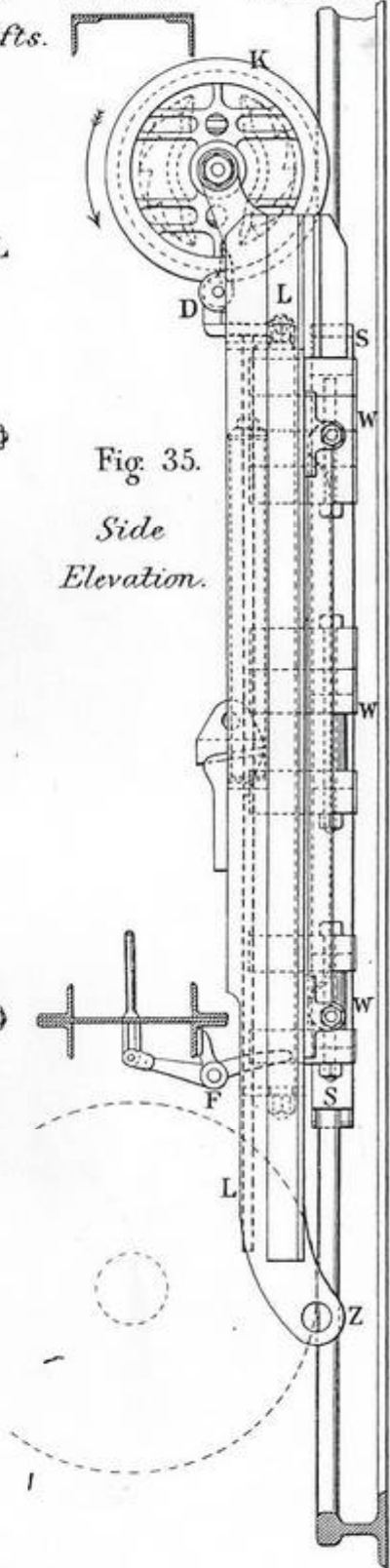
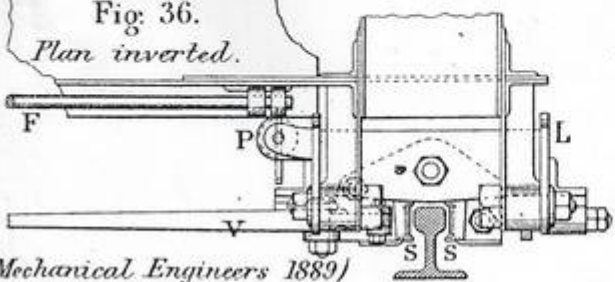


Fig. 36.

Plan inverted.



(Mechanical Engineers 1889)

Inches 12 6 0 1 2 3 4 Feet

Scale 1/16th

EIFFEL TOWER LIFTS.

Plate 75.

Otis Lifts.

Cabin Safety-Brake.

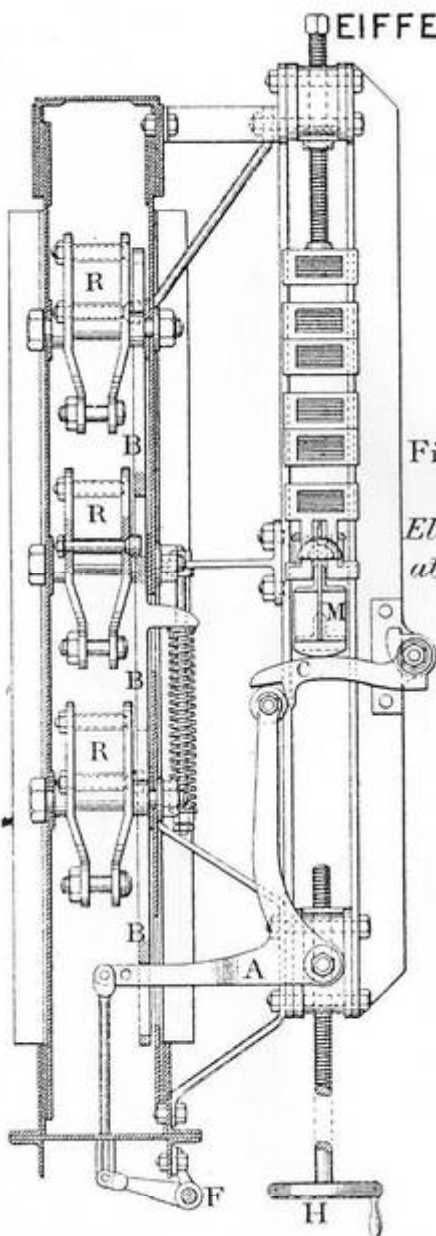


Fig. 37.
Side
Elevation
at centre.

