

# Empire State Building process design for speed

# October 29, 1929

## Stock Market Crash

- Dow drops from 381 to 228
  - 40% decline
  - Attributed to leveraged stock purchases
- Didn't recover until outbreak of WWII in 1939.
- Widespread unemployment meant good bidding climate

# The tallest building in the world 1931-1971

- 2,768,591 square feet
- 102 floors
- 1,250 ft. to roof
- 1,472 ft. to spire
- Demolition of Waldorf Astoria started Sept. 22, 1929
- Construction of Empire State building started March 17, 1930
- Construction had to be complete by May 1, 1931.

## Planning and Control Permit Erection of 85 Stories of Steel in Six Months

Empire State Building in New York City Involving 57,000 Tons Goes Up in Record Time—Nine Derricks Starting Work on 425x198-Ft. Site Reduced to Five Above Twentieth Floor—Relay Platforms Necessary in Hoisting Steel—All Hoists Inside of Building

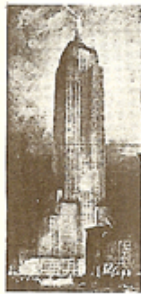


FIG. 1—EMPIRE STATE BUILDING, NEW YORK CITY

THE PLACING of more than 57,000 tons of structural steel in an 85-story building between the months of April and October is the task which has confronted the steel erector on the Empire State Building in New York City. Eighty per cent of this total tonnage was in place on Aug. 1, when the building had reached to about the 50th story. During July, 22 stories of steel were placed in 22 working days, involving regular hours and no night work. As progress has averaged about 10,000 tons of steel per month (working five days a week), it seems probable that the difficult schedule will be met.

This article is devoted to an account of the steel erector's methods and equipment which are of interest and value both because of the magnitude of the project and the careful planning and control which has been exercised. The steel tonnage in the Empire State Building exceeds by a large margin that used in any comparable structure. The Chrysler Building utilized 21,000 tons and the 70-story Manhattan Company Building, both in New York City, required 18,500 tons. The Merchandise Mart in Chicago, recently characterized as the world's largest building, required only 38,000 tons. The principal roof of the Empire State Building is 1,043 ft. above the curb, and latest plans contemplate the addition of a combination airship mooring mast and observation tower approximately 200 ft. tall above this point. The building's completed height will exceed that of the Chrysler Building, now the tallest structure, by something over 200 feet.

In preparing a plan of procedure for the steel erection, it was necessary to consider four major problems: (1) steel supply, which had to take into account the fabrication schedule and methods of delivery; (2) plant layout, including number, size and location of derricks and hoisting engines; (3) steel-handling methods at the job, which necessarily had to be considered as complementary to plant layout in the planning; and (4) actual erection procedure, including methods of setting, fitting up and riveting.

### Steel Supply

The large tonnage in the building and the urgency for completion made it advisable to divide the fabricating contract between two firms, the American Bridge Co. and the McClintic-Marshall Co. Alternate sections from the basement to the roof, comprising from two to eight floors each, were assigned to each fabricator. All steel is shipped to a joint waterfront supply yard near Bayonne, N. J., and steel for erection is ordered from

this supply yard one lift (two floors) at a time, as needed. Because of possible delays in loading and shipment it is necessary for the steel erector to order steel two days in advance of the time it is to be used. Since there is no storage space at the building site, it is absolutely necessary that everything be in readiness to erect the steel when it arrives.

Steel is delivered from the supply yard to docks on the East River waterfront by derrick-equipped lighters. Columns and heavy members are transferred to trucks at 23d St. while the smaller material comes ashore at 19th St. Since the Empire State Building is between 33d and 34th St. on Fifth Ave., the haul through city streets is not long. The largest shipping pieces were the two bottom column sections, the lower one 15 ft. 8 in. long, weighing 44 tons, and the upper one having about the same weight but being 33 ft. long. By using a two-wheel trailer, the trucks were able to handle these sections as easily as the smaller ones.

At the beginning of the job steel was delivered to the 33d St. side of the building; an unusually wide sidewalk on 34th St. made it impossible for the derricks standing in the excavation to reach trucks on this side. When erection had reached the second floor, however, the derricks could reach either street and steel was delivered on both the 33d and 34th St. sides until erection reached the 46th floor, when unloading on 34th St. was discontinued. All steel is now being received along 33d St. which, although narrow, is a westbound street permitting the trucks to reach the building from the East River waterfront in the most direct manner.

The erection plant is divided into two main parts—

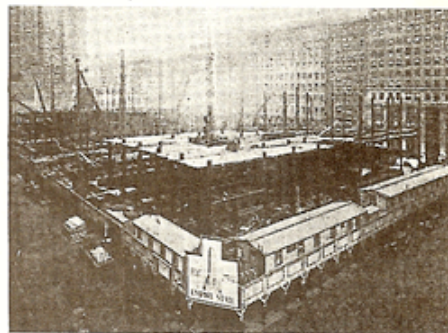


FIG. 2—EARLY ERECTION VIEW OF EMPIRE STATE BUILDING

At stage shown almost 8,000 tons of steel had been erected. Note extent of site which is 198x425 ft. General contractor's offices on bridge over 19th Ave. in foreground. Note complete planking of top floor forming a safe working platform for the steel erectors. Also at left, trucks unloading steel and materials along 33rd St. side.

# The People with the Plan

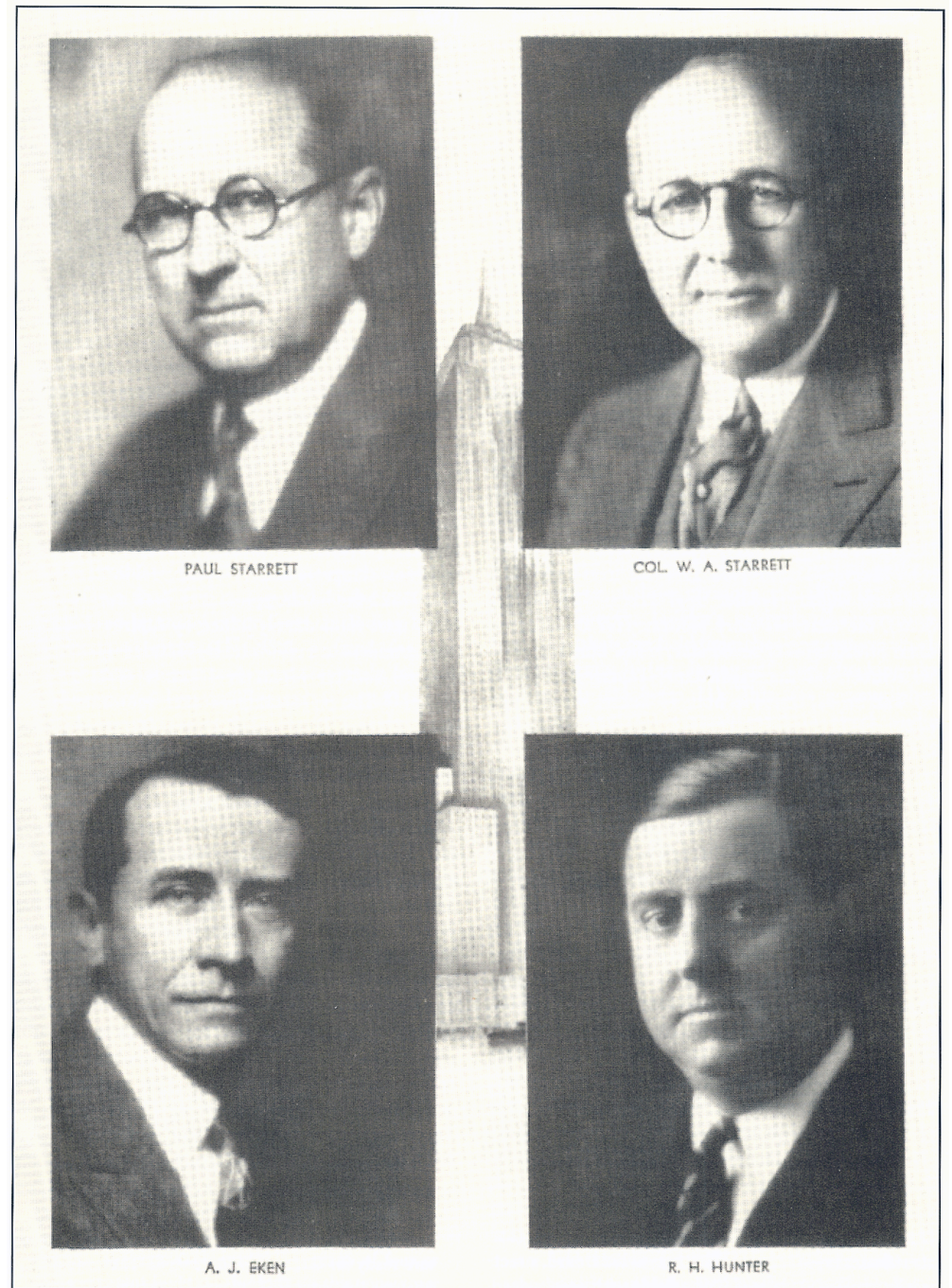


Fig. 7. The builders: Paul Starrett, William A. Starrett, Andrew J. Eken, and R. H. Hunter, a vice president of Starrett Brothers and Eken. From *Empire State: A History*. New York, 1931.

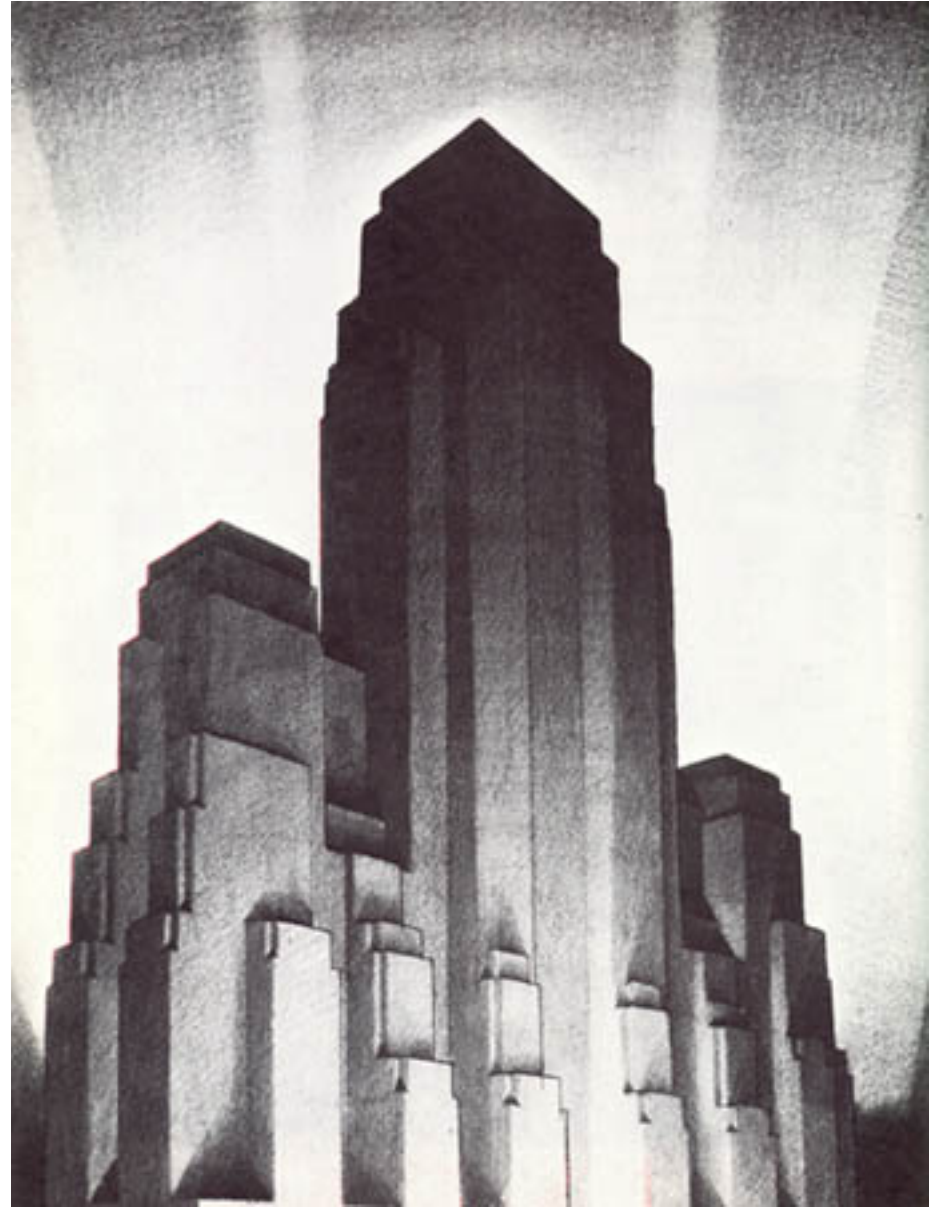
# The need for speed

... 2,768,591s.f. in 410 days?  
6,752 s.f. per day!

- Owners specified completion by May 1, 1931 to meet standard leasing window.
- Interest and taxes cost owner \$10,000/day

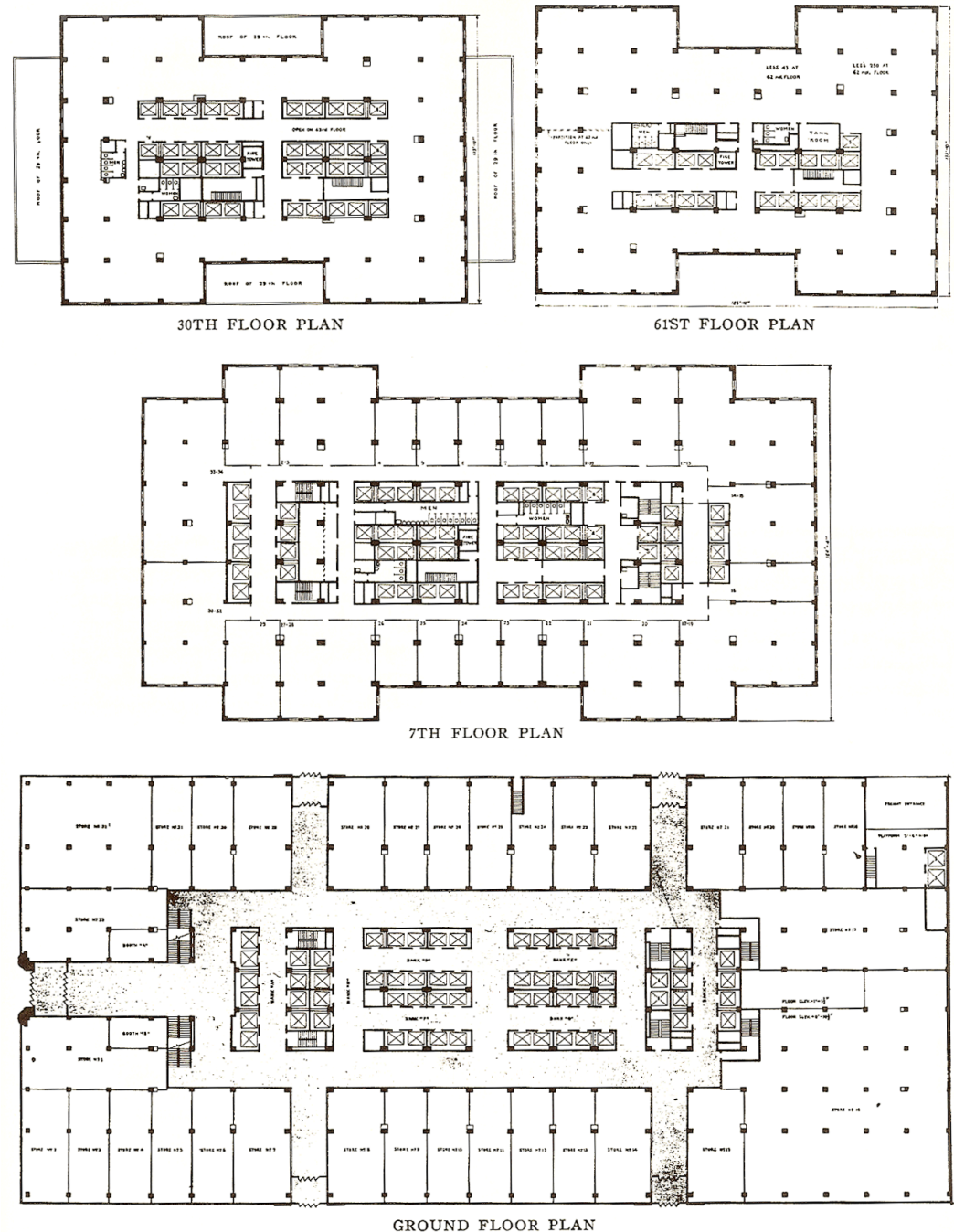
# Skyscraper Setbacks

- Growing height and bulk of skyscrapers raised outcry about quality of life at street level
- NY Zoning ordinance of 1916 was among the first to require that the skyscraper “step back” to leave a wider opening for the sun to reach the street.



