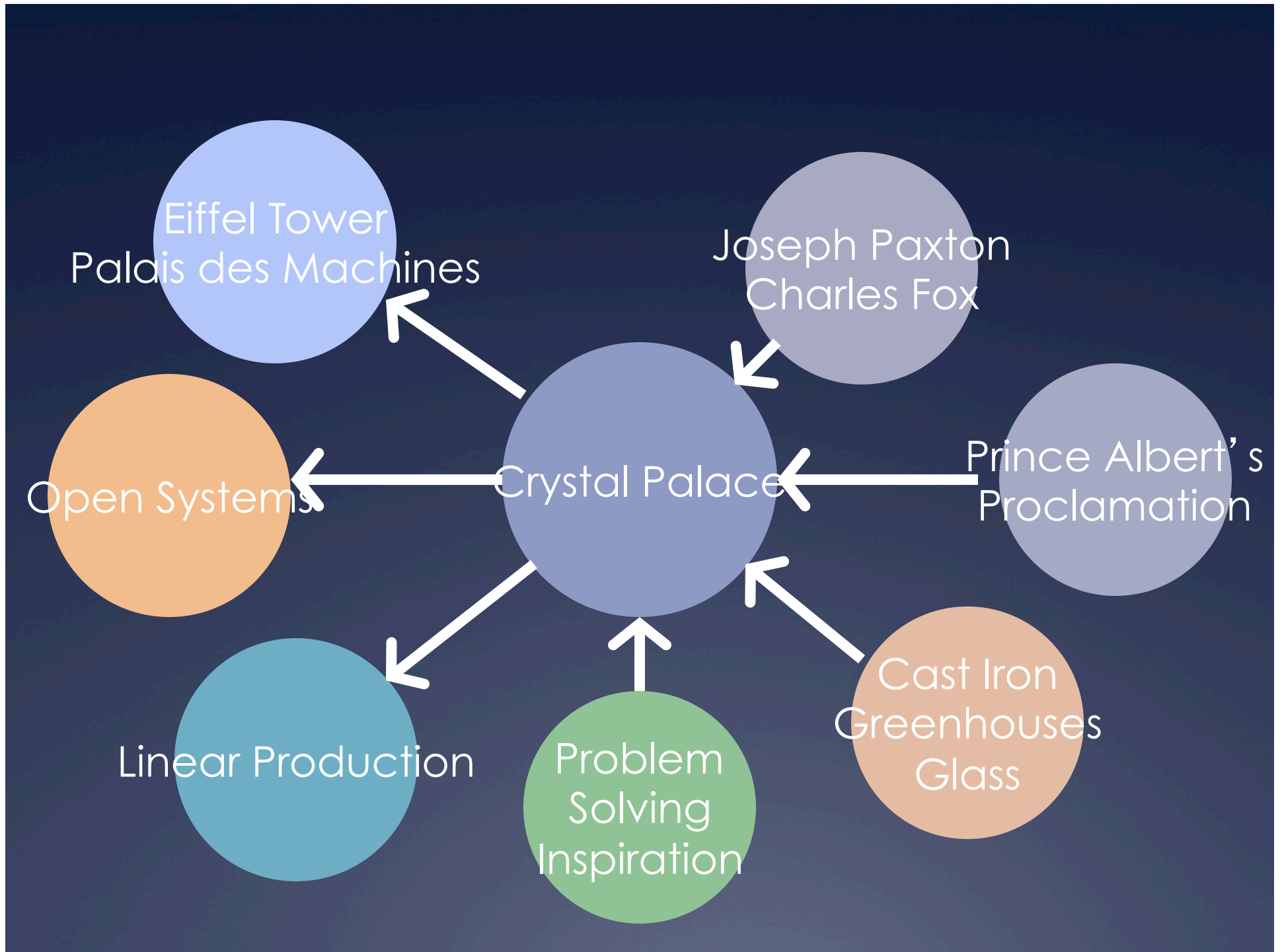
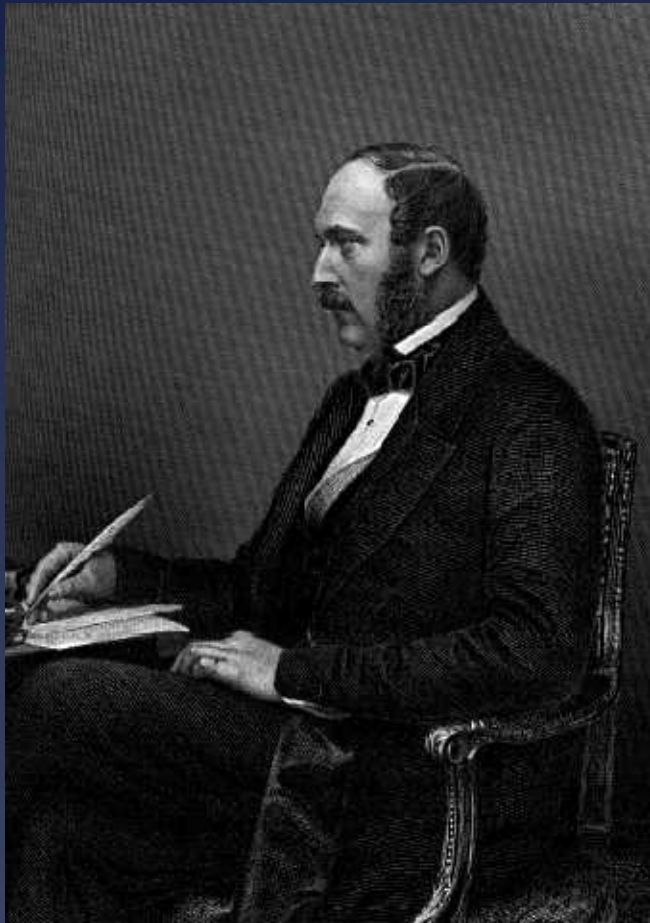


Crystal Palace

1850 feet in 1850,
Joseph Paxton



Prince Albert, a.k.a. Francis Augustus Charles Albert Emanuel



- * Social reformer
- * Interested in role science and technology might play in improving quality of life
- * Planned “Great Exhibition of Industry of All Nations”

Hyde Park site

- * 26 acres
- * 2,300 x 500 ft
- * Flat
- * Mature Elms have to remain unharmed
- * ... and the building has to be removed by 1853.

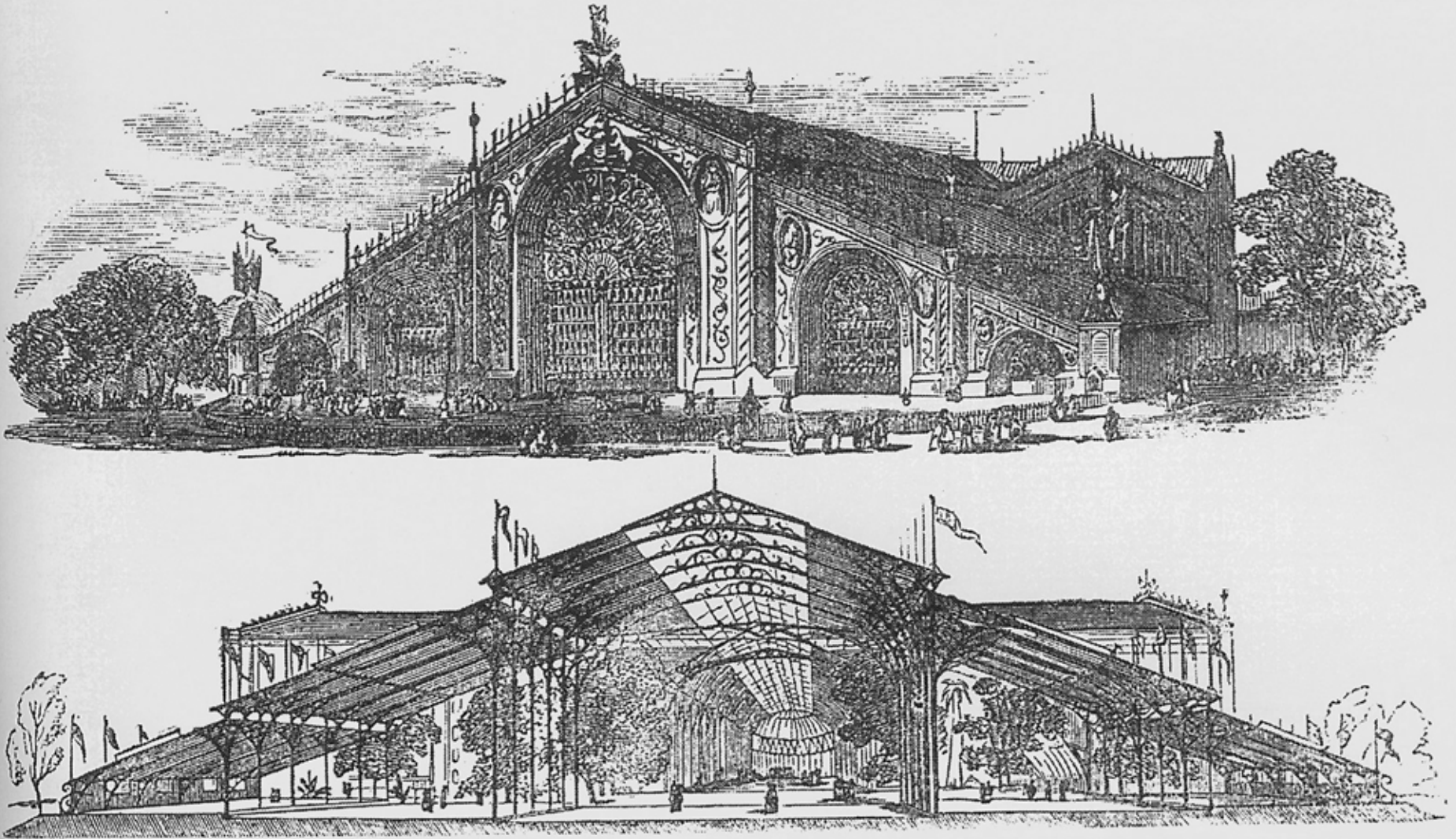


Good News! We're hosting a world exhibition!...it opens in about 14 months!

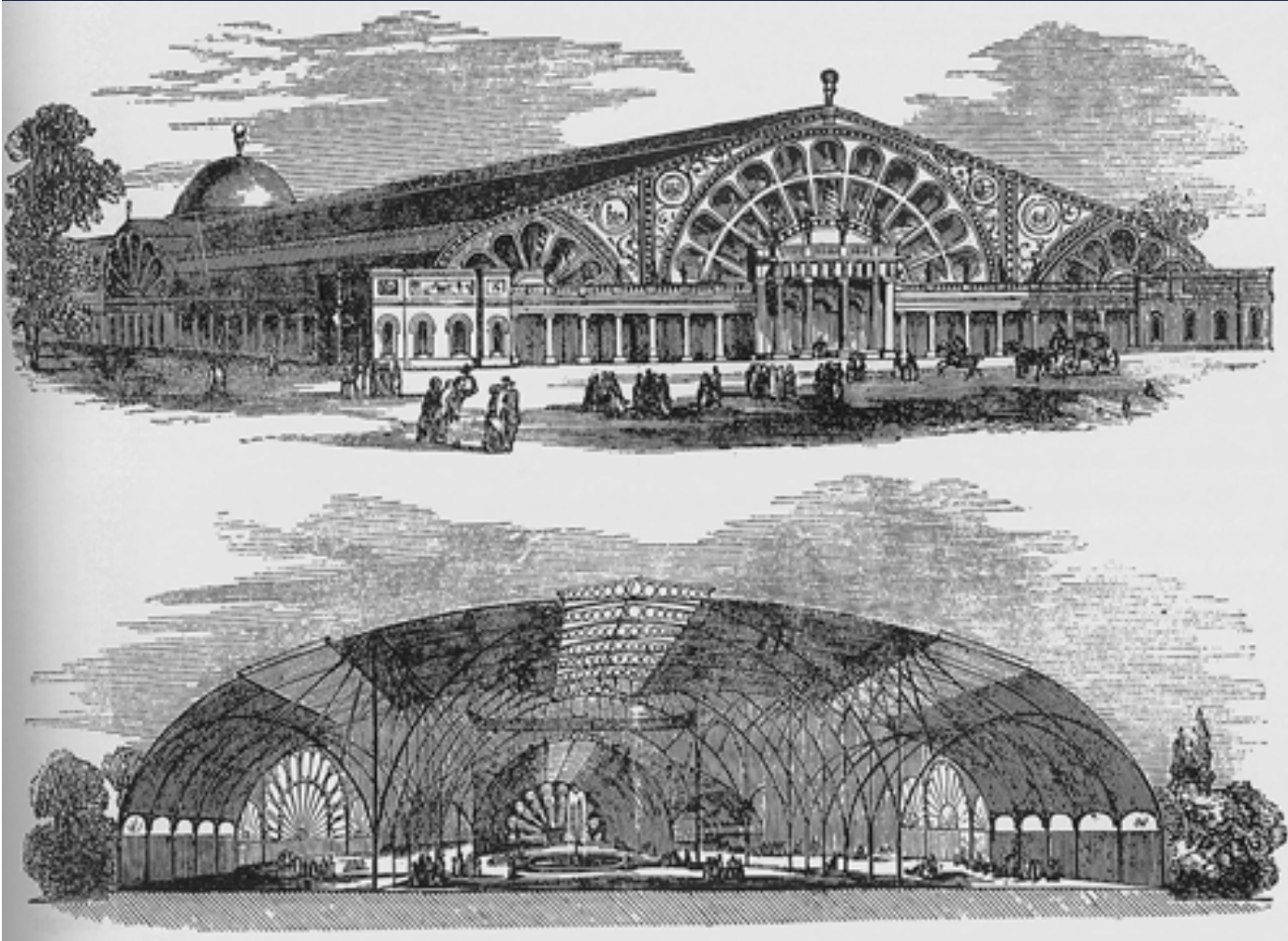
- * Hold a Design Competition
- * 245 designs entered
- * All were rejected by the design review team.

And the winner is...French?

Hector Horeau, Graduate of the Ecole de Beaux Arts...



We' ll use the second place entry ...wait
he' s not British either...



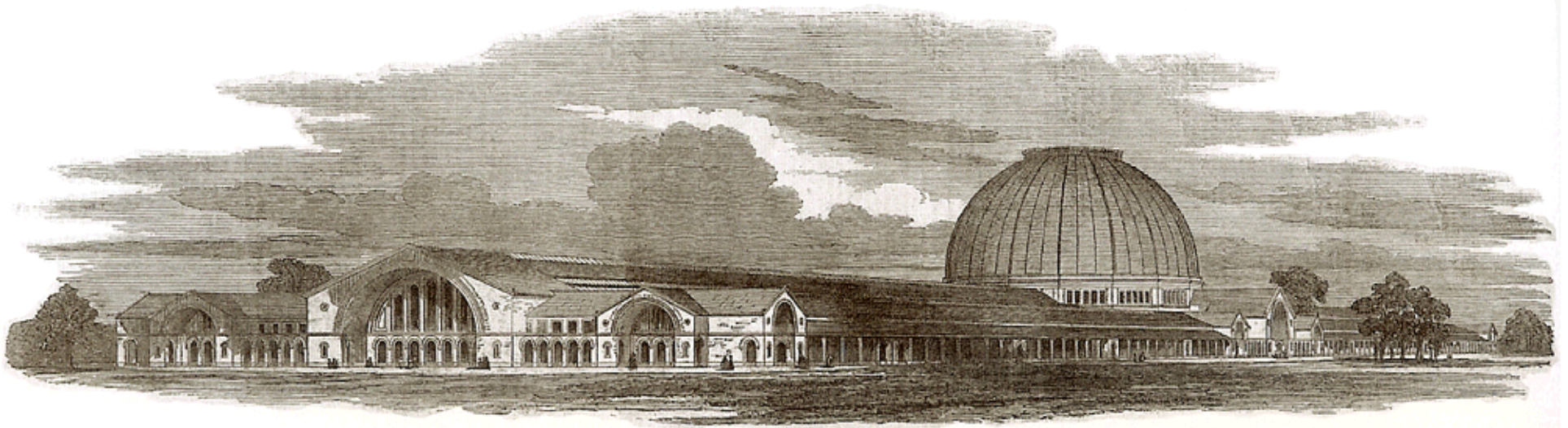
- Richard Turner
- Irish
 - Designer of Glasshouses

Some pretty nice Glasshouses

Palm House, Kew Gardens, Richard Turner and Decimus Burton 1840



Maybe **we** (the review committee) can do better



Committee design, 'The Building for the Great Industrial Exhibition', 1850.

Committee's design catches a lot of criticism in the press
"Train station meets St. Peter's Basilica..."

But only 17 million bricks are required.

04 27 Multiple-Wythe Unit Masonry

04 27 10 – Multiple-Wythe Unit Masonry

04 27 10.20 Cavity Walls

0010	CAVITY WALLS									
0200	4" face brick, 4" block	D-8	165	.242	S.F.	5.20	8.30		13.50	18.35
0400	6" block	↓	145	.276	↓	5.65	9.45		15.10	20.50
0600	8" block	↓	125	.320	↓	5.70	10.95		16.65	23

04 27 10.30 Brick Walls

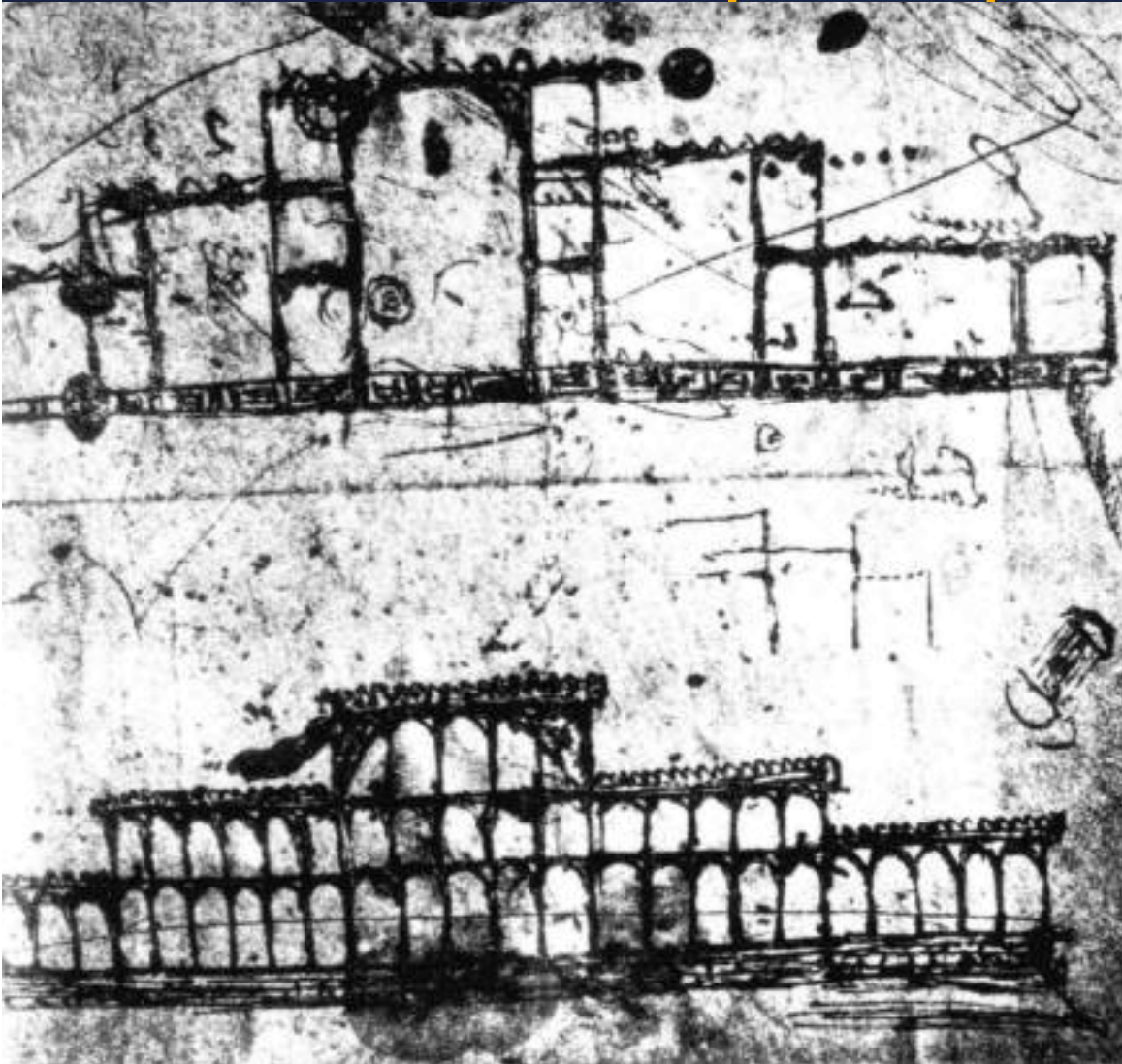
0010	BRICK WALLS		R042110-20							
0140	4" thick, facing, 4" x 2-2/3" x 8"	D-8	1.45	27.586	M	415	945		1,360	1,900
0150	4" thick, as back-up, 6.75 bricks per S.F.	↓	1.60	25	↓	415	855		1,270	1,750
0204	8" thick, 13.50 bricks per S.F.		1.80	22.222		435	760		1,195	1,625
0250	12" thick, 20.25 bricks per S.F.		1.90	21.053		435	720		1,155	1,575
0304	16" thick, 27.00 bricks per S.F.		2	20		440	685		1,125	1,525
0500	Reinforced, 4" wall, 4" x 2-2/3" x 8"		1.40	28.571		420	980		1,400	1,950
0550	8" thick, 13.50 bricks per S.F.		1.75	22.857		510	785		1,295	1,750
0600	12" thick, 20.25 bricks per S.F.		1.85	21.622		510	740		1,250	1,700
0650	16" thick, 27.00 bricks per S.F.		1.95	20.513		520	705		1,225	1,650
0660	4" thick, select common, face, 4" x 2-2/3" x 8"	↓	1.45	27.586	↓	495	945		1,440	2,000
0790	Alternate method of figuring by square foot									
0800	4" wall, face, 4" x 2-2/3" x 8"	D-8	215	.186	S.F.	3.79	6.40		10.19	13.85
							5.70		8.51	11.80
							10.15		16	22
1000	12" thick wall, 20.25 bricks per S.F.		95	.421		8.80	14.45		23.25	31.50
1050	16" thick wall, 27.00 bricks per S.F.		75	.533		11.95	18.30		30.25	41
1200	Reinforced, 4" x 2-2/3" x 8" , 4" wall		205	.195		2.81	6.70		9.51	13.30
1250	8" thick wall, 13.50 brick per S.F.		130	.308		5.85	10.55		16.40	22.50
1300	12" thick wall, 20.25 bricks per S.F.		90	.444		8.80	15.25		24.05	32.50
1350	16" thick wall, 27.00 bricks per S.F.	↓	70	.571	↓	11.95	19.60		31.55	43

How much time would this take to build today?

