Certainty of Operations:

the origins of reliability engineering in Boston's fire alarm and transit systems

A presentation for Boston's Reliability Chapter

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Outline

- Introduction
- Electrical technology in 1850s? none
- William Channing’s great innovation - 1848
- Boston’s electric fire alarm system - 1852
- Introduce Fred Stark Pearson
- Electrification of Boston’s rapid transit system – 1889
- Pearson’s engineering methods and techniques
- New York City’s electric conduit system
- Pearson’s great hydroelectric projects
- Q & A

State Street

Electrical technology in 1850s? none

- Poor construction methods, materials, glass insulators, test instruments, few skilled technicians

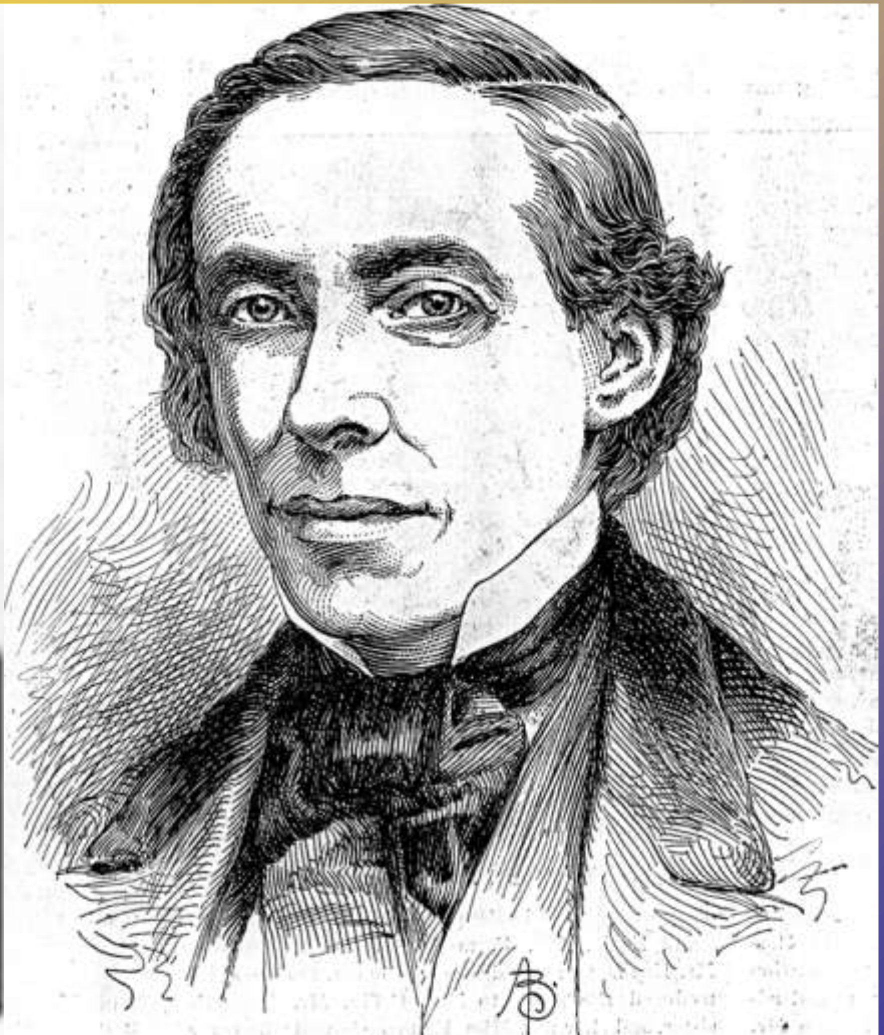
- Telegraph lines exposed to bad weather

- Telegraph lines overhead on poles and roof tops. No underground yet

- In 1852, Boston designed and built the first telegraphic fire alarm system in the world. A precursor of "Call 911 Emergency"..

William Channing
1820-1901

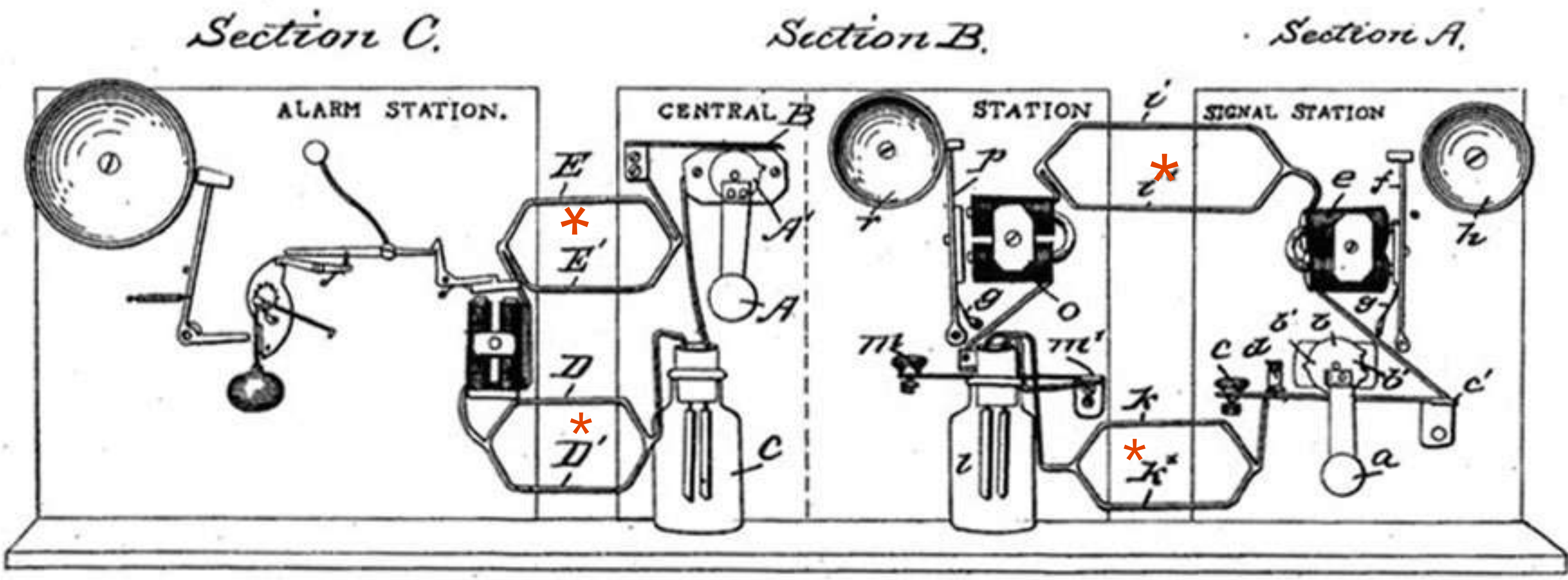
Moses Farmer
1820-1893

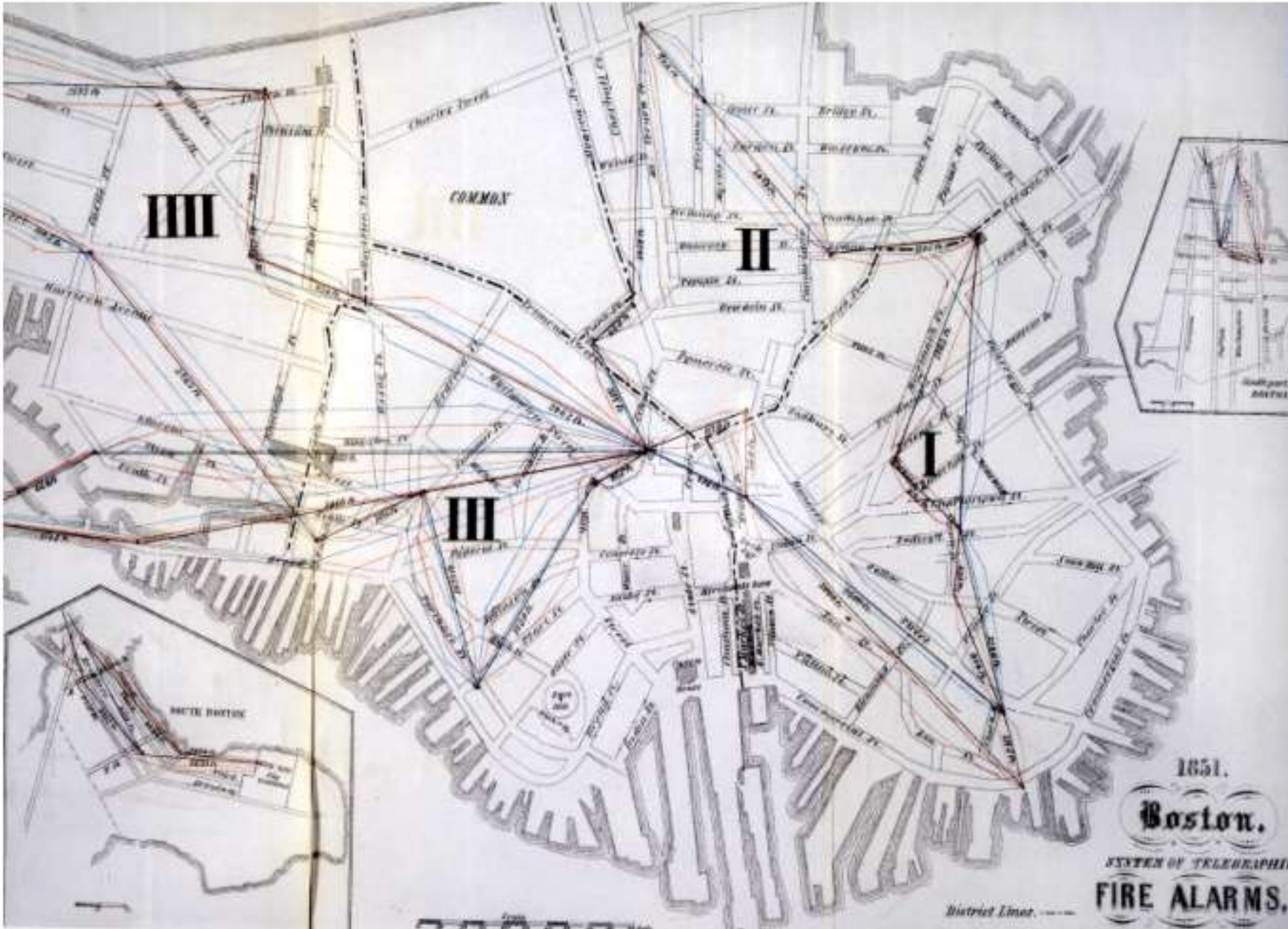


Moses G. Farmer. (*Taken in 1848.*)