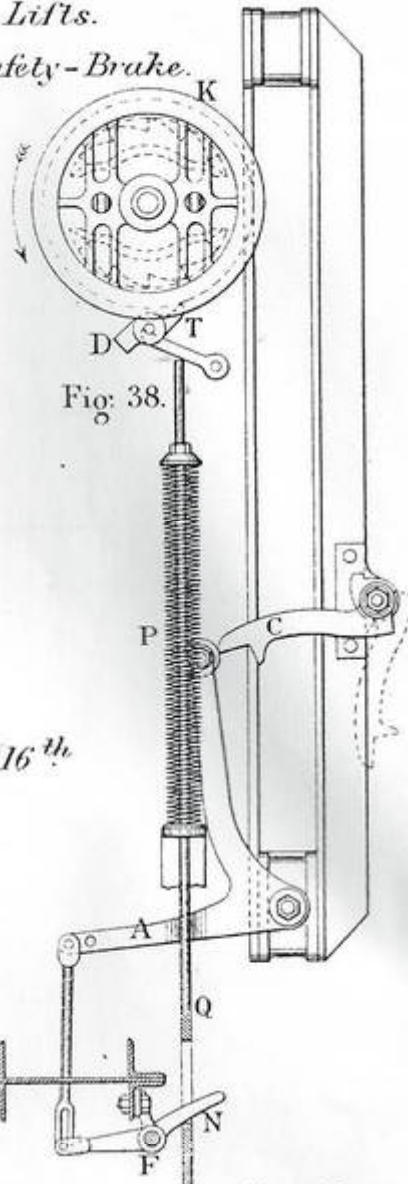


Fig. 38.

Scale $\frac{1}{16}^{th}$

Centrifugal Governor in Lorry Wheel.

Fig. 39. Elevation.

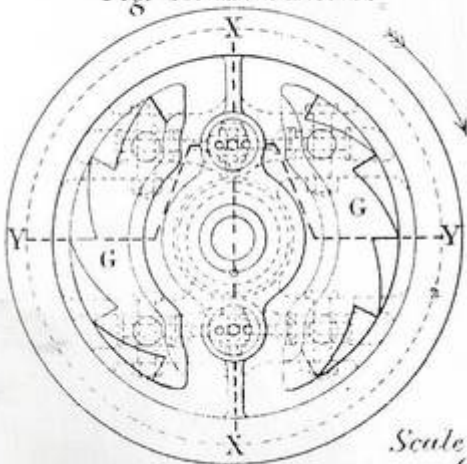
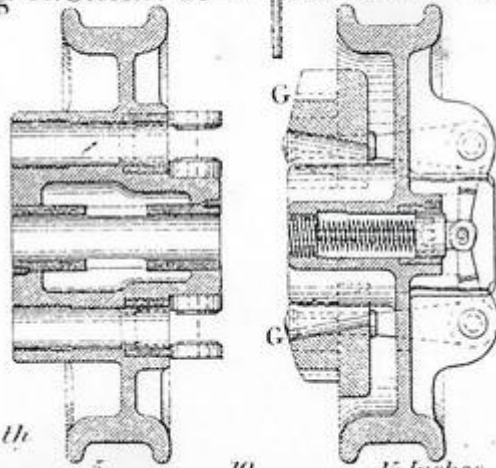


Fig. 40. Section at XX.

Section at YY.



Scale $\frac{1}{8}^{th}$

(Mechanical Engineers 1889)

0 5 10 15 Inches.