Even *if* the aesthetics were not a problem

- * 16" thick multi wythe wall
- * 75 s.f. per day
- * 27 bricks per s.f.
- * That's 2025 bricks per day
- * We have 17 million bricks to lay so...
- * 17 million / 2025 is
- * 8,395 days or ...
- *about 23 years.
- * We *could* double up the crews to speed things up...but it'll cost extra.

Now it's June 1850, 11 months to opening day.



* “It’s like my glasshouses only a bit bigger” we might imagine Paxton thinking as he sketched on the blotter paper while at a meeting.



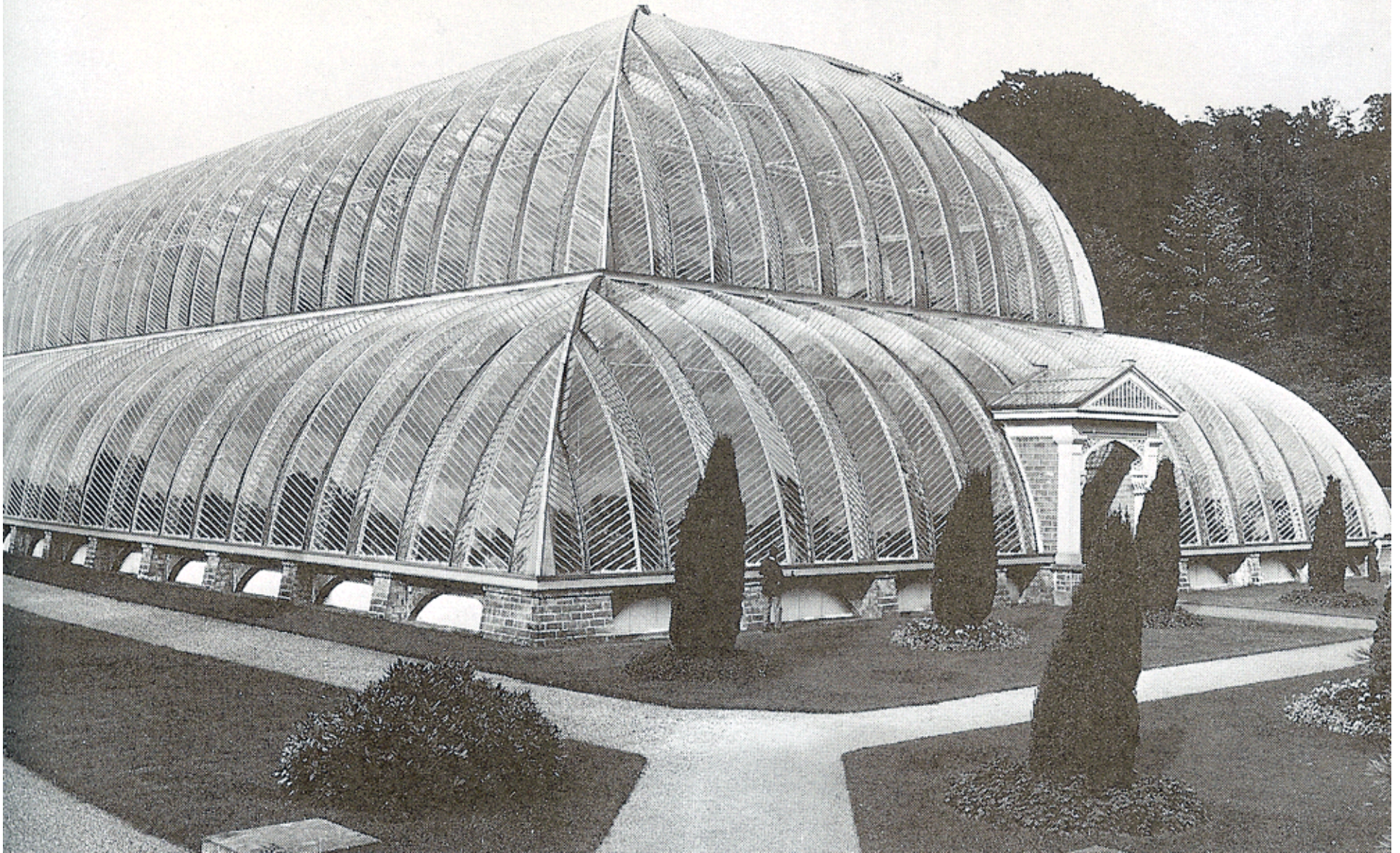
L.C. Wyon, *Joseph Paxton*, 1854.

Paxton, the Gardner

- * Not an Engineer
- * Not an Architect
- * A Gardner, famous for raising (and getting it to flower) an amazonian lily, *Victoria regia*



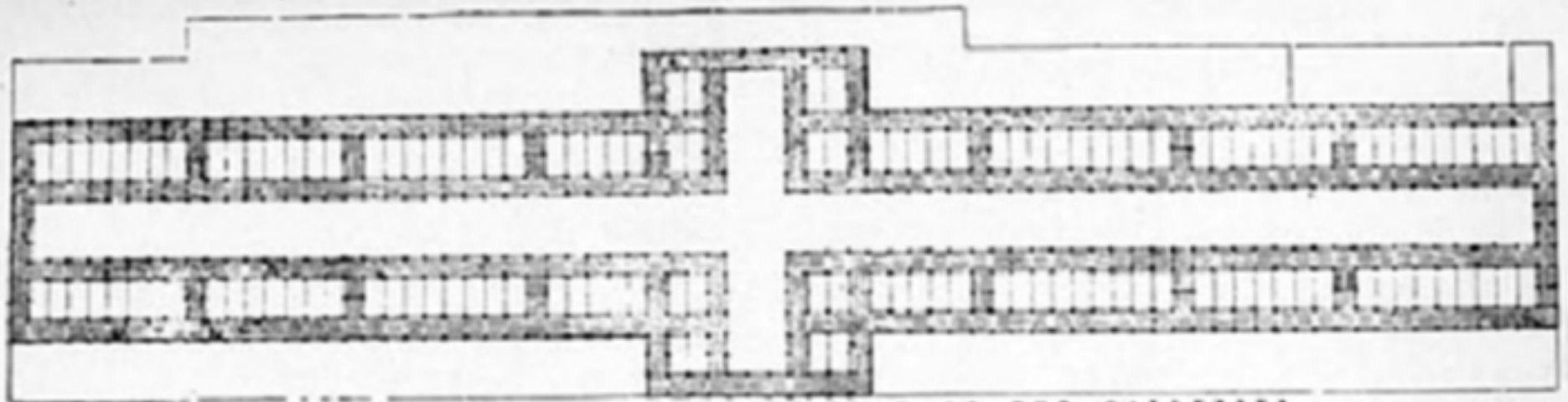
Paxton's first glass house Chatsworth Conservatory



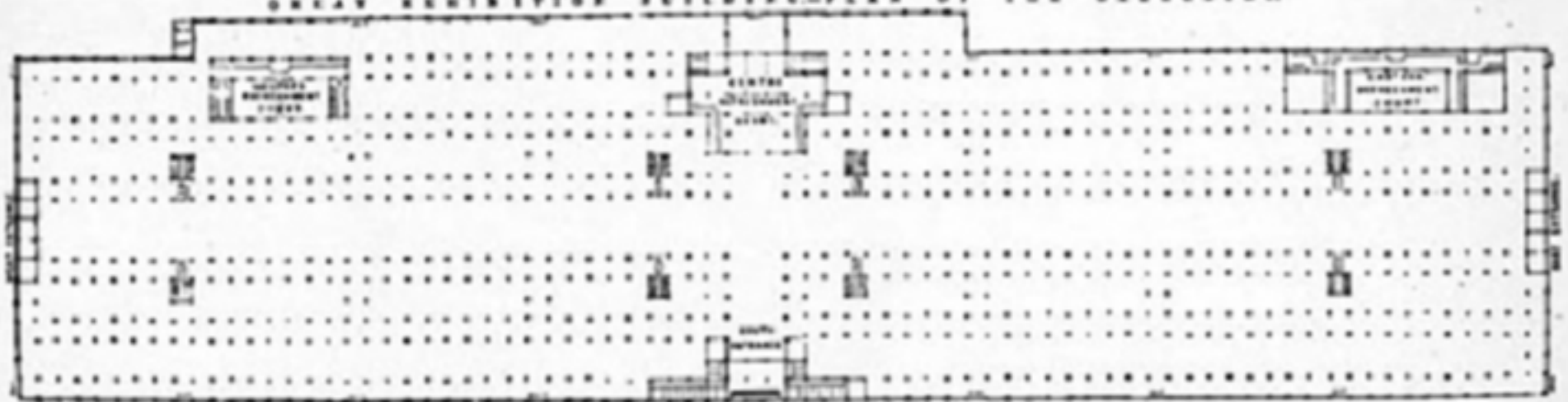
275 ft long x 121 ft wide 33,275 s.f. largest conservatory in the world in 1837. Heated by 7 miles of hot water pipe

The Great Exhibition Building...27

times bigger than Chatsworth



GRAND EXHIBITION BUILDING—PLAN OF THE GALLERIES.

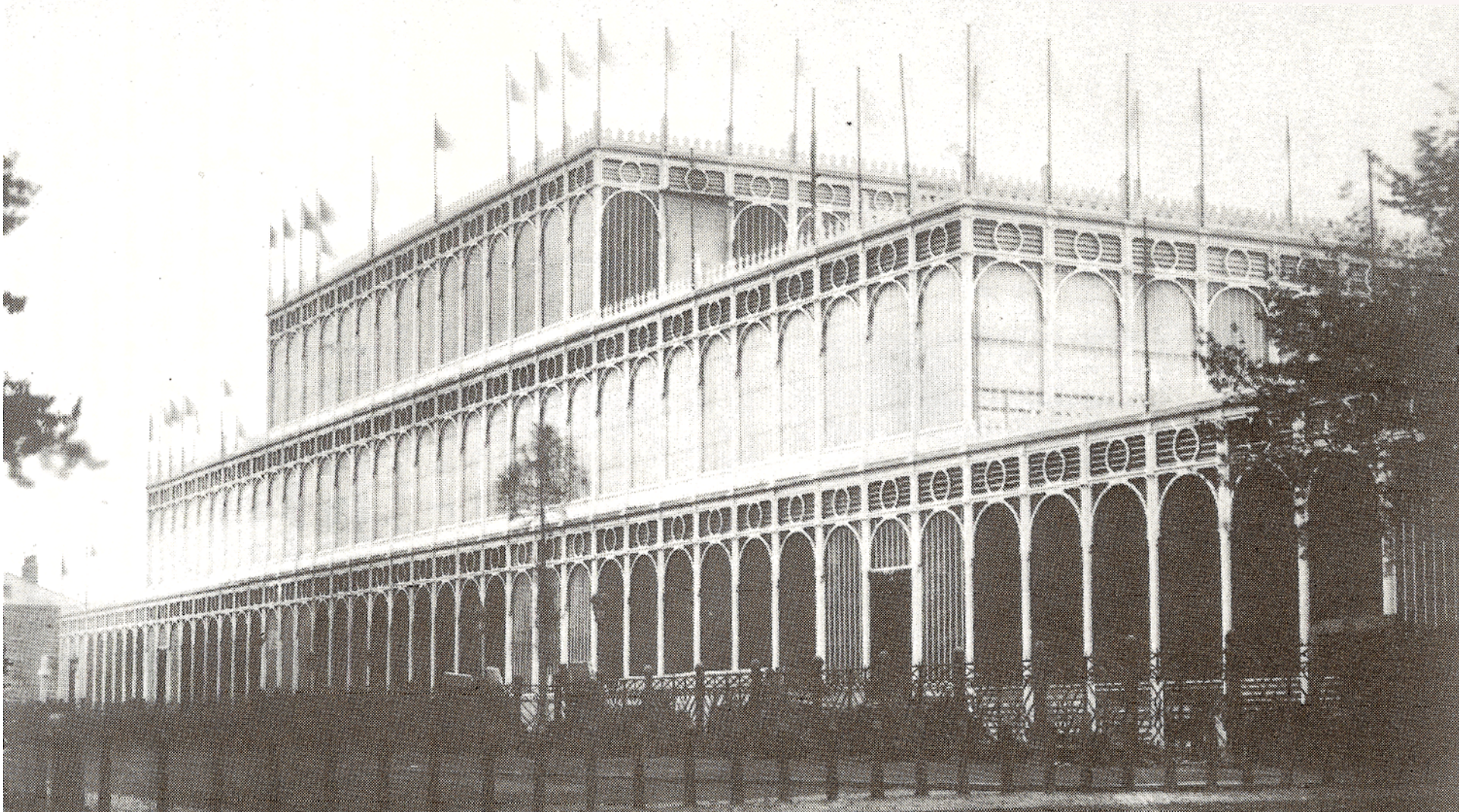


GROUND-PLAN OF THE GREAT EXHIBITION BUILDING.

Joint Venture with Fox and Henderson

- * Paxton prepared construction documents for the million square foot iron, wood and glass building in seven days.
- * Fox, and the board began the calculations and entered into a contract to build the building on July 26, 1850...279 days until opening day.

Opened by the Queen, May 1
1851, Shell complete in 22 weeks, fitout, painting took 16 more



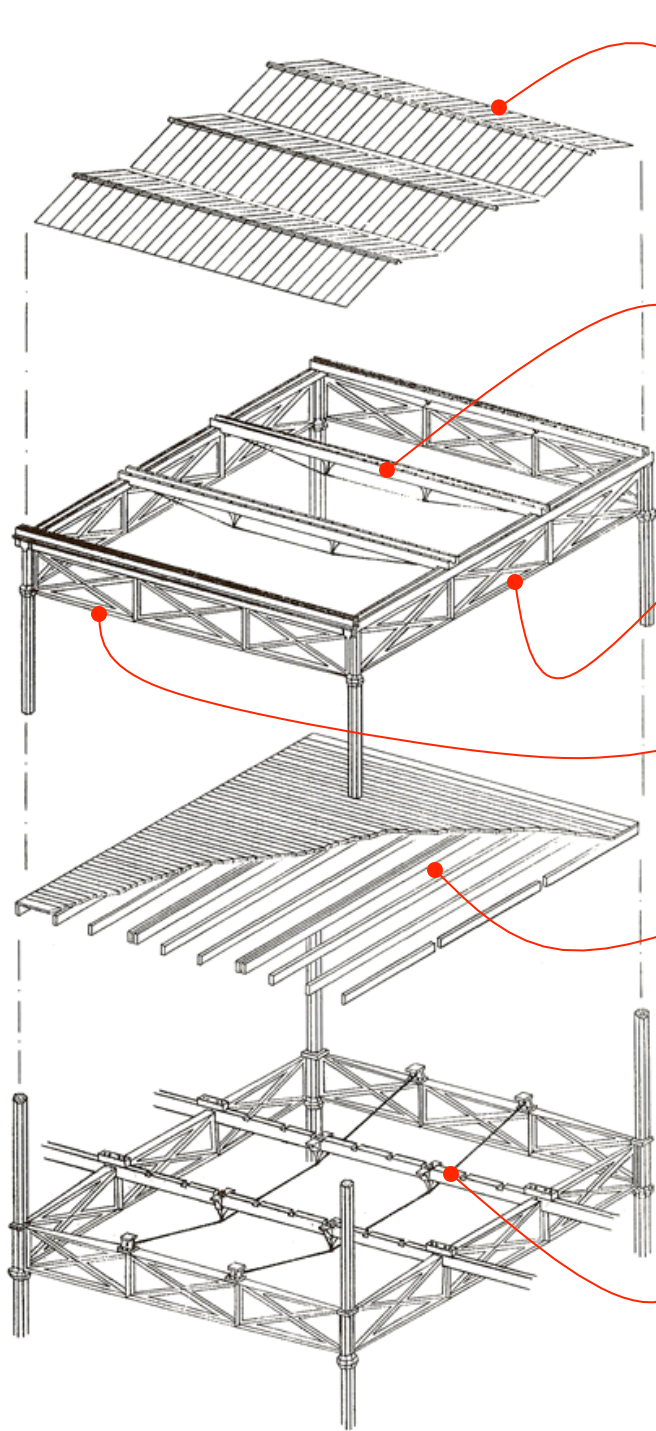
Final Design Stats

- * 989,884 s.f. total
- * 772,784 s.f. ground floor
- * 108,500 s.f. 2nd fl. Gallery
- * 108,500 s.f. 3rd fl. gallery
- * 900,000 s.f. of glass
- * 1,500 window frames
- * 61 feet high at side galleries
- * 104 feet high at center of vaulted transept.