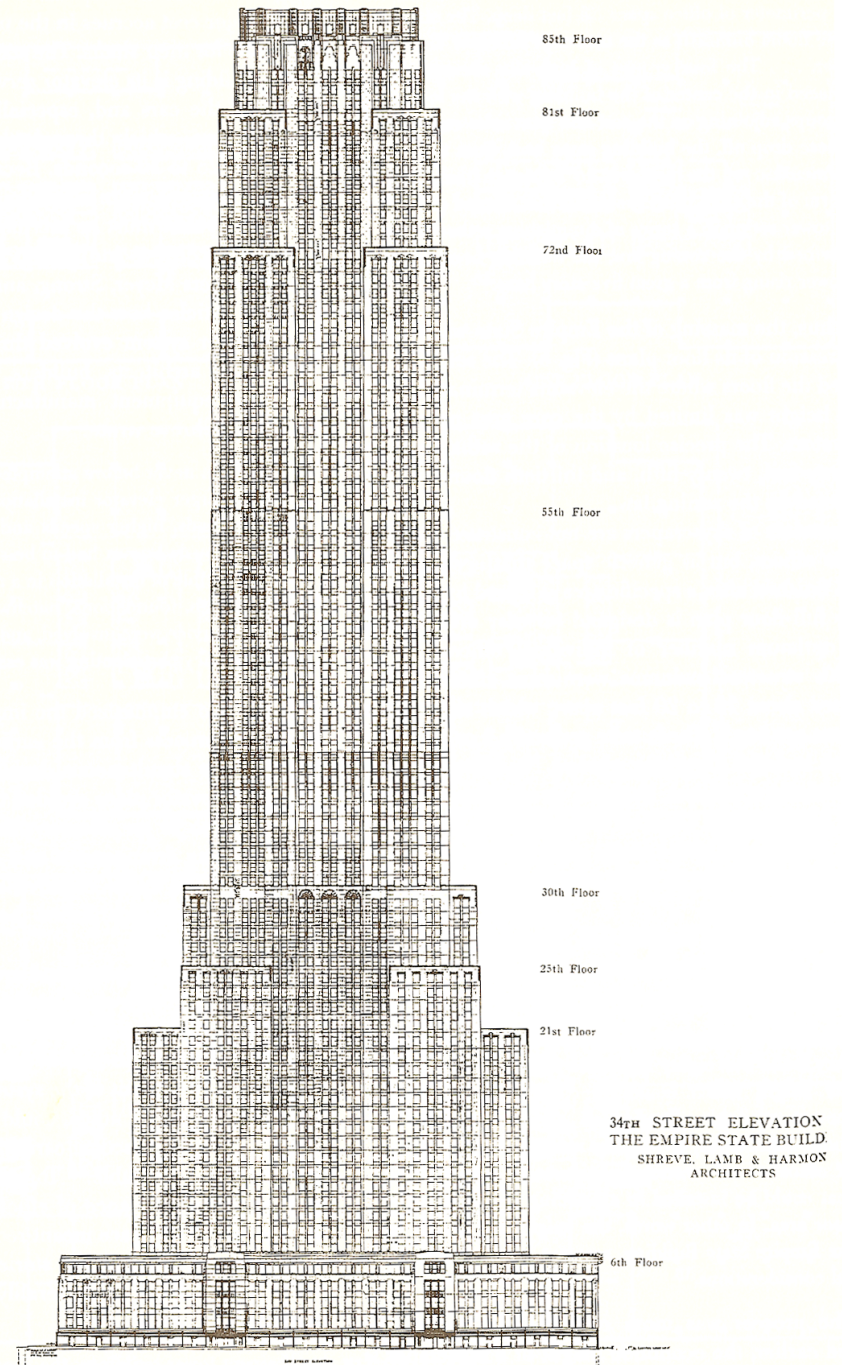
# Setbacks change floor plates

- Meeting zoning required stepping back the building, reducing the number of repeated floors
- Upper floors consumed by elevators (73 total)

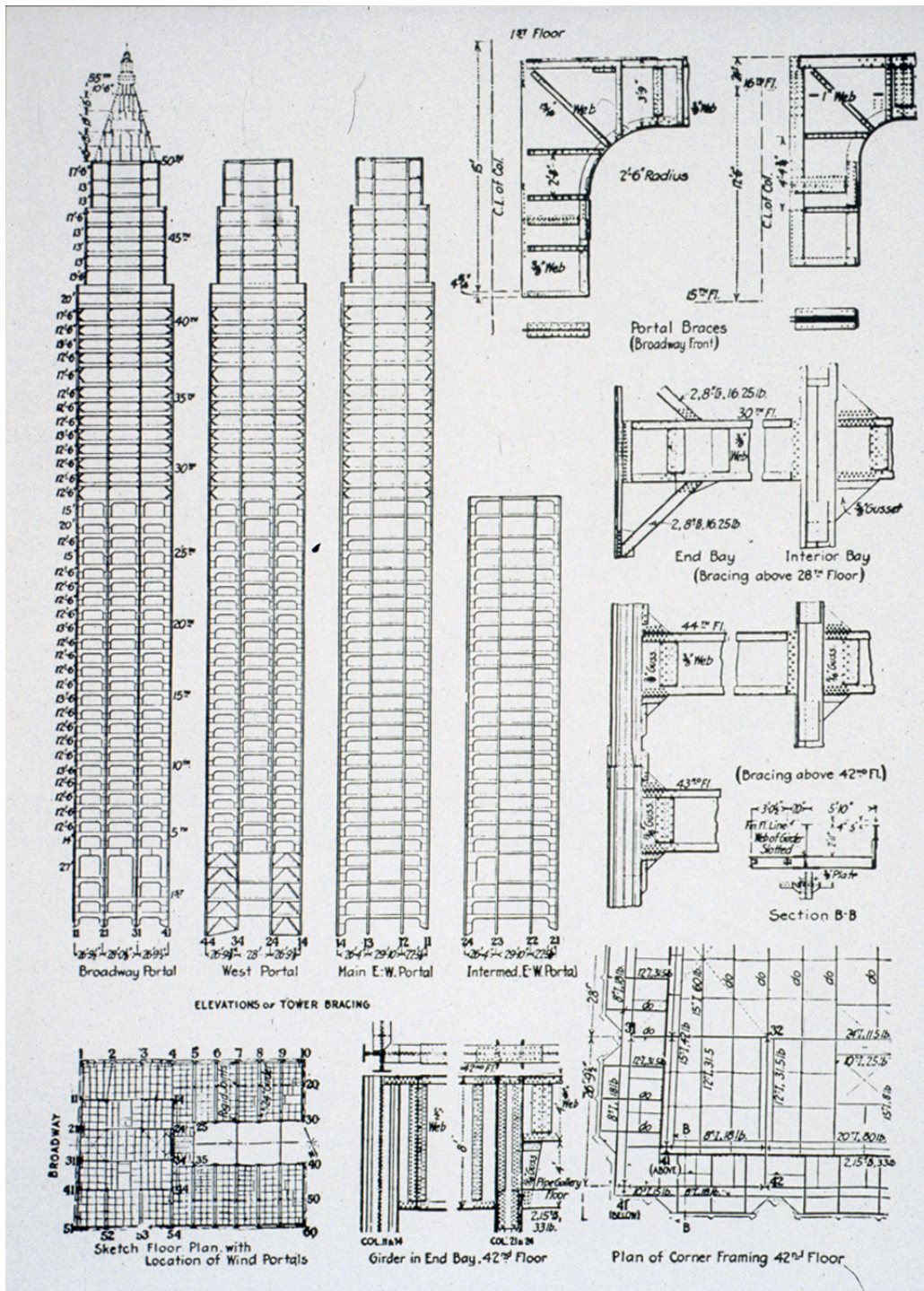


# Designed for Rapid-Building

- Standard Bay sizes
- Standard Mullion spacing
- Stone sizes fit to milling equipment
- Steel sizes fit to transport/lifting equipment



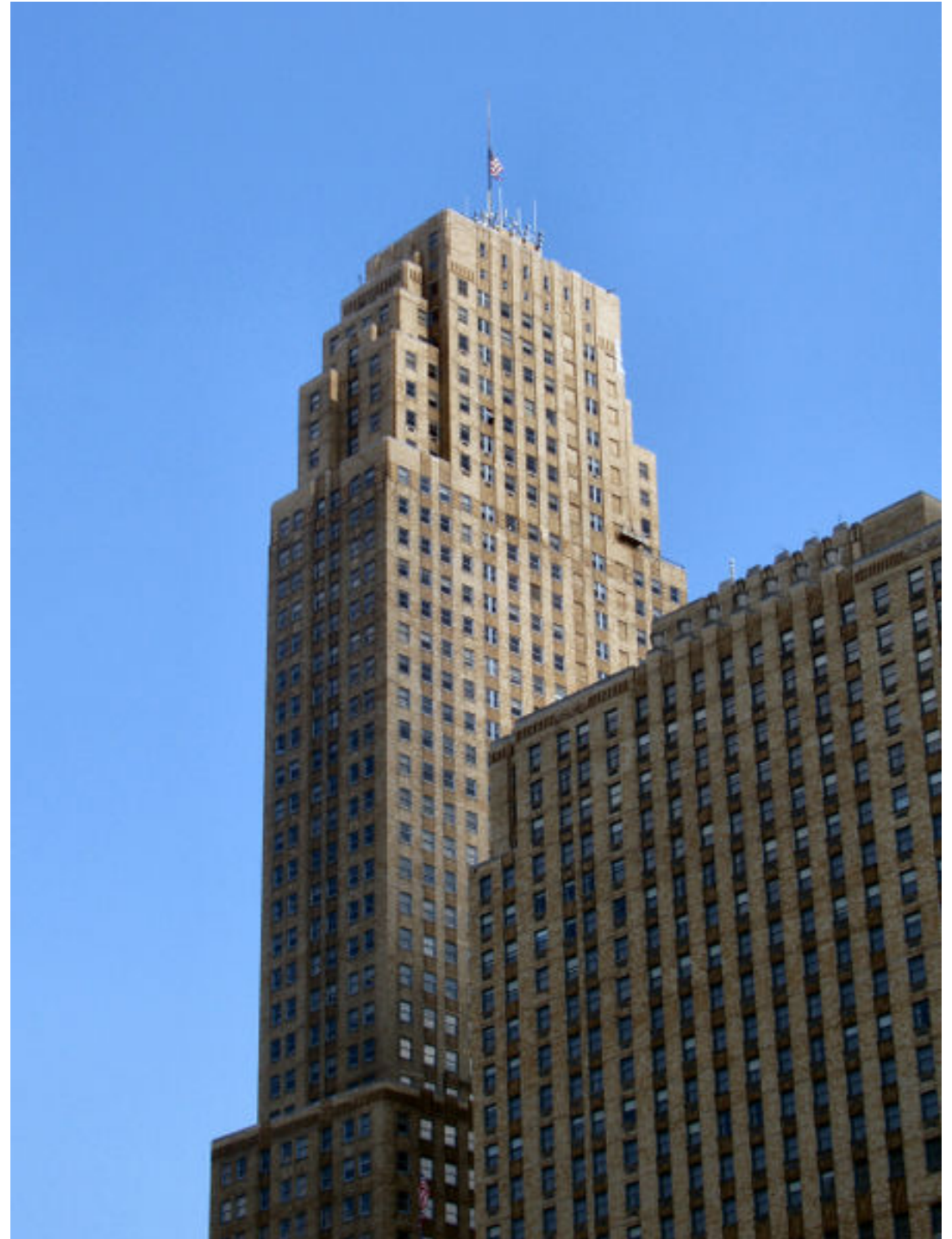
# Portal Frame for Lateral stability



# Building drawings produced in 2 weeks!

By architects Shreve, Lamb and Harmon

- How?
- Carew building Cincinnati
- 51 floors, 1.3 million s.f.
- Started Sept. 1929
- Completed Oct. 1930



# Achieving Speed

- World recession/everyone willing to work overtime to have work to do
- August 14, 1930 Superintendent J.W. Bowser's daily log lists 3,439 people on the jobsite among 23 subs and G.C. Starrett Brothers.
- Early use of Fast-Track construction process, Just-in-Time deliveries, Linear Scheduling

# A Time and Place for Everything

- Close scheduling of
  - Drawings
  - Fabrication
  - Delivery
  - Installation
- Floor by floor, week by week