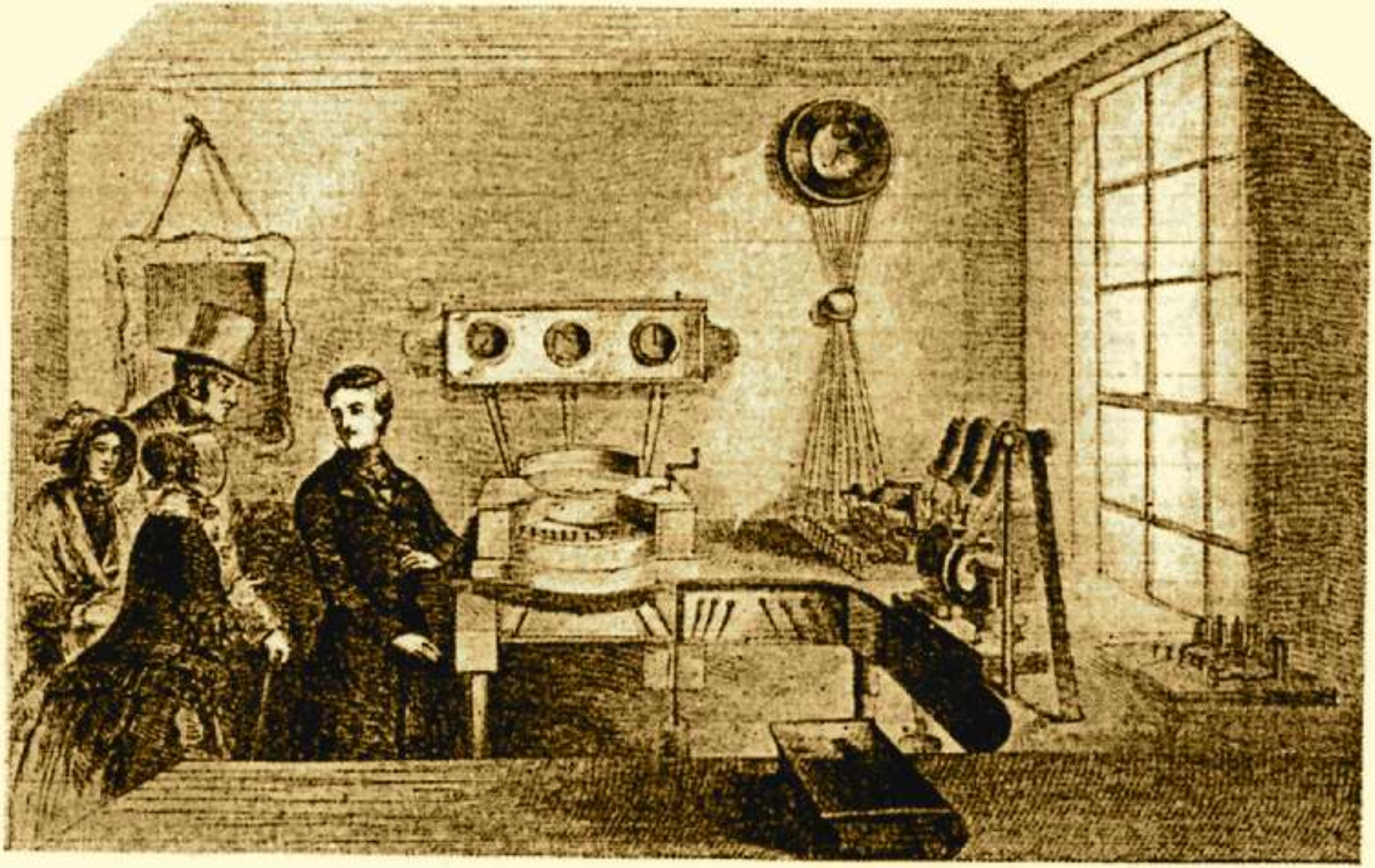
Channing / Farmer schematic diagram

* Redundant isolated wires



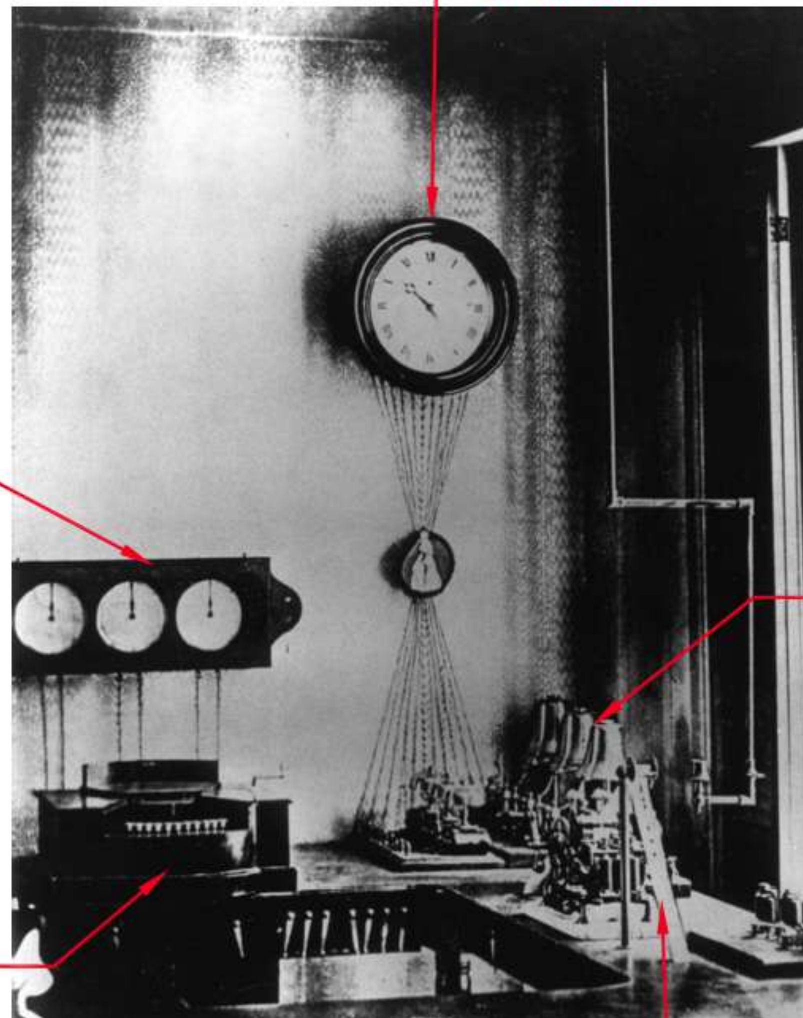


1851.
Boston.
SYSTEM OF TELEGRAPHIC
FIRE ALARMS.
District Lines.
COMMON
IIII
II
III
I
SOUTH BOSTON



Boston Fire Alarm Headquarters 1852

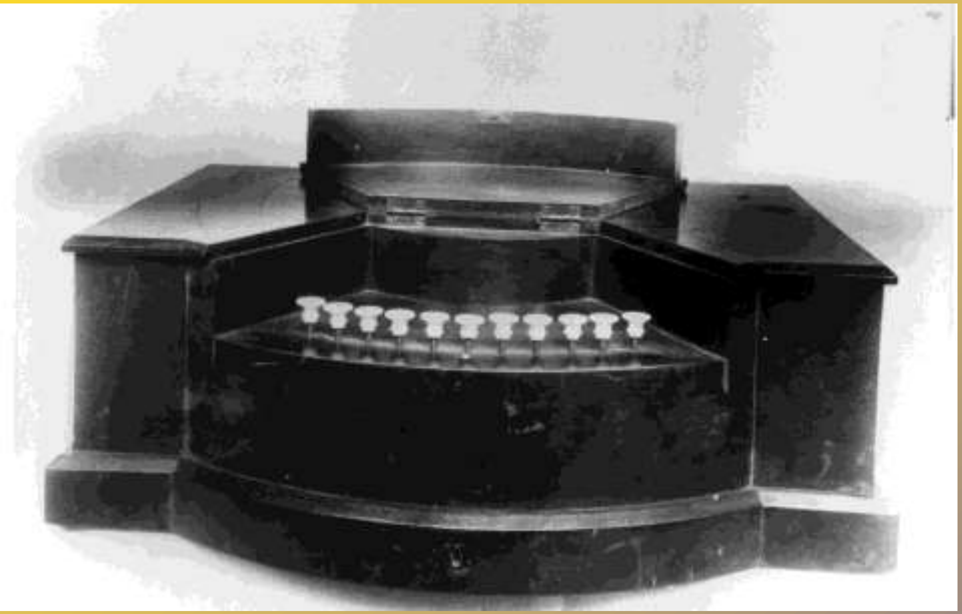
An actual view of the original installation published in a Boston paper shortly after the system was placed in operation



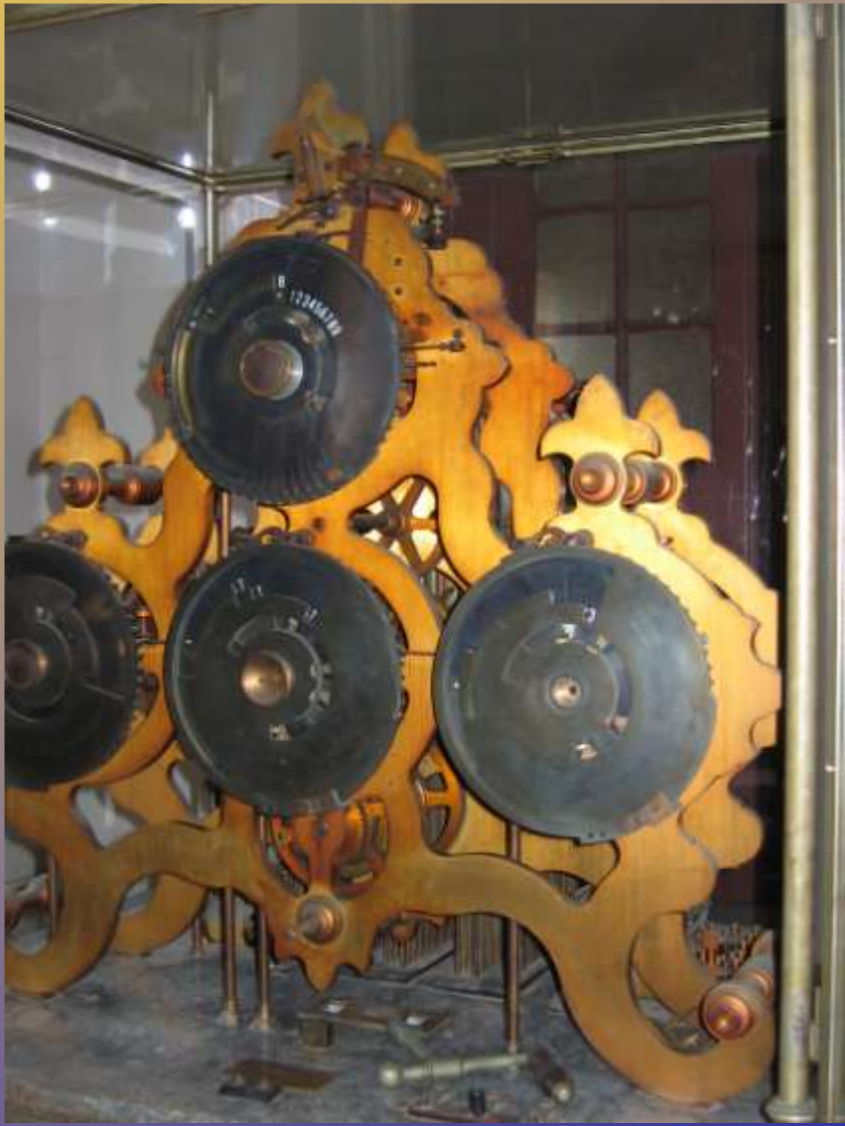
1852 FIRE ALARM CONTROL CENTER

FIRE ALARM TRANSMITTER
engineered to prevent operator errors

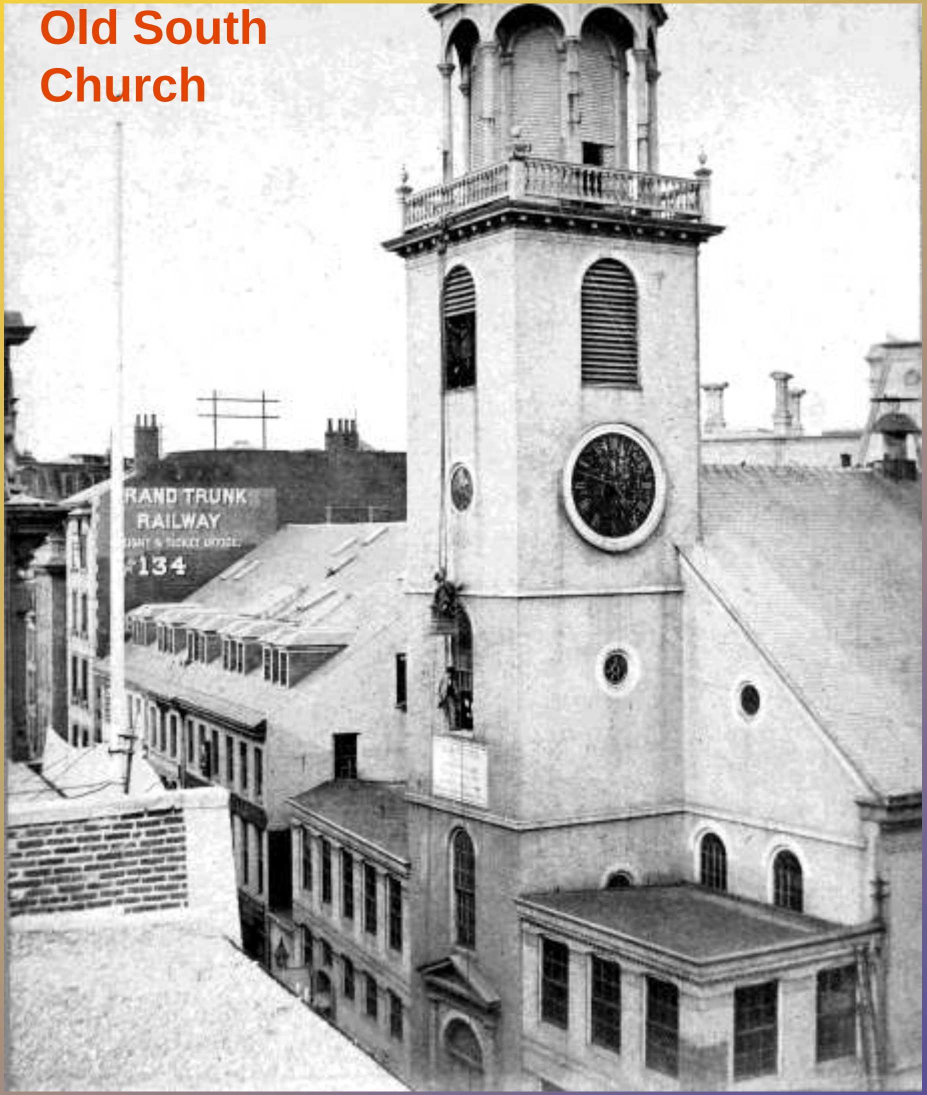
Original keyboard of 1852



Allowed the control operator to automatically initiate the correct alarm codes quickly and accurately by pressing one single button.



System reliable enough to give Bostonians accurate time. The city subscribed to a first class chronometer signal from Harvard's Observatory in Cambridge.



22 bells were struck by telegraph at noon each day.

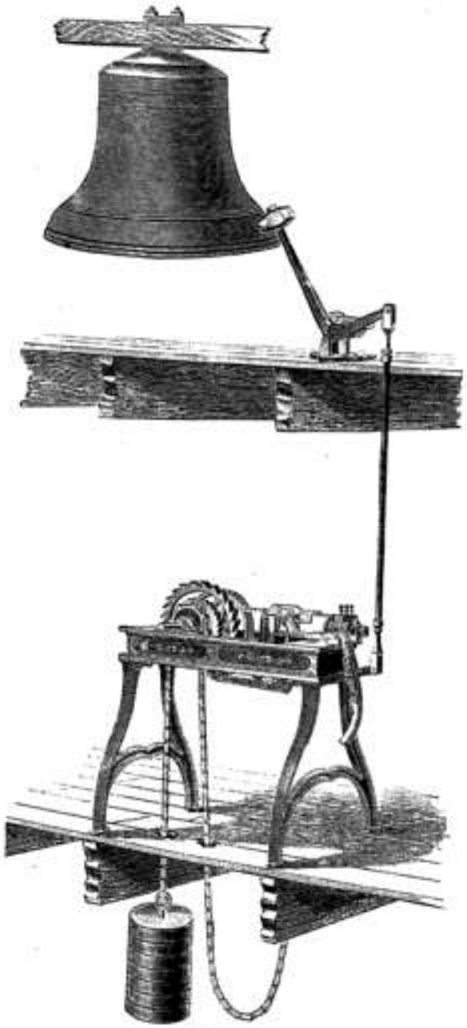


Fig. 22.

TOWER BELL STRIKER.

THE BELL STRIKERS,

for church or tower bells. Wherever call-men are in any way relied on for a fire-department, it is absolutely essential that general alarms should be sounded, in cases of fire, upon large bells. The machines which we furnish for this purpose enable us to give the full tone of the heaviest bells, or to sound alarms by steam whistles.

It is not necessary that bells should be especially provided for fire-alarm purposes where our telegraph is used, as our bell-strikers can be attached, and used with any school or church bell without in any way interfering with their ordinary use.

HOW AN ALARM IS GIVEN.

We will suppose a fire breaks out in a city where our automatic system of fire-telegraph is in use. The party who first discovers the fire runs to the nearest signal-box, and obtaining a key, which is easily accessible, he opens the outer door of the box, and pulls down the brass hook, which is plainly in sight, once only, and lets go. Before he can turn his back upon the box, its clock-work is in motion, and an alarm is being sounded upon the little bells in every signal-box, the gongs in the engine-houses, and upon the large tower-bells. Suppose the hook of Box 21 has been pulled, the blows upon the bells and gongs will be given thus: 1–1 (two blows), then a pause of five or six seconds, and then 1, making 21; and this is repeated four times. If this is not considered sufficient, another pull of the hook will give the alarm four times more. Now, the localities of all the boxes being well understood by the firemen, they run directly to that box from which the alarm originates, and no time is lost in hunting for the fire.