What does it take to build a million square feet in 9 months?... *a system*

- * Before Paxton's design
 - * Buildings were built "outside - in" out of closed systems derived from the outline of the building





• "Ridge and Valley" glazing

• "Paxton" wood gutters

• Load bearing trusses

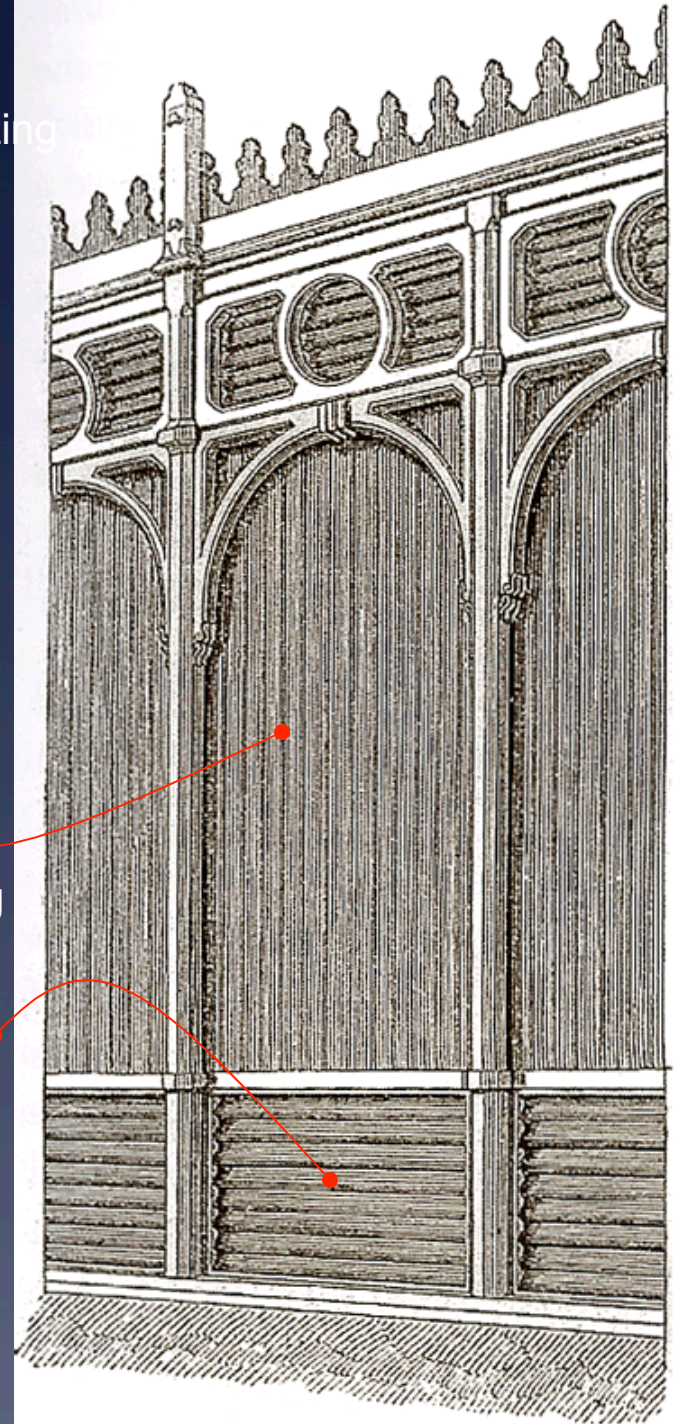
• Lateral bracing trusses

• Ext. wood siding

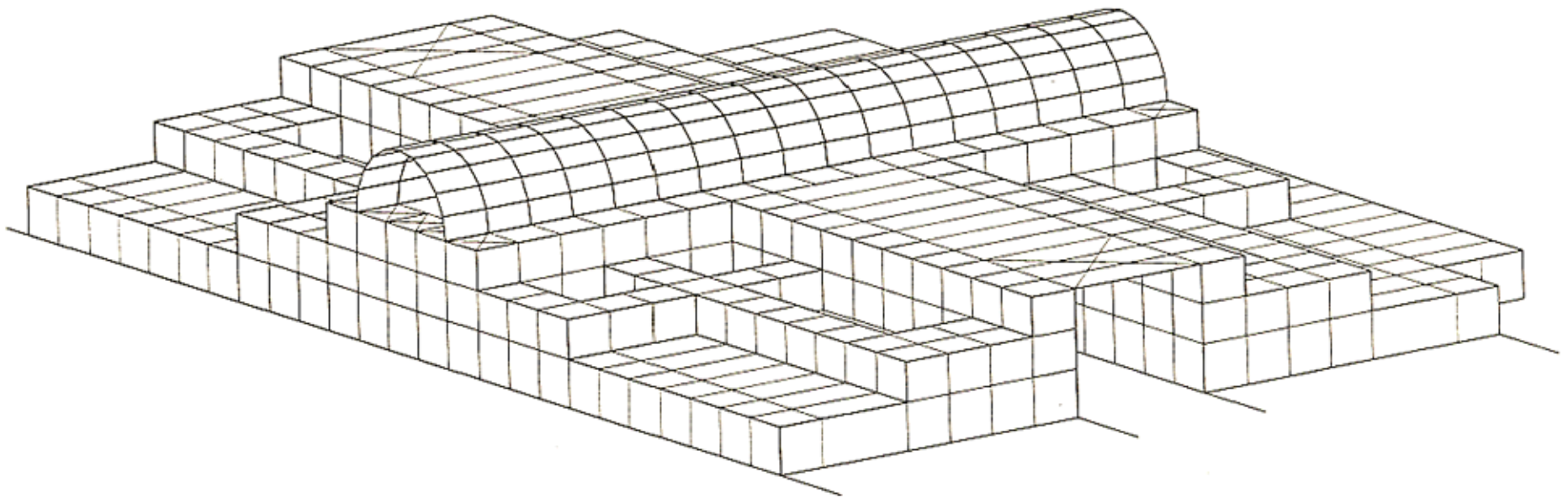
• 2x8 gallery floor framing

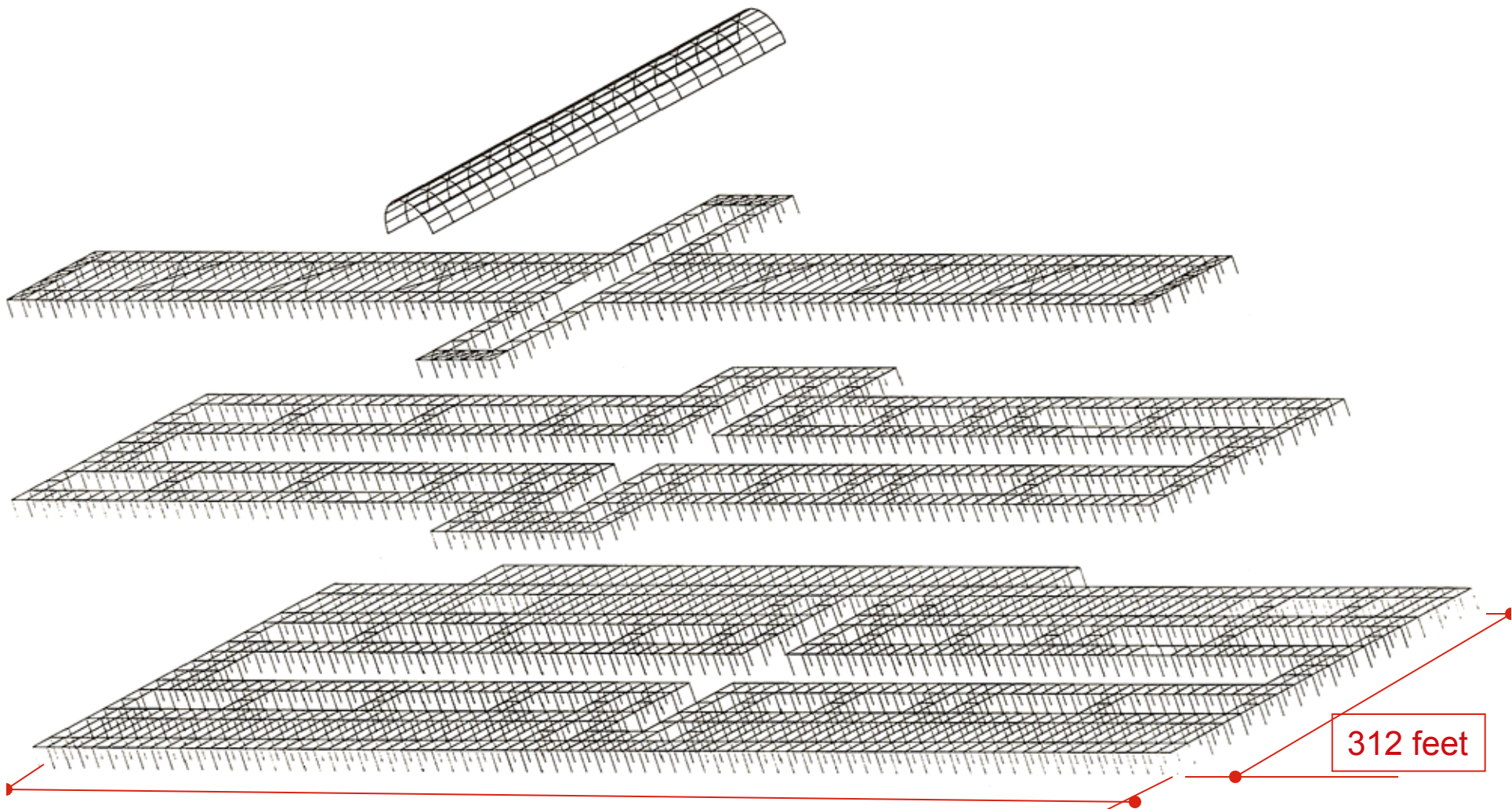
• Ext. wood vent louvers

• gallery floor structure



A collection of kernals...sugar cubes?





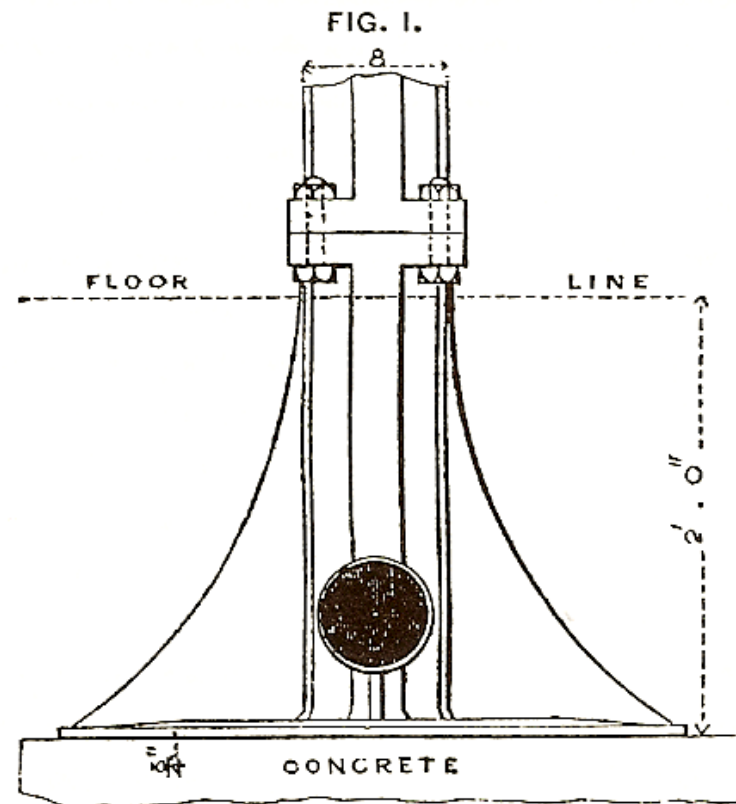
1,608 feet

312 feet

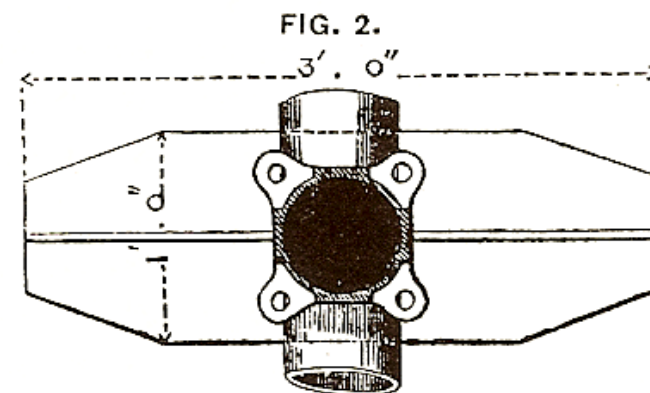
1,074 thus

- Column bases anchored to concrete pad footings
- Columns functioned as downspouts
- Base plates were light enough for two people to position

THE FOUNDATION AND BASE-PLATES (Figs. 1 & 2).

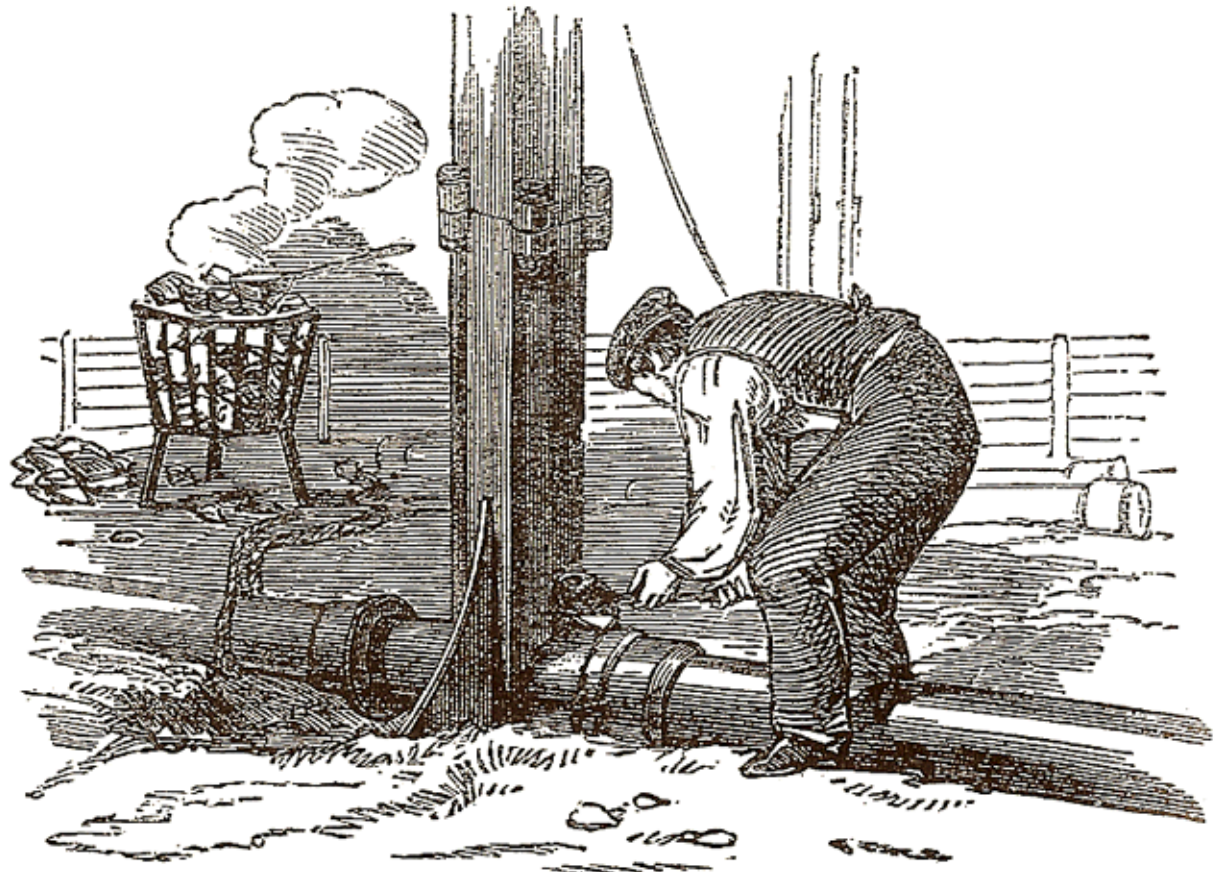
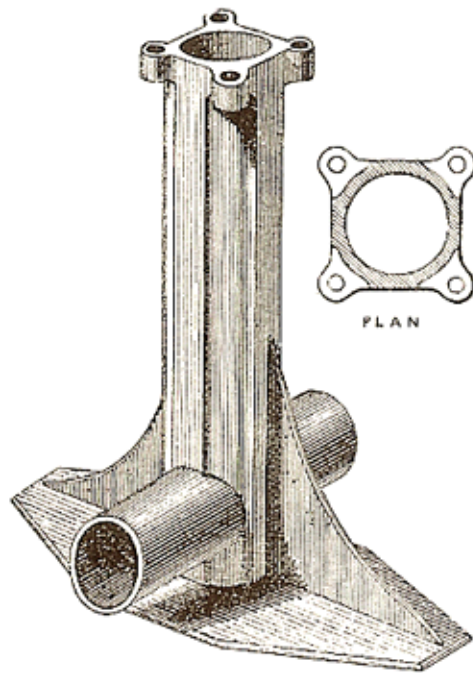
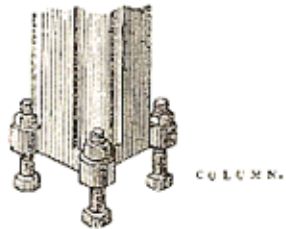


Elevation of base-plate, showing connexion with column above it.



Plan of base-plate.

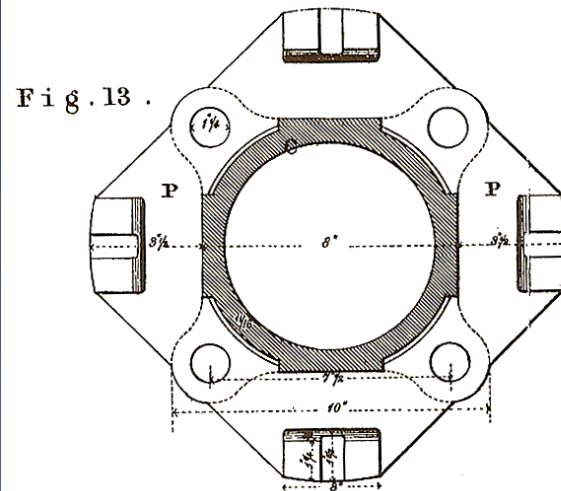
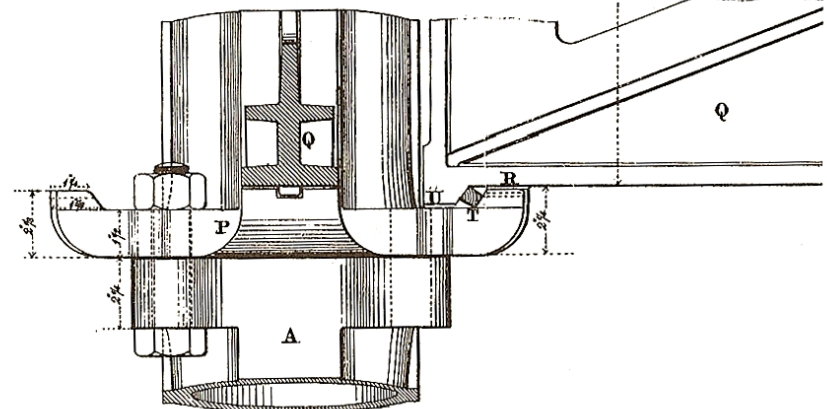
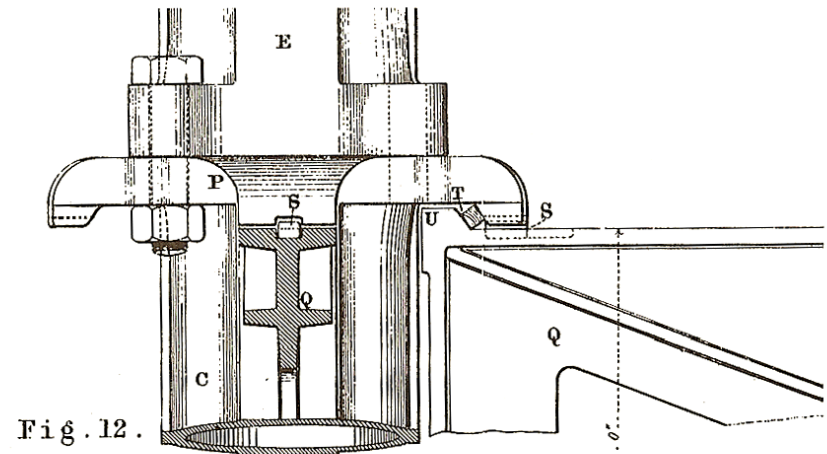
Seal with plumbum...lead



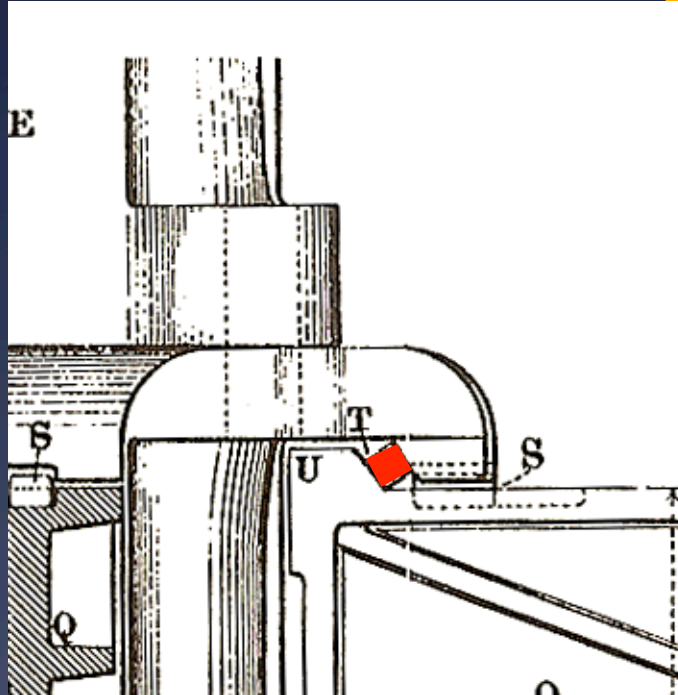
What happens when you assemble 1,800 linear feet of Cast iron?