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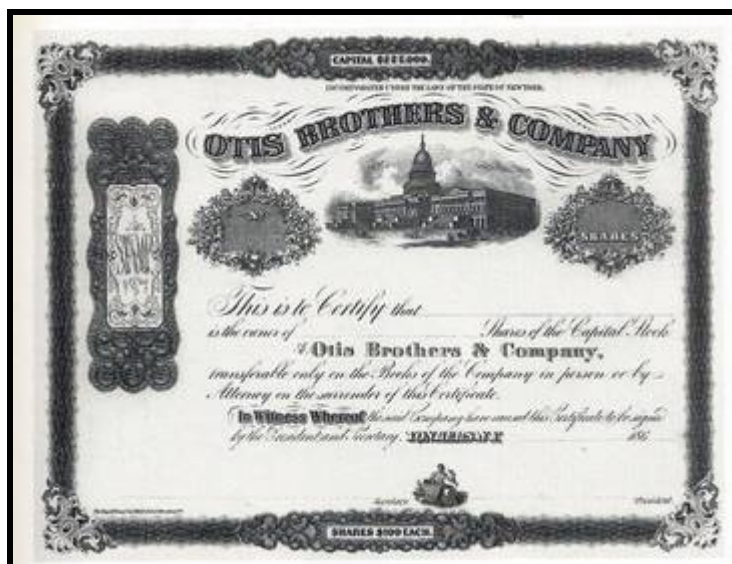
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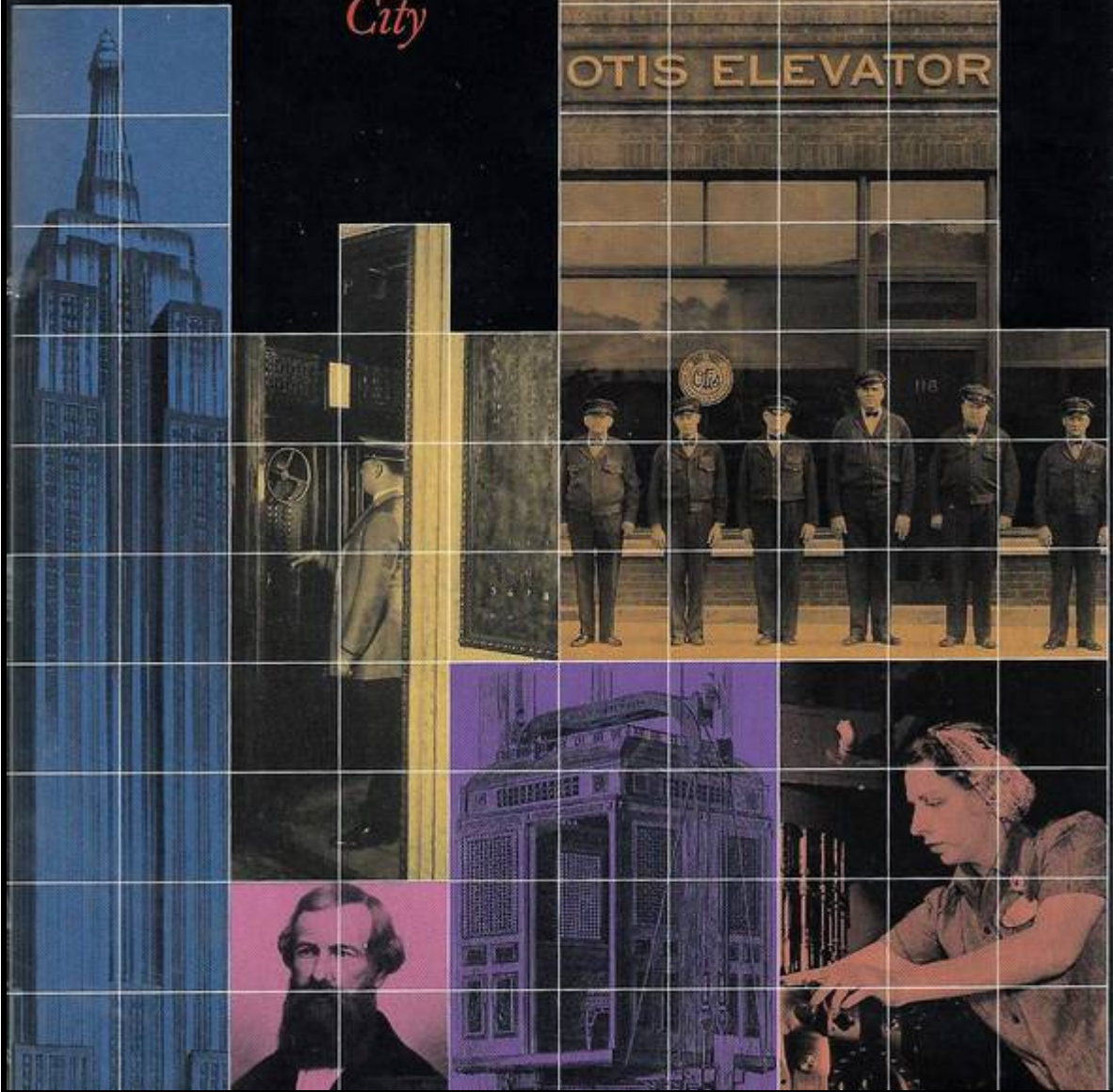
Note: Nineteenth century drawings of early elevators are shown in technical magazines of the day such as *Scientific American*, *La Nature* and *De Natuur*. Other early drawings, documents and photographs originate mainly from the *United Technologies Archive*, now owned by the Parent Company of Otis.



OTIS

Jason Goodwin

*Giving
Rise
to the
Modern
City*



EPITAPH

Though Elisha Graves Otis obtained a patent for his design of the Safety Elevator, his talents did not extend to business and he died in 1861 at the age of 49 and in debt. His sons Charles and Norton took over the business and made it a resounding success.



The Otis Monument at Oakland Cemetery in Yonkers



Tomb of Gustave Eiffel at Levallois-Perret Cemetery, Paris outskirts