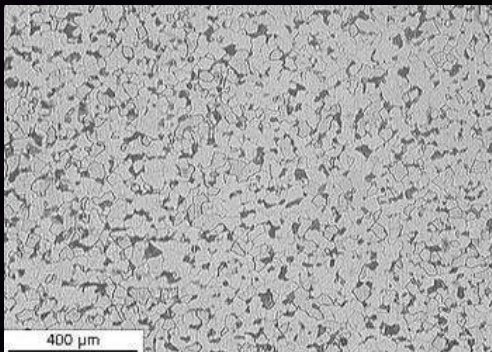
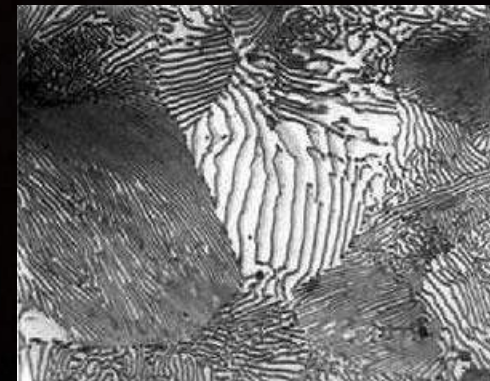



IRON & STEEL INSTITUTE.



150 years of steel



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1903-05 Andrew Carnegie LLD	1942-44 James Henderson	1968-69 Dr John Hugh Chesters OBE FRS
1905-07 Sir Robert Abbott Hadfield Bt DSc FRS	1869-71 William 1944-46 Arthur Dorman	1969-70 Niall Cambell Macdiarmid
1907-10 Sir Hugh Bell Bt CD DCL LLD	1946-48 Dr Cecil Henry Desch DSc PhD LLD FRS	1970-71 Norman Cecil Lake CBE
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1912-14 Arthur Cooper LLD	1950-51 James Robert Menzies-Wilson OBE	1972-73 Geoffrey Thomas Harris CBE
		1973-74 Lionel Roger Price Pugh CRD DL

# Iron & Steel Institute 1869

## THE JOURNAL

OF THE

## IRON & STEEL INSTITUTE.

LONDON:

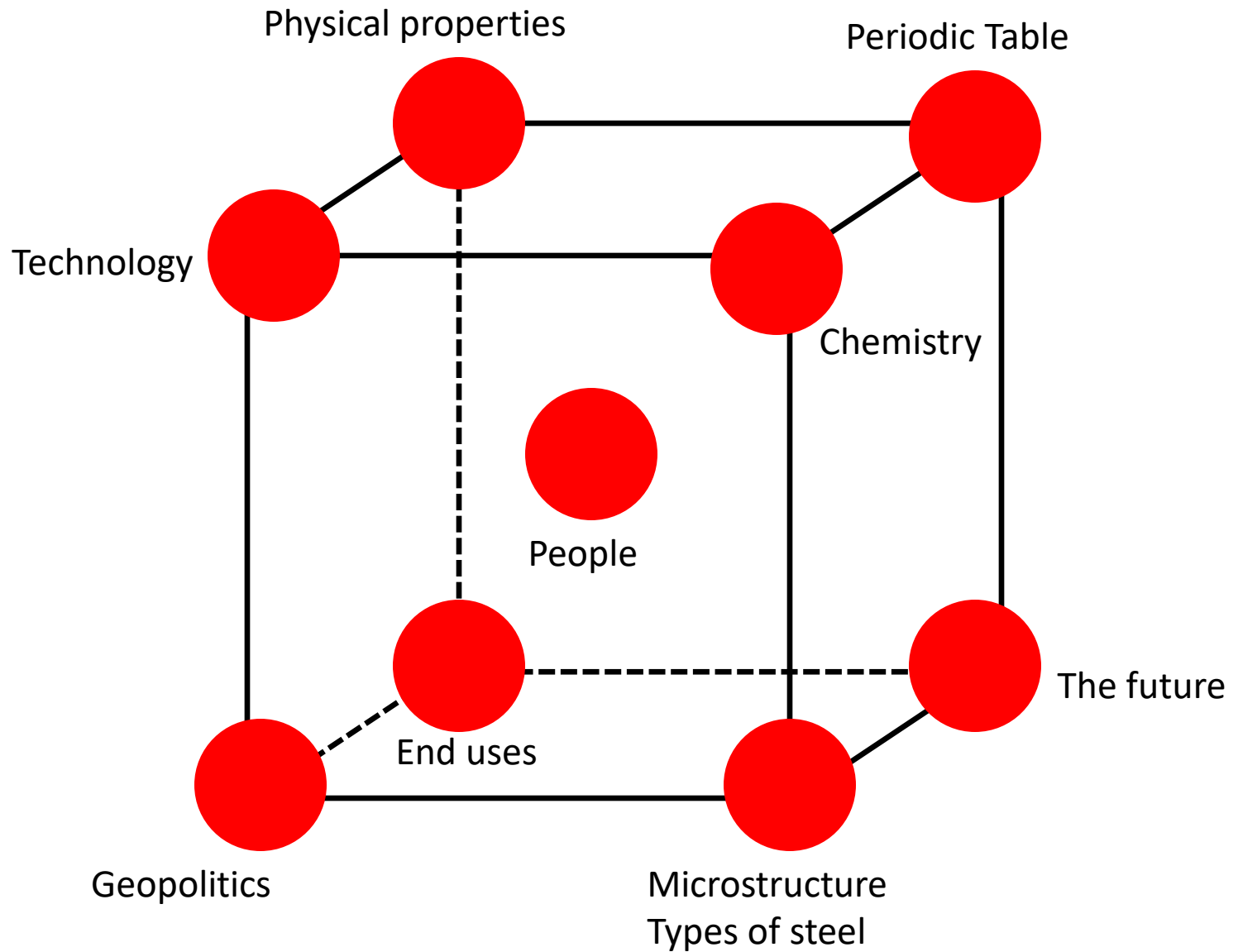
E. & F. N. SPON, 48, CHARING CROSS.