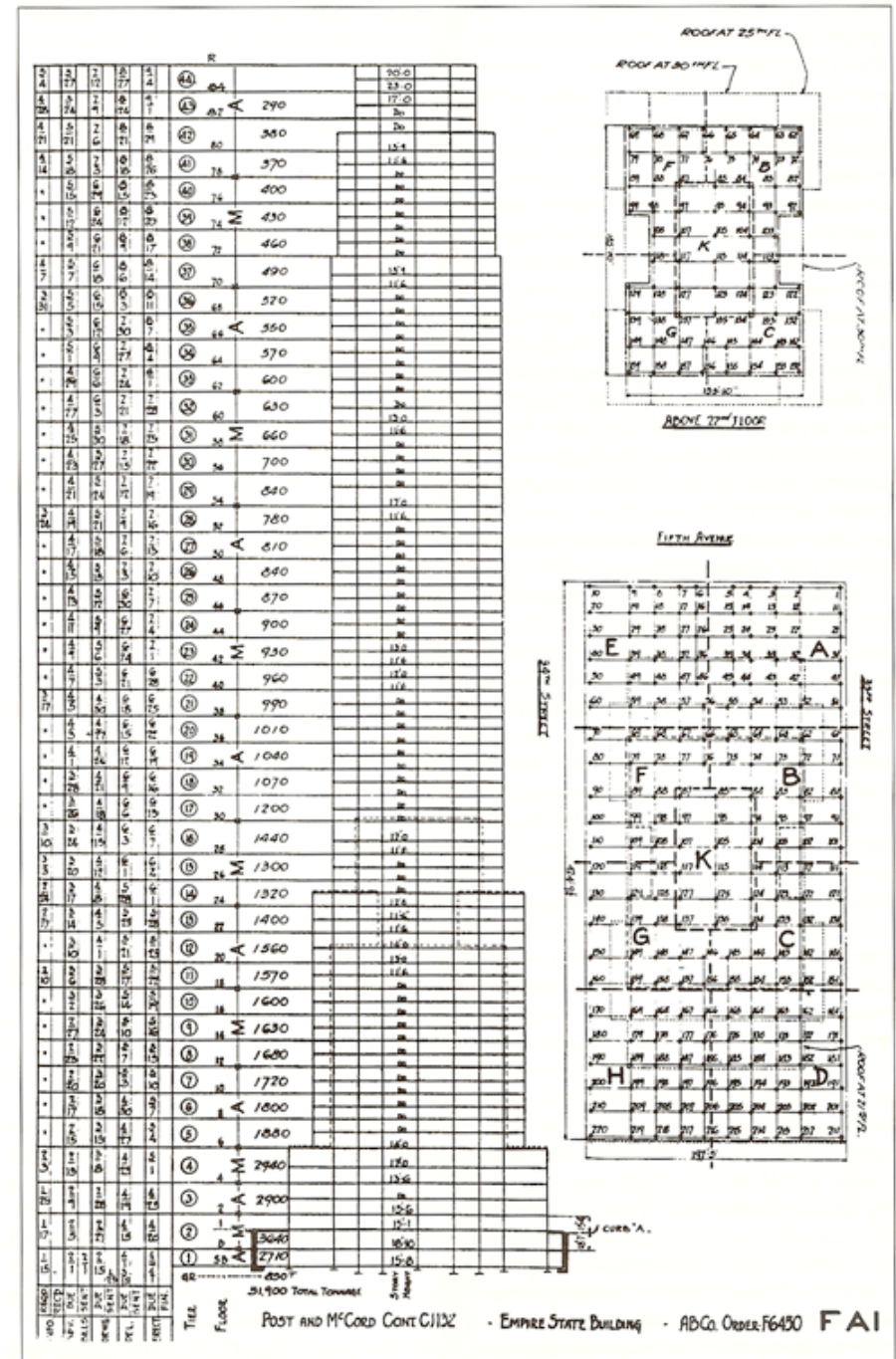
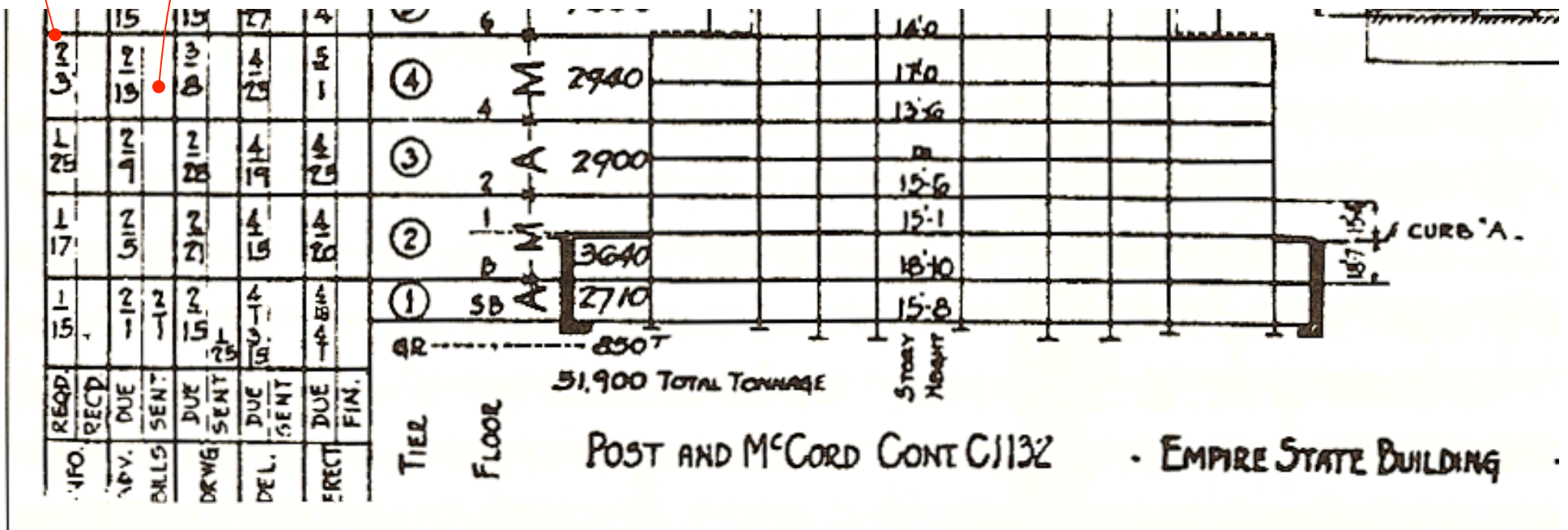


Fig. 1. Schedule for the structural steel for the Empire State Building, with dates of information and drawings required from the architects, mill orders, shop drawings, steel delivery, and steel erection. From *Architectural Forum* 52 (1930): 772.

# Beginning Schedule, like CPM

Required dates

Space for actual dates



# Finishing Schedule

R

INFO.	REQD. RECD	APV. DUE	BILLS SENT	DRWG DUE SENT	DEL. DUE SENT	ERECT DUE FIN.	TIER	FLOOR						
54	527	712	827	94	(44)	84					20.0			
428	524	79	824	91	(43)	82	290				23.0			
421	521	76	821	821	(42)	80	380				17.0			
414	518	73	818	826	(41)	78	370				Do			
"	515	629	815	823	(40)	76	400				Do			
"	512	624	812	820	(39)	74	430				Do			
"	595	621	895	817	(38)	72	460				Do			
47	57	516	816	814	(37)	70	490				Do			
											15.9			



# “Pacing” activities (the critical path activities)

- Structural Steel 58,000 tons in 189 days (+12)
- Concrete Flooring 2,768,591s.f. in 203 days (+4)
- Exterior metal trim
- Exterior Limestone

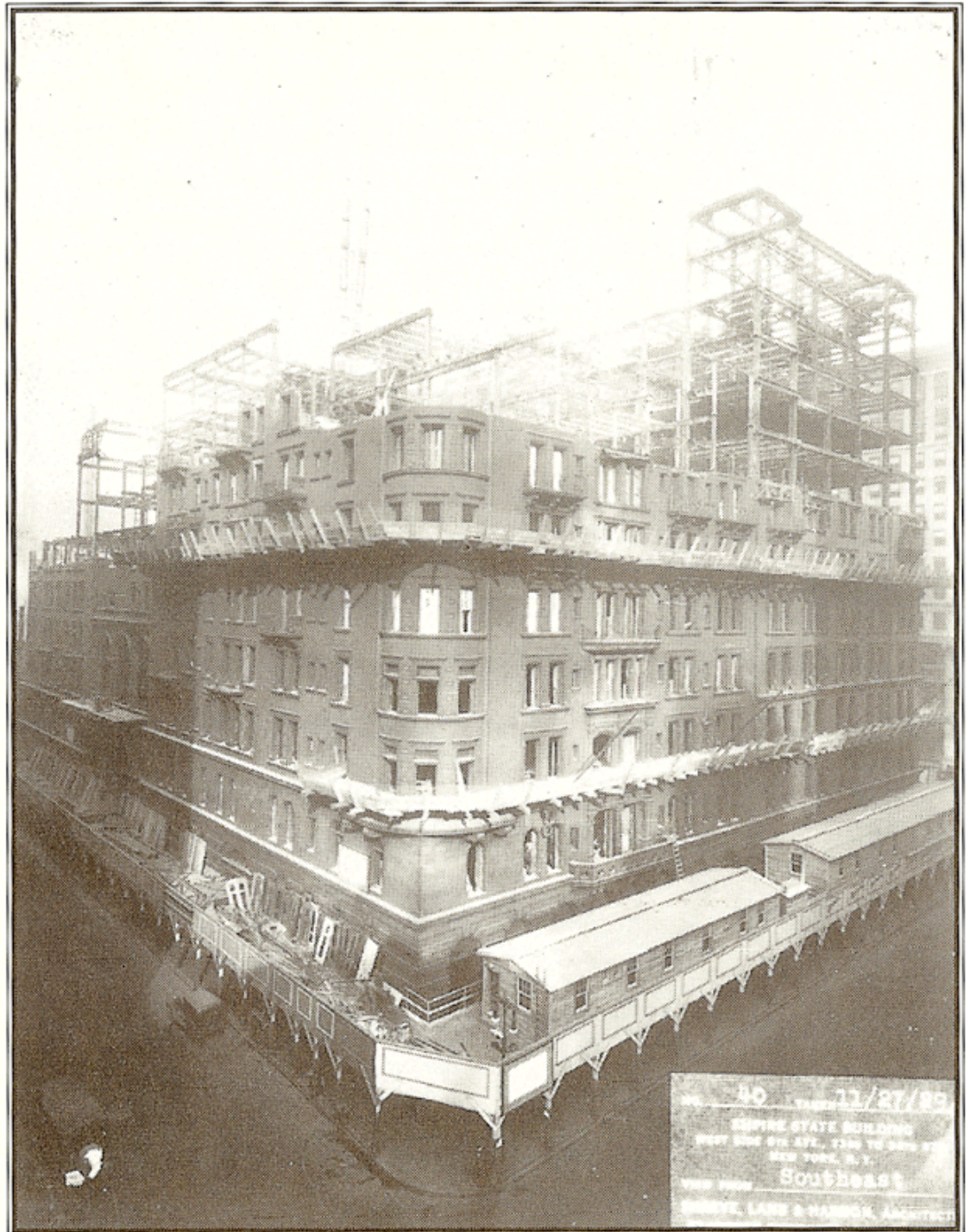
177 days for  
demolition,  
excavation,  
production  
planning

- Waldorf Astoria
  - contributed to the “Urban Canyon”
  - Robbing Daylight from the street



# Cut apart for Safety

- To increase the safety for workers and passers by, the Waldorf was taken apart, not knocked down as was the custom



# Cut apart for Safety

- This careful dis-assembly allowed for more salvage & recycling
  - Elevators
  - Piping
  - Bronze
  - Iron

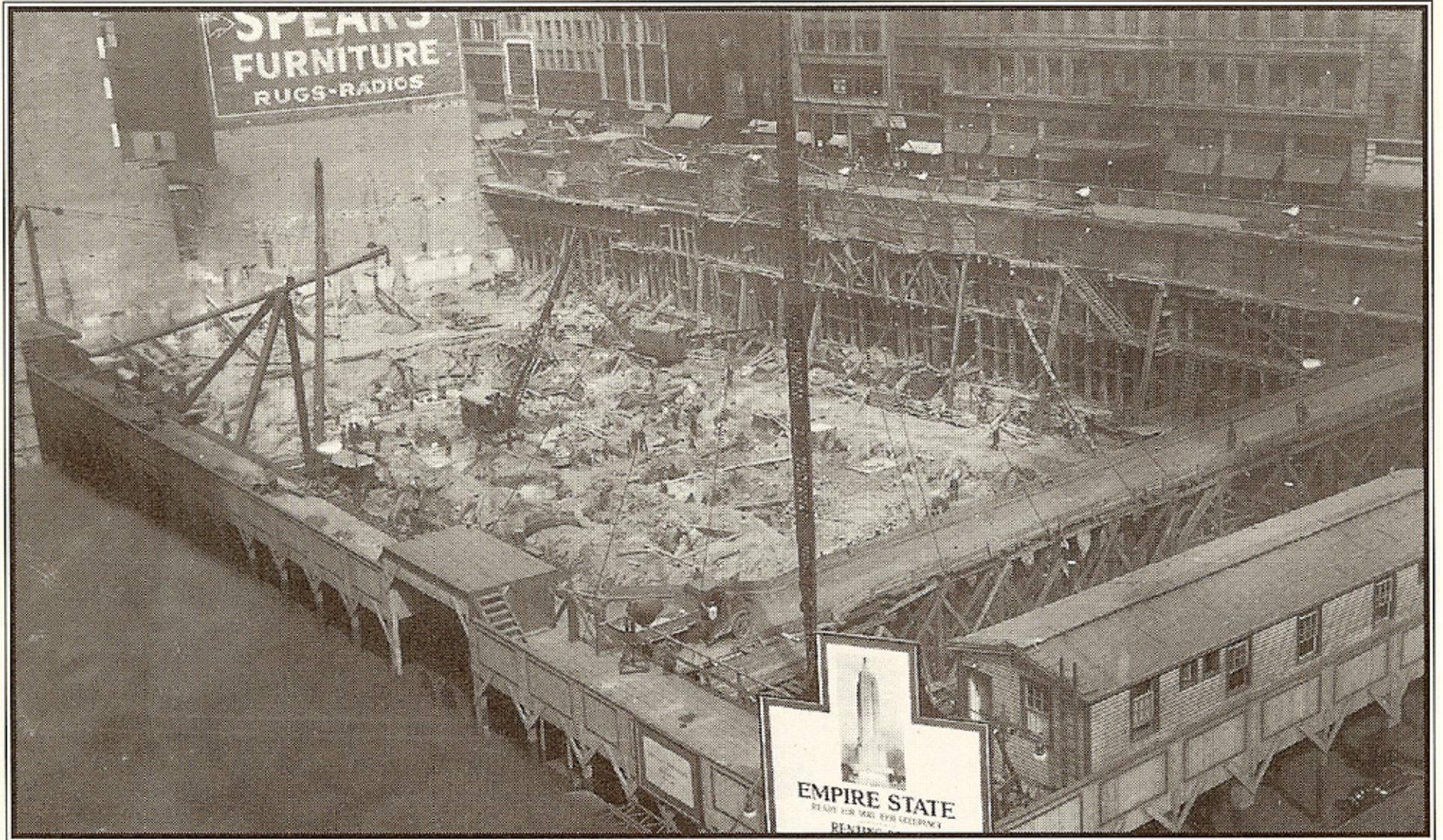




ON FINISH IN 1931-32 THE  
**EMPIRE STATE**  
*The Great Building of America*  
READY FOR OCCUPANCY MAY 1931  
RENTING OFFICE  
200 MADISON AVE.  
NEW YORK