ADVANTAGES SECURED BY ADOPTING THE FIRE-ALARM TELEGRAPH.

It furnishes to every property-holder the means near at hand, in case of fire, for giving an *instantaneous* and *definite* alarm, thus saving thousands of dollars in property, and sometimes human life.

It *saves the first ten, twenty, or thirty minutes' time* after the discovery of a fire, which is inevitably lost where the ordinary means of creating an alarm is relied upon.

It is the cheapest insurance which property-holders can secure upon their buildings, and it is the *only* insurance which a city, in its corporate capacity, can place upon the property generally, from which its revenue is derived in the shape of taxes. Every building in a city pays a certain amount in taxes into the city treasury. If burned or destroyed, so far as the city is concerned, it is a source of revenue gone. This consideration alone should induce city governments to spare no means or reasonable expense to prevent conflagrations.

Boston's fire alarm system .....

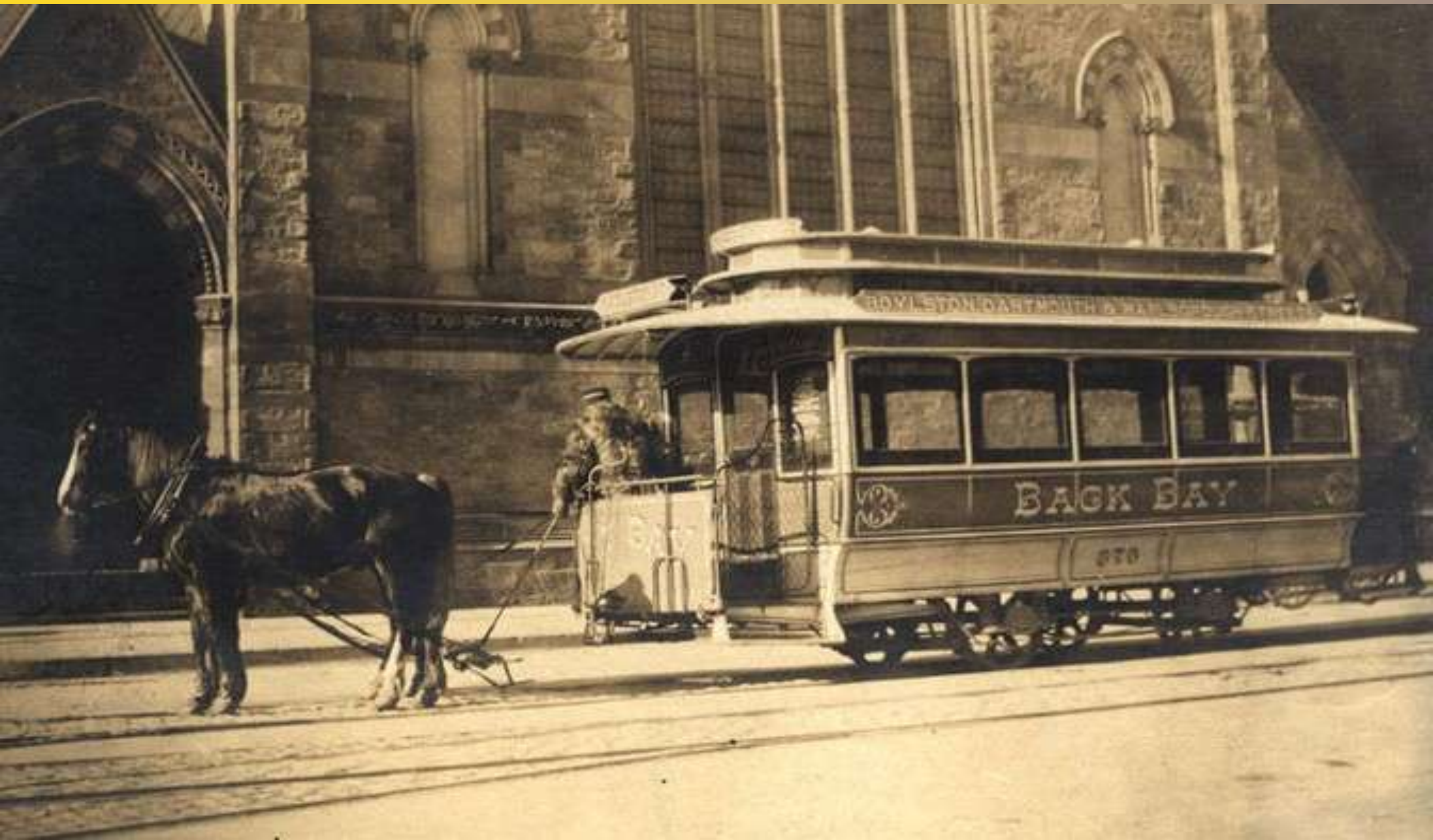
- ✓ FAS saved lives, property, and preserved wealth
- ✓ Effectiveness in 1854: 195 alarms, 12 false alarms; 6 alarms were unexplained or false; the other 6 alarms were reported incorrectly
- ✓ Adopted nation wide in US and Canada:
  - ✓ 1871 - 50 towns and cities
  - ✓ 1884 - 150 towns and cities
- ✓ Gamewell Fire Alarm Company was incorporated in 1871.
- ✓ Overall performance: in 150 years of service, the system has never once broken down.
- ✓ Reliability requirements adopted by the NFPA
- ✓ Awarded the IEEE Milestone in 2004

Fred Stark Pearson: 1861 – 1915

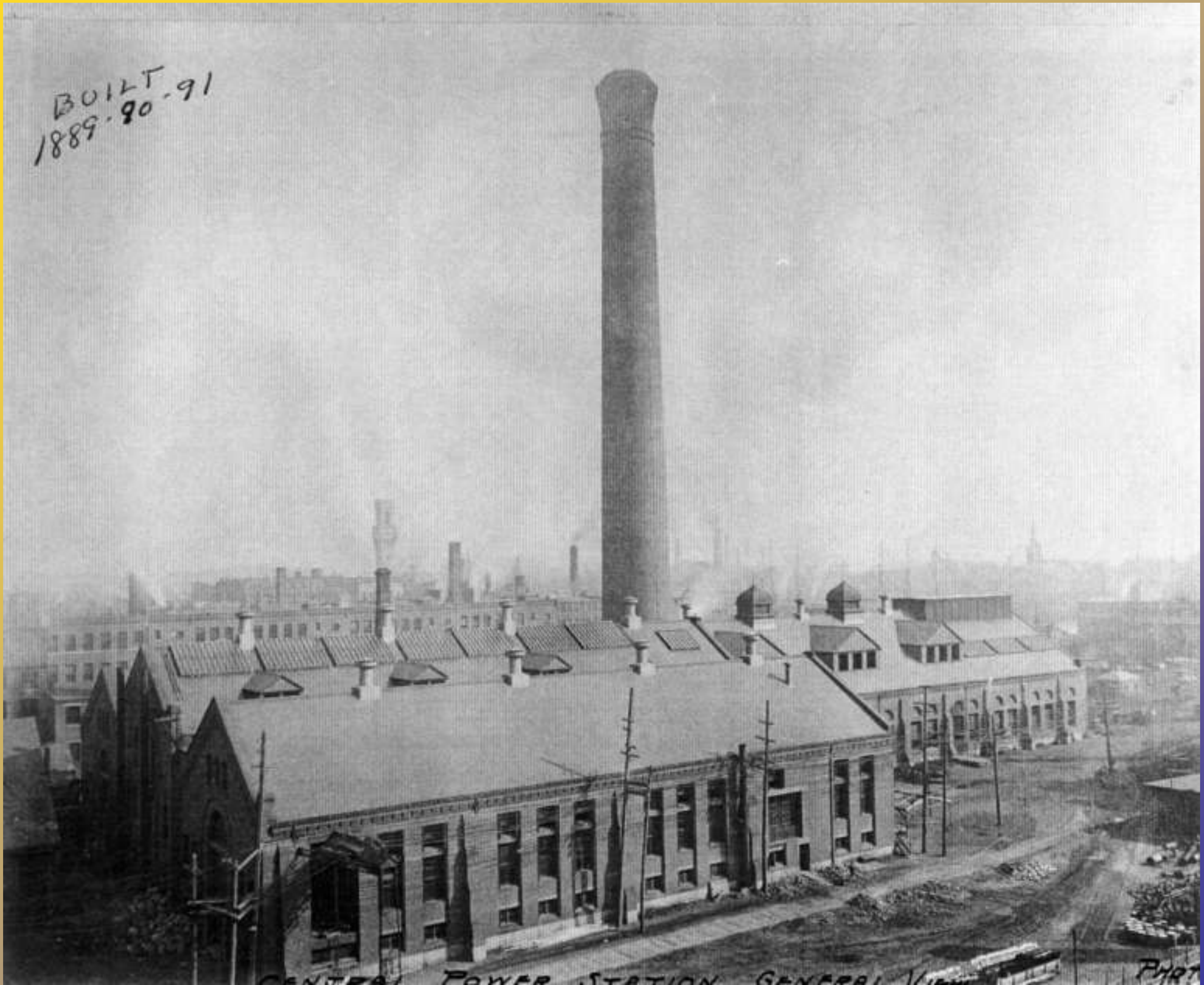
Pearson's memorial in Barcelona was dedicated 19 May 1928.

Electrification of streetcars in 1889 was a quantum leap in engineering, construction, and manufacturing of heavy equipment.