PRICE, SEVEN SHILLINGS AND SIXPENCE.

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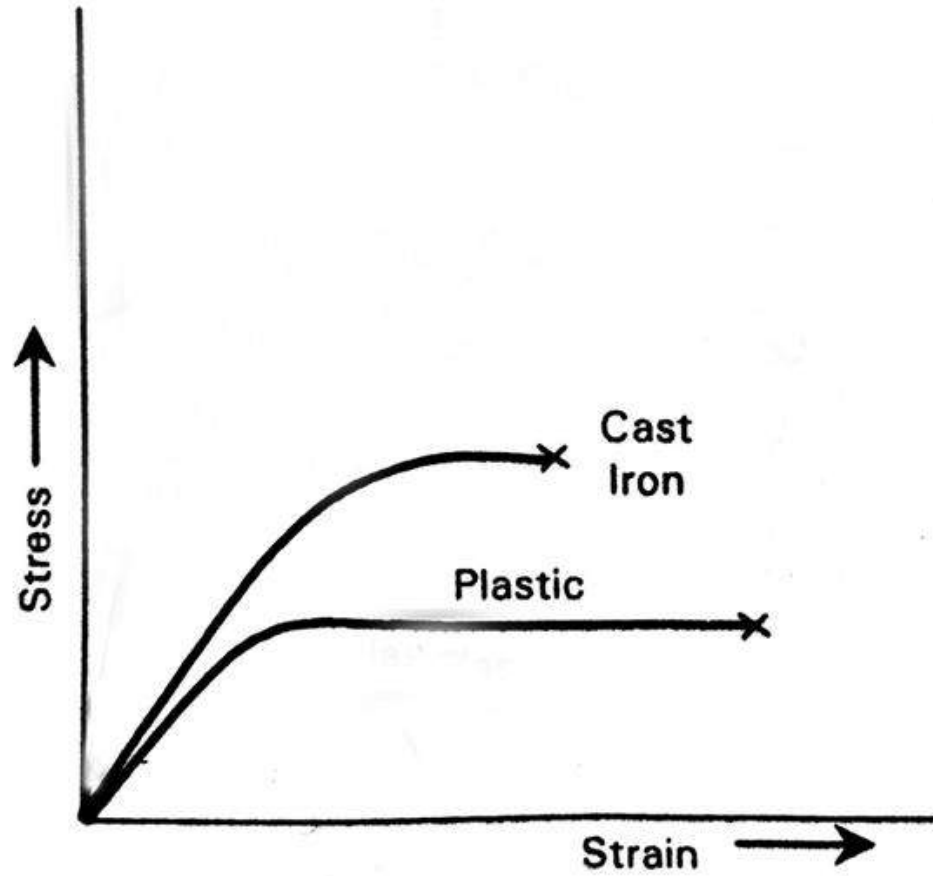
# 150 years of steel – what this talk is about