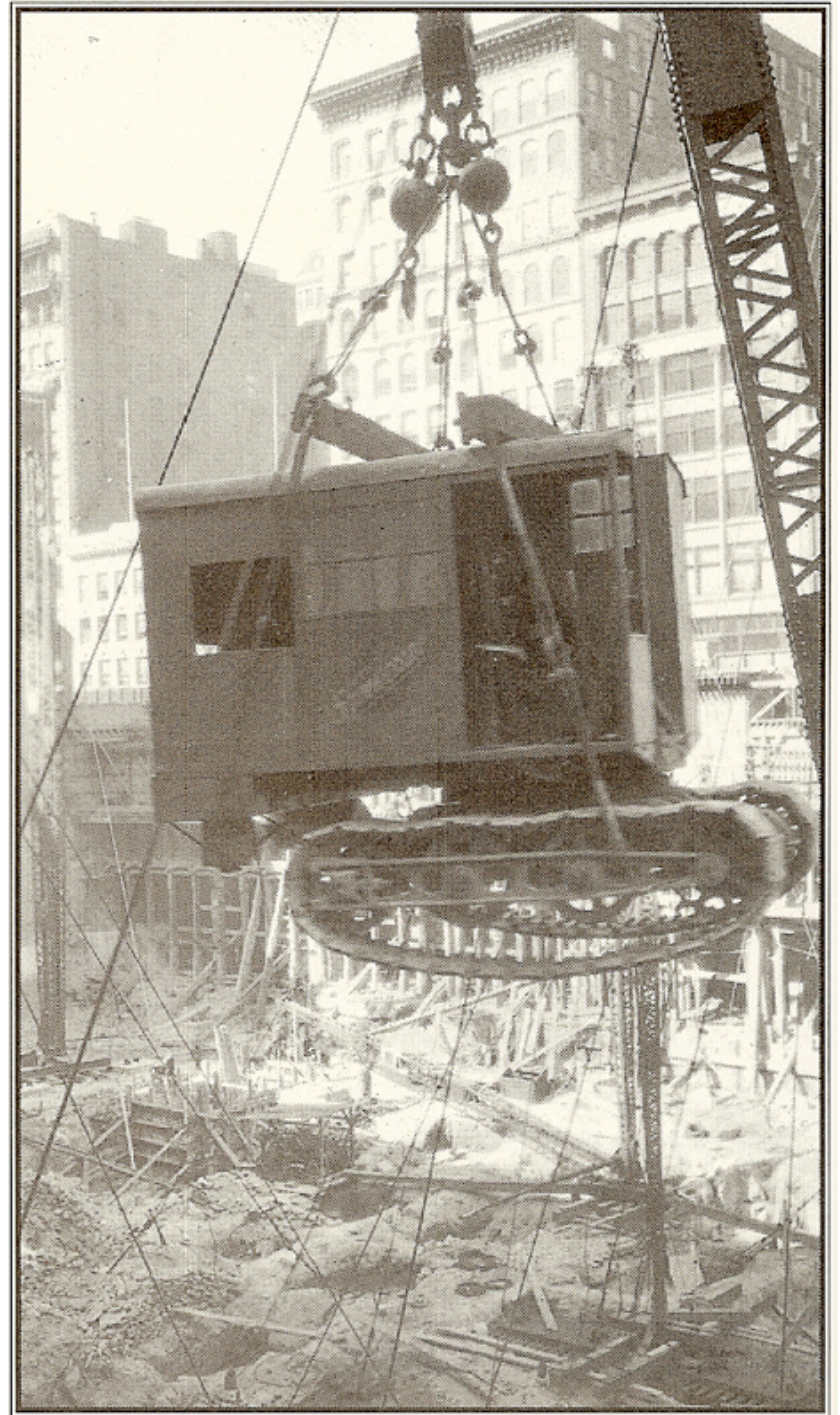
NO. 63 TAKEN 1/9/30  
EMPIRE STATE BUILDING  
WEST SIDE 5TH AVE., 33RD TO 34TH ST.  
NEW YORK, N. Y.  
VIEW FROM Southeast  
SHREVE, LAMB & HARMON, ARCHT

# Excavation almost done



# Demobilize Steam Shovel 1930

“Browning 16 ton Speed Crane”



# Like Jenney, Grillage

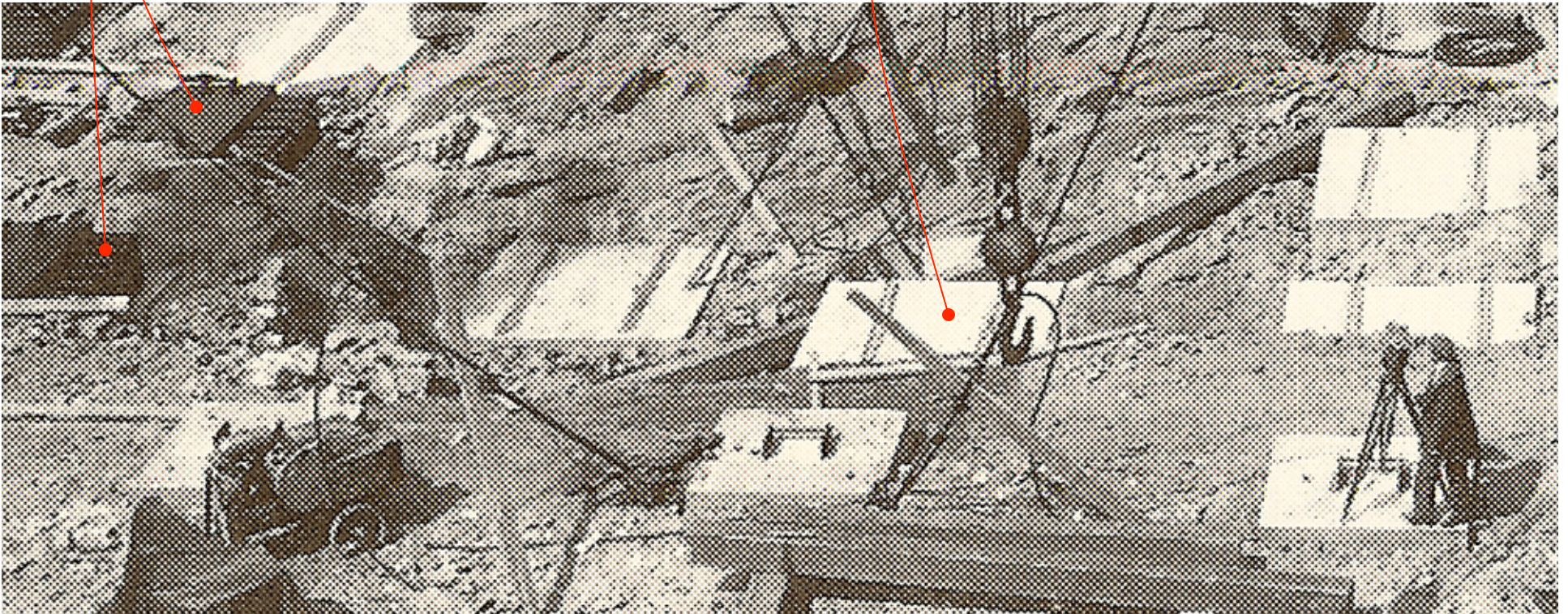
with Billets of steel as base plates, cast in concrete



• grillage

• billet

• concrete pier



# Ready for steel



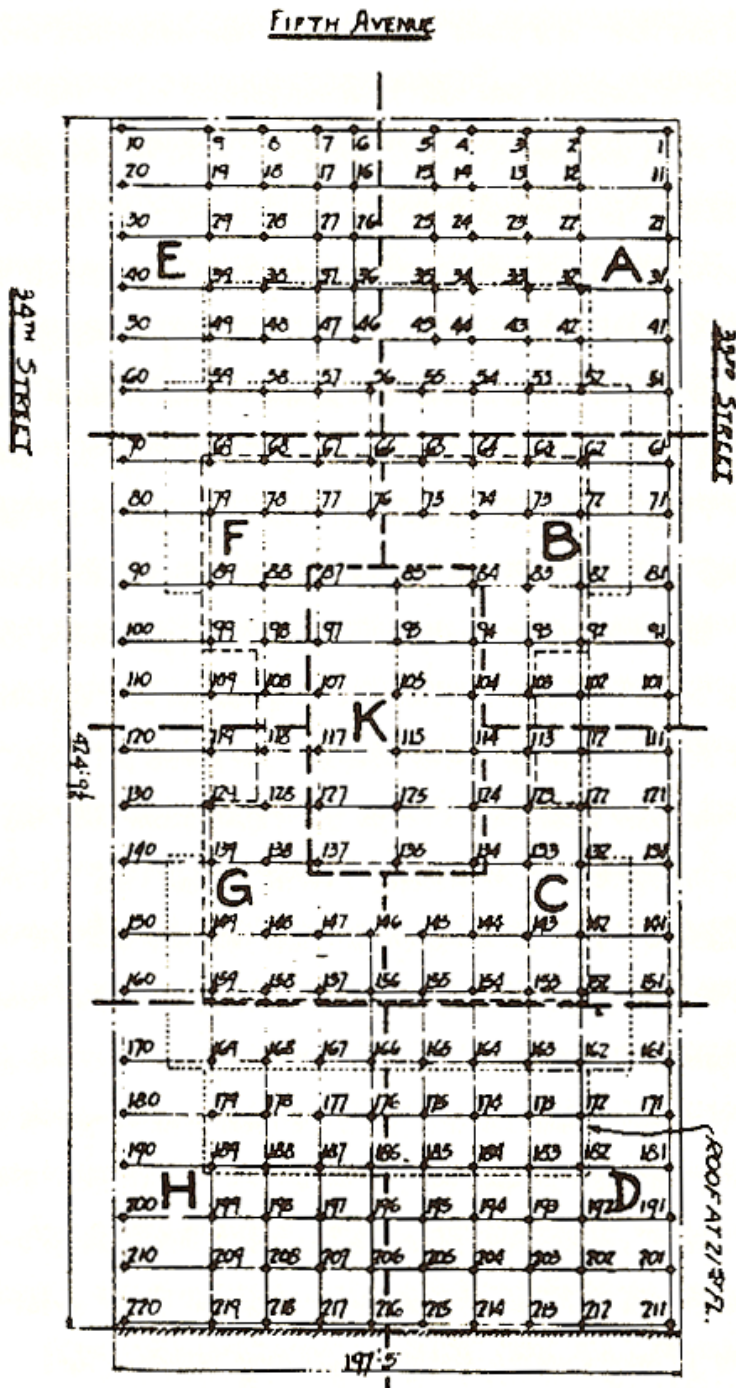
# Bolt together derrick cranes

Bolts were uncommon as a fastener for the building structure

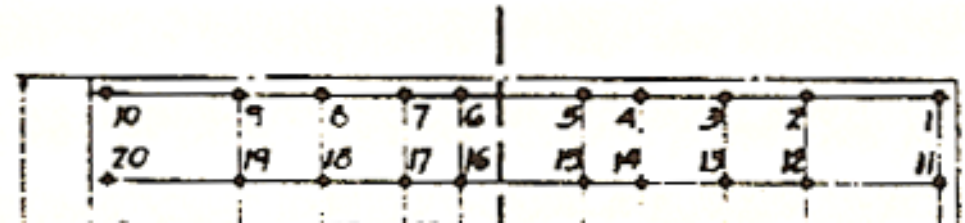
Bolts were temporary fasteners, Rivets were permanent until 1957