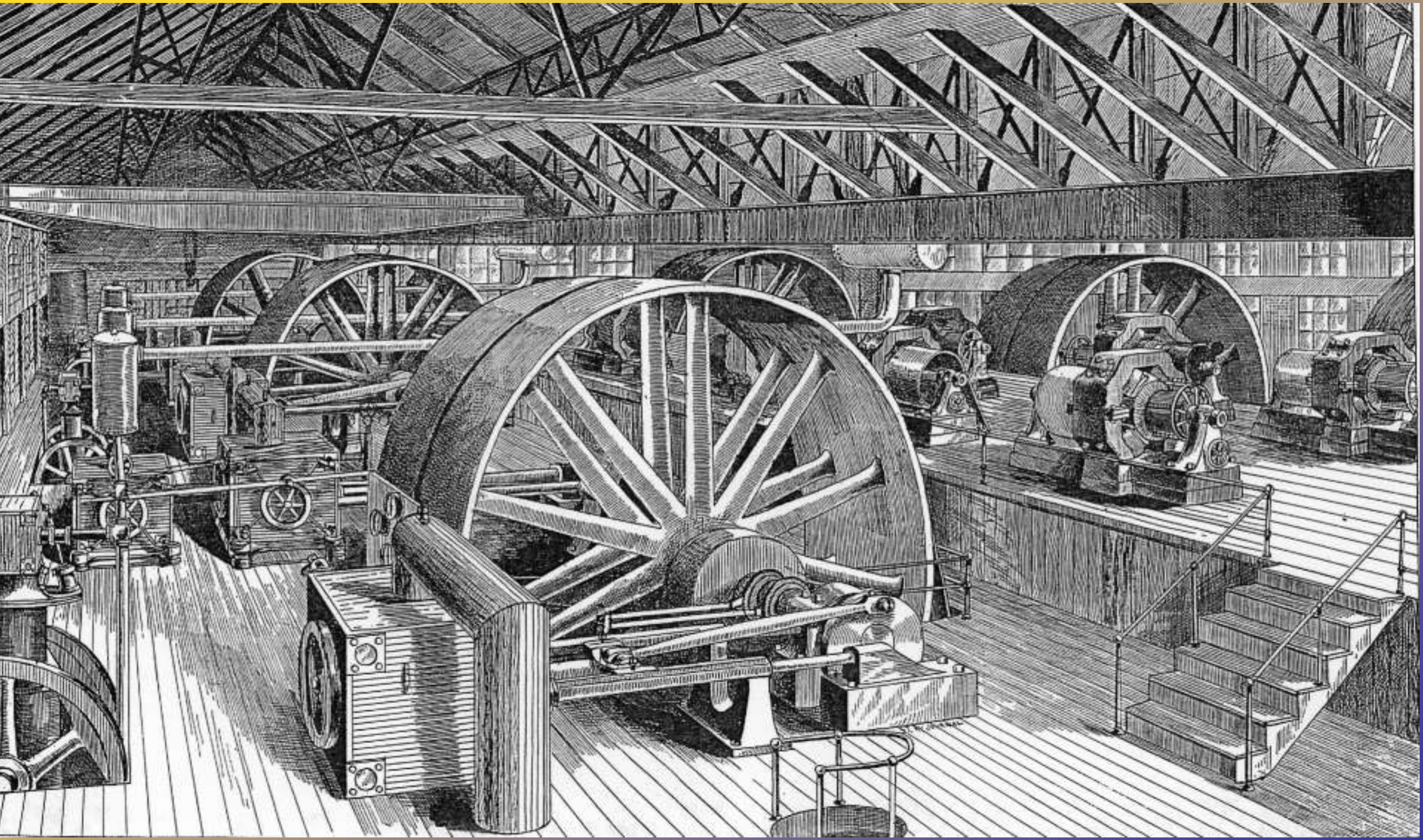
Electric traction had iffy start



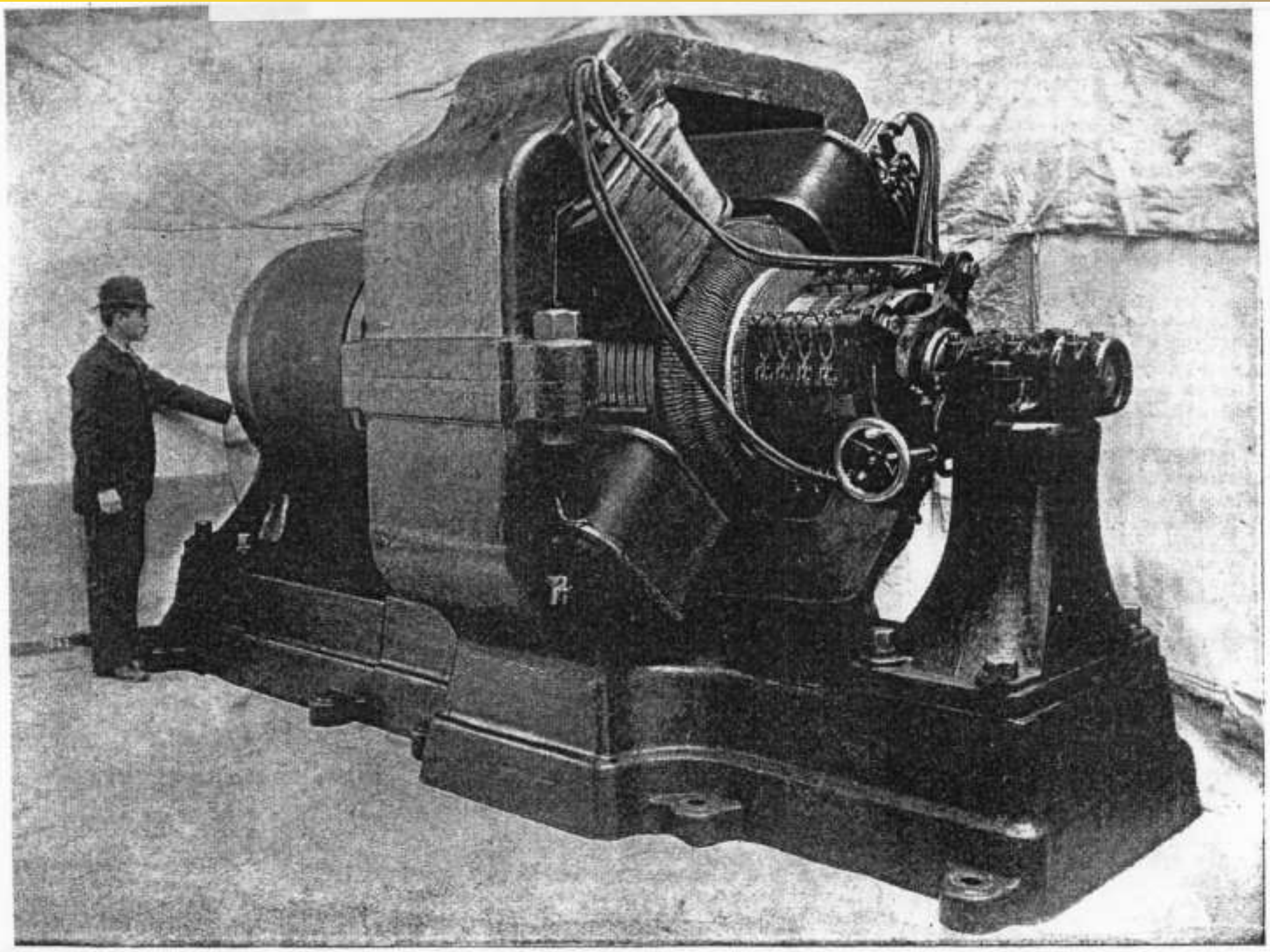
Central Power Station 1889-1891



Central Power Station 1889 - 1891



was 3 times the size of earlier generator



THE THOMSON-HOUSTON 250,000-WATT GENERATOR.

LARGEST ELECTRIC STREET RAILWAY IN THE WORLD.

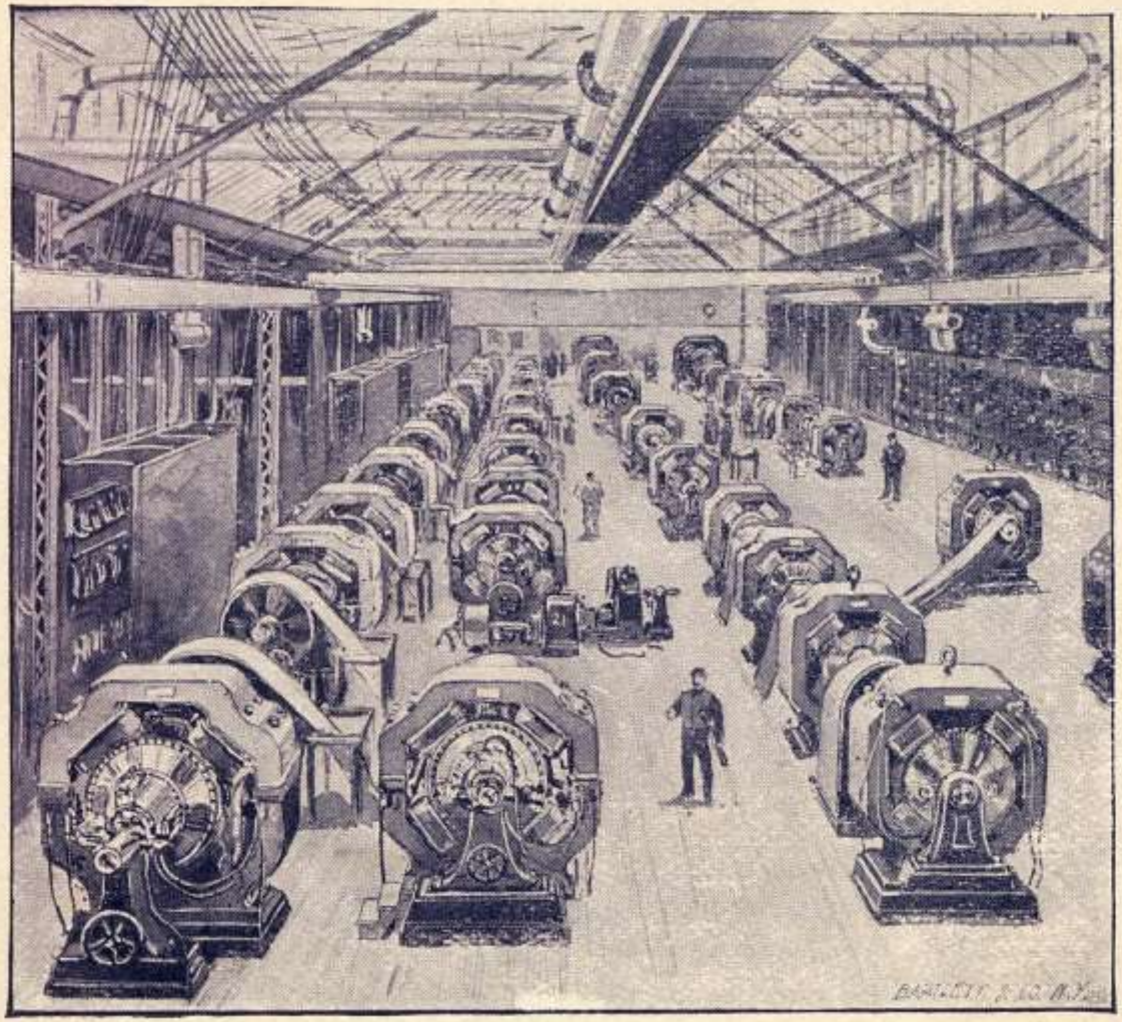
WEST END STREET RAILWAY, BOSTON, MASS., 1893.

77 Dynamos, 2,119 H. P. 15,785,000 Watts.

691 Electric Motor Cars: 150 Miles of track.

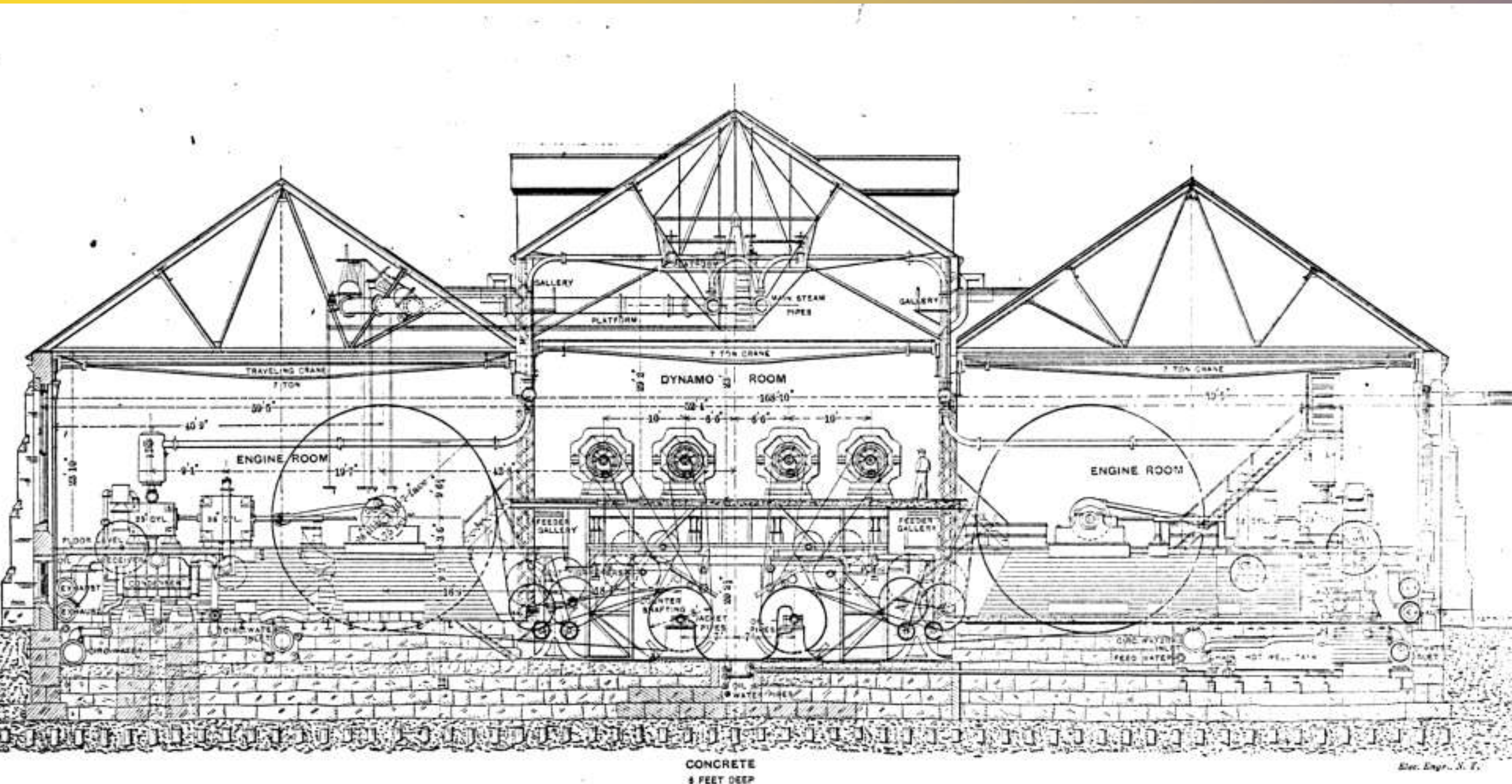
Our system exclusively employed.

Entirely equipped with our material.