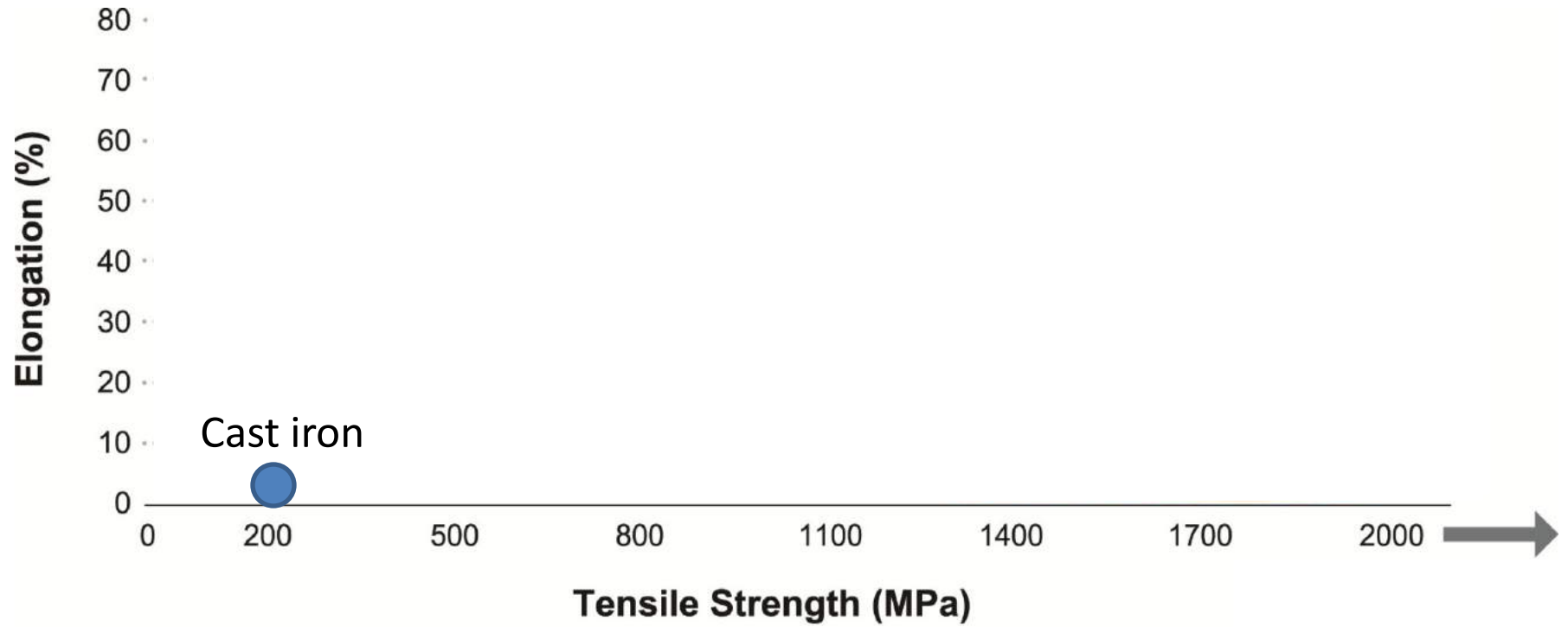
# Ironbridge – 1779 – Abraham Darby III – cast iron