((coefficient of thermal expansion x temperature differential) x length of wall in inches)

1,800ft x 12 = 21,600 inches
.000006 coefficient of exp for iron
80 degrees temp differential
10.36" of expansion overall, **5.18" on each end.**

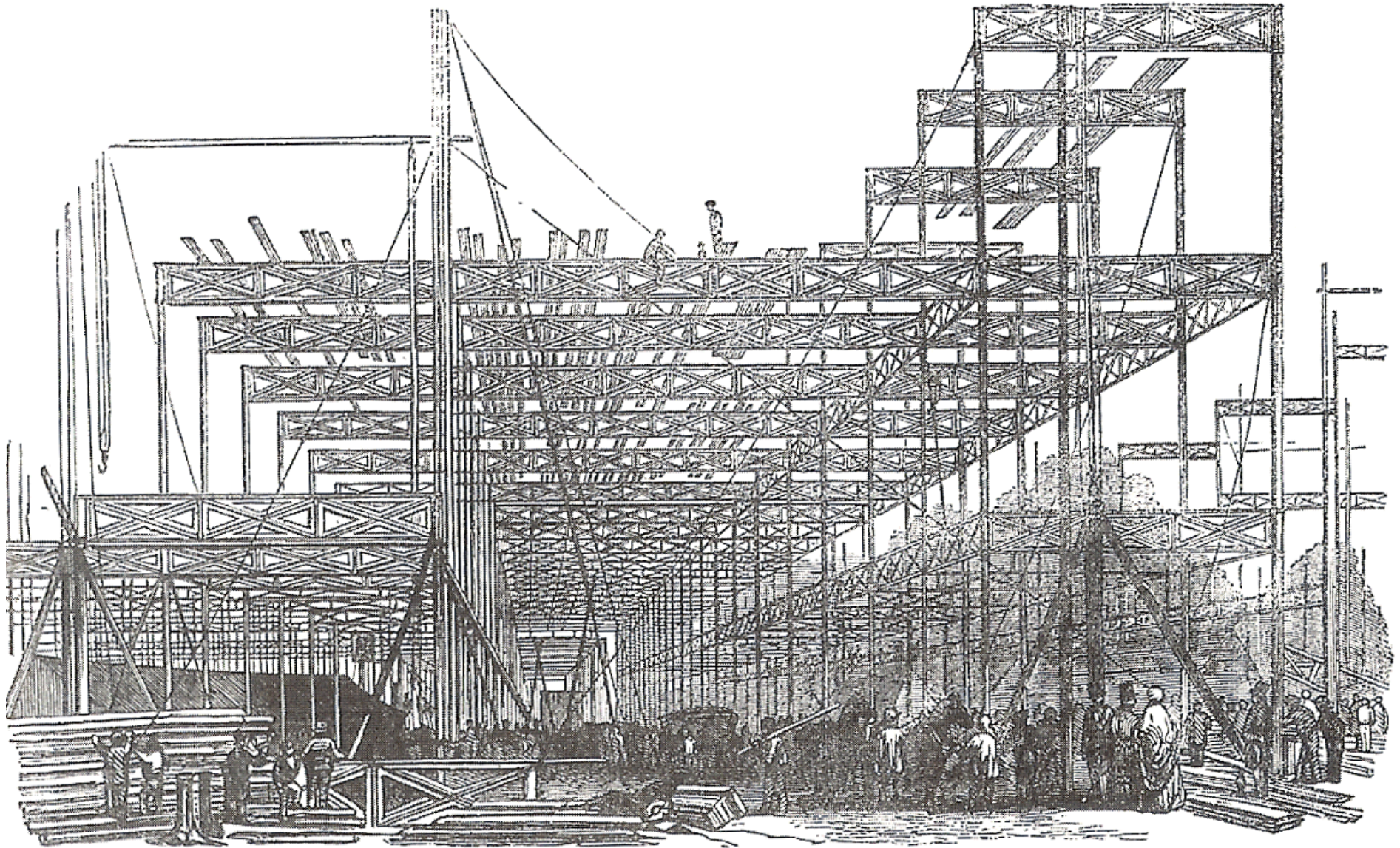


But that's only 1/16 inch on each end of a 24' bay!



Paxton and Fox thought that by installing an oak wedge where the red square is would provide “crush” space and accommodate expansion, but the trusses expanded *into* the column, *away* from the wedges, and the end walls deflected about 5 inches at each end.

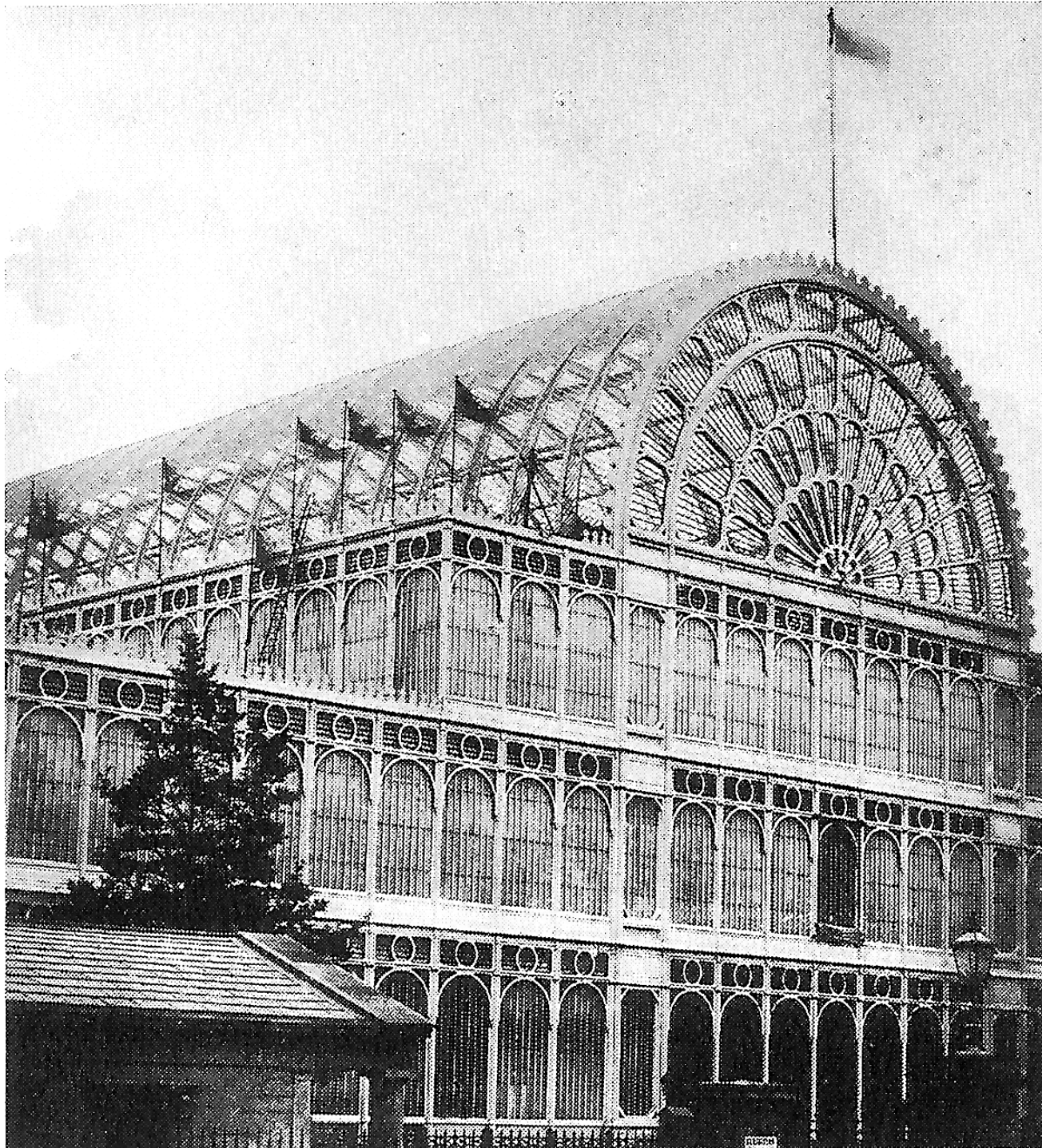
Side Gallery underway



Geared Manual Derrick with shear legs

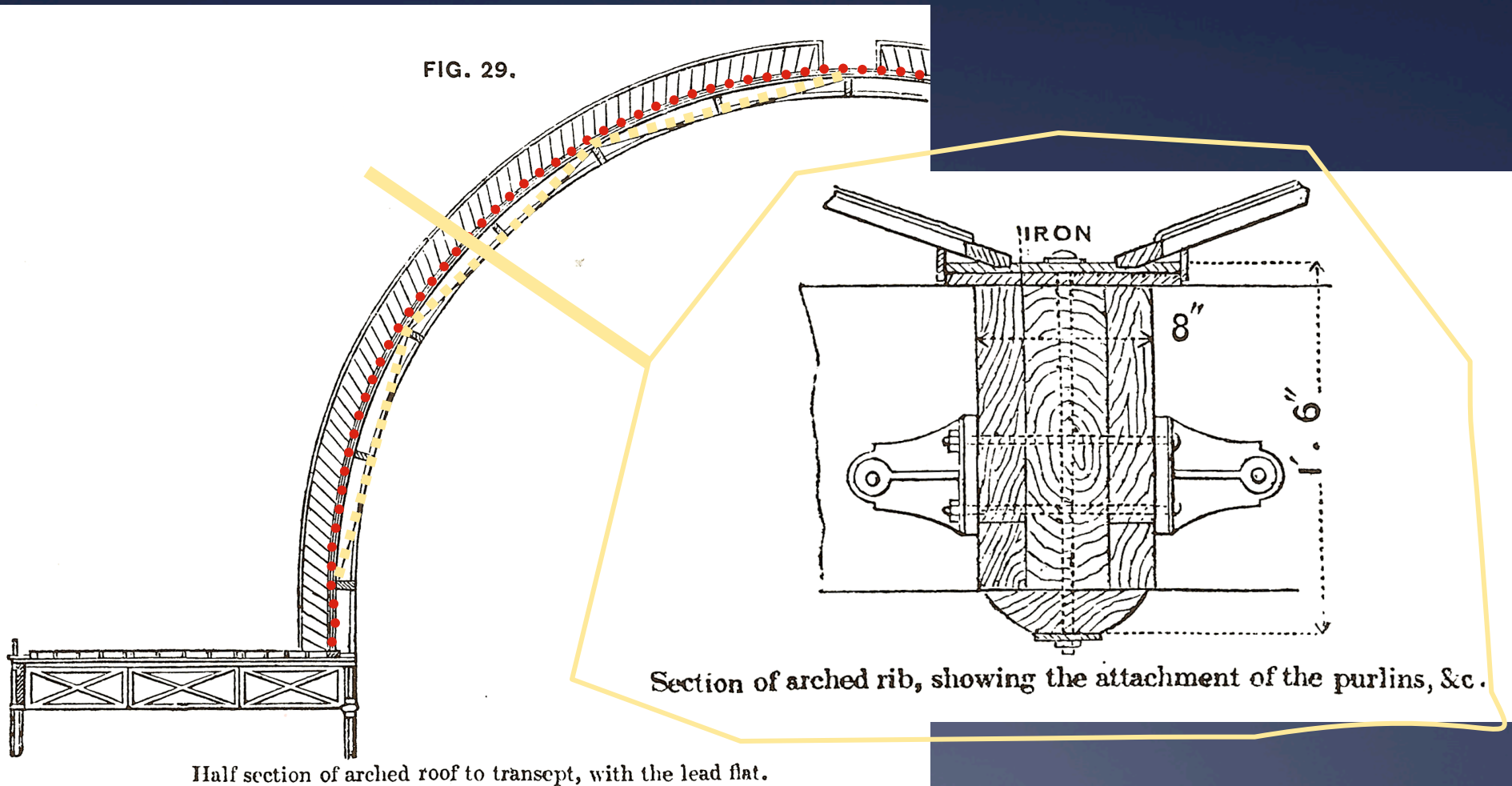


Derrick crane used at Granton Pier (Edinburgh.)



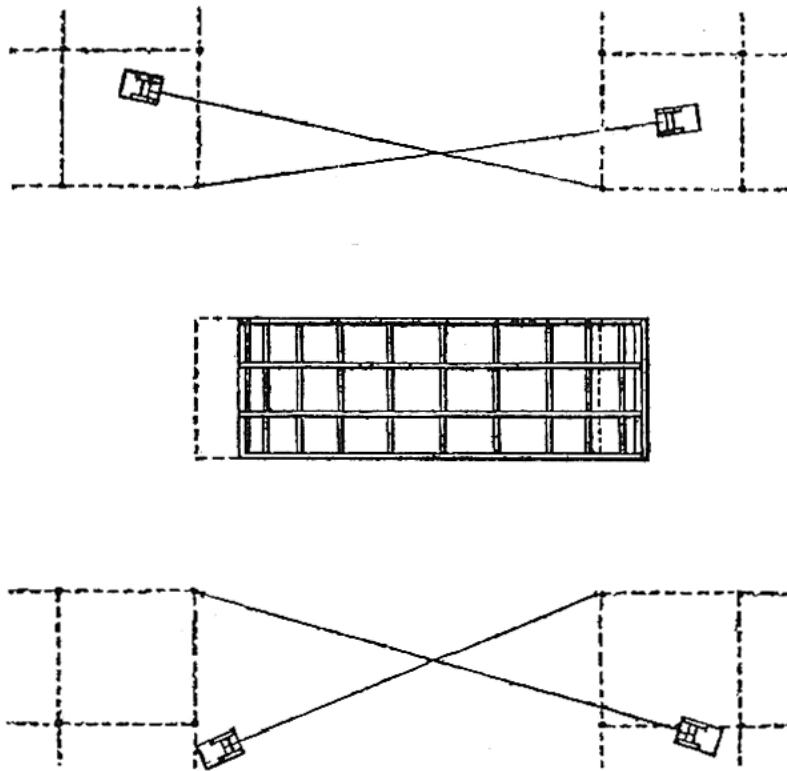
Not to make
this harder than
it needs to be...
how about a 72
foot vault on the
roof?

Laminated wood arches with iron rods



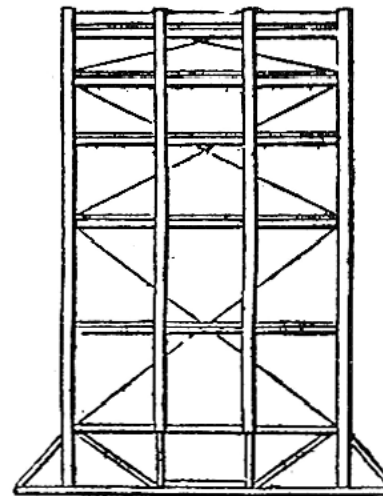
Rig diagonally to increase lift stability

FIG. 48.



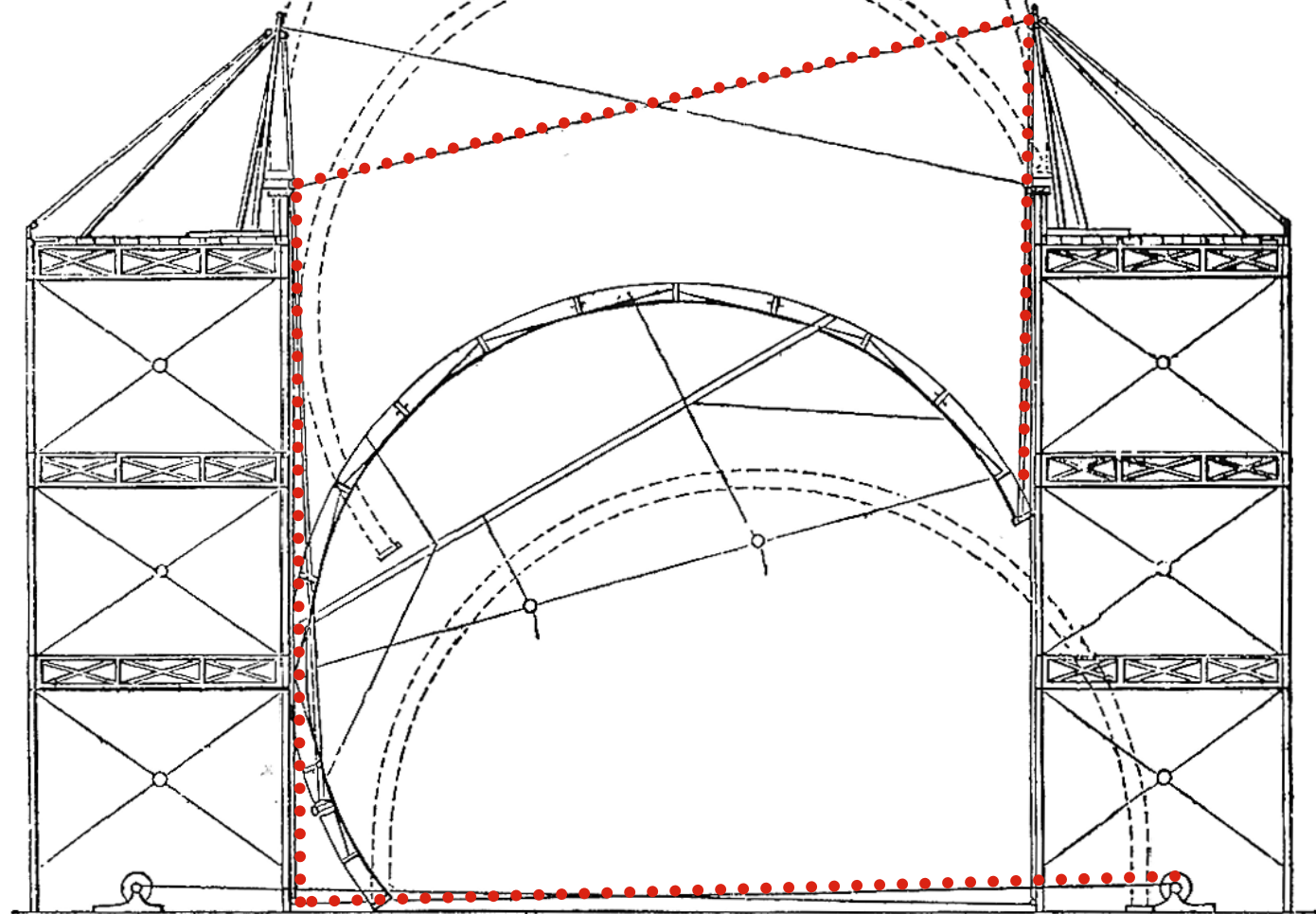
Plan of centre of transept, showing the position of the crabs for hoisting the ribs, &c.

FIG. 49.



End view of a pair of ribs, framed together, previous to being hoisted.