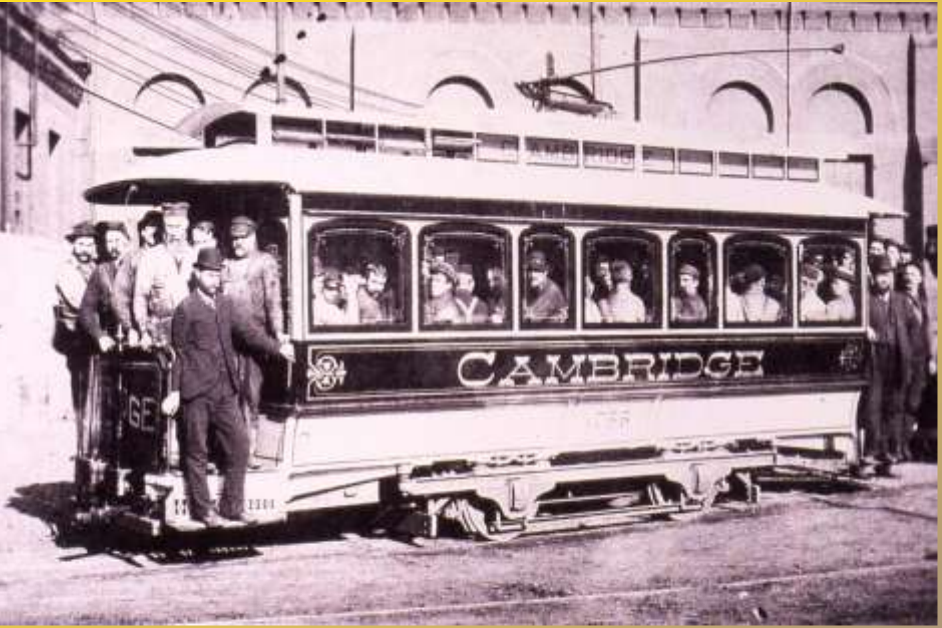


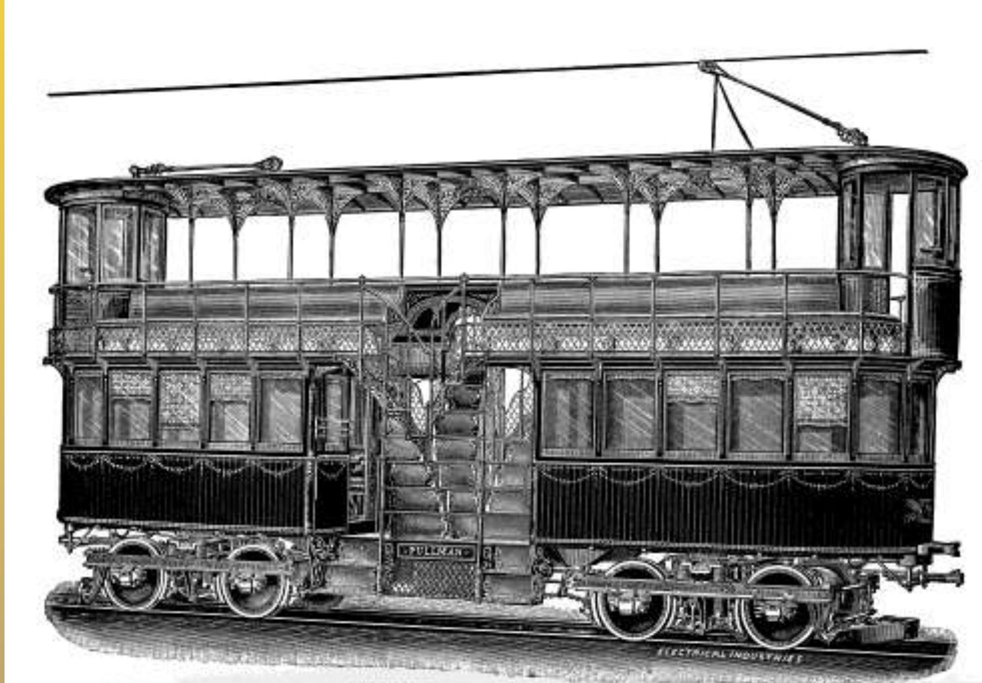
Pearson’s signature

mirror image layout for operator function & piping design



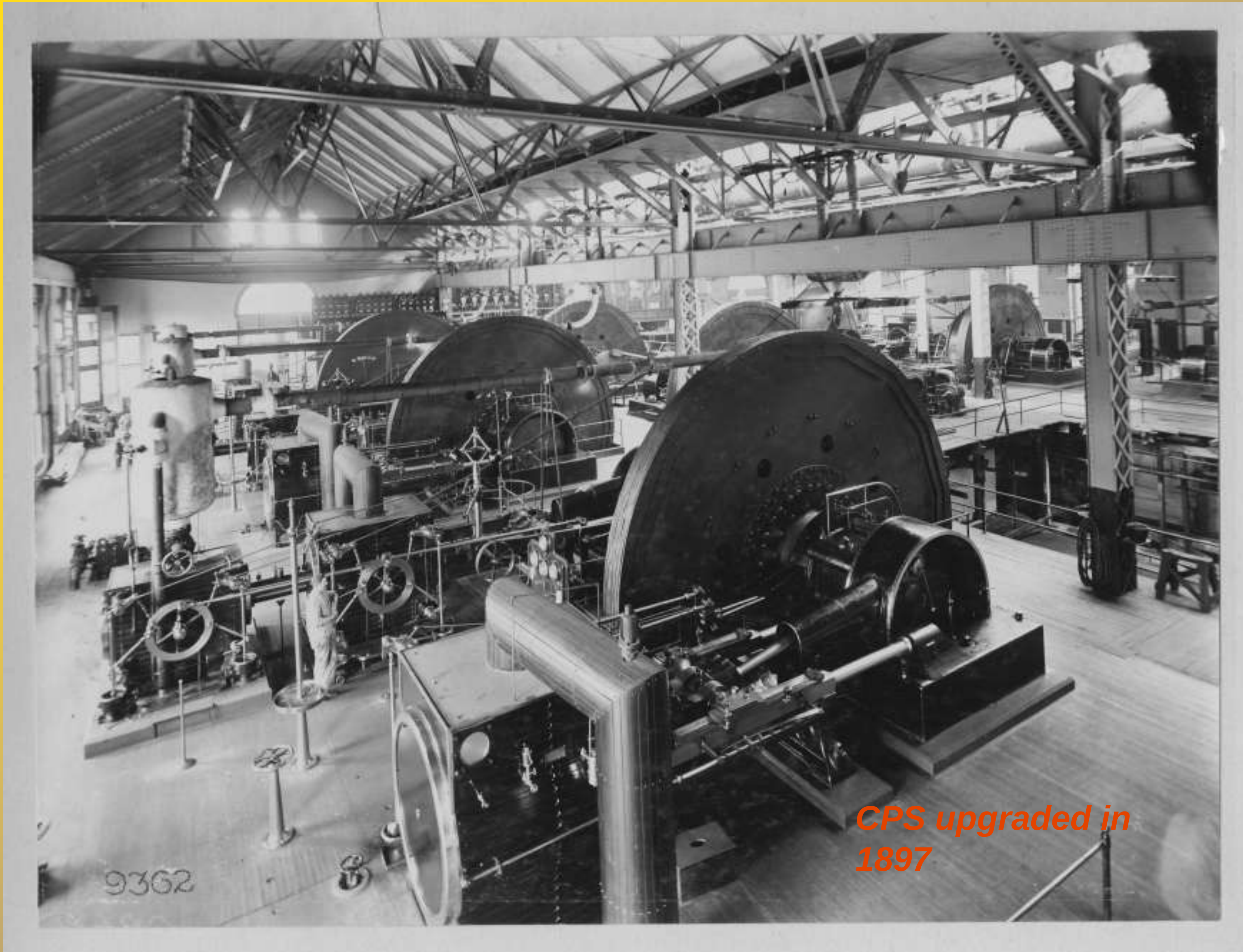
Capacity tests with machine shop





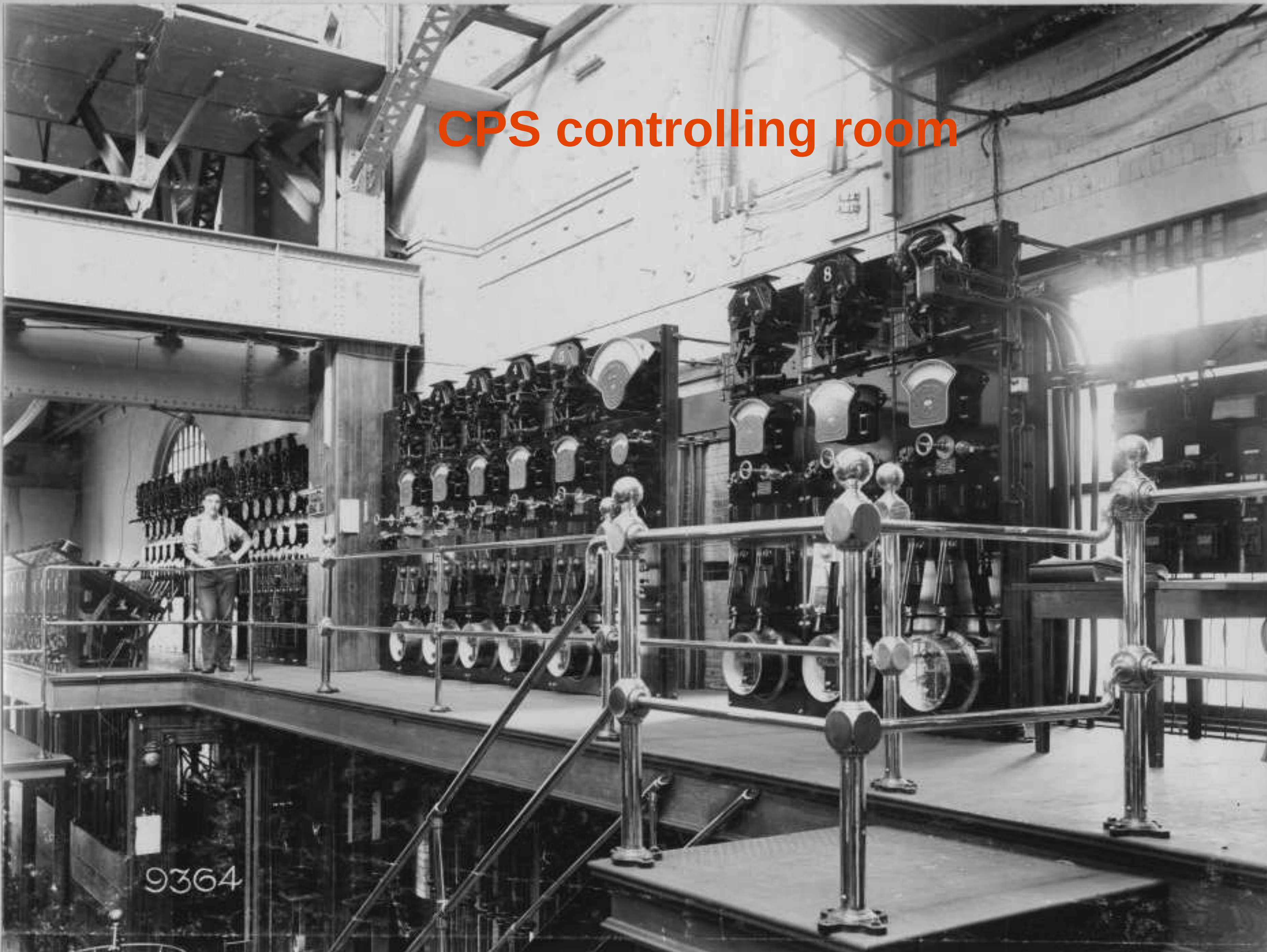
THE "DOUBLE-DECKER" OF THE WEST END.

Field tested this double decker

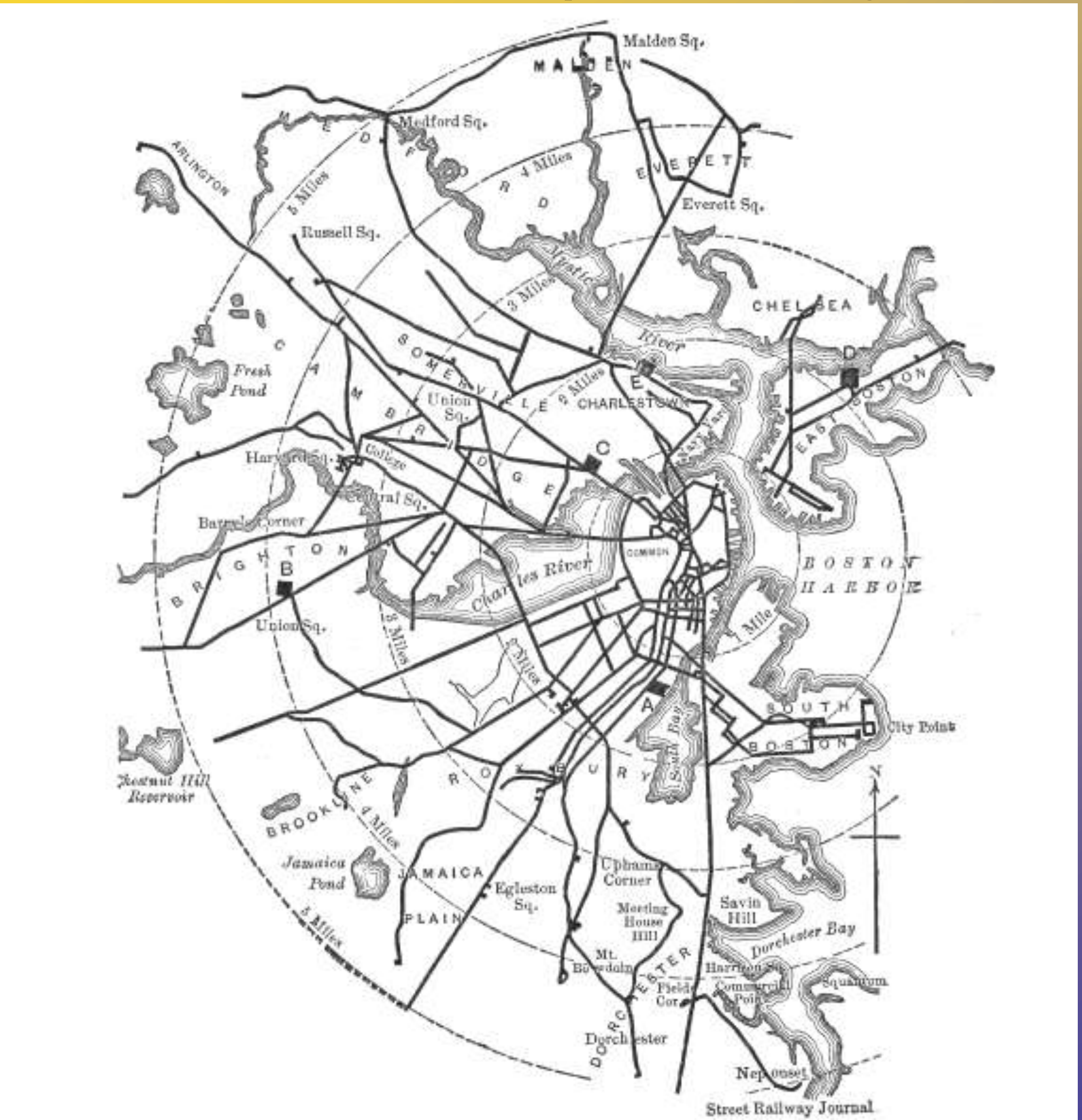


CPS upgraded in 1897

CPS controlling room



The accomplishment was real!
9000 horses were replaced by electricity

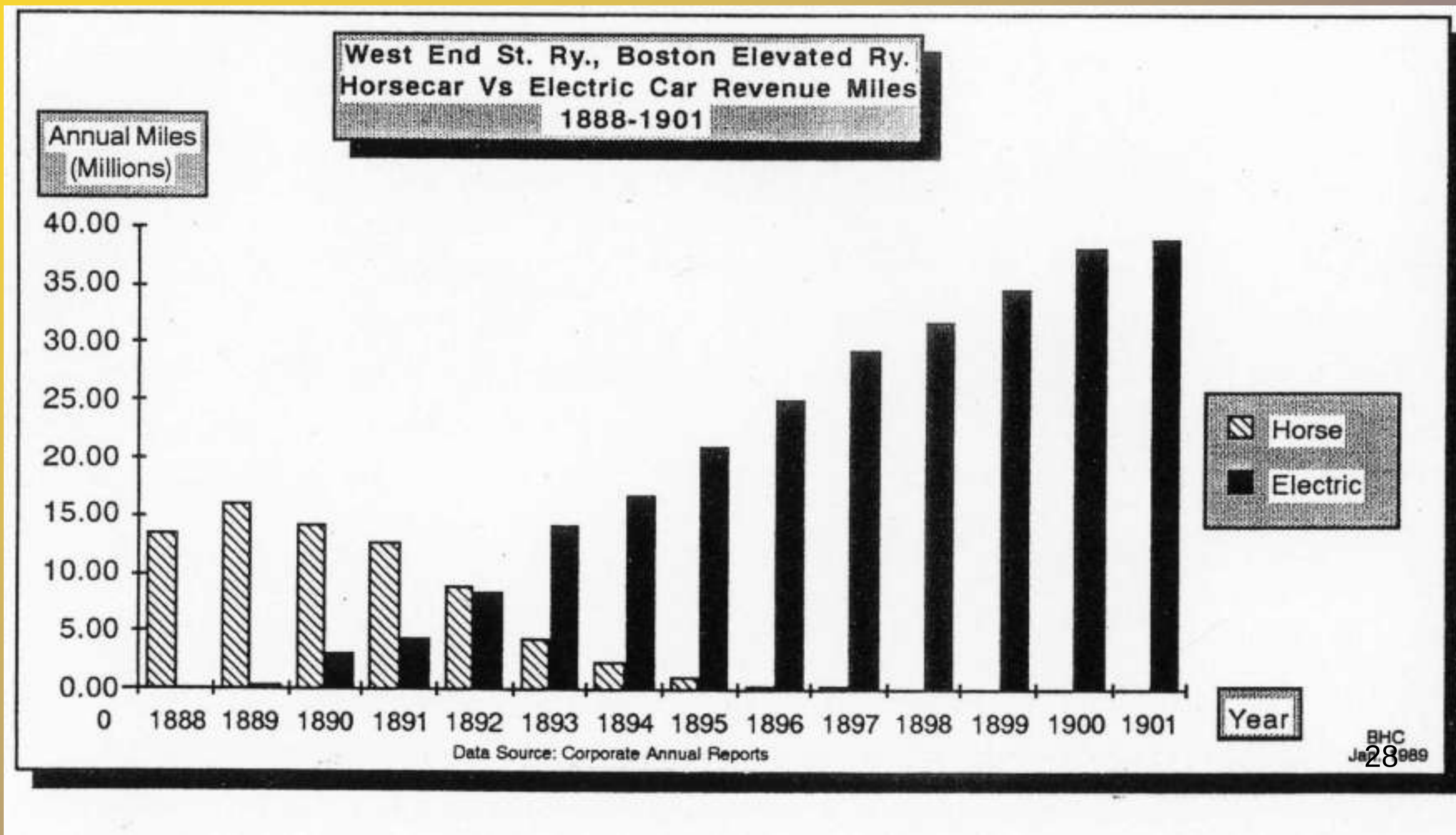


Pearson's engineering methods included ..