# Steel Sequence



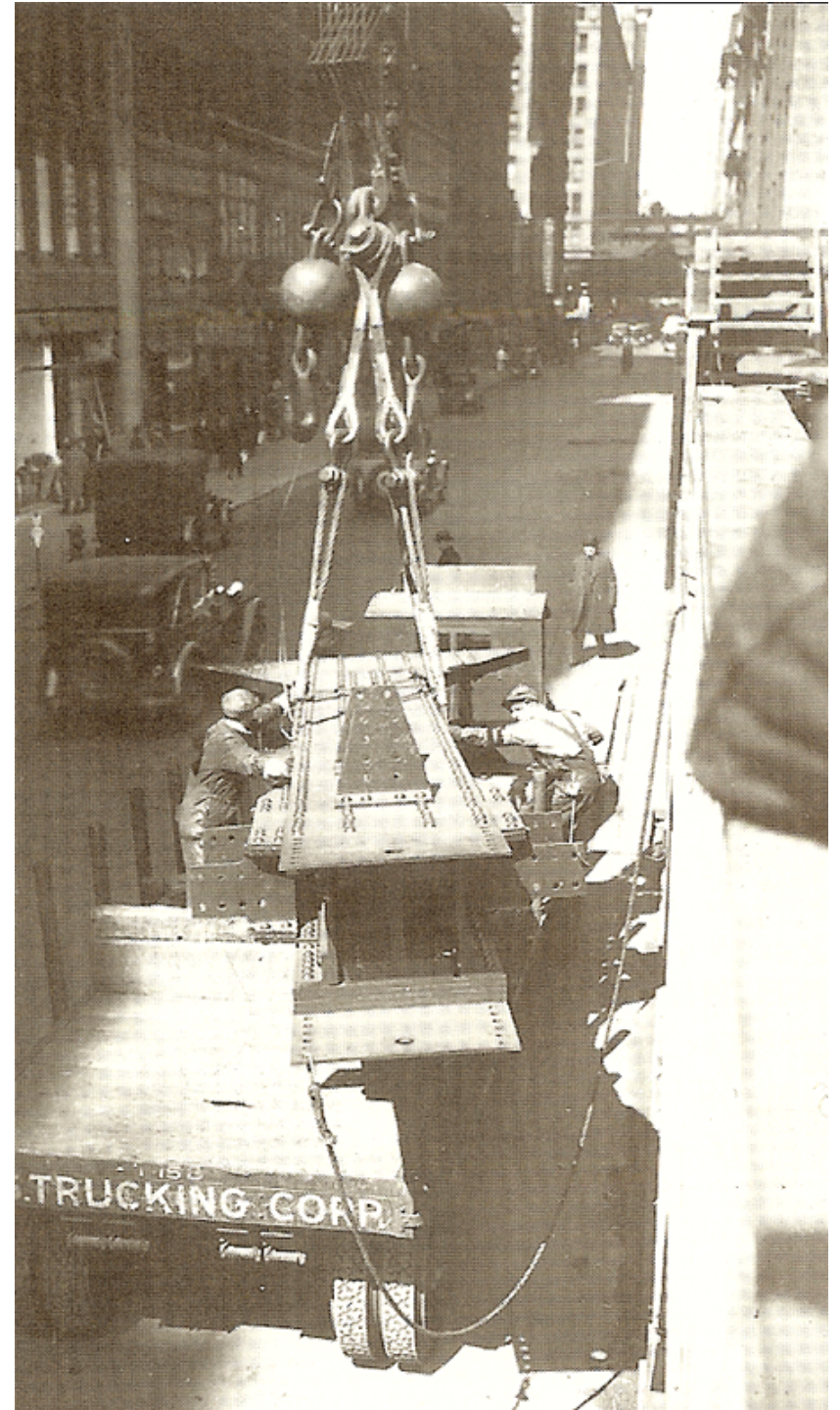
FIFTH AVENUE

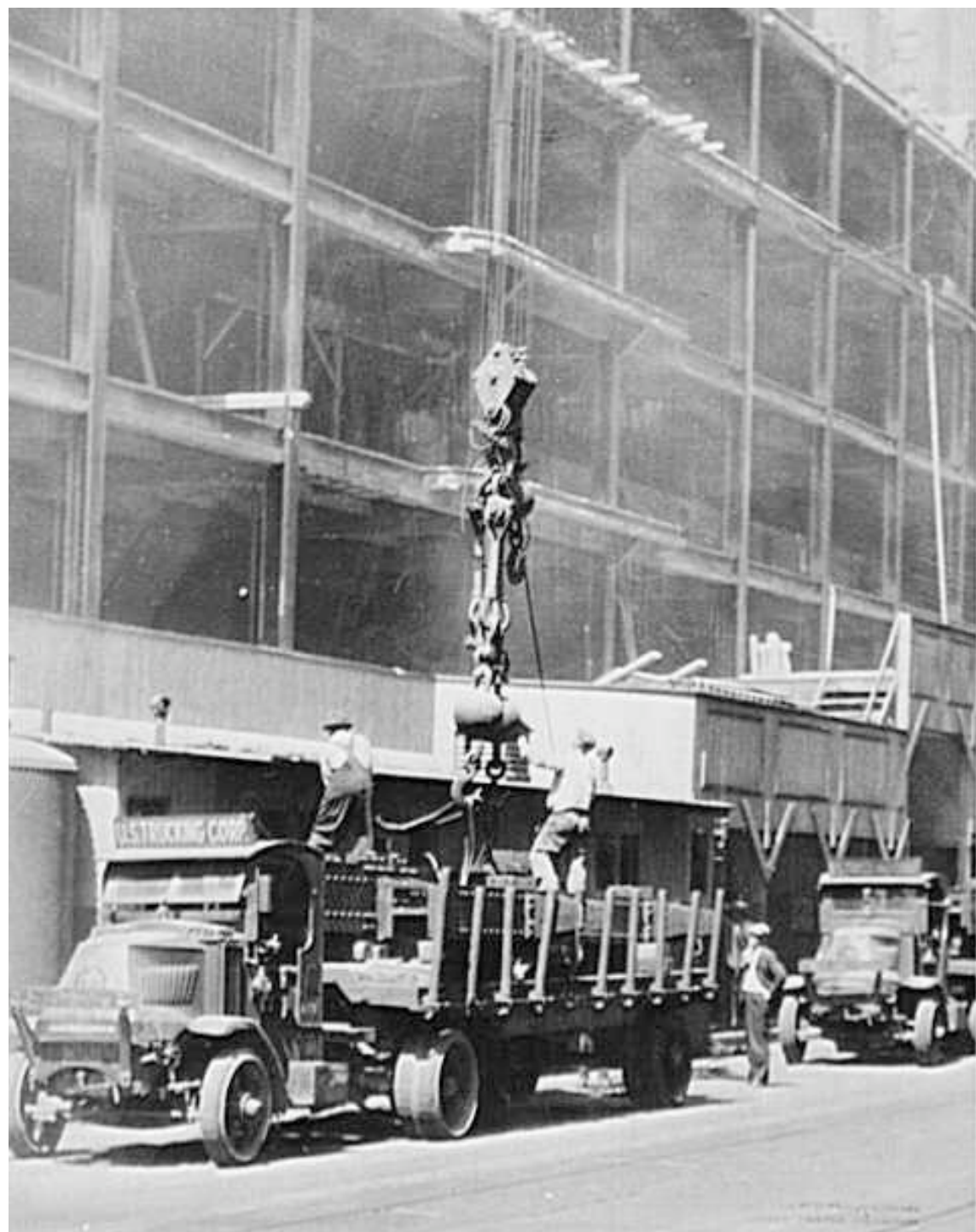


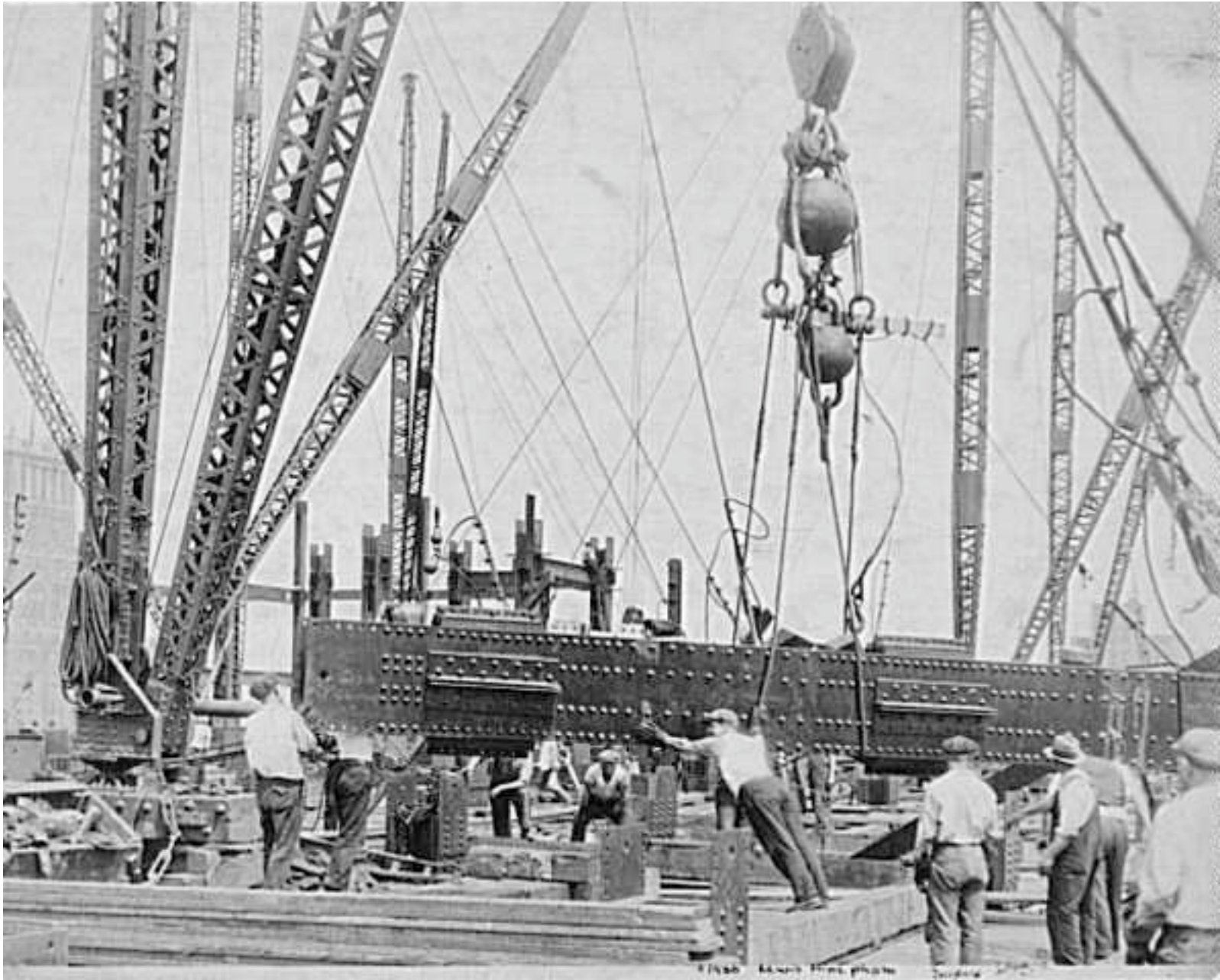
# Stage across the river,

- Produced in Pittsburg (Carnegie)
- 3 day supply on hand (supply chain buffer)
- Shipped to NY side on boats (overnight)
- Transferred to trucks (at daylight)
- Delivered just in time to install
  - (no onsite storage for steel)