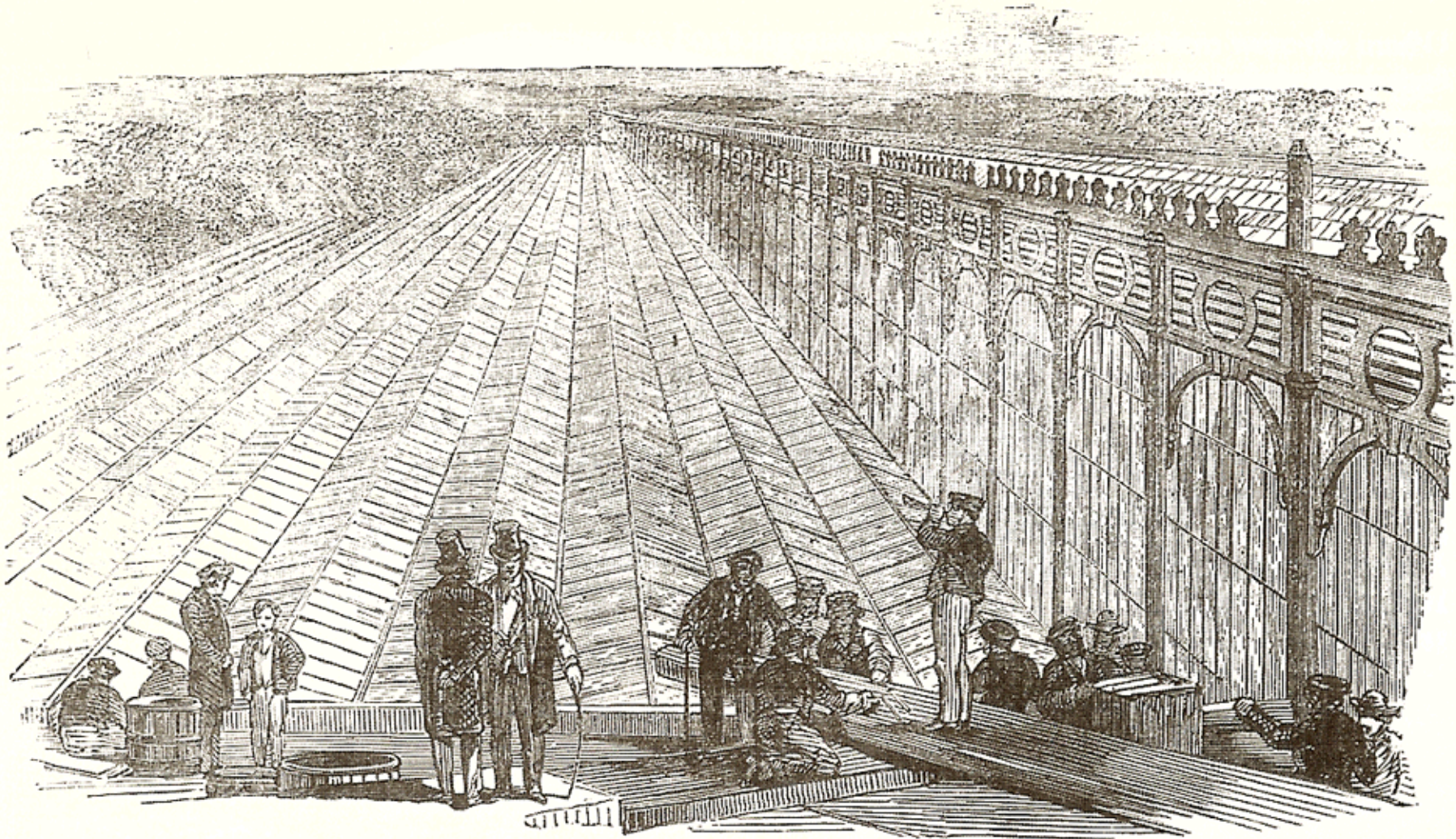
Pre-assemble sections on the ground, hoist into place



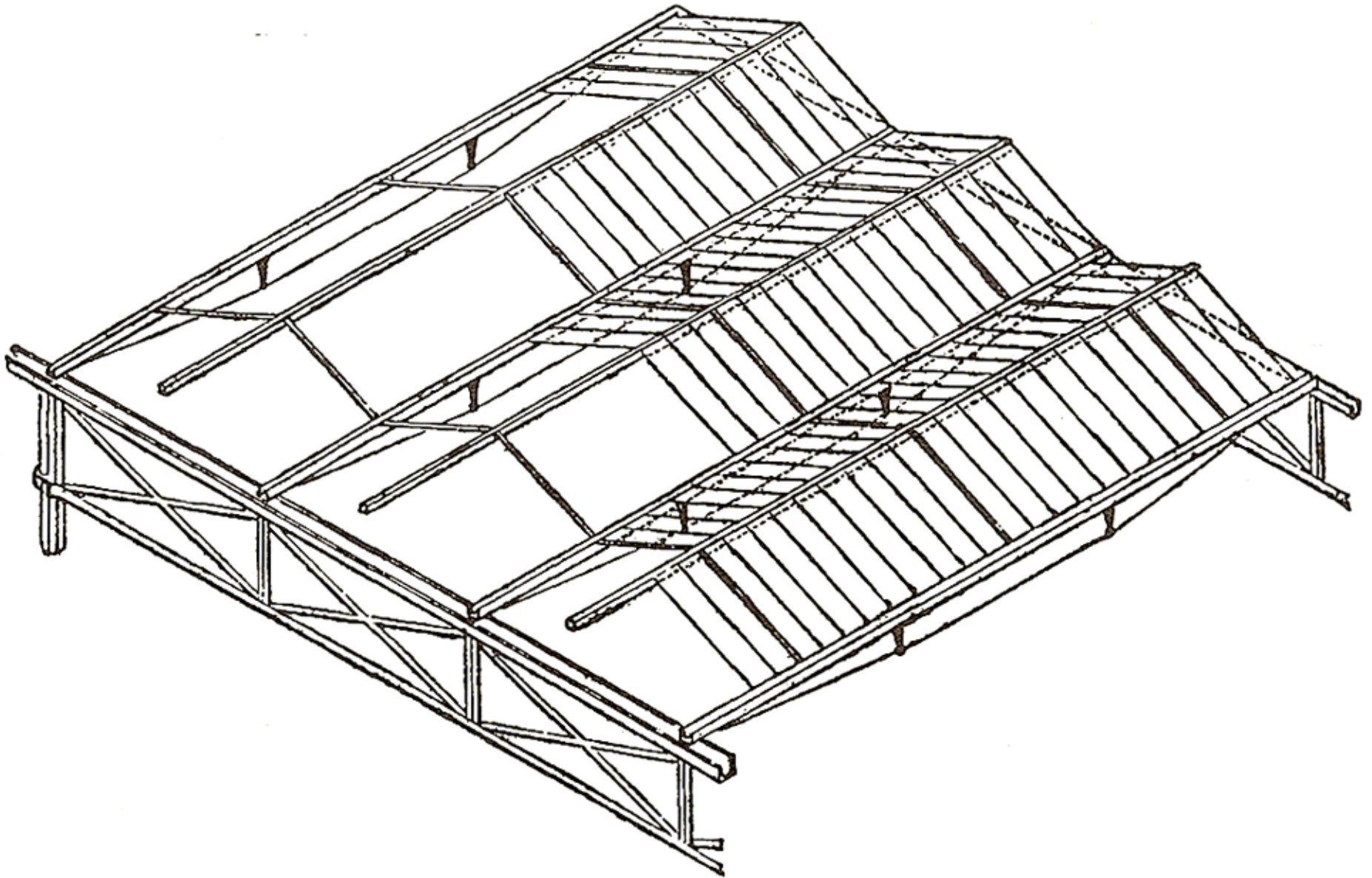
Section through the transept, showing the arrangements for hoisting the semicircular ribs. The dotted lines indicate the various positions of the ribs during the hoisting.

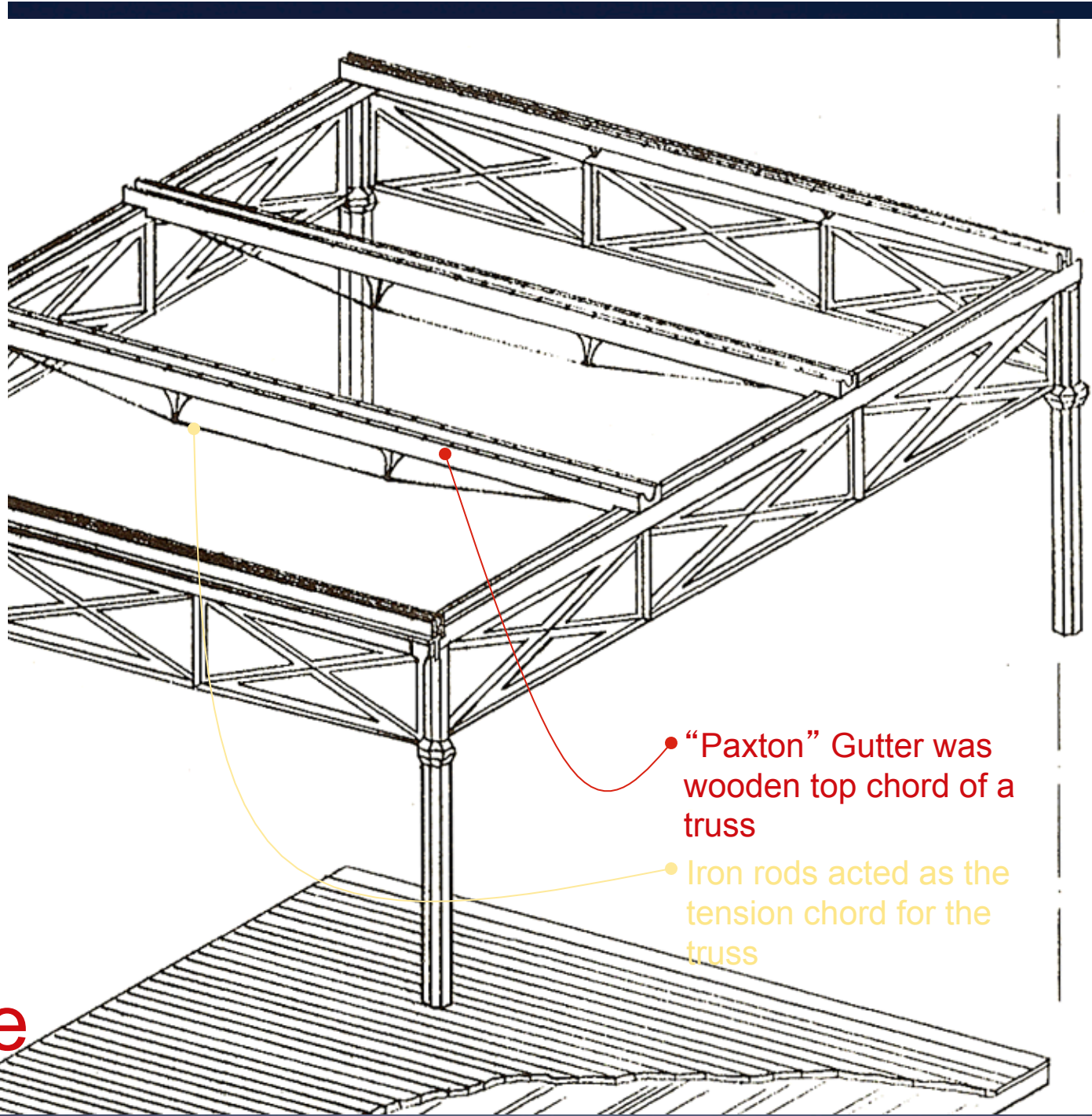
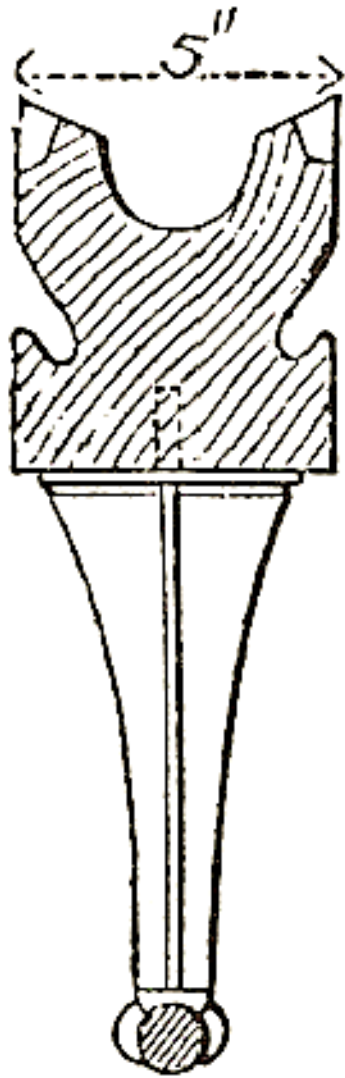
All that's left is glazing

...900,000 s.f. (20 acres) of it.



Typical roof glazing

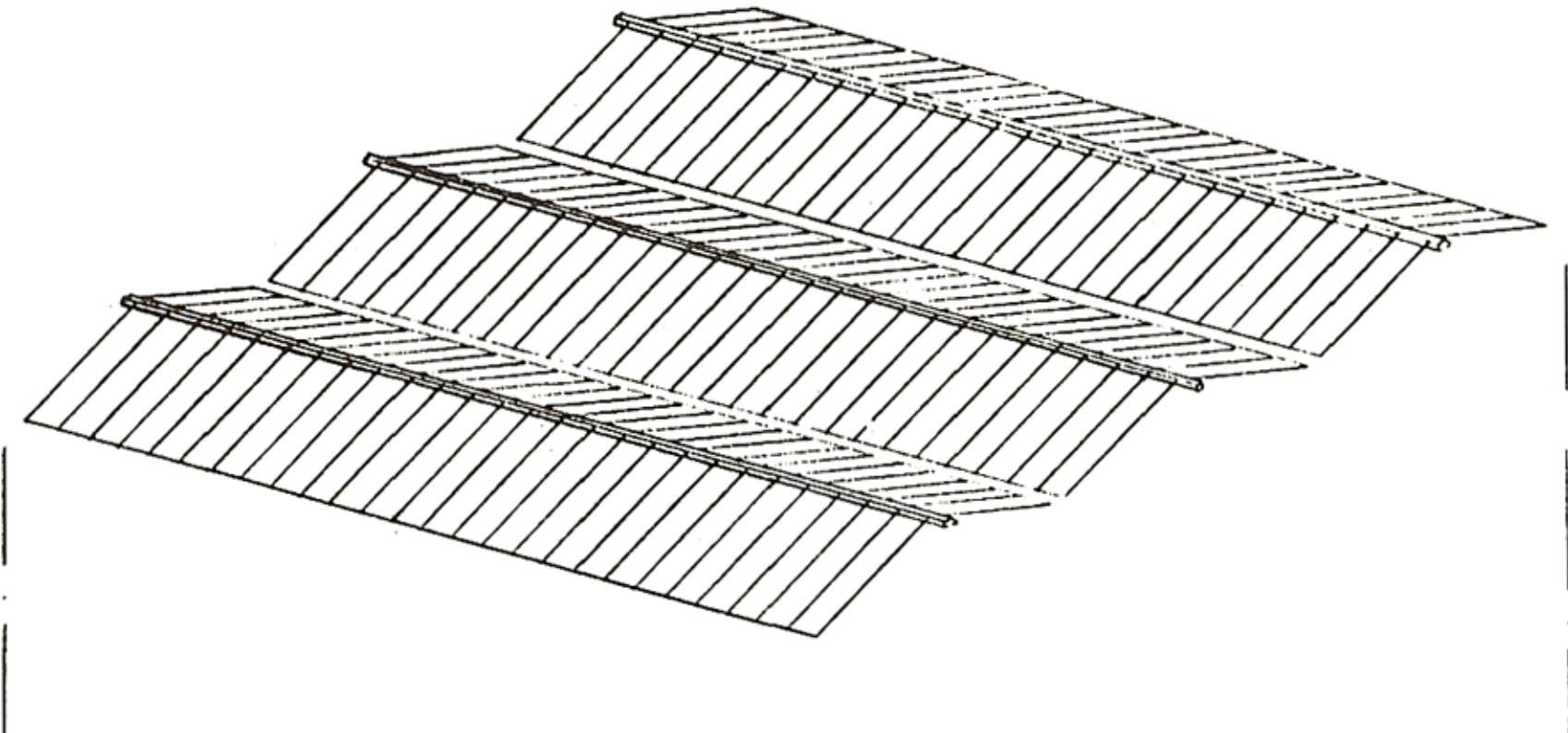




- "Paxton" Gutter was wooden top chord of a truss
- Iron rods acted as the tension chord for the truss

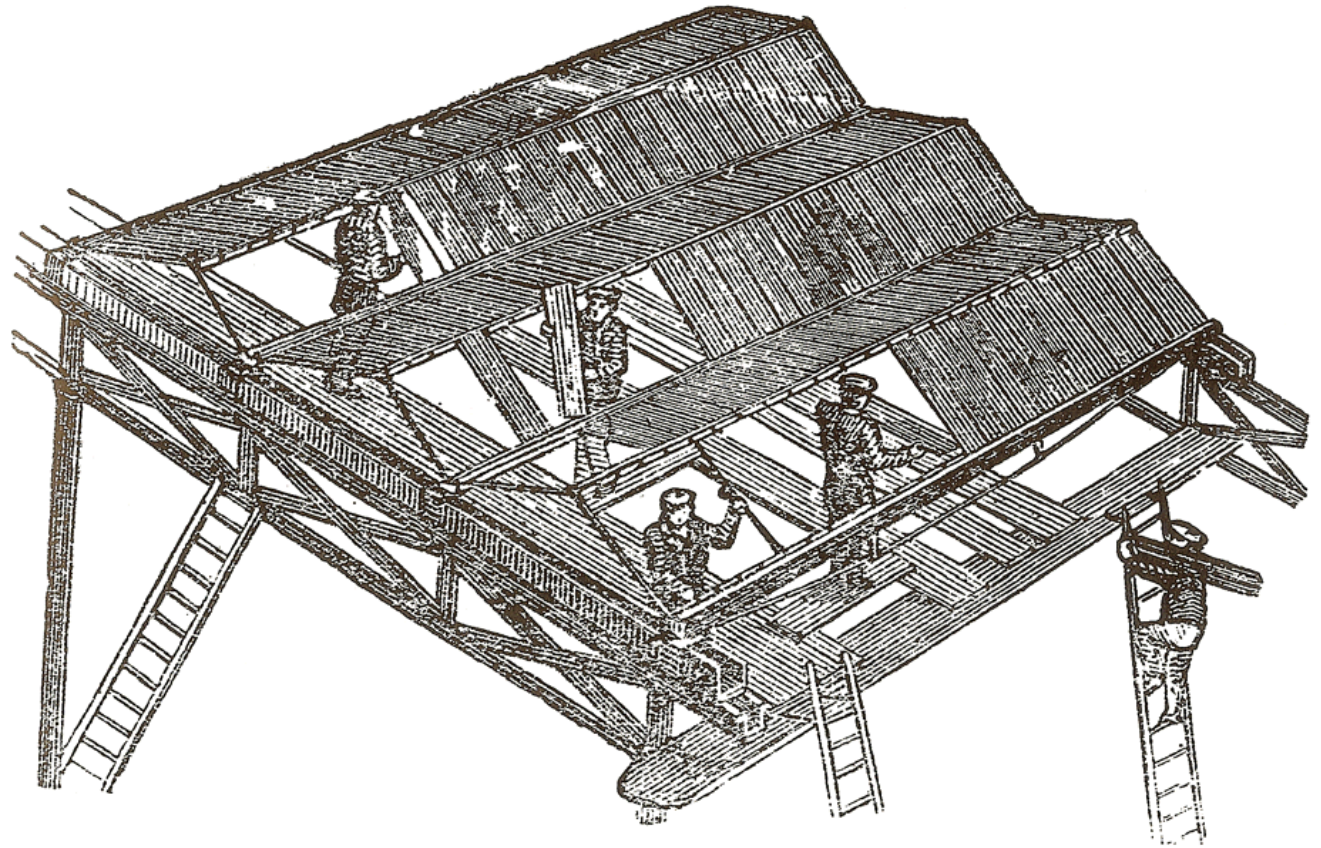
Roof Structure

Ridge and Valley Glazing



Tradition says work vertically

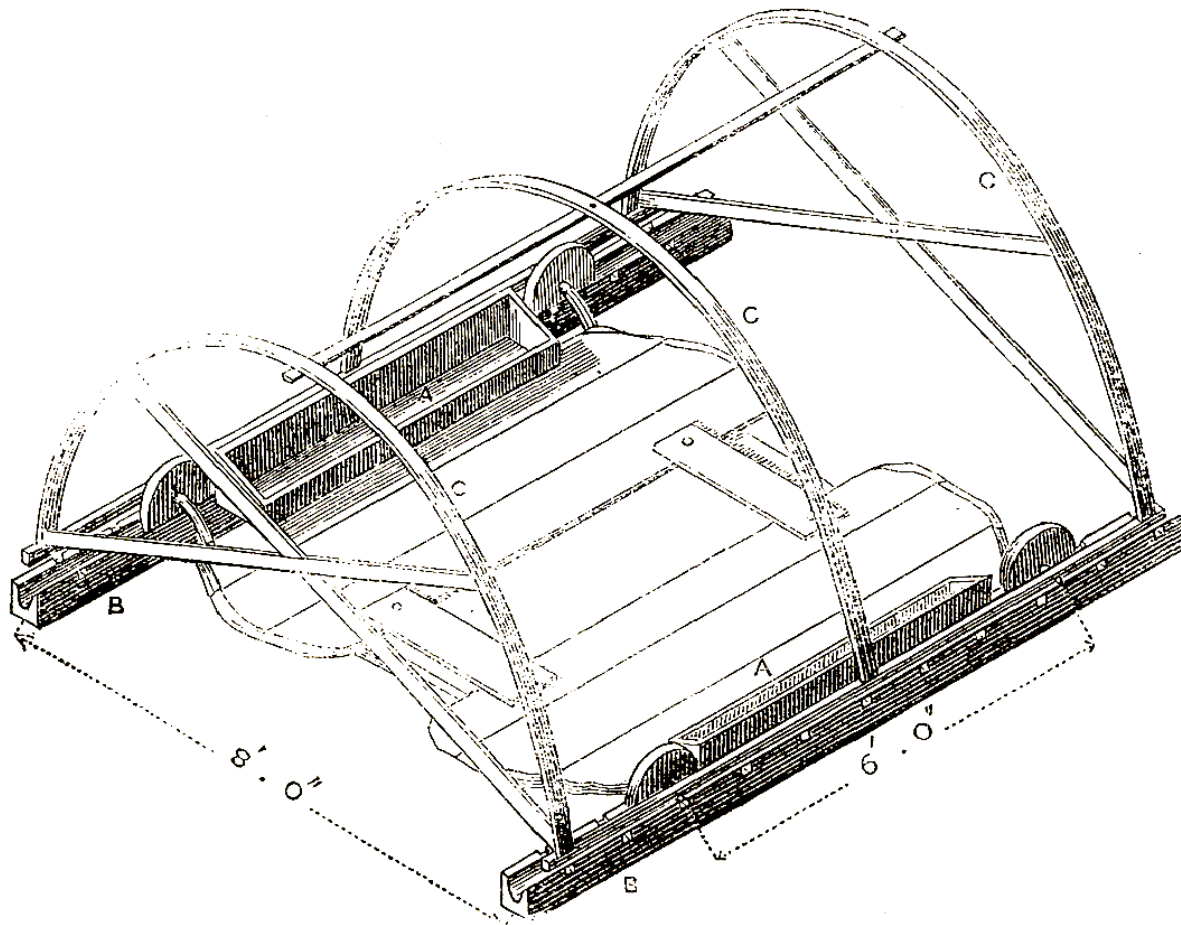
...and produce 200 s.f. of roof per worker per day