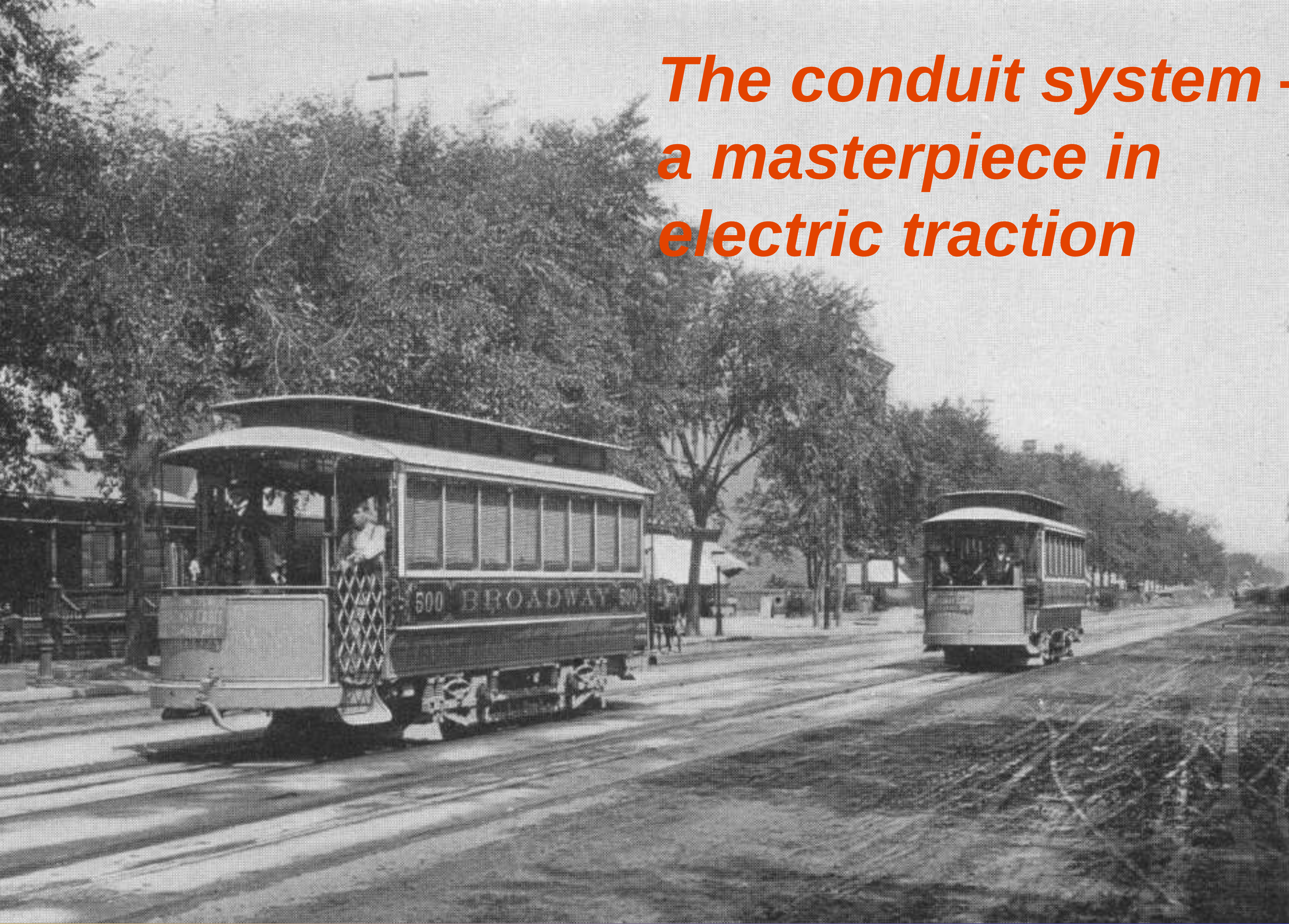
1 Independent engineering review by prominent engineers
2 Rapid startup using temporary power plant
3 Layout arrangement and space for future upgrade
4 Provisions for cutover to final configuration
5 Mechanical strength: 'acid test' for tracks, towers, piping, structure steel, foundations
6 Redundancy in mechanical, electrical cables, and piping
7 Provisions to sectionalizing and controlling duplicate equipment
8 Operator training school
9 Routine inspections of cars, etc.
10 Routine inspection of rolling stocks, surveillance stations on transmission lines
11 Company machine shops with foundry, major repairs and fabrication
12 Field trials on motors with press release to Boston Globe
13 Rapid construction
14 Periodic testing of cable
15 Trails on different types of cable insulation and manufacturers
16 In-situ tests of building steel elements
17 ISO 9000: personally addressed important problems as they occurred
18 Encouraged project engineers to write articles for Engineering News, Electrical World,

real and rapid accomplishments!

9000 horses were displaced in 8 years powered by a reliable network of steam



The conduit system - a masterpiece in electric traction



Pearson’s reliability engineering ideas were imbedded in Manhattan’s conduit system

Metropolitan Street Railway System c1898

- - - - - - Dash lines are mechanical cable

---------- Solid lines for electric conduit

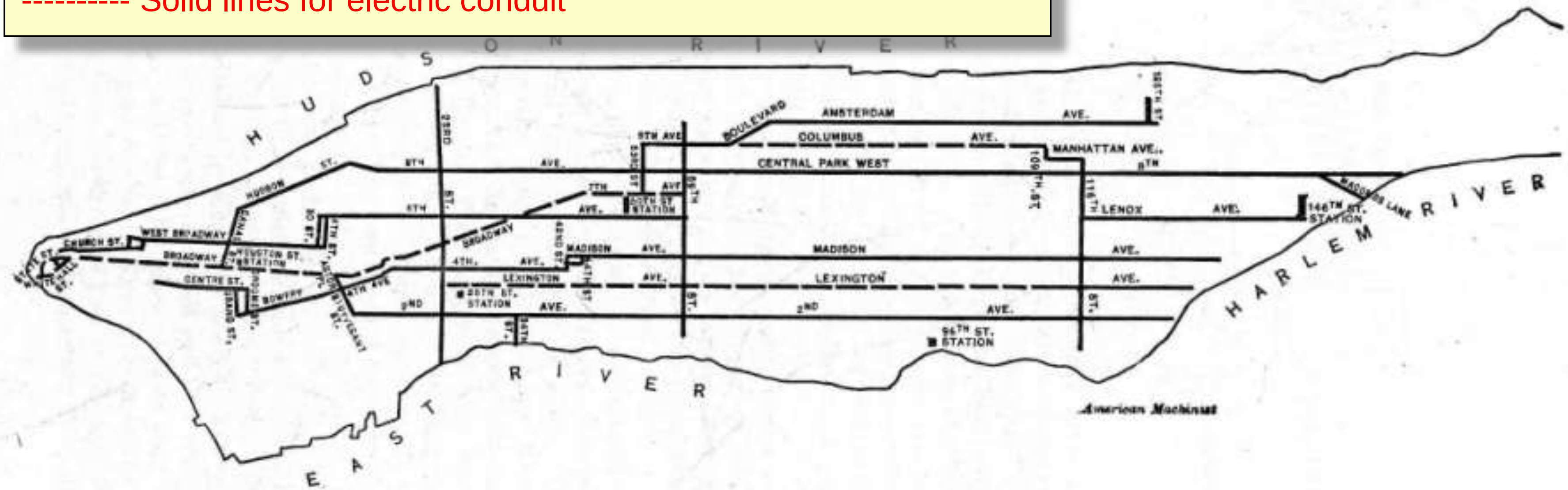
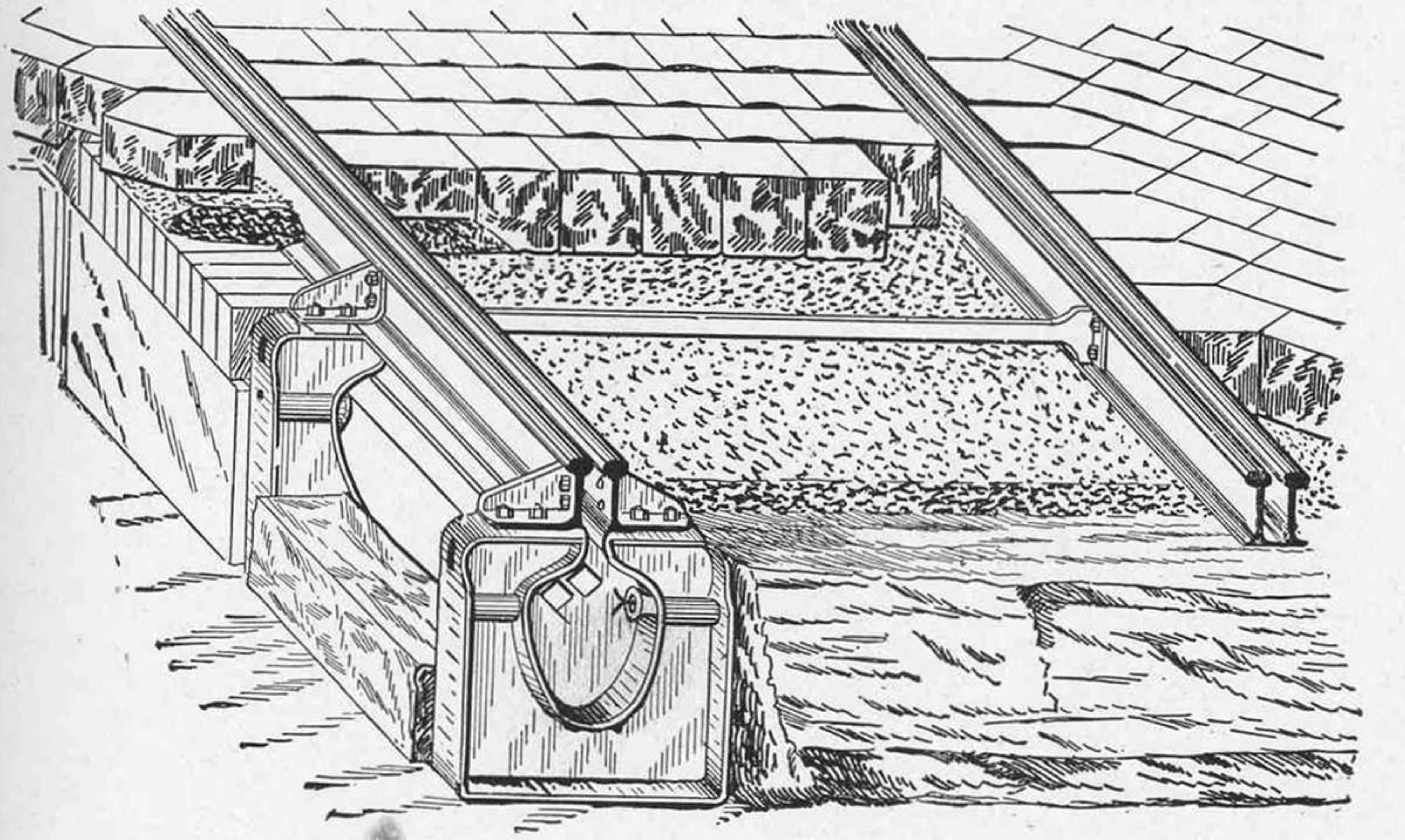


Fig. 8.