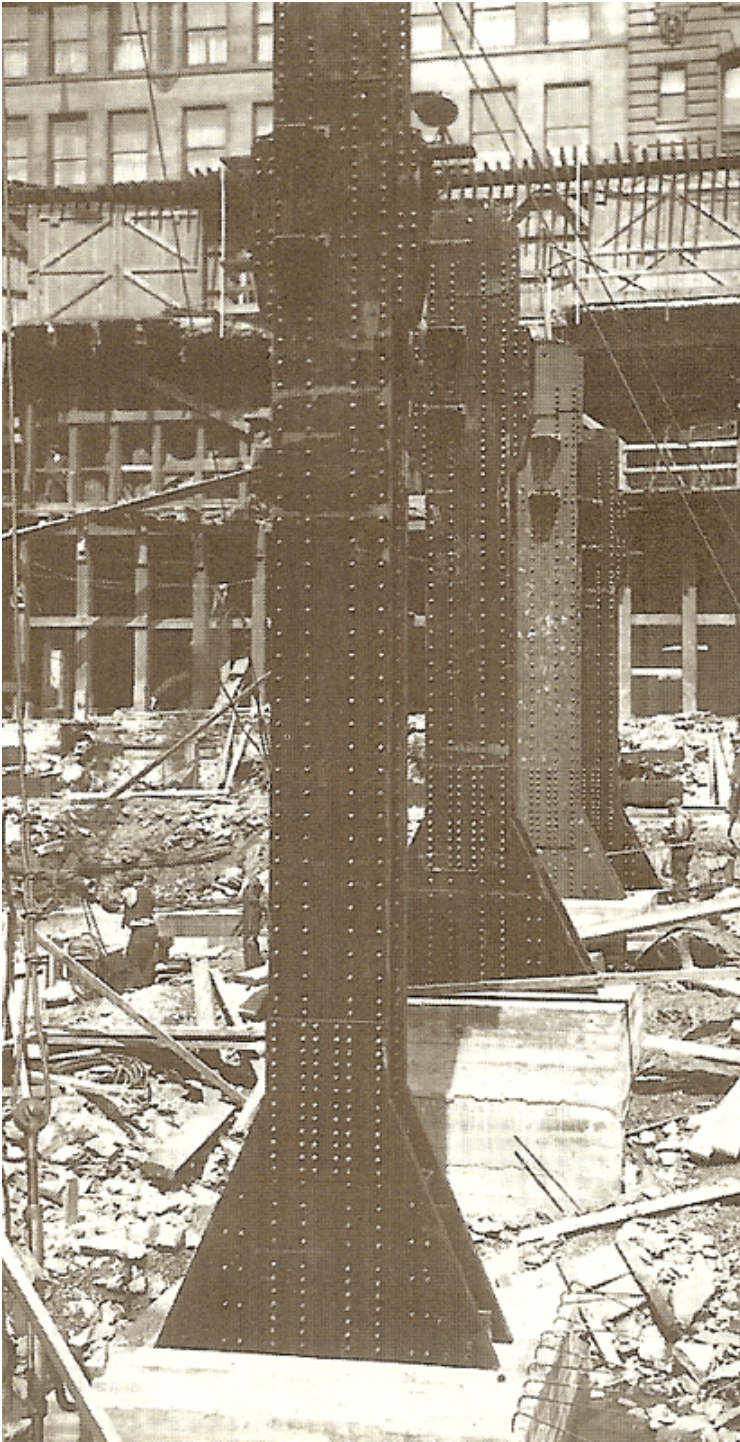
# Just in Time Delivery



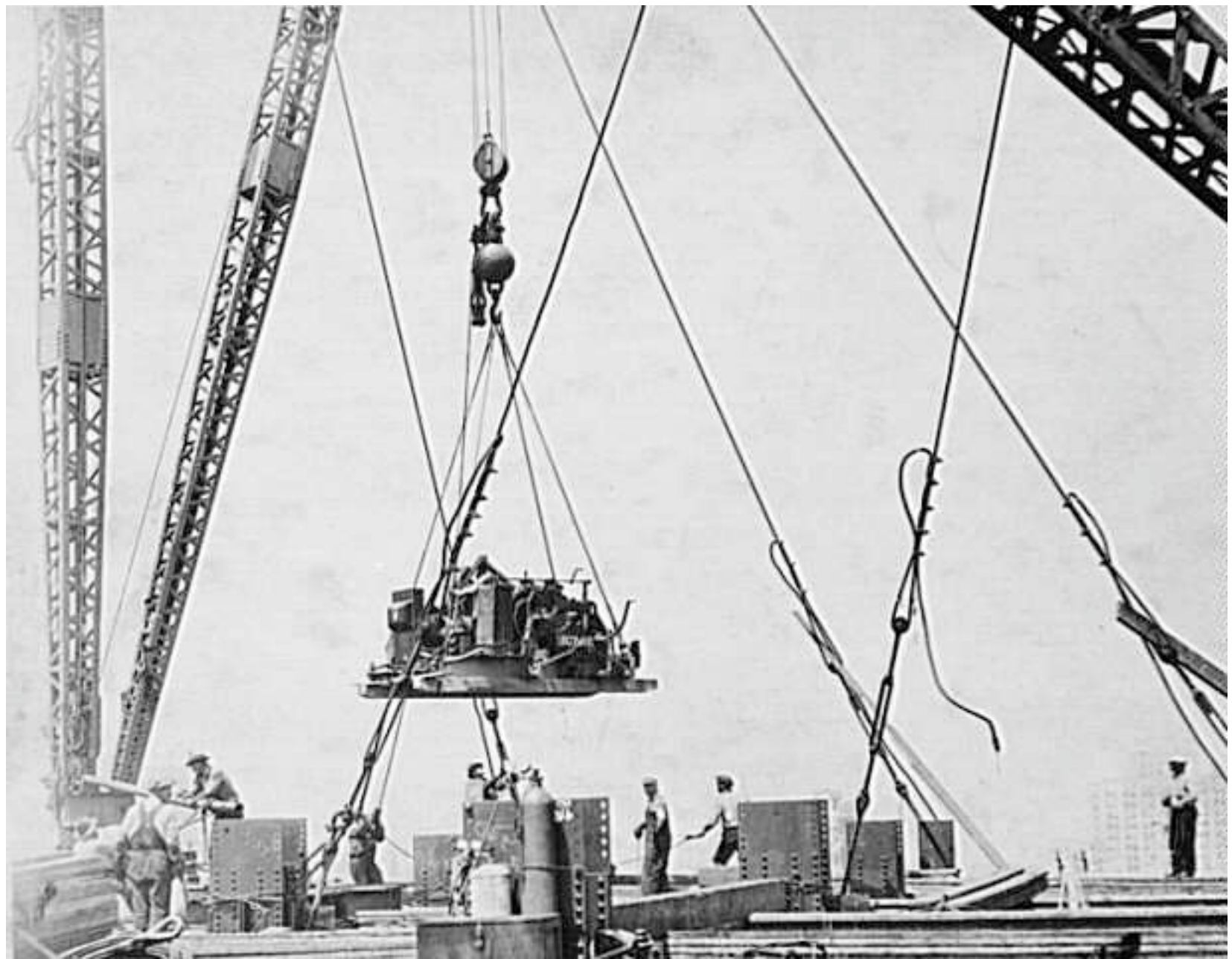


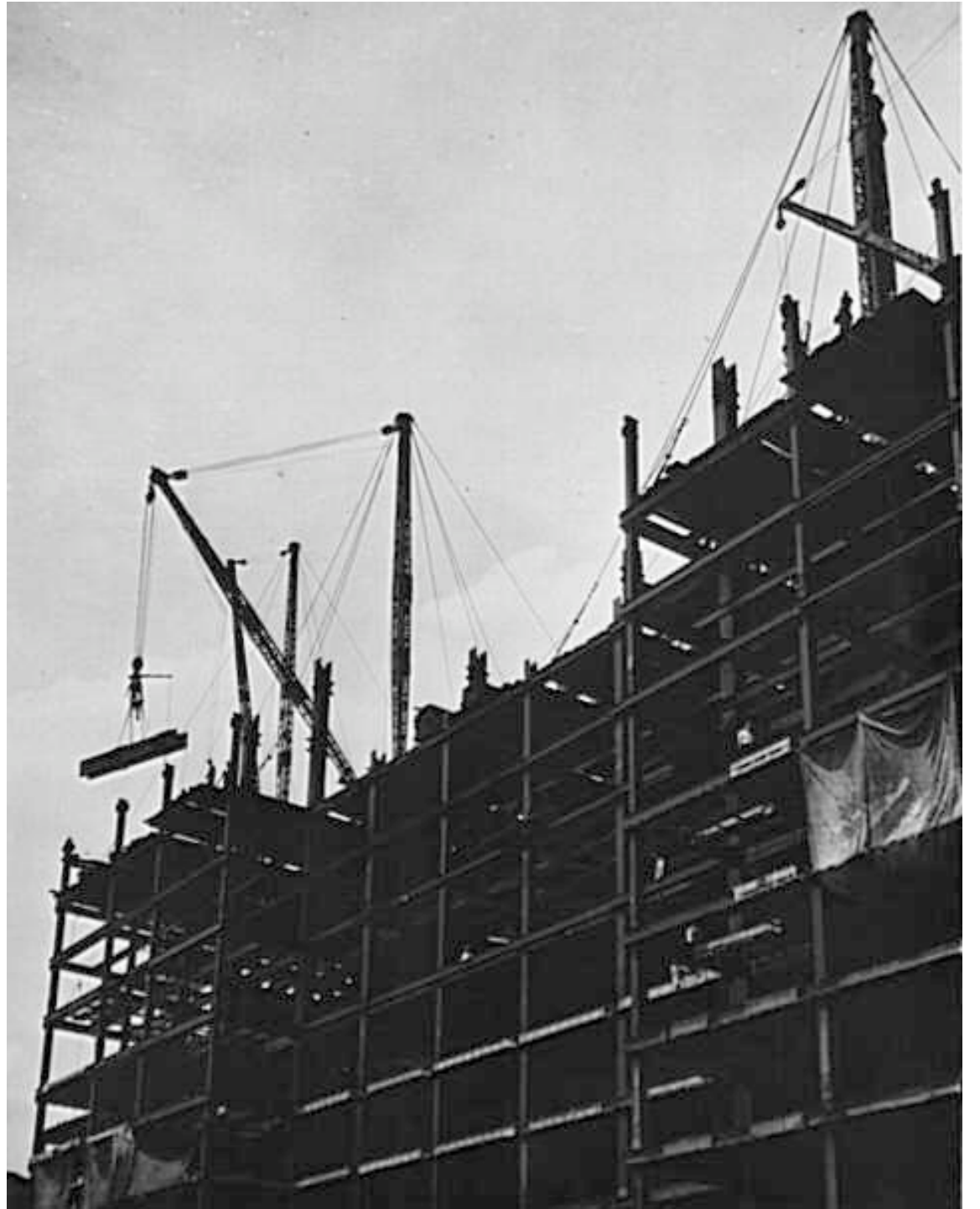


1/15/36 AP Wire photo





















*Steel construction*



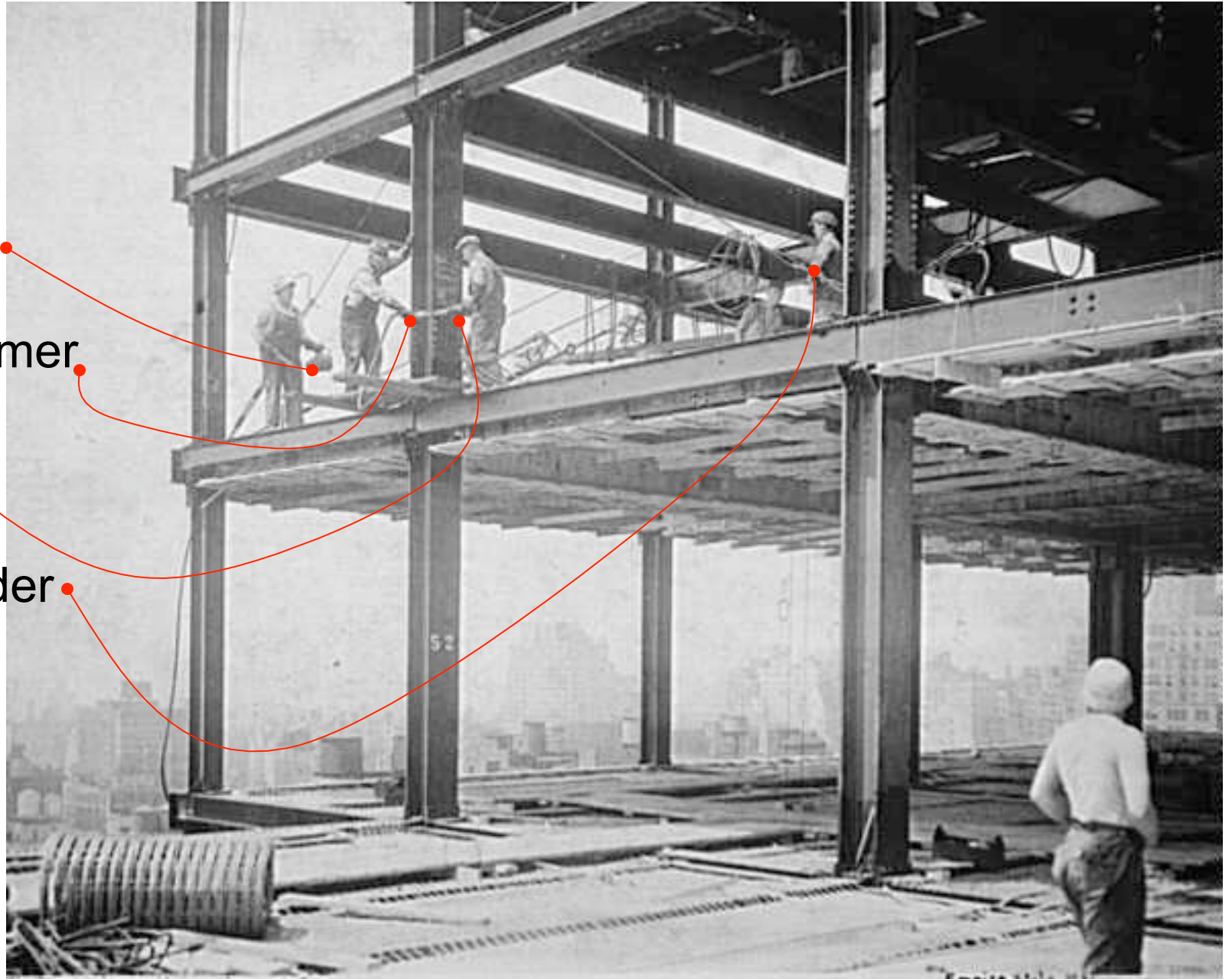
# 4 in rivet crew

Catch can

Rivet hammer

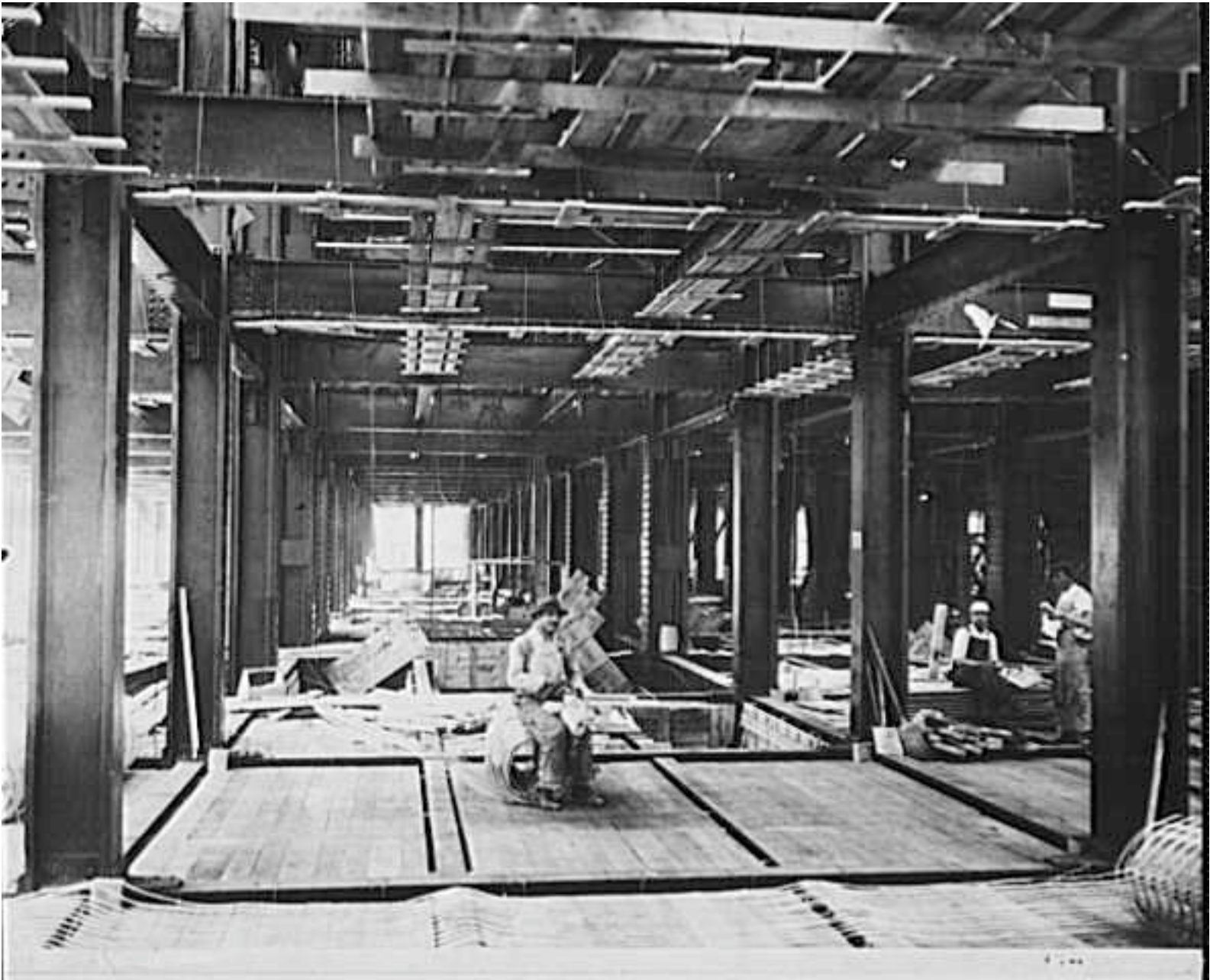
Backer

Forge tender

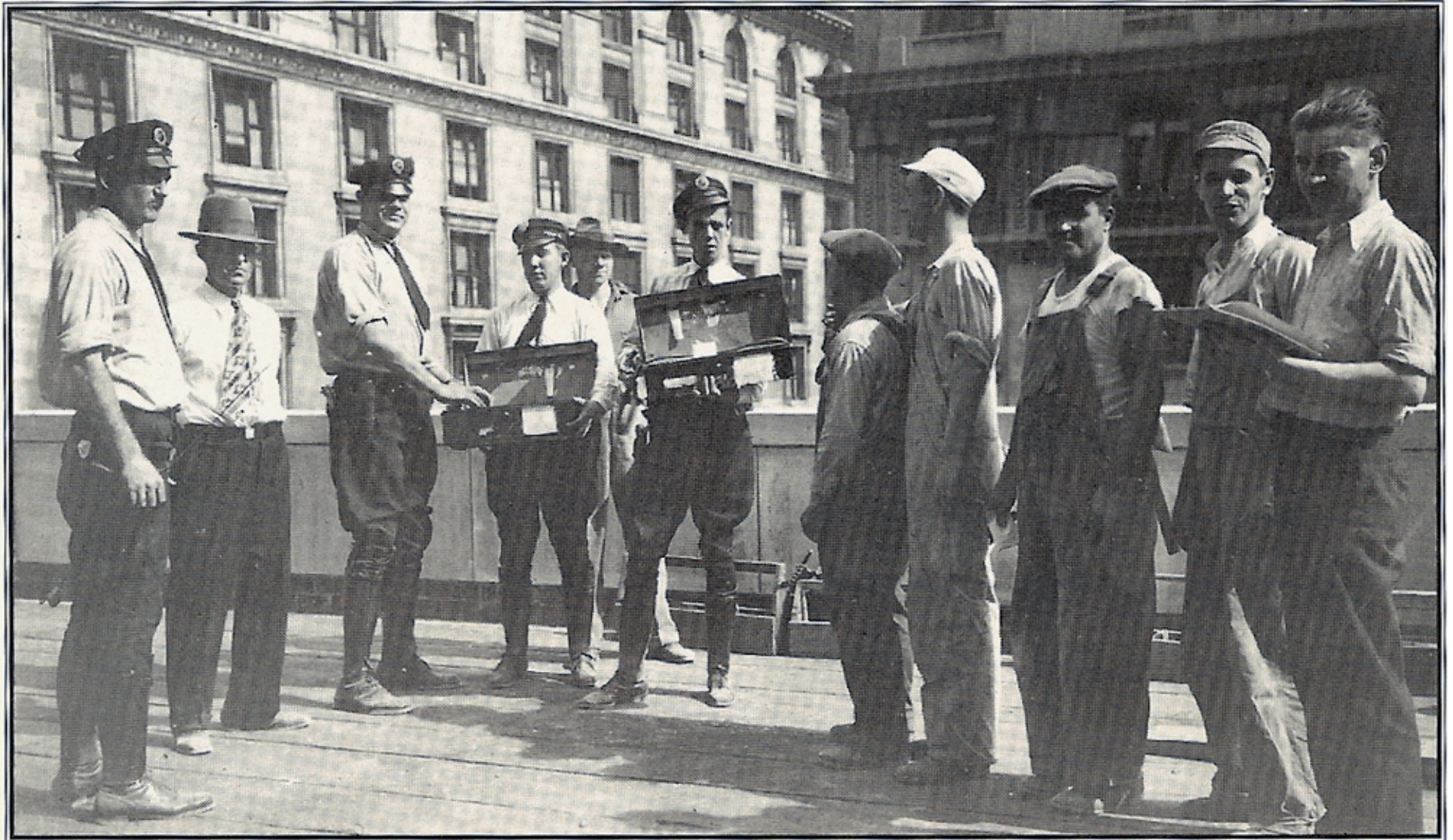




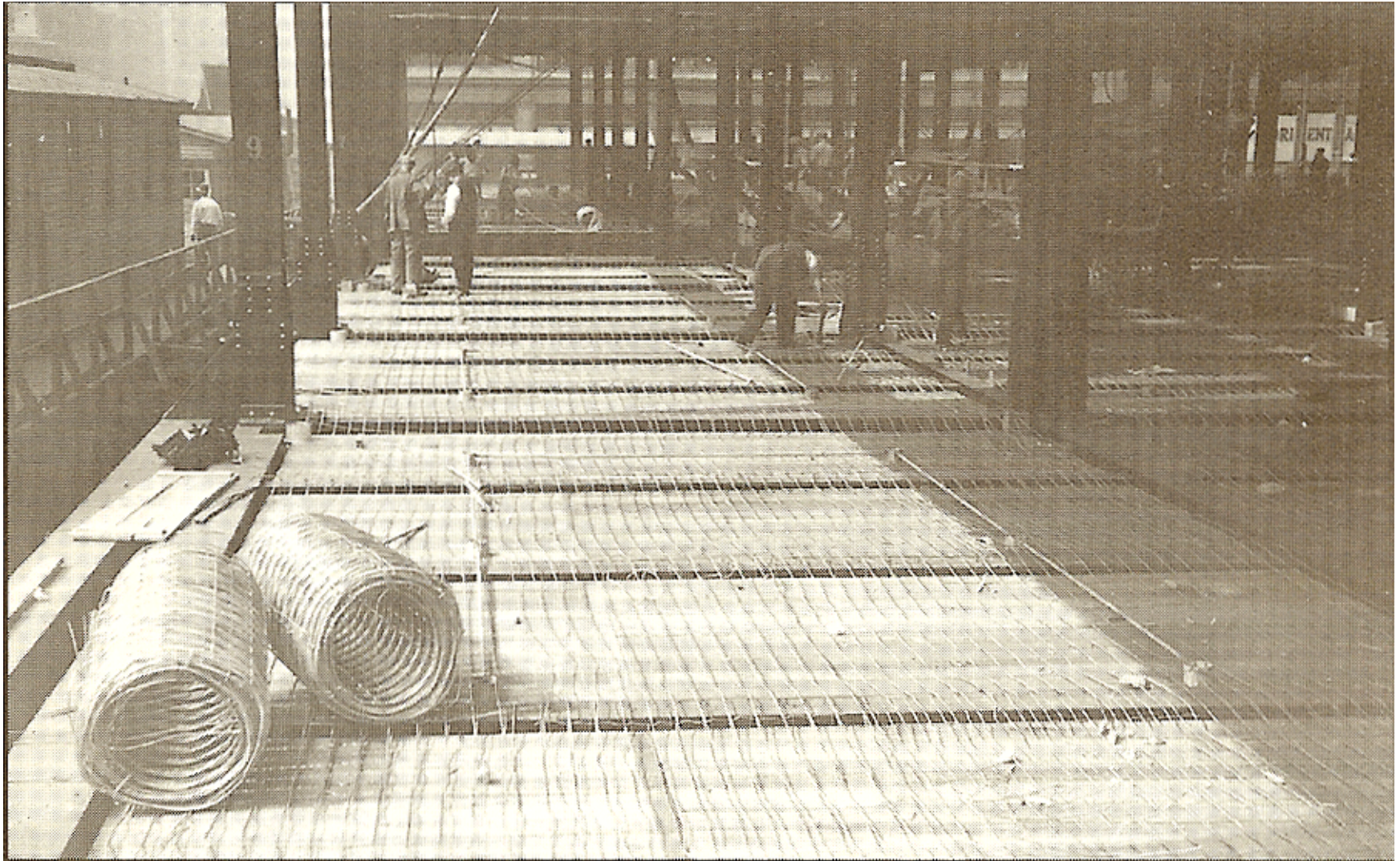


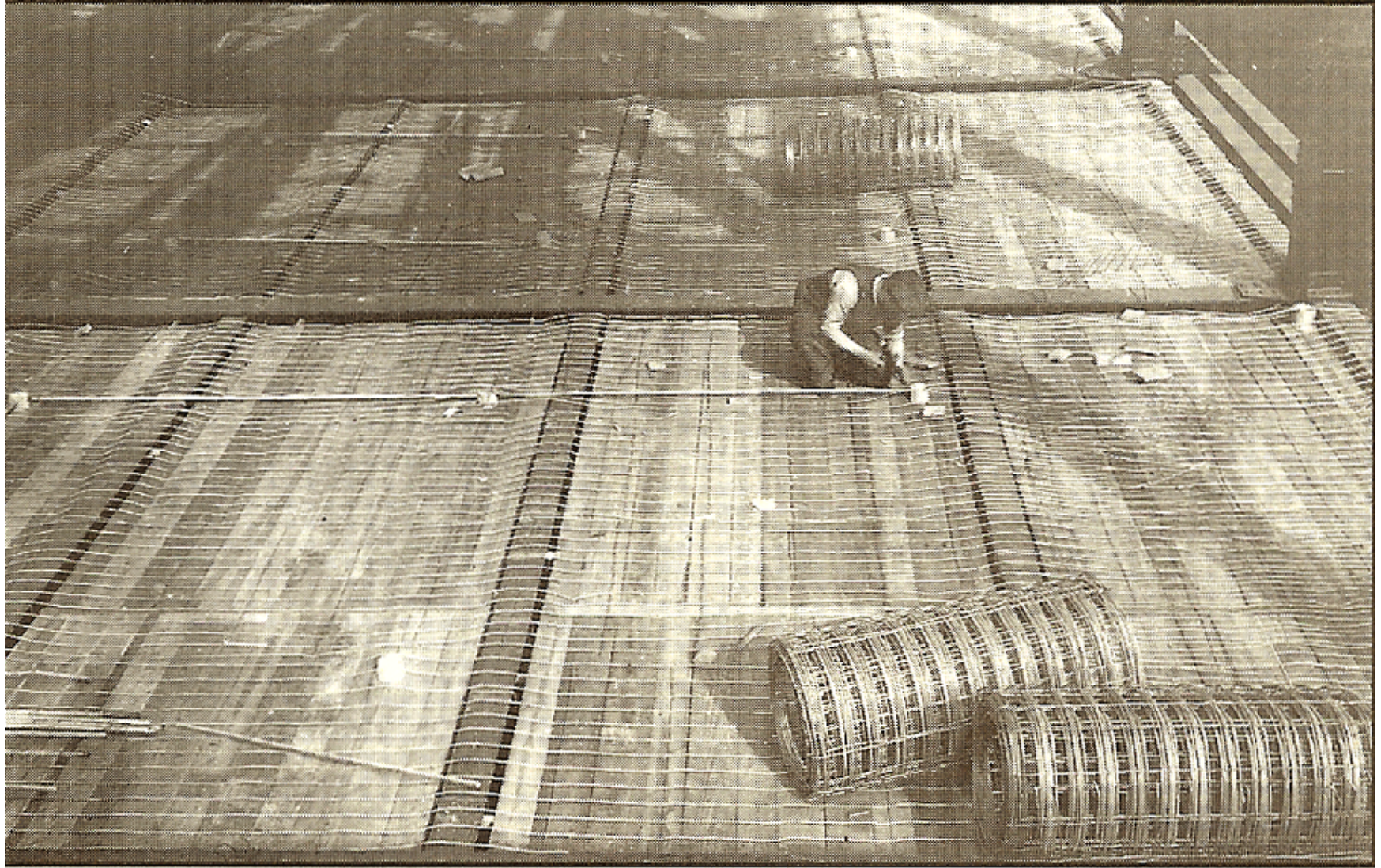