**Cast iron – stronger than plastic. Brittle. Good in compression.**



# Position of cast iron



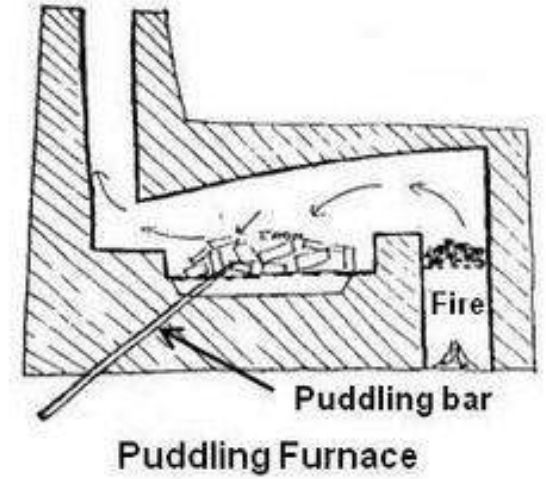
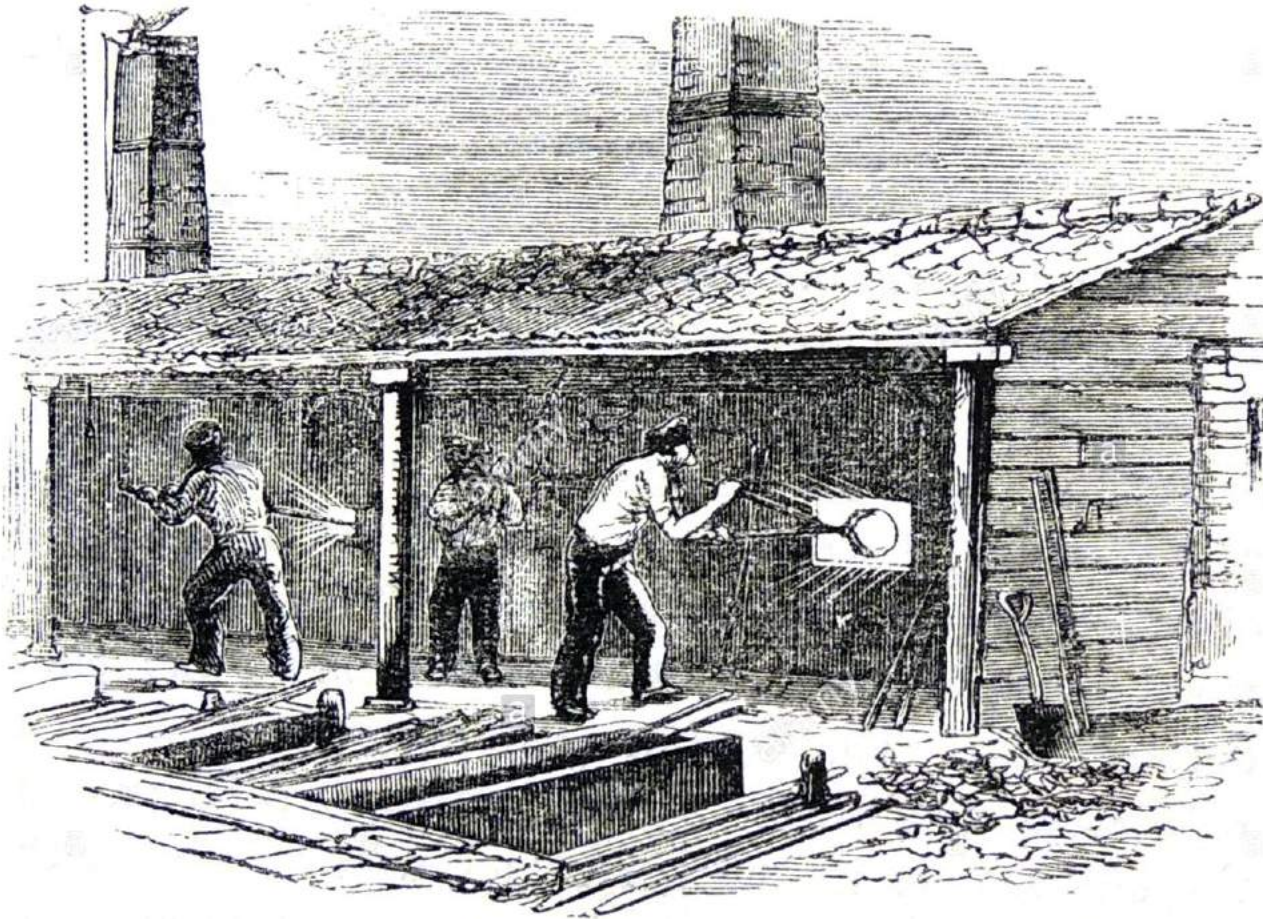
# 150<sup>th</sup> anniversary of the Periodic Table – knowledge in 1869