Systems thinking says glaze horizontally ... and produce 370 s.f./worker/day

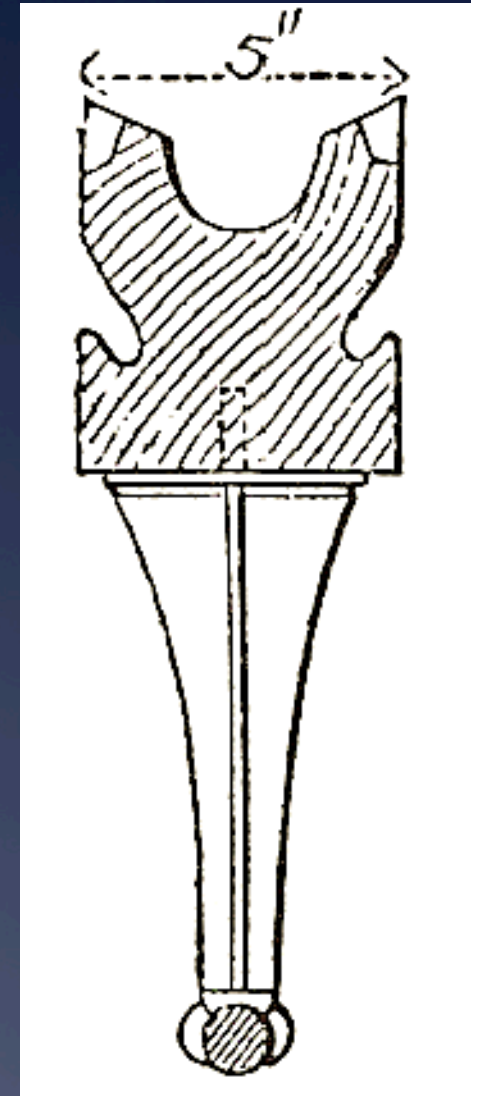
THE GLAZING MACHINES.

FIG. 45.



Travelling stage for glazing the roofs.

A. Box for glass. B. Trussed girder. C. Frame to support the covering used in wet weather.



Linear Production

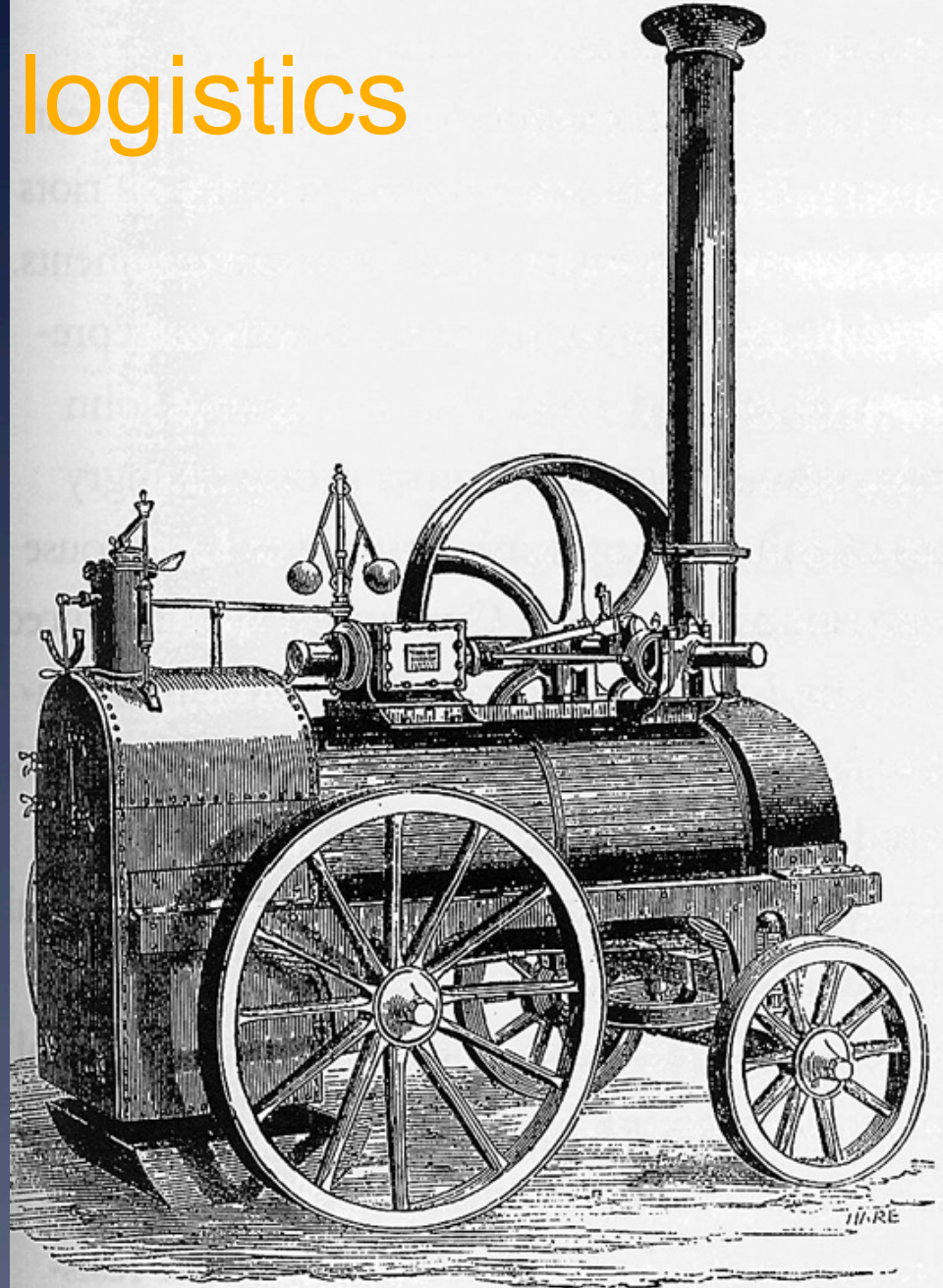
...almost doubles productivity



Credit for this machine goes to the contractor, Charles Fox, who used 76 of these, how many total glazing days are required?

Some logistics

- * 4 steam engines onsite to aid in lifting and hauling
- * Up to 2,260 workers onsite per day
- * Most wood components fabricated/shaped in onsite factories



Construction Schedule

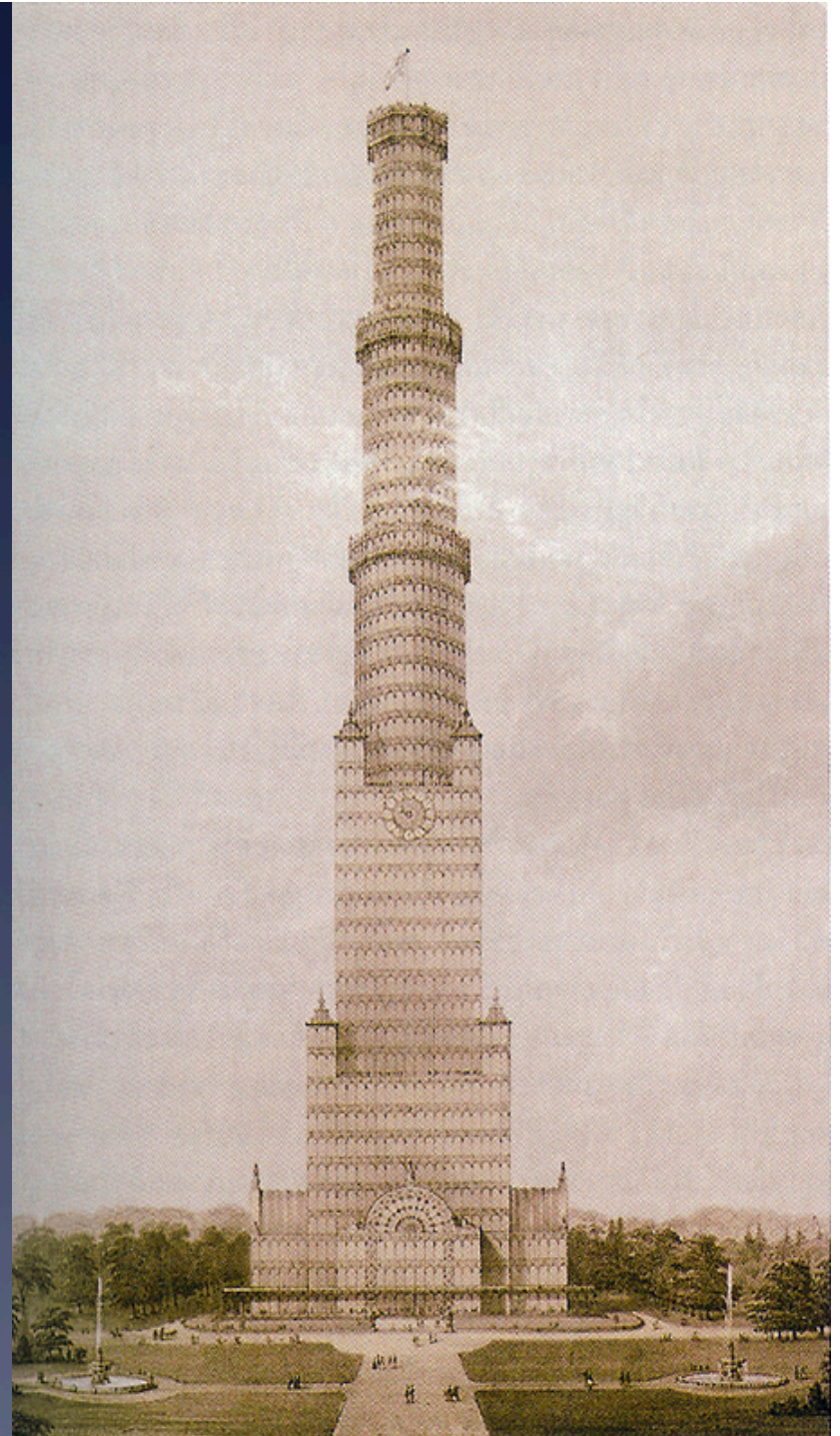
- * 1st column set Sept. 26 1850, 217 days to opening.
- * Shell was completed in 22 weeks (154 days)
- * Interior painting and exhibit installation completed in 16 weeks (5 wk overlap)
- * $989,884 / 154 = 6,427$ s.f. per day

Open for 5 1/2 months

- * 6.6 million visitors
- * 1/5 of the British population attended
- * 13,937 exhibitors
- * Sold 536,000 bottles of soda
- * The stack of catalogs sold would be 24,000 ft high
- * Paid for itself and financed construction of two other museums
- * Show's over
- * What to do with a million square foot building?

Make a Tower?

- * Paxton and Fox's system building inspired re-use, not demolition
- * Building had become a symbol of the industrial and engineering capability of Great Britain



Saving the Palace of the People

Reconstruction in
Sydenham
1853 - 1855

Uncertain future

April 1852, “Save the Crystal Palace” ... 100,000 sign a petition to keep it where it was.

- * Paxton petitions the House of Commons to keep the Crystal Palace intact until May 1, 1852.
- * April 29, 1852, the House votes to “return the site to turf”

Competing Ideas

- Prince Albert opposed the use of the palace for simple leisure

A Commercial Ballroom

A Winter Garden

A Center for Design and
Technology

Sell parts to Kew Gardens for an
addition

Make a U.S. Exhibition from one
wing.

A Polytechnic Institute

A Riding School

Sold!!!?

To Francis Fuller, original surveyor for the Hyde Park Construction.

- * Behind the scenes forces:
 - * The Southwest railroad company
 - * The London, Brighton and South Coast Line railroad (Fuller's company association)
- * Why were the railroads pushing relocation over demolition?

Competing Locations

Sydenham hill, an estate Penge Hall

Had small LBSC RR station, no other attractions

* South Kensington,

* Had Kew Gardens

* Was called
“Albertopolis” (Prince
owned land there)

Why was the LBSC railroad so interested?

Fuller, LBSC
purchases the
Crystal Palace

Leo Schuster
LBSC Board member
provides land

Crystal Palace Company,
Directors,
Samuel Laing, LBSC
Fuller, LBSC
Paxton,
Wyatt,
Jones

What happens when infrastructure gets built into undeveloped countryside?



The compromise use

- * An exhibit hall
 - * “Machinery at Work”
 - * Geology
 - * Botany
 - * Sculpture
 - * Archeology
- * A “Victorian” exhibit hall...
 - * No dancing saloon
 - * No tea garden
 - * No “intoxitcating beverages”
 - * No Sunday hours

Funded by an IPO stock offering... (initial public offering)

- * Sold 25,000 shares of stock in the first 4 days.
- * Ultimately sold 200,000 shares at 5 pounds per share... today that would be about \$70 million.

THE CRYSTAL PALACE COMPANY.
Capital £100,000, in 100,000 Shares of £5 each.
Paid up in full.
Provisionally registered pursuant to Statute 7 and 8 Victoria, cap. 110.

DIRECTORS.
Chairman—SAMUEL LAING, Esq., Chairman of the London, Brighton, and South Coast Railway Company.
Arthur Anderson, Esq., M.P., Leadenhall-street.
Charles Lushington, Esq., M.P., Kensington Palace Gardens.
John Scott Russell, Esq., F.R.S., Great George-street, late Secretary to the Royal Commission of 1851.
Francis Fuller, Esq., Abingdon-street, late Member of the Executive Committee of the Great Exhibition of 1851.
Thomas N. Farquhar, Esq., Sydenham, Kent.
Charles Geach Esq., M.P., Park-street, Westminster.
Edmond S. P. Calvert, Esq., Upper Thames-street.
Thomas Brassy, Esq., Lowndes-square.

DIRECTOR OF WINTER GARDEN, PARK, AND CONSERVATORY.
Sir Joseph Paxton.

DIRECTOR OF WORKS.
Matthew Digby Wyatt, Esq.

DIRECTOR OF DECORATIONS.
Owen Jones, Esq.

SECRETARY.
George Grove, Esq.

CONTRACTORS FOR THE RE-ERECTION OF THE BUILDING.
Messrs. Fox, Henderson, and Co.

SOLICITORS.
Messrs. Johnston, Farquhar, and Leech.

BANKERS.
The Union Bank of London.

To rescue the country from the disgrace of parting for ever with the magnificent structure, with whose existence so happy a portion of the life of the people of England is identified, the Crystal Palace has been purchased by private individuals from Messrs. Fox and Henderson, the spirited contractors who erected it.