# Payday's Friday ...\$250,000.00 cash per week

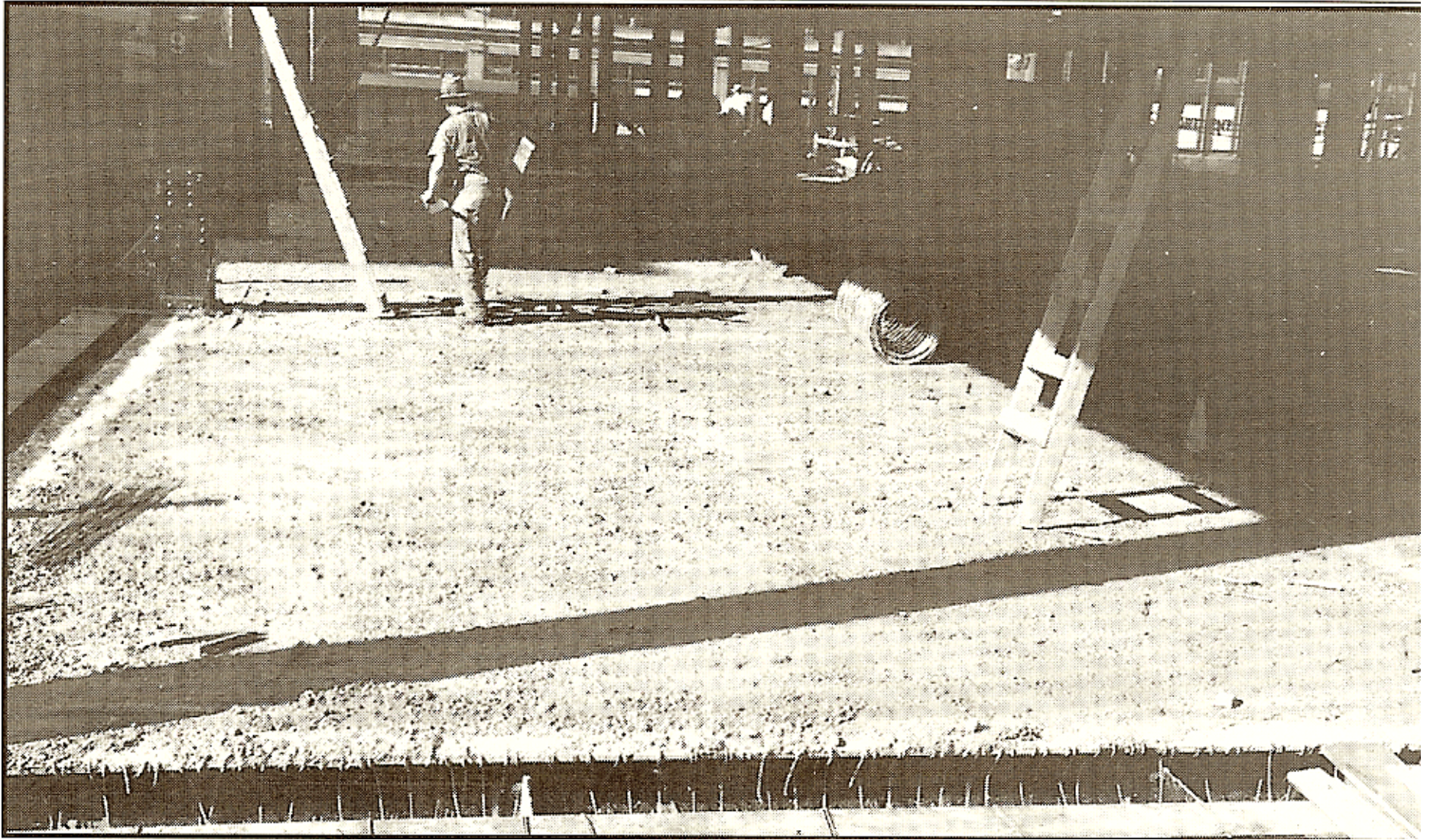












# Nets for safety

6 deaths overall, 1 steel, 2 carpenters, 3 laborers



Brick handled  
like concrete



# Material hoist

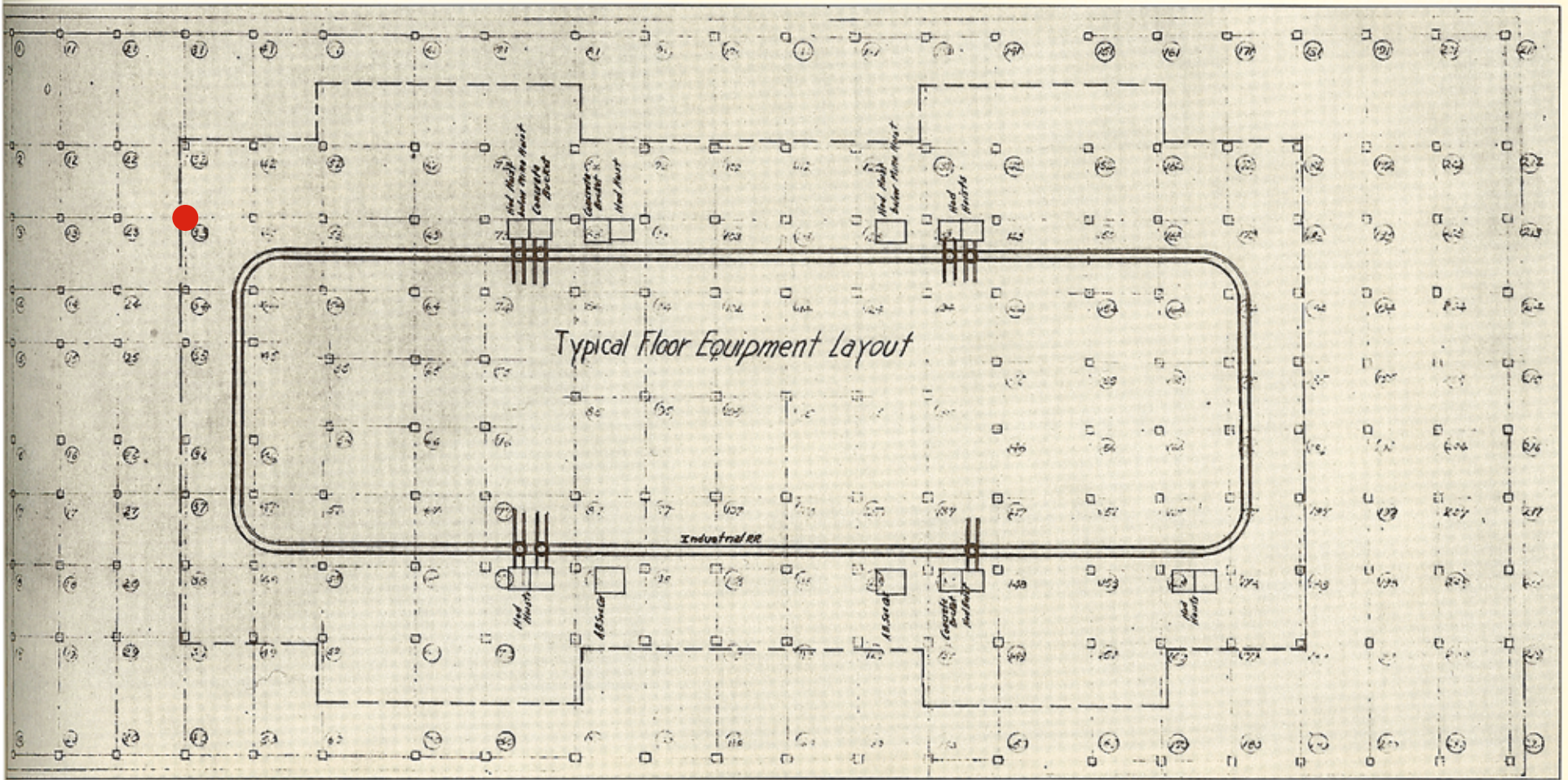


# Salvaged from Waldorf



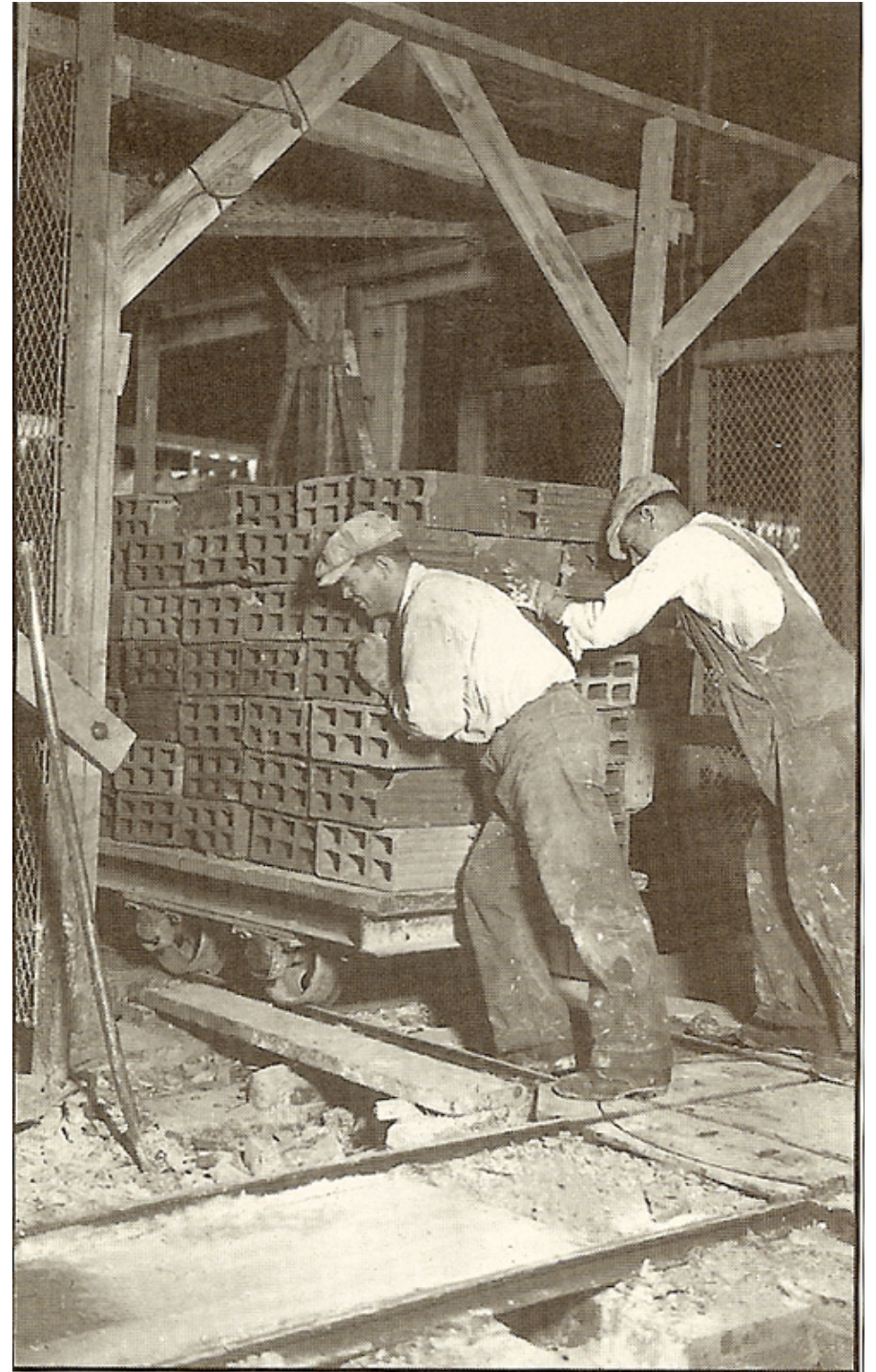
# Empire State Railroad

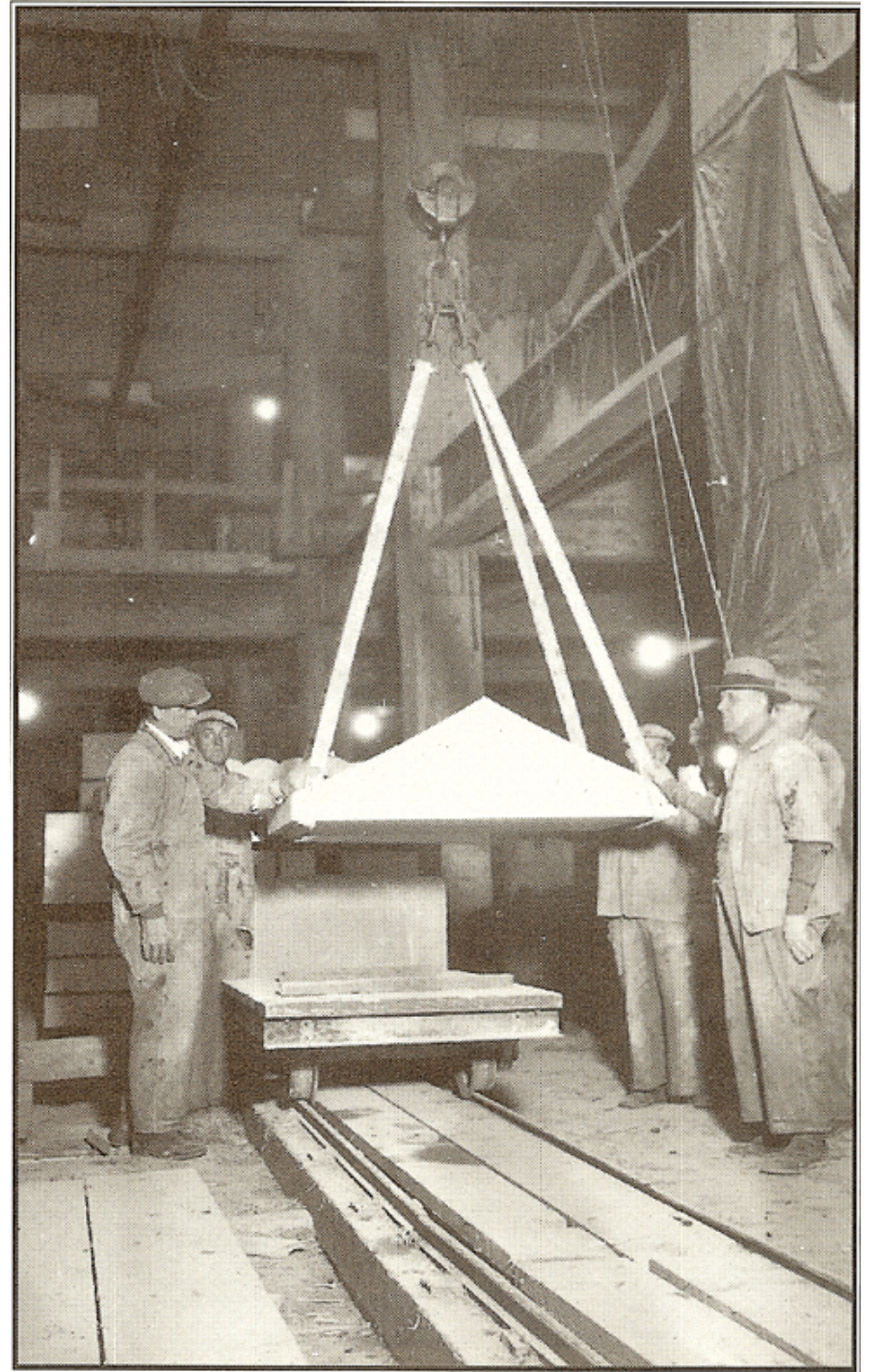
Industrial RR
Overhead Trolley System
1 Brick Hopper
2 Hod Hoist
3 AB See Elevator
4 Sand Hopper
5 Cement Slide
6 Cinder Hopper
7 Hod Hoist below Mine Hoist
8 Rubbish Chute
Overhead trolley OTIS Elev Co