Period	1 I A	2 II A	3 III B	4 IV B	5 V B	6 VI B	7 VII B	8 VIII B	9 VIII B	10 VIII B	11 I B	12 II B	13 III A	14 IV A	15 V A	16 VI A	17 VII A	18 VIII A
1	1 H hydrogen 1.008																	2 He helium 4.003
2	3 Li lithium 6.968	4 Be beryllium 9.012											5 B boron 10.81	6 C carbon 12.01	7 N nitrogen 14.01	8 O oxygen 16.00	9 F fluorine 19.00	10 Ne neon 20.18
3	11 Na sodium 22.99	12 Mg magnesium 24.31											13 Al aluminum 26.98	14 Si silicon 28.09	15 P phosphorus 30.97	16 S sulfur 32.07	17 Cl chlorine 35.45	18 Ar argon 39.95
4	19 K potassium 39.10	20 Ca calcium 40.08	21 Sc scandium 44.96	22 Ti titanium 47.87	23 V vanadium 50.94	24 Cr chromium 52.00	25 Mn manganese 54.94	26 Fe iron 55.85	27 Co cobalt 58.93	28 Ni nickel 58.69	29 Cu copper 63.55	30 Zn zinc 65.38	31 Ga gallium 69.72	32 Ge germanium 72.63	33 As arsenic 74.92	34 Se selenium 78.97	35 Br bromine 79.90	36 Kr krypton 83.80
5	37 Rb rubidium 85.47	38 Sr strontium 87.62	39 Y yttrium 88.91	40 Zr zirconium 91.22	41 Nb niobium 92.91	42 Mo molybdenum 95.95	43 Tc technetium 98	44 Ru ruthenium 101.1	45 Rh rhodium 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	54 Xe xenon 131.3
6	55 Cs cesium 132.9	56 Ba barium 137.3	† 57 Lu lutetium 175.0	† 58 Hf hafnium 178.5	† 59 Ta tantalum 180.9	† 60 W tungsten 183.8	† 61 Re rhenium 186.2	† 62 Os osmium 190.2	† 63 Ir iridium 192.2	† 64 Pt platinum 195.1	† 65 Au gold 197.0	† 66 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium 209	85 At astatine 210	86 Rn radon 222
7	87 Fr francium 223	88 Ra radium 226	† 67 Lr lawrencium 262	† 68 Rf rutherfordium 267	† 69 Db dubnium 268	† 70 Sg seaborgium 271	† 71 Bh bohrium 272	† 72 Hs hassium 270	† 73 Mt meitnerium 276	† 74 Ds darmstadtium 281	† 75 Rg roentgenium 280	† 76 Cn copernicium 285	113 Nh nihonium 284	114 Fl flerovium 289	115 Mc moscovium 288	116 Lv livermorium 293	117 Ts tennessine 292	118 Og oganesson 294