The existing Siemens & Halske conduit system in Budapest



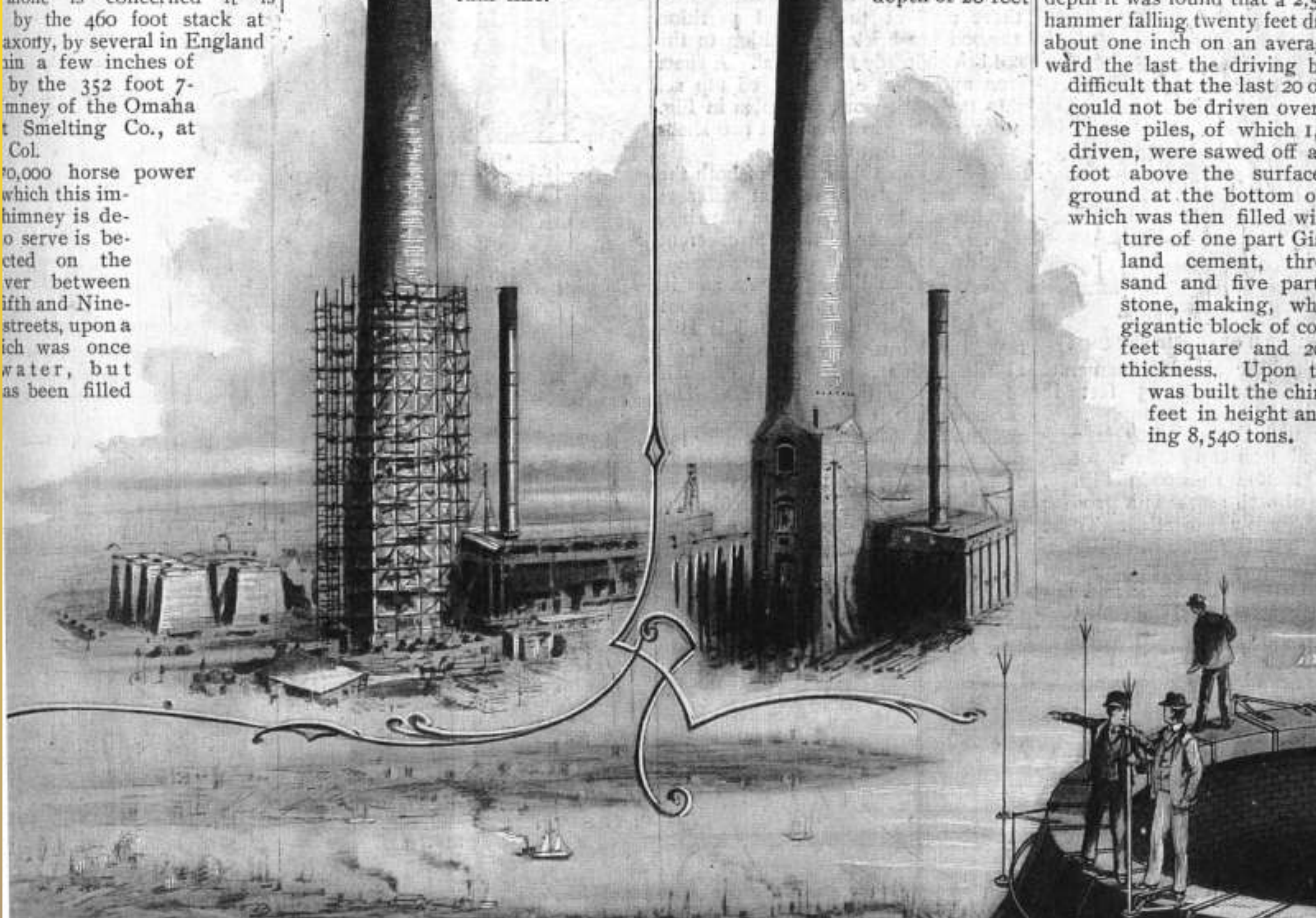
96th Street Power Plant (1897 - ??)

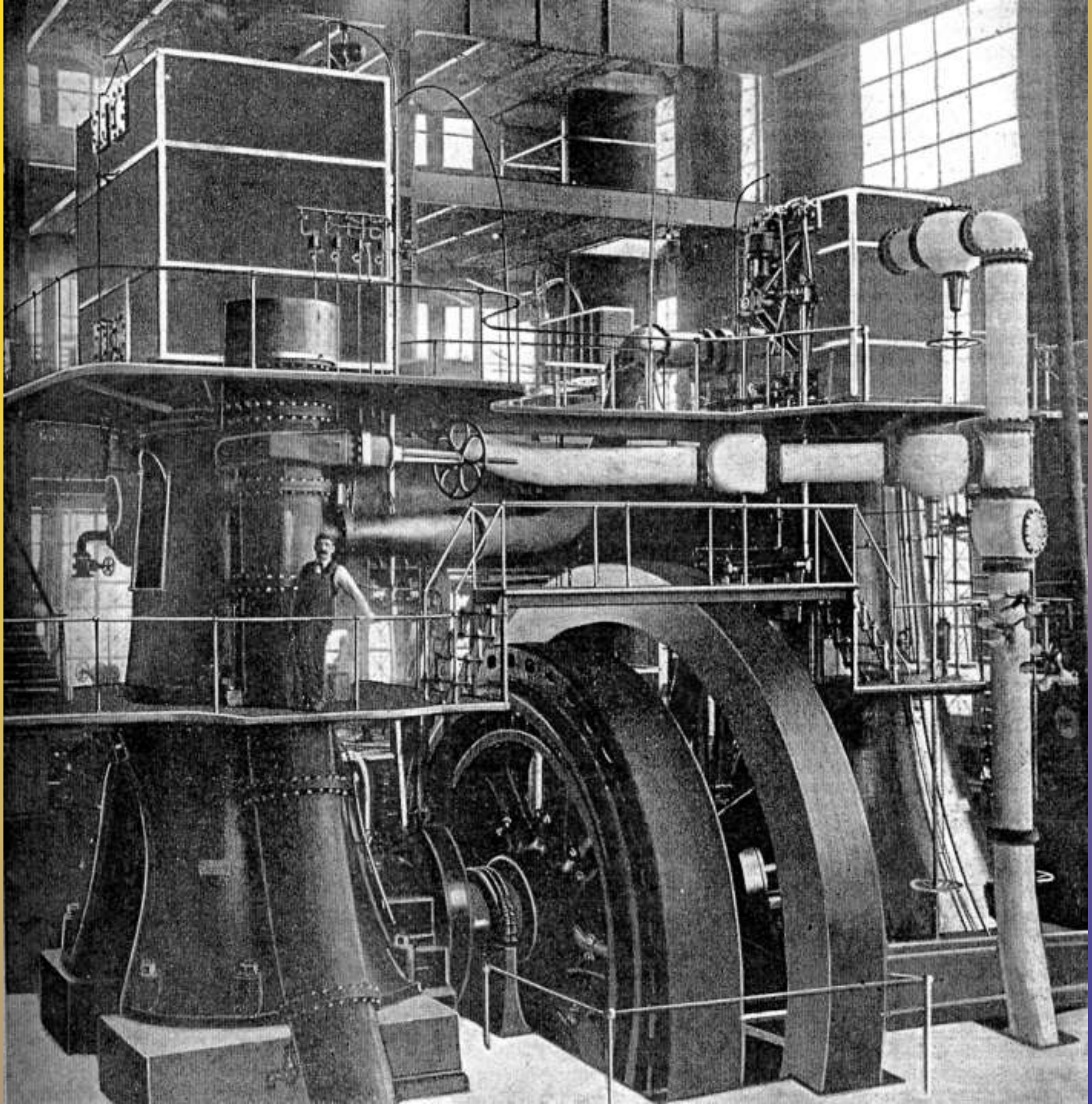
argest Chimney in the World.

353-foot chimney with a 22 e which has just been com t the Ninety-sixth street sta- the Metropolitan Street Rail- mpany, New York, is said to largest in the world, and the n the continent. So far as alone is concerned it is by the 460 foot stack at axony, by several in England in a few inches of by the 352 foot 7- mney of the Omaha t Smelting Co., at Col.

0,000 horse power which this im- himney is de- o serve is be- cted on the ver between ifth and Nine- streets, upon a ich was once water, but as been filled to a depth of about 25 feet with earth and ashes. Beneath this filling borings revealed successive layers of blue clay, beach sand, fine red sand and clay; rock being struck at 125 feet below the datum line.

To provide a suitable foundation for the great shaft, the earth and ash filling was removed from a space about 85 feet square to a depth of 20 feet below the level of the stat Into the floor of the basin th piles were driven by dri upon booms as shown in ou ing, over the entire area two feet three inches feet six inches apart. T depth to which the pi driven was forty feet, a depth it was found that a 2,5 hammer falling twenty feet dr about one inch on an averag ward the last the driving b difficult that the last 20 o could not be driven over These piles, of which 1, driven, were sawed off al foot above the surface ground at the bottom of which was then filled wit ture of one part Gis land cement, thre sand and five part stone, making, whe gigantic block of con feet square and 20 thickness. Upon th was built the chim feet in height and ing 8,540 tons.





Redundancy was extended throughout electrical, mechanical and piping

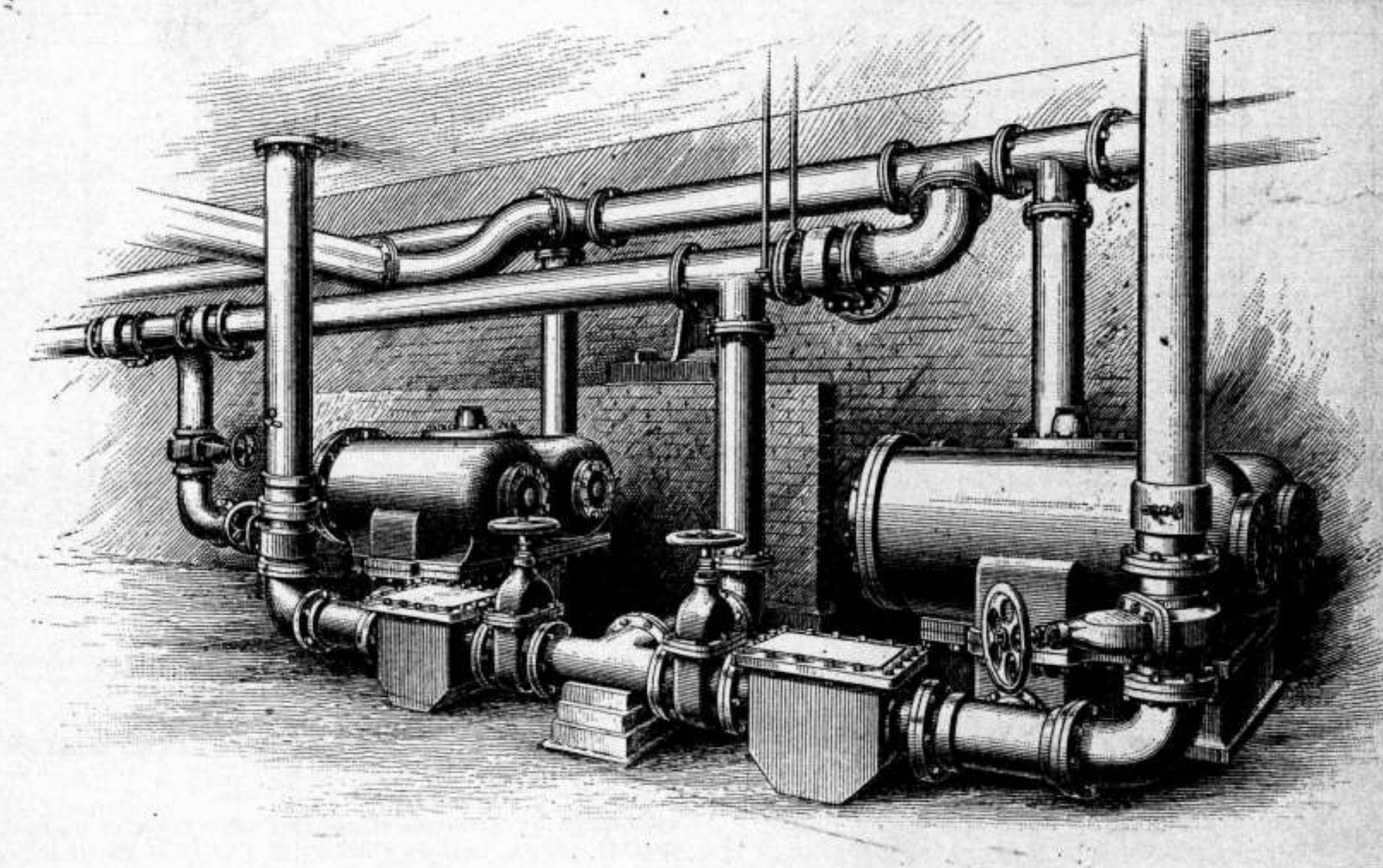
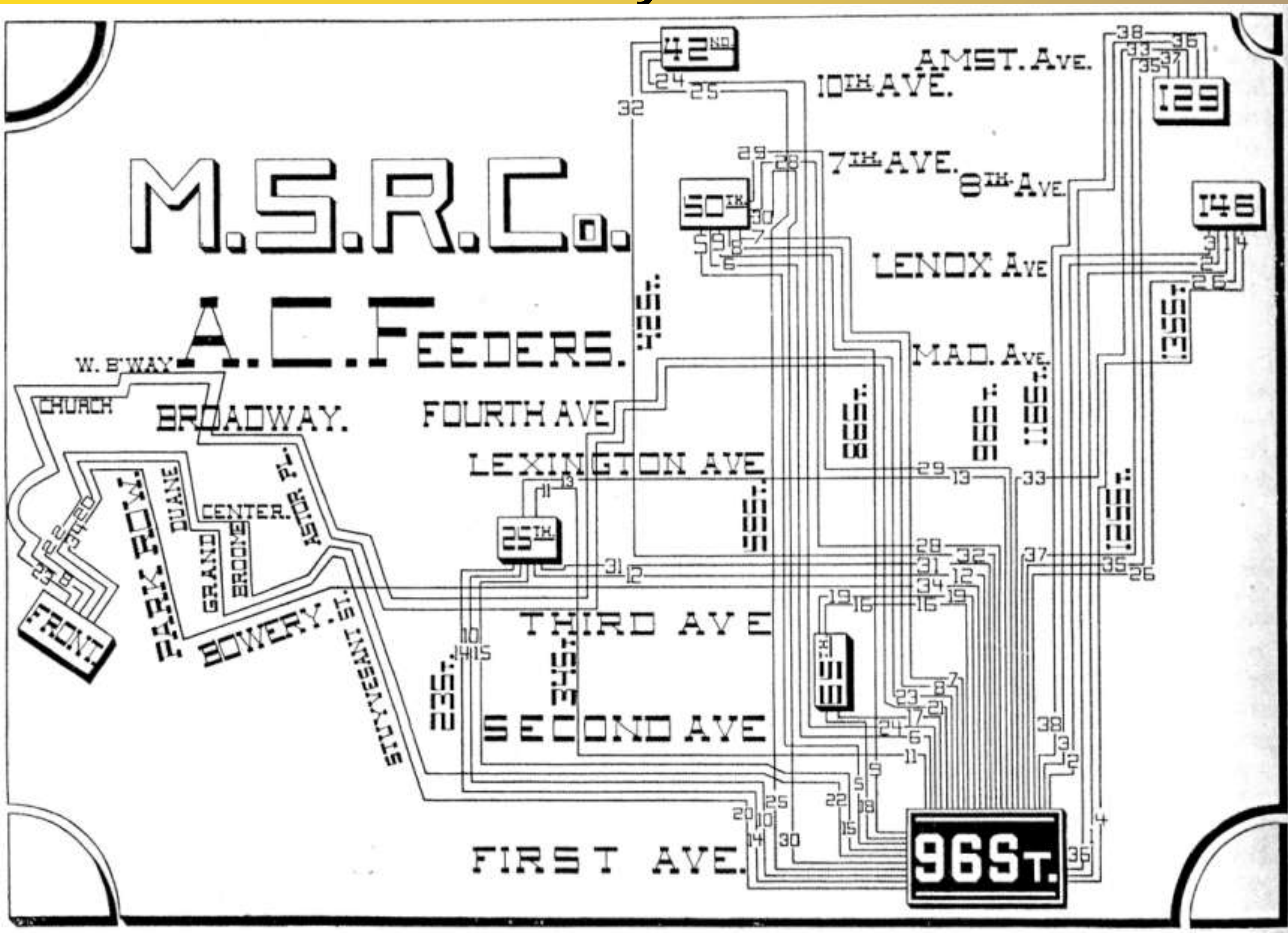


Fig. 5.—General View, Showing Supply Pipes, Fish Traps, Meters, Air Chambers, &c.