Bigger, Taller, more Refined

- * Hyde Park Site 1851

- * 1608 long

- * 312 wide

- * 106 tall

- * All iron

- * Sydenham Site 1854

- * 1848 long

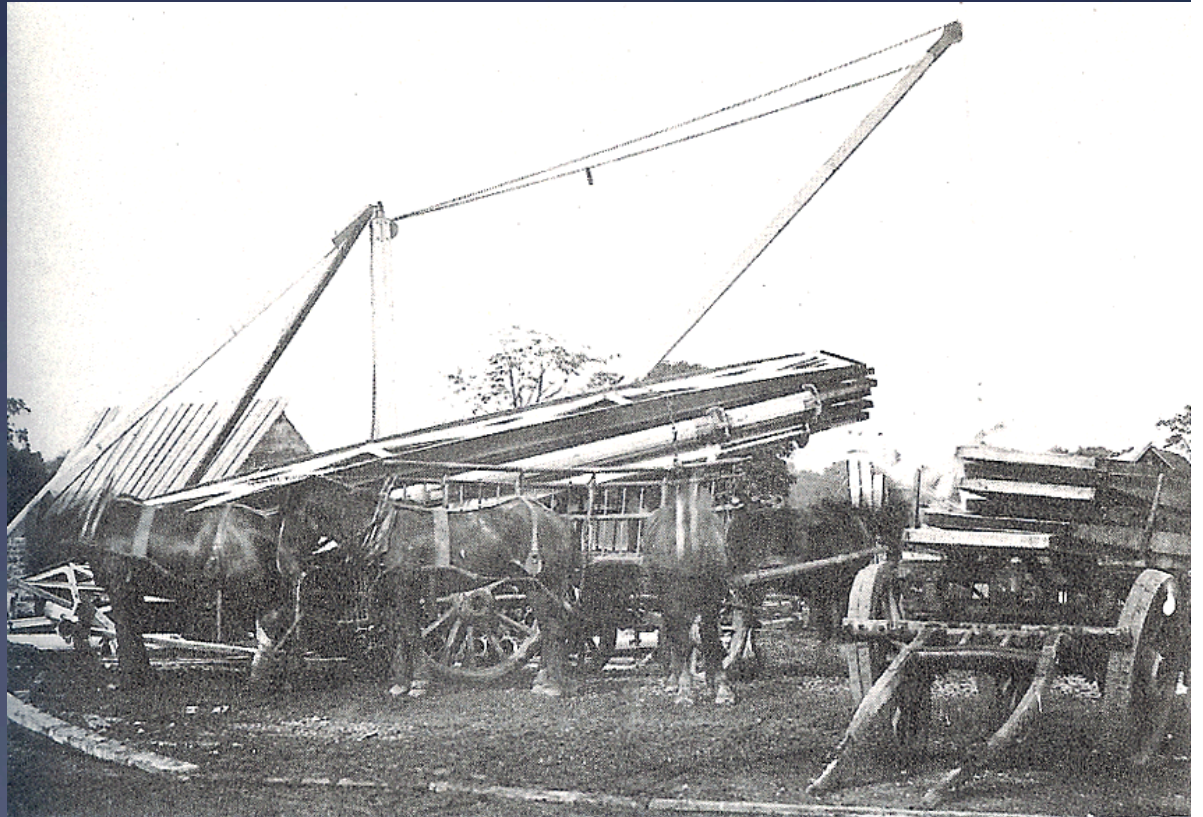
- * 456 wide

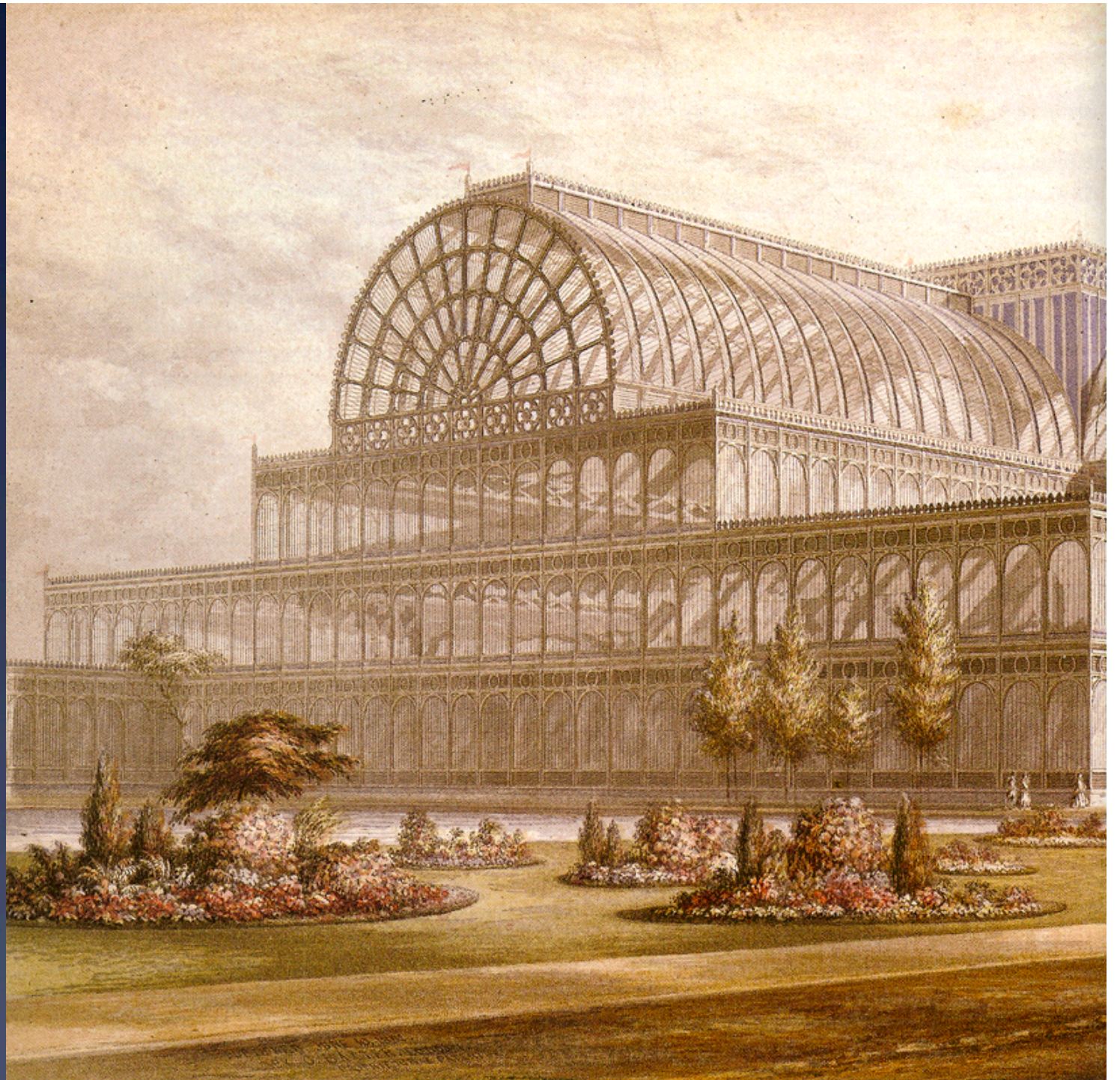
- * 168 tall

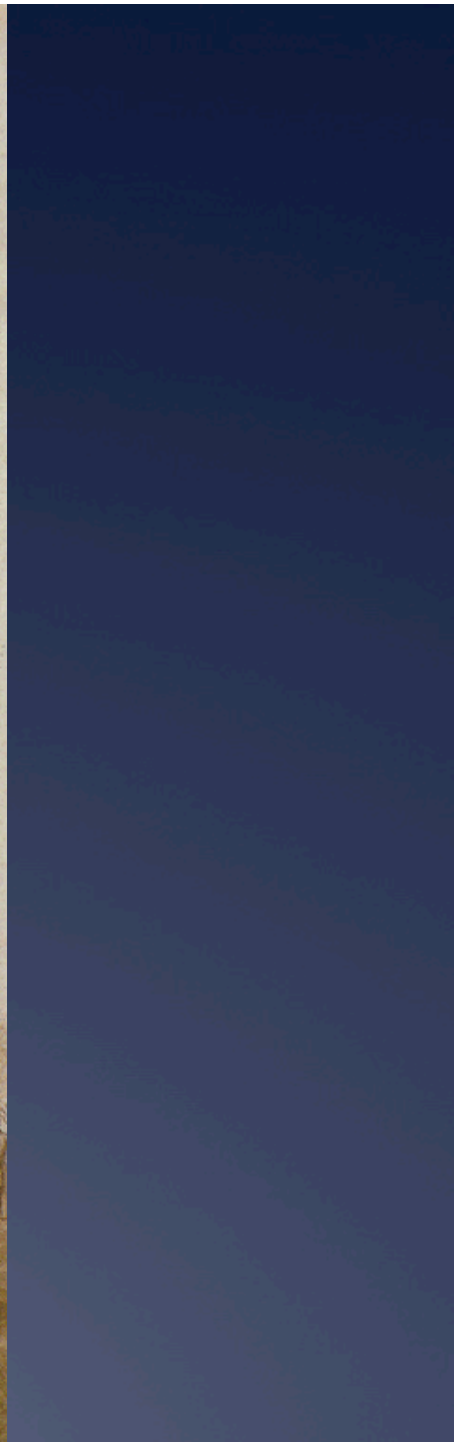
- * Iron and steel

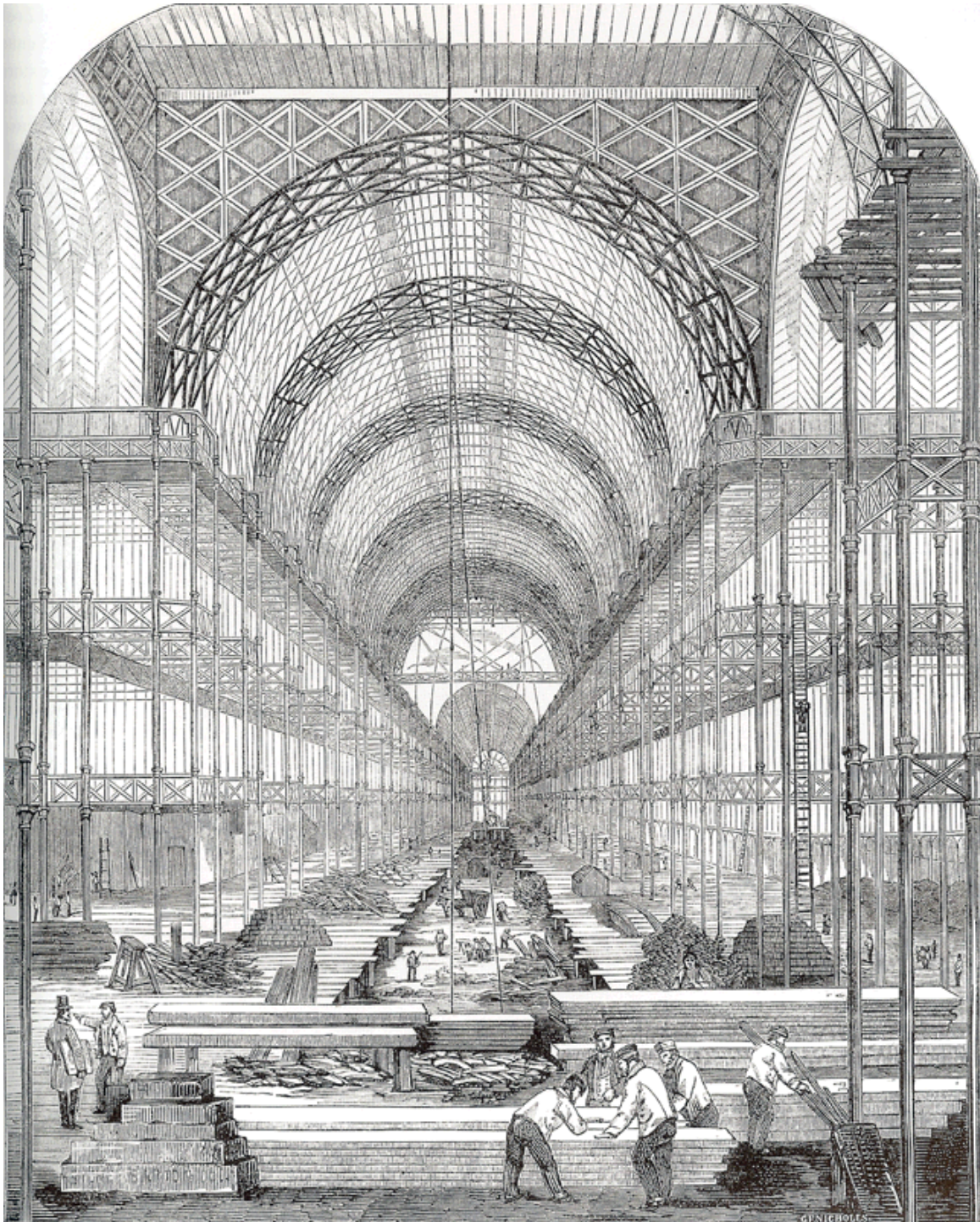
But slower

- * Built in 8 months in the Hyde Park location
- * Took 23 months in the Sydenham location (15 miles from Hyde Park)
- * First column set August 5, 1852









Not much
Lateral
Bracing in
sight

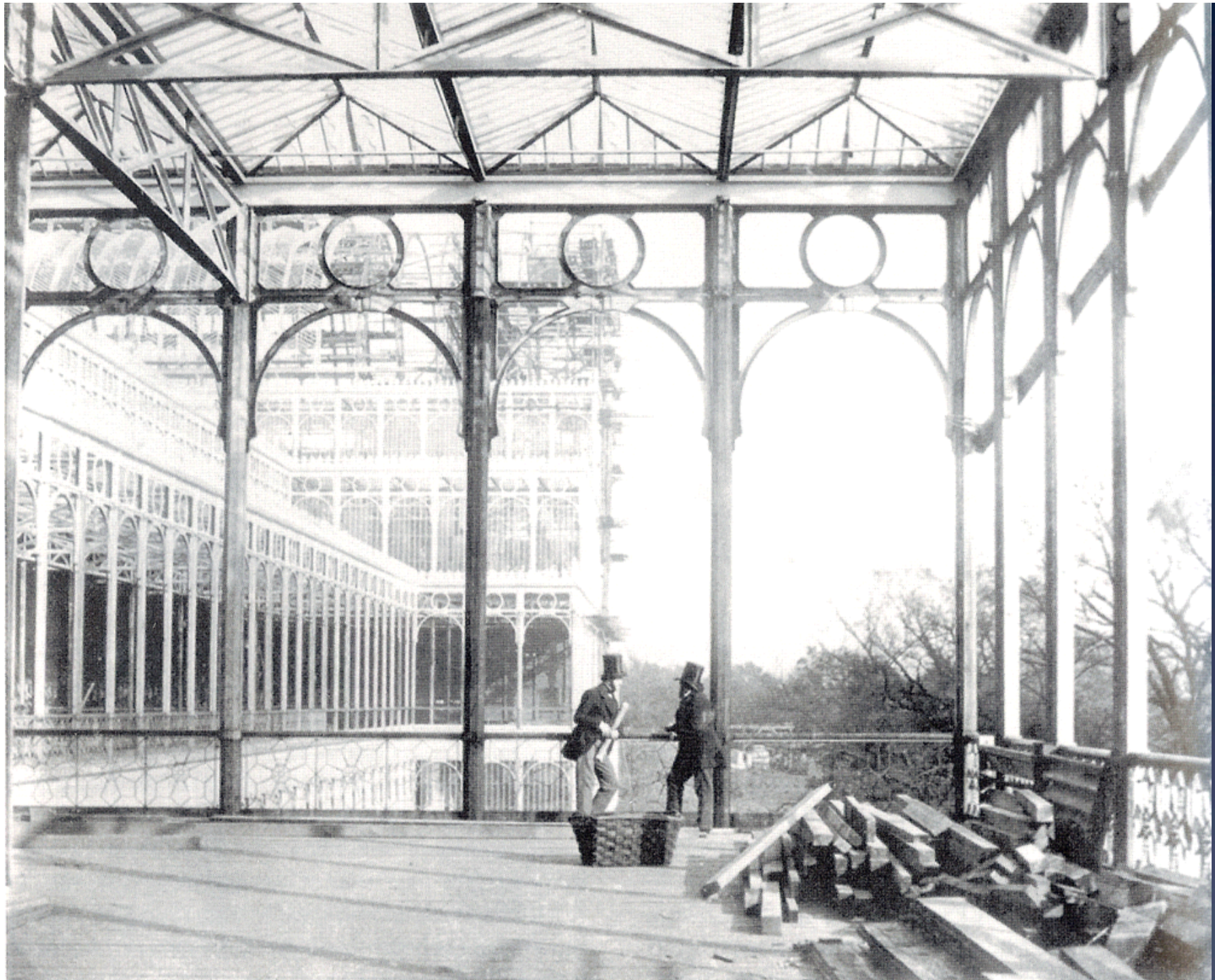


Other collapses

- * Scaffolding for the circular ribs 1853
- * The North Wing during the “Great Gale” of 1861



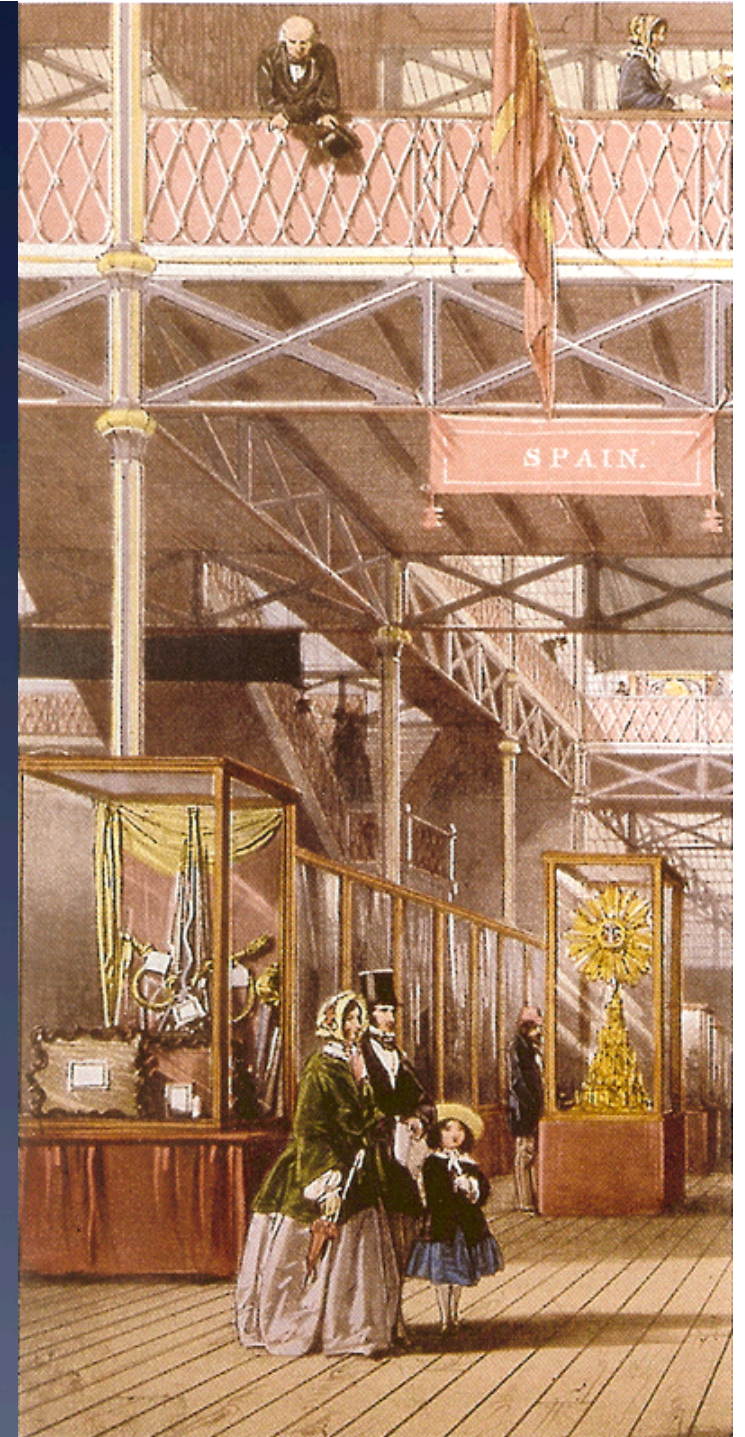
Why was this “Bulls-eye” framing added to the upper gallery walls?