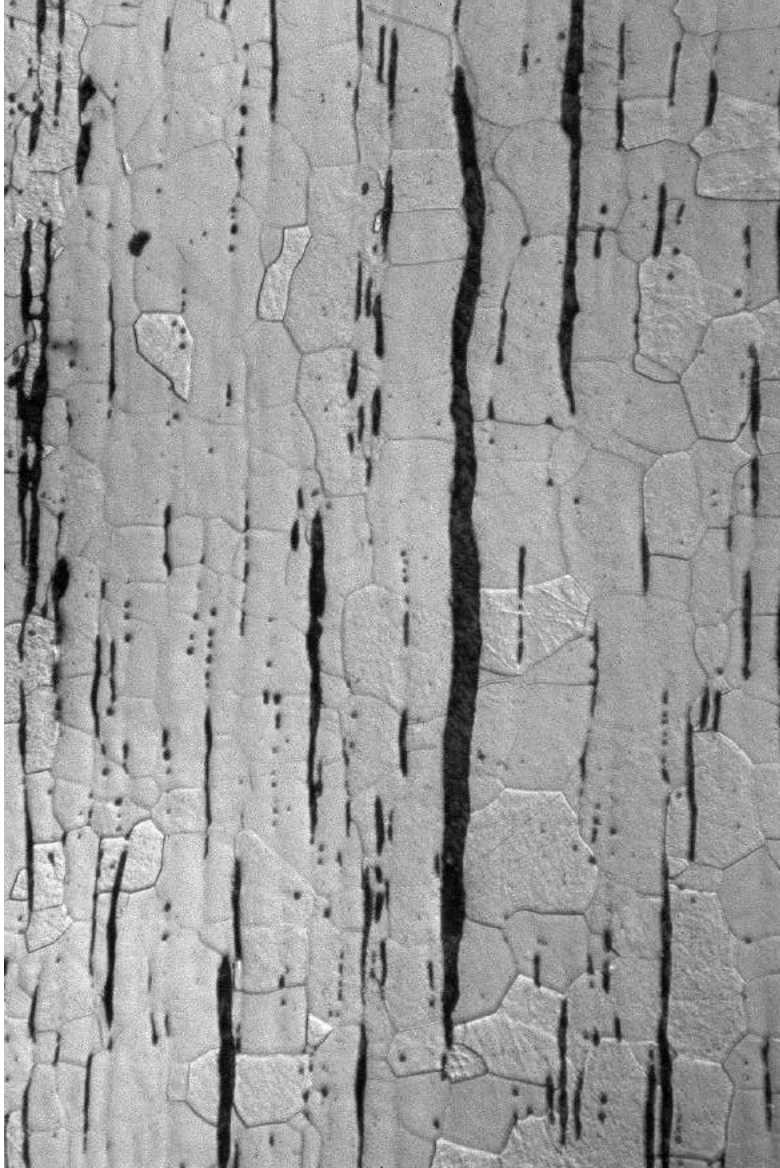
29	+2.1	← ions commonly formed
<b>Cu</b>		
copper		
63.55		← atomic mass (rounded)



6000 puddling furnaces in the UK make 2 million tonnes of wrought iron - 1869



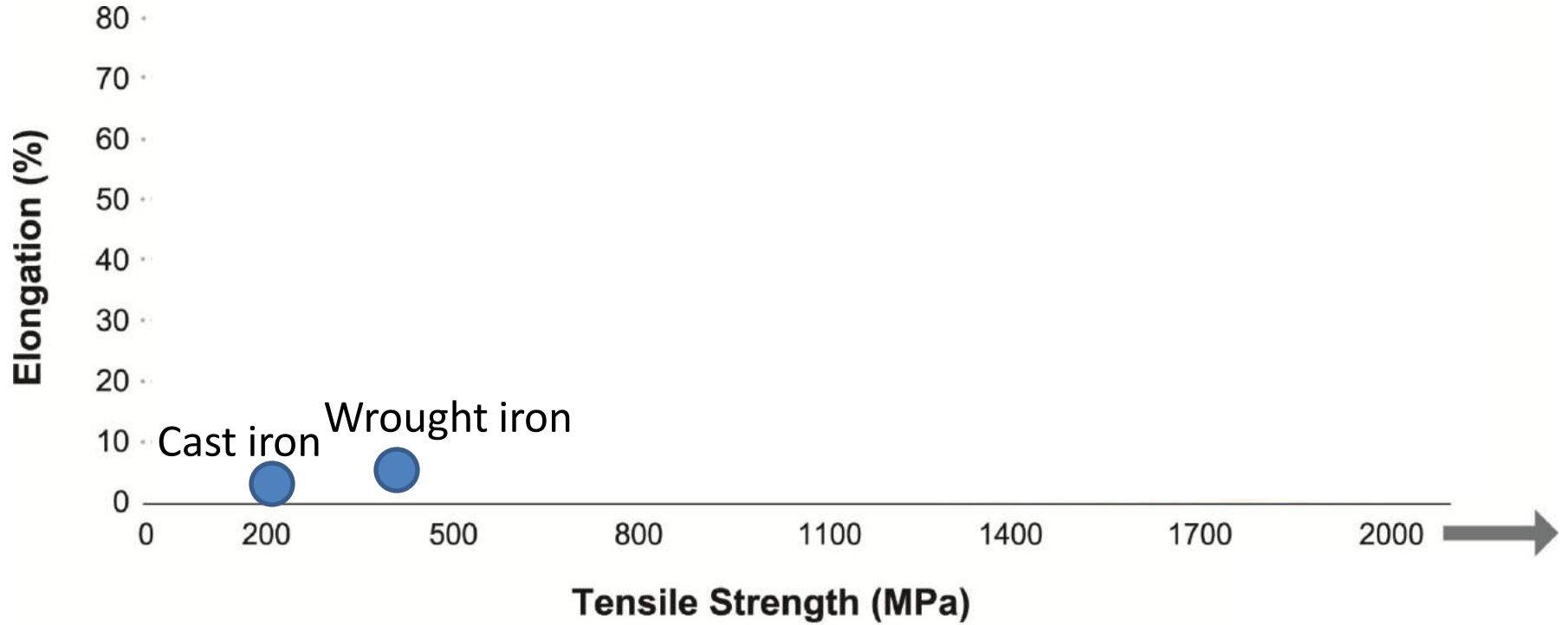
# Henry Clifton Sorby – Father of Metallography – 1826 - 1908