HYDRAULIC ENGINEERING IN THE METROPOLITAN POWER HOUSE

Duplicate and segregated AC System



THE PLOW

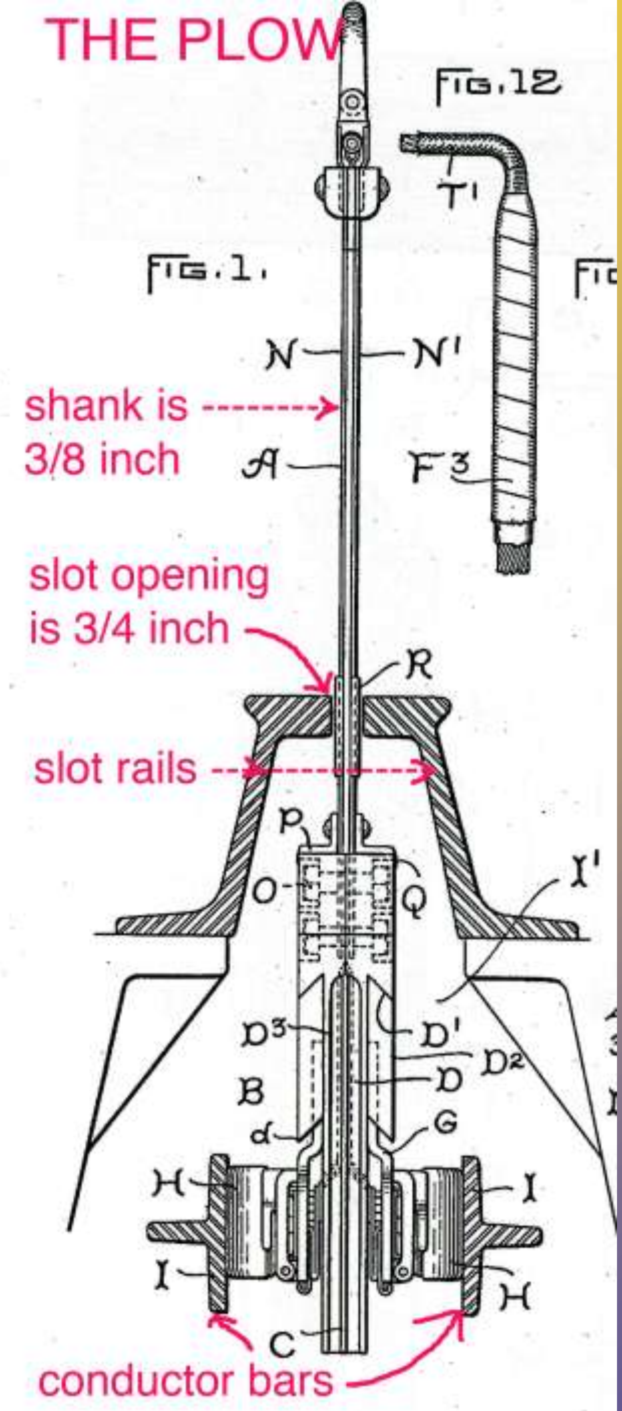


FIG. 12
T'
FIG. 1.
N
N'
shank is 3/8 inch
A
F3
slot opening is 3/4 inch
R
slot rails
P
O
Q
I'
D3
D'
D2
D
B
G
d
H
I
I
H
C
conductor bars

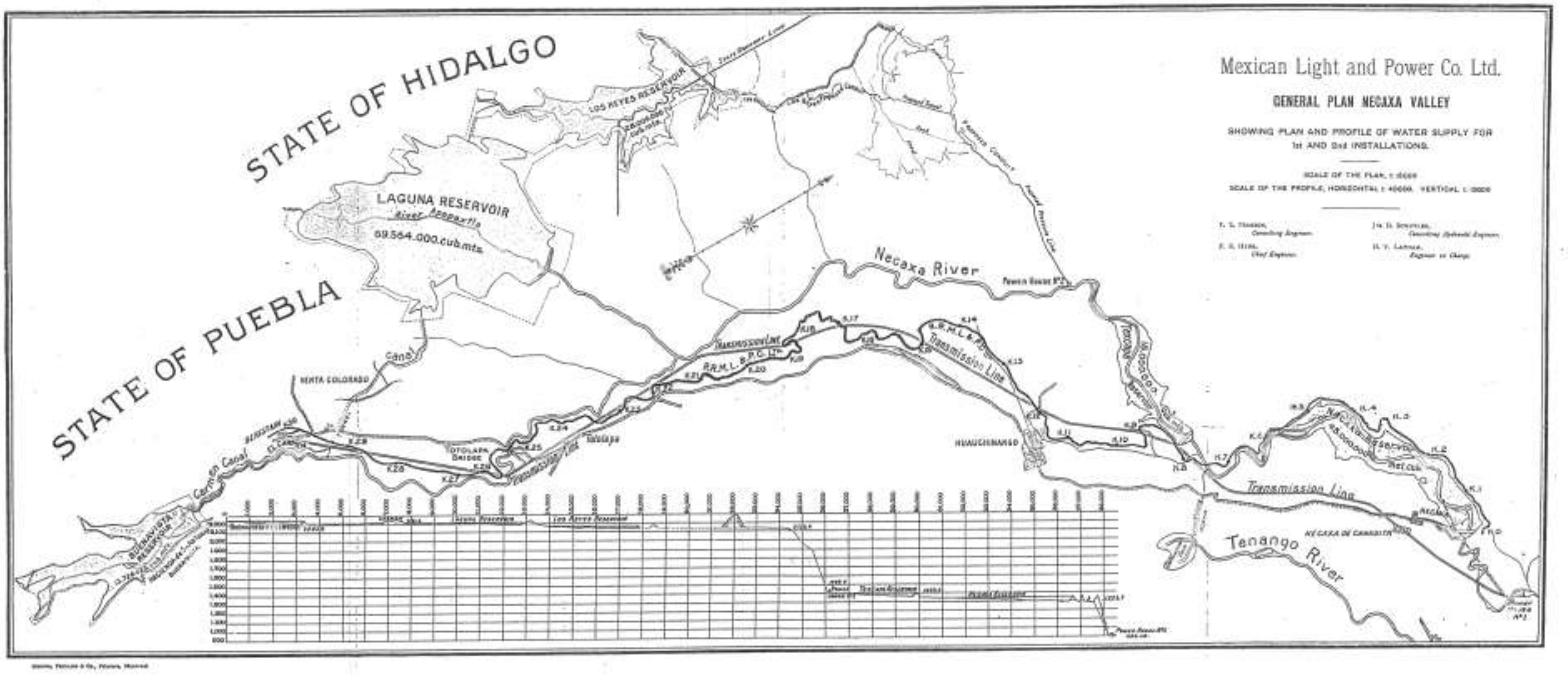

Winged dam
Toronto Power Stat

Passive duplicate ice protection


Ice floats over Horseshoe Falls
instead of clogging up water turbines
Ice barrier # 2
Ice barrier # 1

hydroelectric development in Necaxa Mexico - 1905

Mexico Light and Power Company




DISTRIBUTION WORKS AND 6' PIPE LINES

landmark transmission lines in Brazil

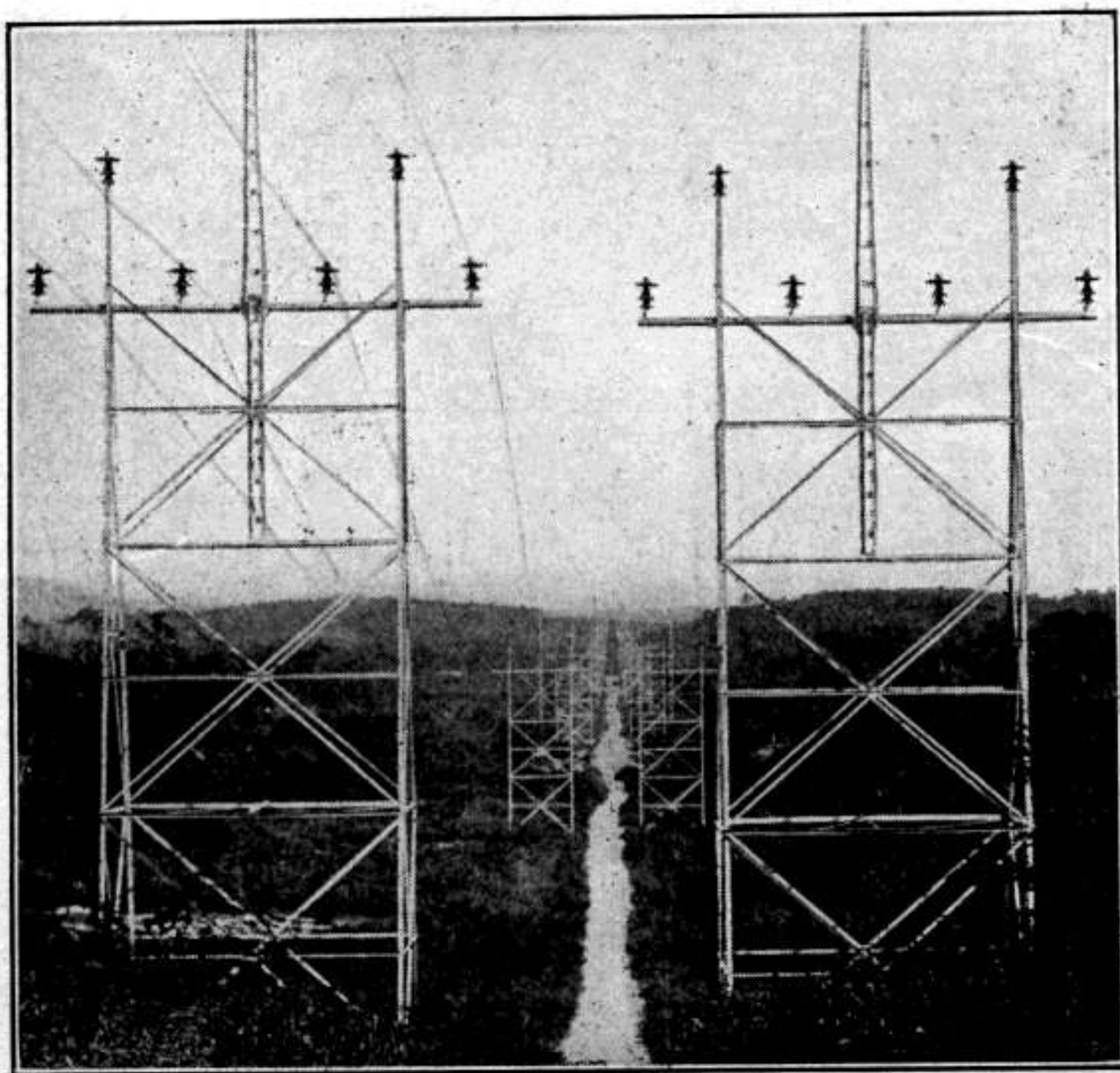


FIG. 2.—TRANSMISSION LINES IN FLAT COUNTRY.

Largest Tramway Car Shops in South America

...recently completed at Rio de Janeiro

THESE great shops for the Rio de Janeiro Tramway, Light & Power Company, Limited, with their 24 buildings and 430,000 square feet of space are unique in their completeness.

Because they are equipped to handle so many manufacturing and repair operations, they place this large utility system in an unusually independent position.

The shops are designed for the following work:

- Maintenance of 1000 tramway cars and buses;
- Construction of new steel cars and buses;
- Repair of heavy machinery, motors and generating equipment;
- Manufacture of power line equipment, many car and bus parts, castings, brake shoes, etc.;
- Manufacture of all bare and weatherproof copper wire required for the system, 850 tons annually;
- Fabrication of substation structures;
- Construction of metal and wood furniture for cars, buses and offices;
- General stores for shops and entire system.

We designed and built the shops in cooperation with our client's organization.

We are prepared to handle construction undertakings anywhere in the world.

UNITED ENGINEERS & CONSTRUCTORS INC.

combining

Day & Zimmermann Engineering & Construction Co.
Dwight P. Robinson & Co., Inc.
The U. G. I. Contracting Co.
Public Service Production Co.
United Engineers & Constructors (Canada) Ltd.
Dwight P. Robinson & Company of Brazil, Inc.
Dwight P. Robinson & Company of Argentina, Inc.

Design and Construct

INDUSTRIAL PLANTS
STEAM POWER STATIONS
HYDRO-ELECTRIC DEVELOPMENTS
RAILROAD WORK
GAS PLANTS
PIPE LINES

Build

APARTMENTS
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OFFICE & MONUMENTAL BUILDINGS

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LOS ANGELES MONTREAL TORONTO BUENOS AIRES RIO DE JANEIRO

MAXIMUM RETURN TO CLIENTS PER DOLLAR INVESTED

“ A magnificent avenue called the Avenida Central has been finished …..” *Pearson 1907*

“taking the public point of view as regards to certainty of operations” ……
……….Pearson 1900

Connected to a backup emergency generator

AVENIDA RIO BRANCO

TWENTIETH CENTURY IMPRESSIONS OF BRAZIL.

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THANK YOU

QUESTIONS OR COMMENTS ?

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