2A Concrete Bucket



# Terra Cotta Partitions

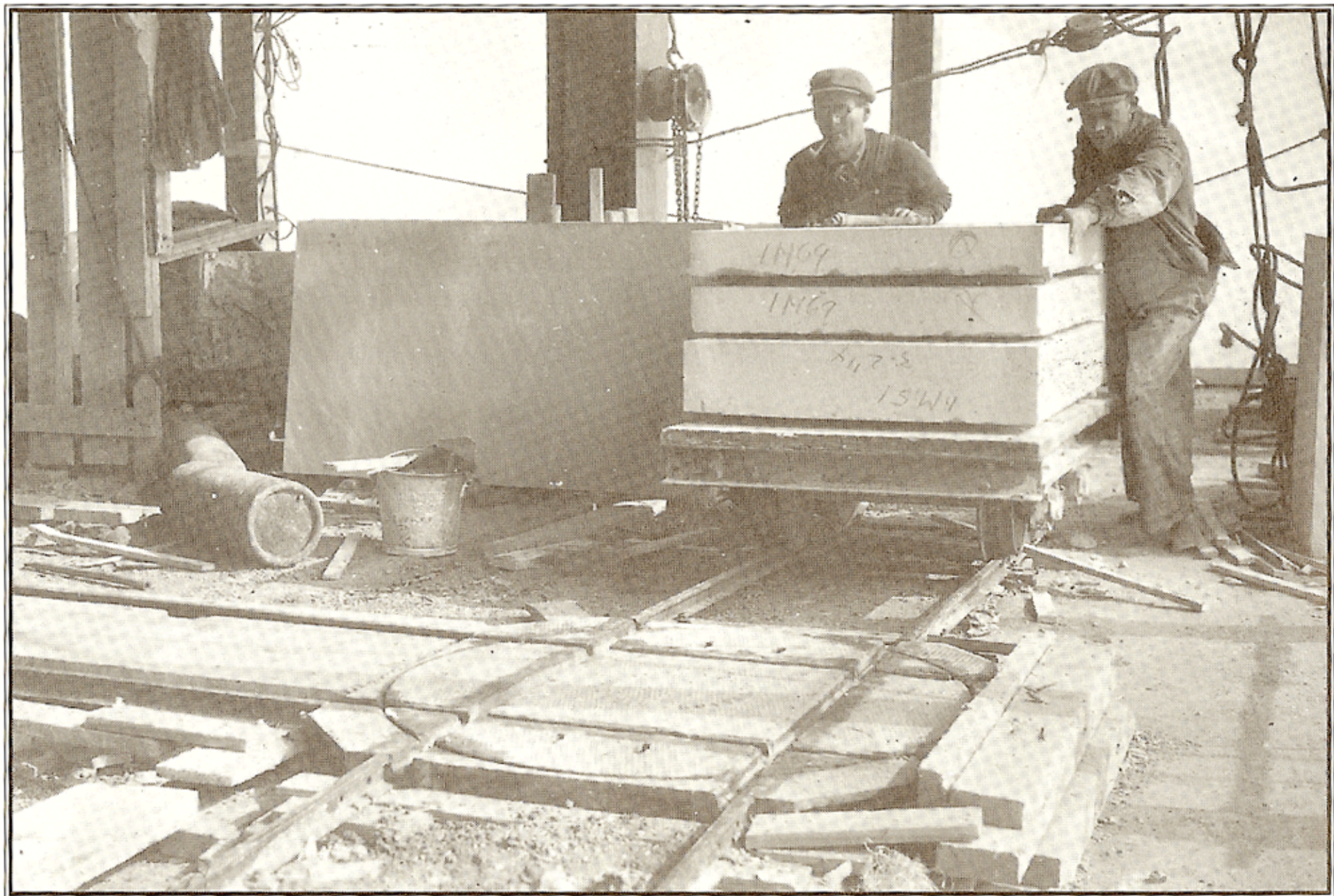
handle with care





# Pre-stage materials





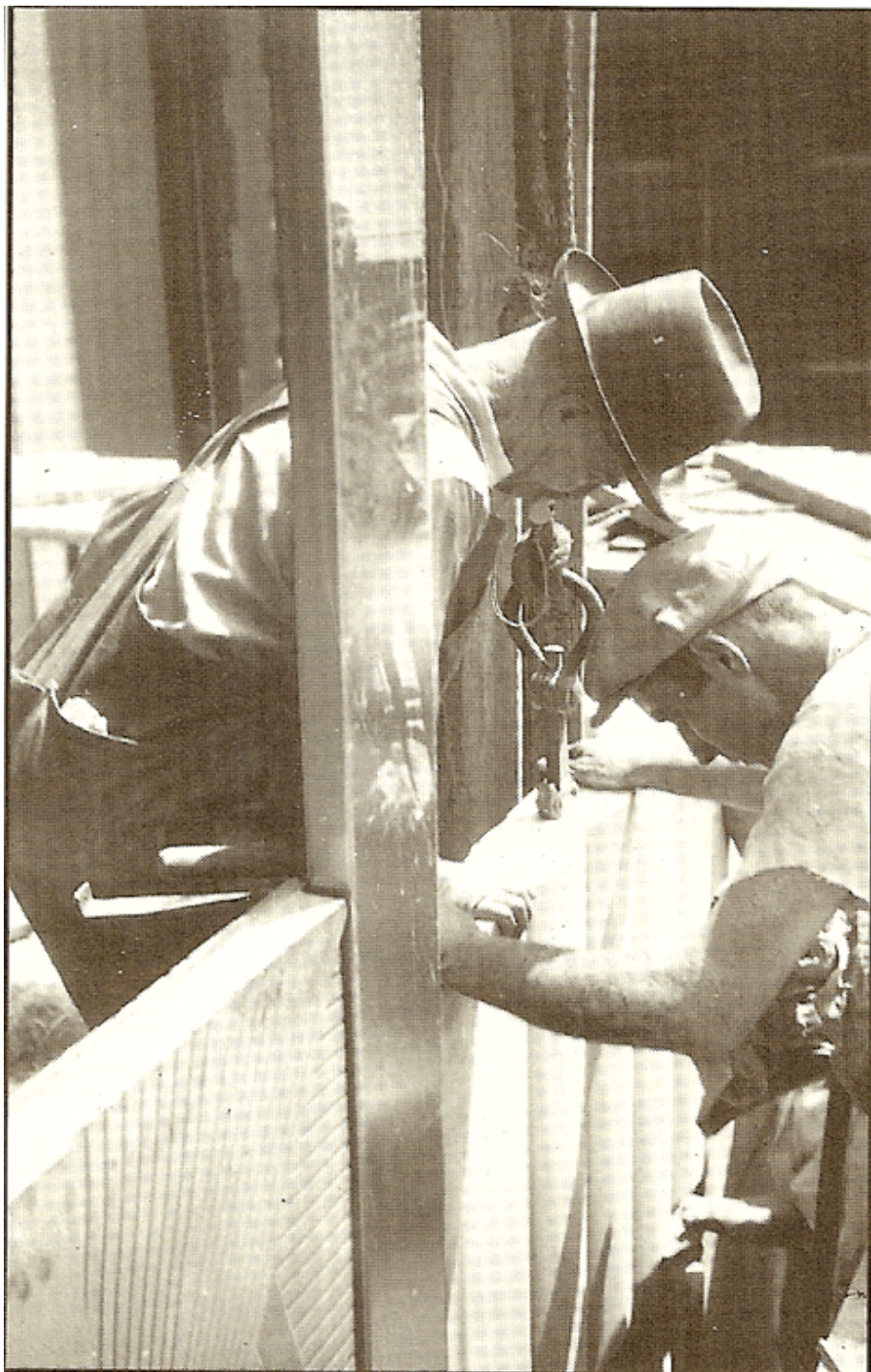
# Hand power for lowering stone

Where are we? Column #33



# Mullion Bracket









# Empire State Building

a.k.a “empty state building” in 1931

11 million visitors to observatory during 1st year. (earned as much as rent that year)

Hit by a bomber in 1945

(established longest fall survived in an elevator, 75 floors)

Didn't break even until 1951