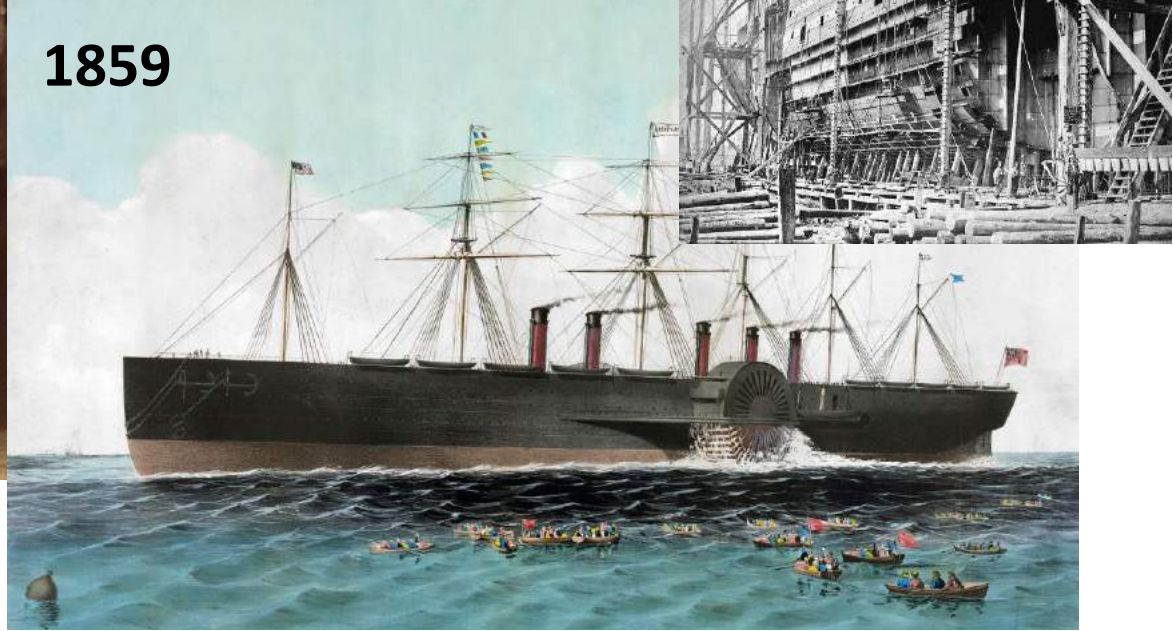
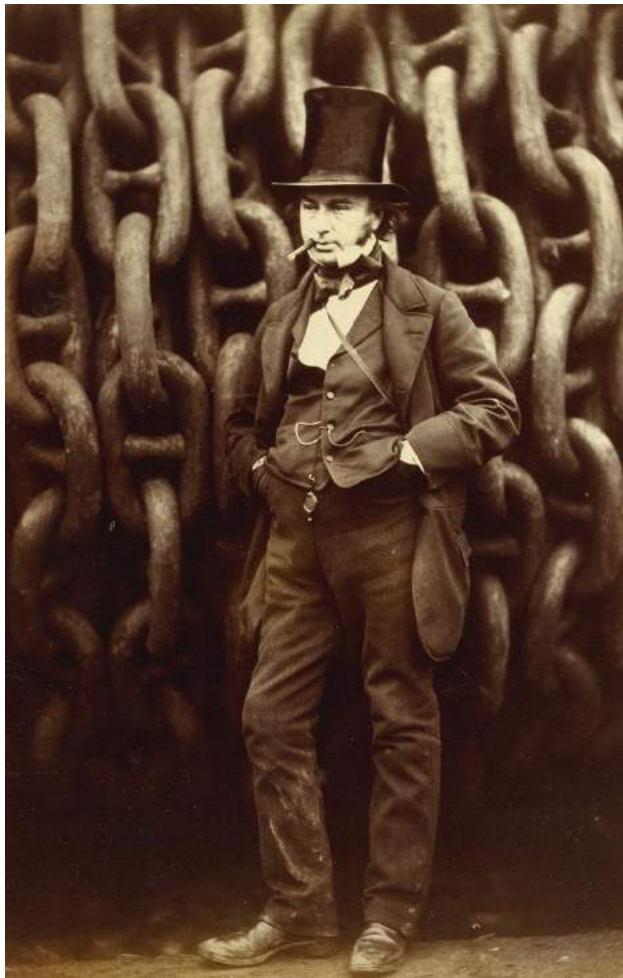
**Wrought iron**