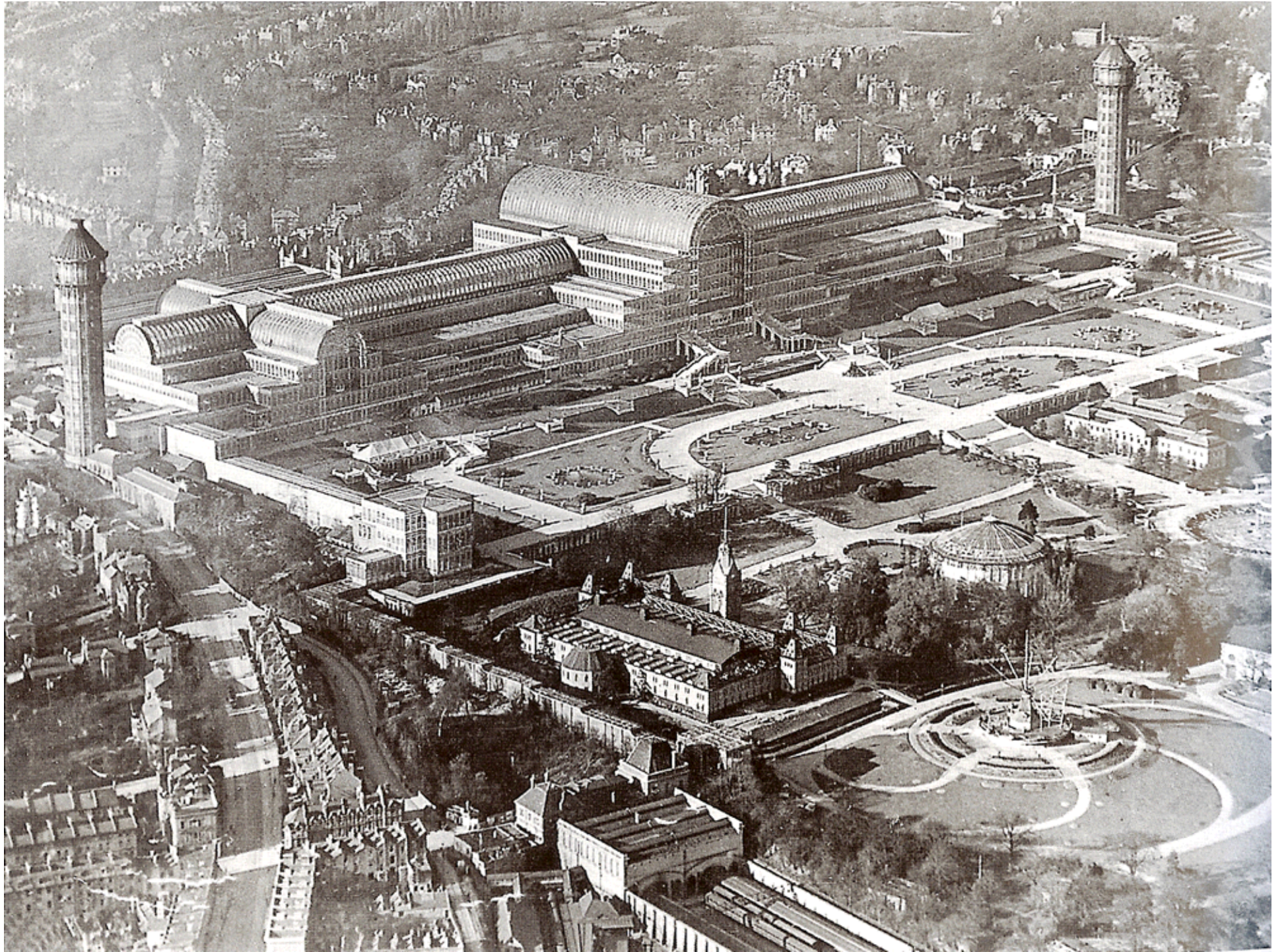


Re-opens in
1854

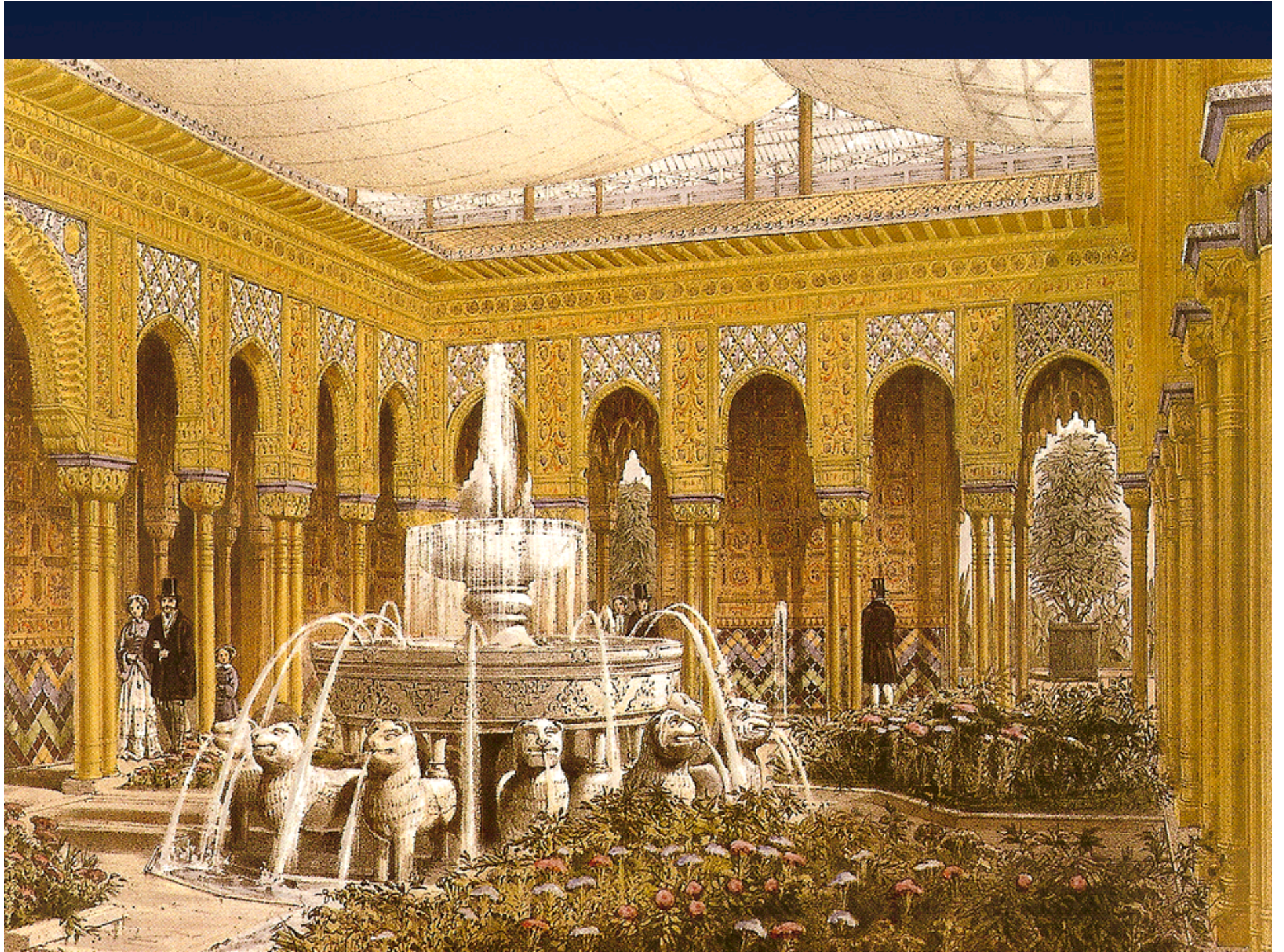


Prominent Visitors









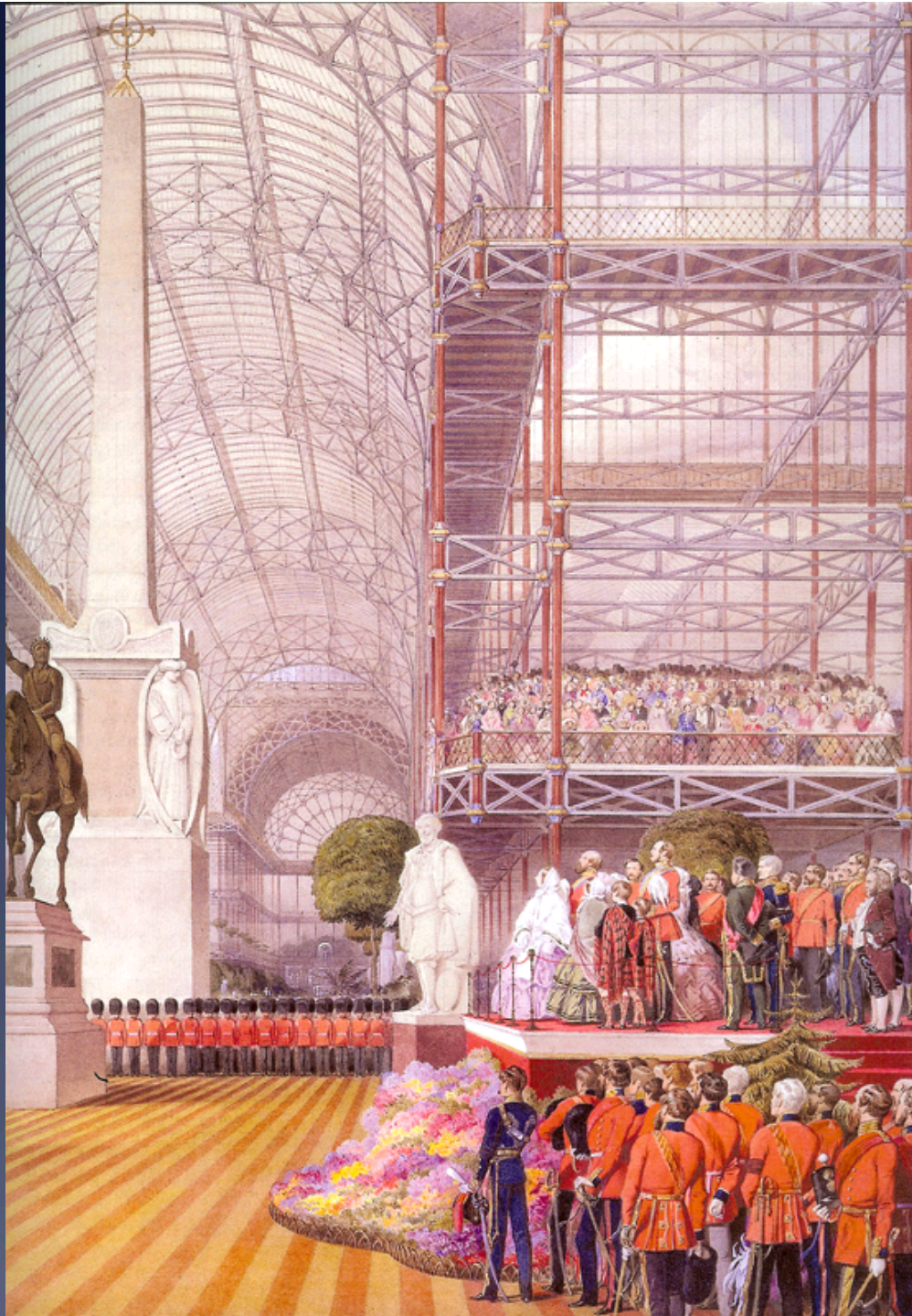




7 miles of
steam pipe
to raise
*Victoria
regia*

What happens when the humid hothouse meets the plaster archeological reproductions? A glass screen is retrofitted between them in 1859





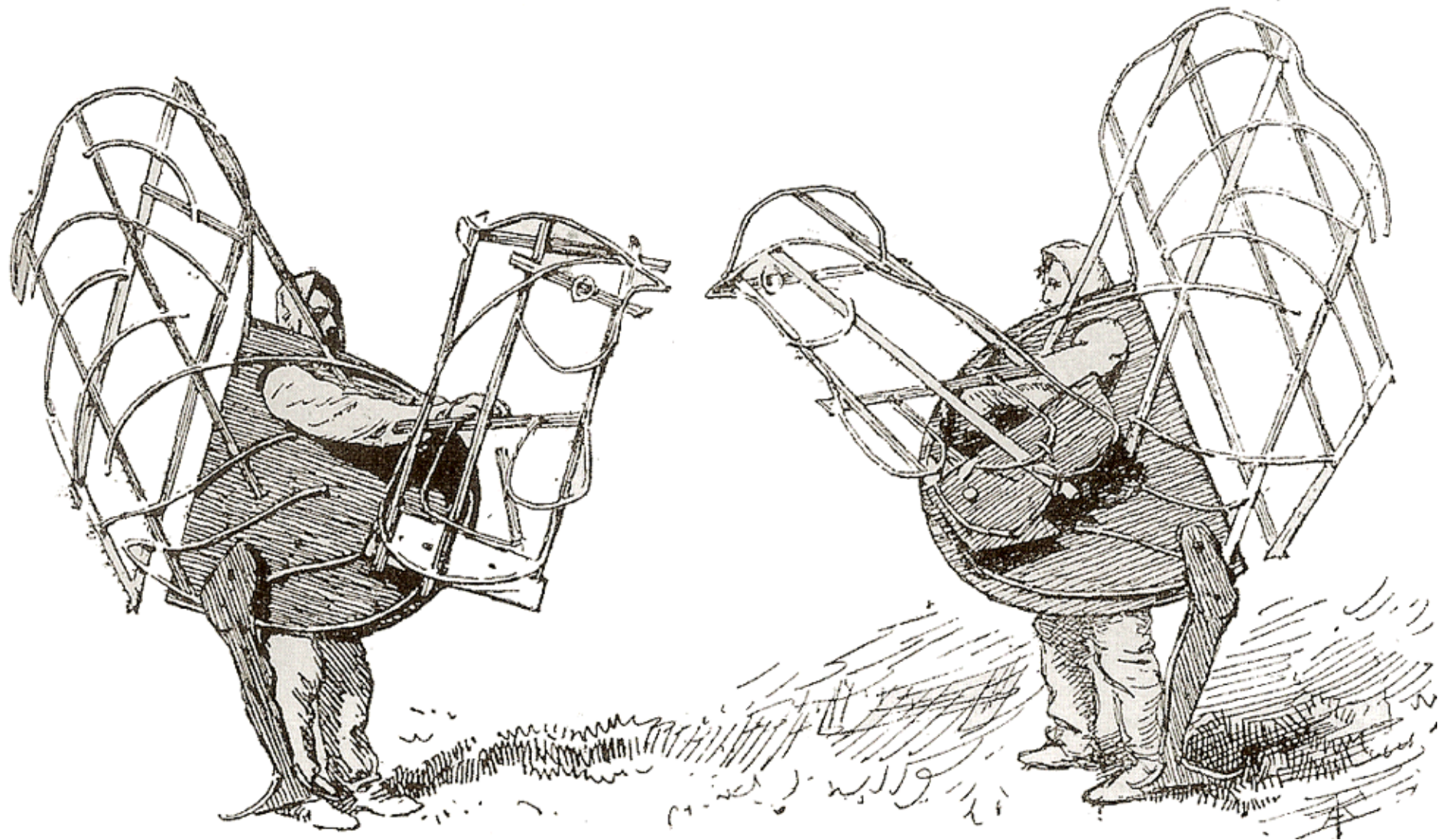


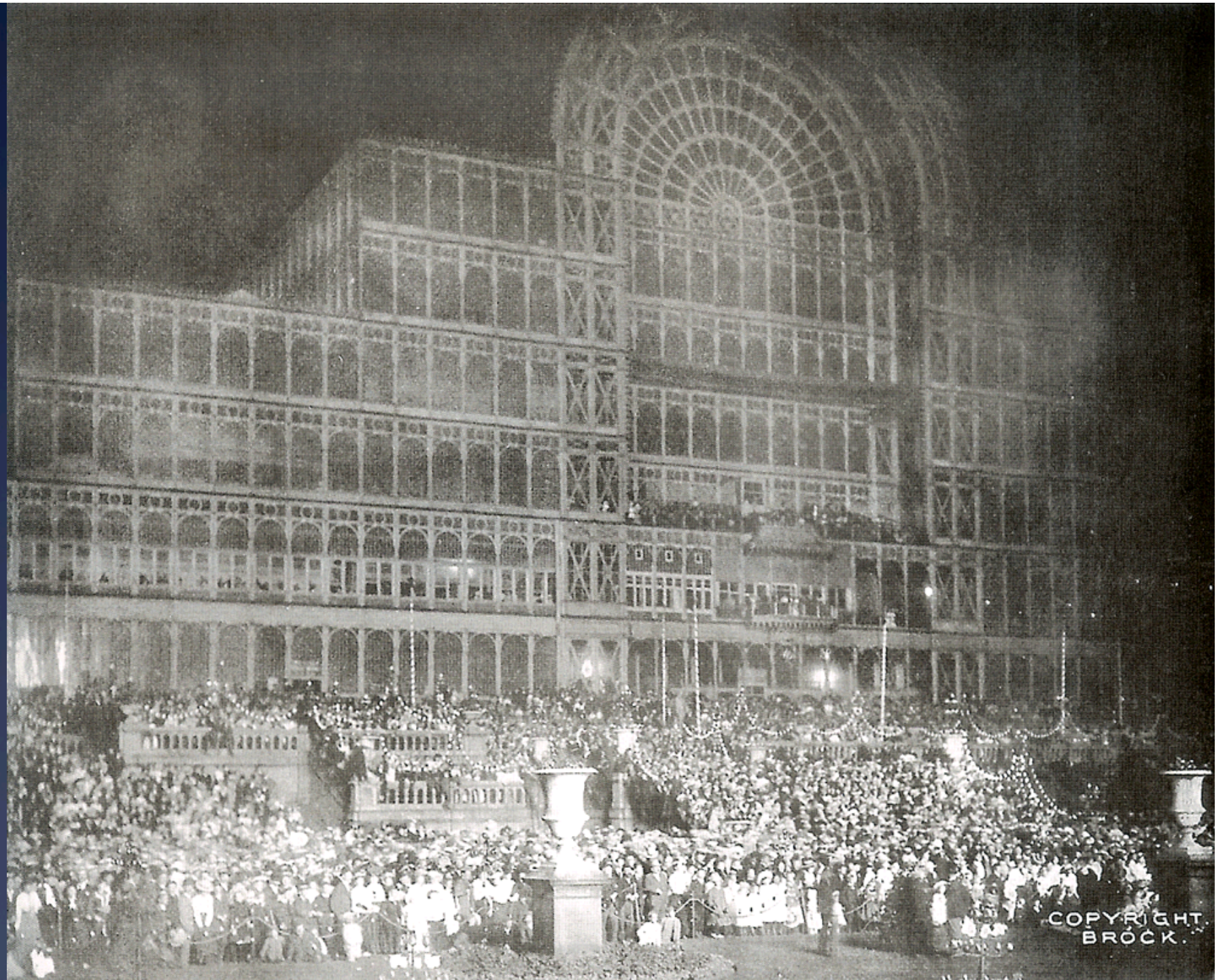


BROCK'S BENEFIT CRYSTAL PALACE SEP 24. "ONE SHILLING DAY."

Inventor of the “living fireworks”

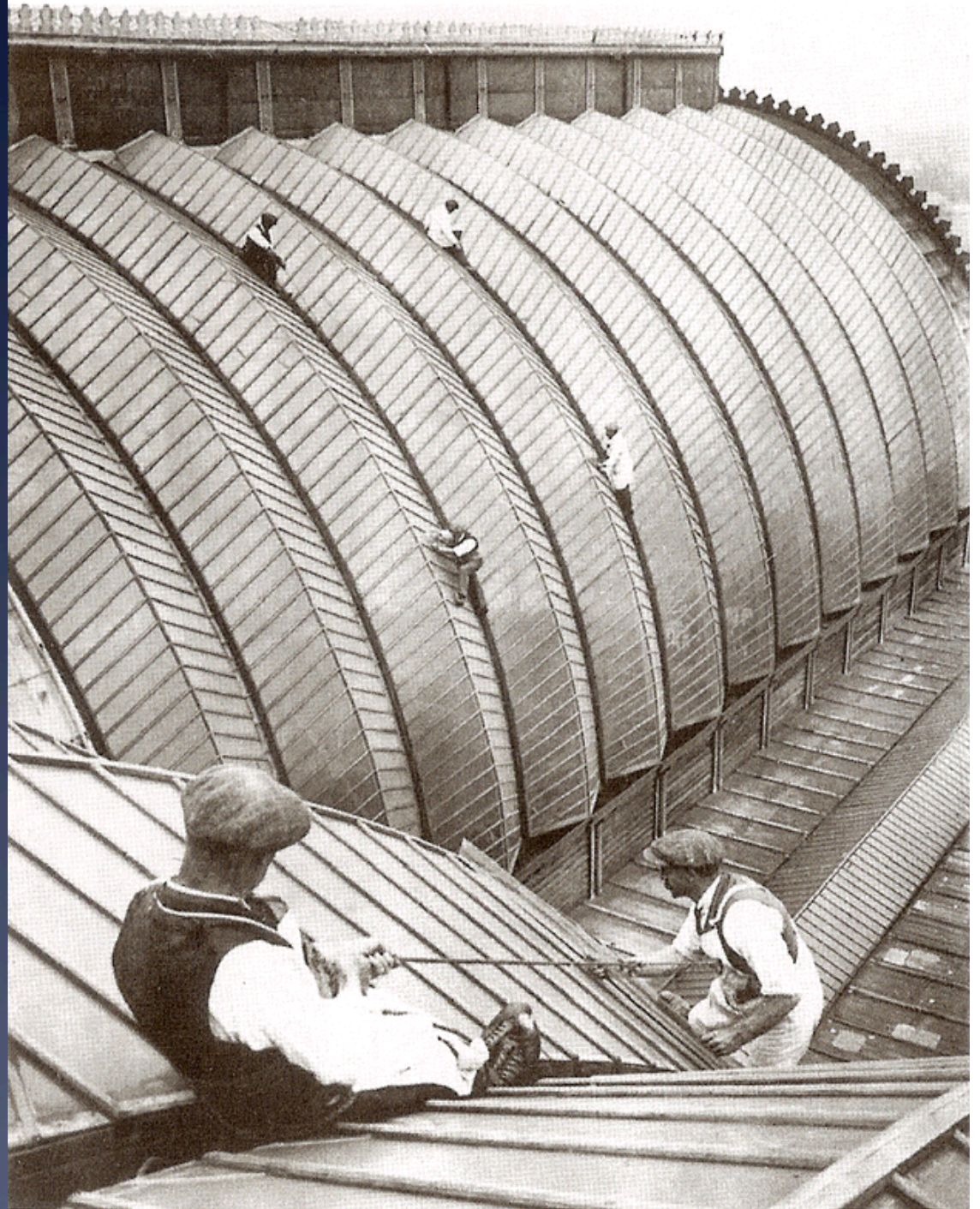








Re-Glazed in 1930



1934 fire



Last fragment
demolished 1950