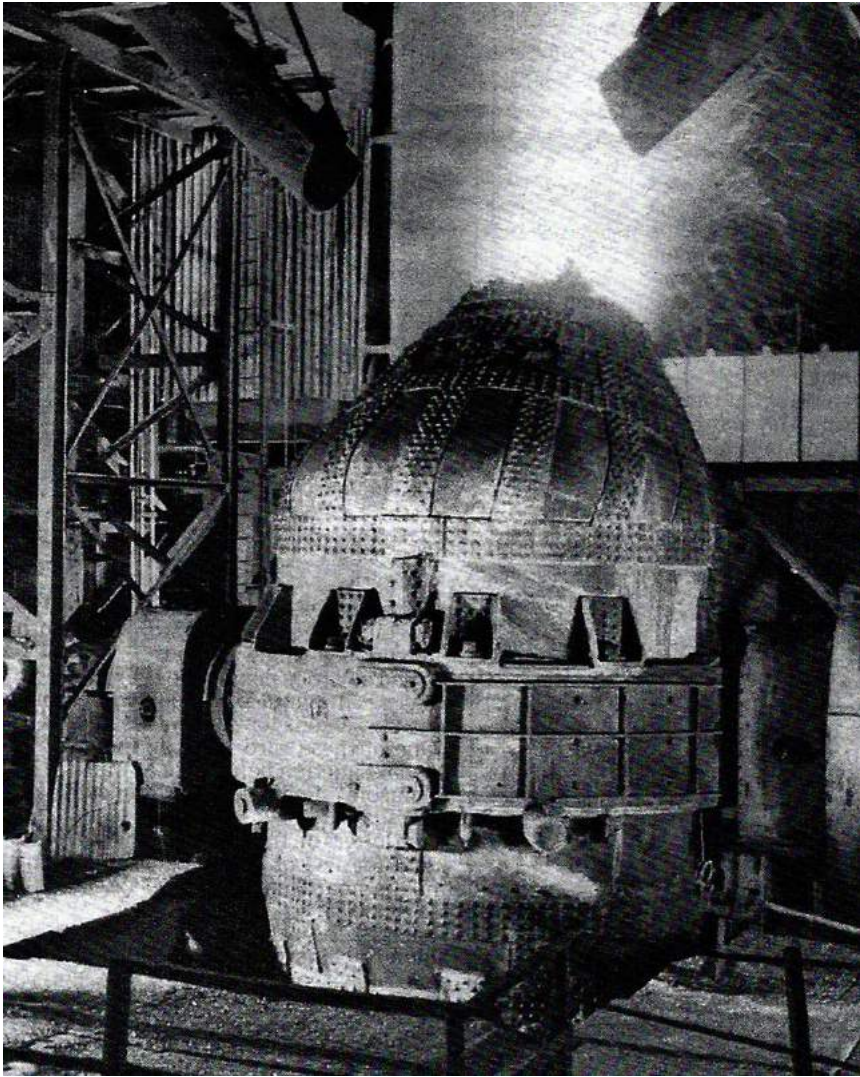
# Position of wrought iron



# Isambard Kingdom Brunel (1806 – 1859)



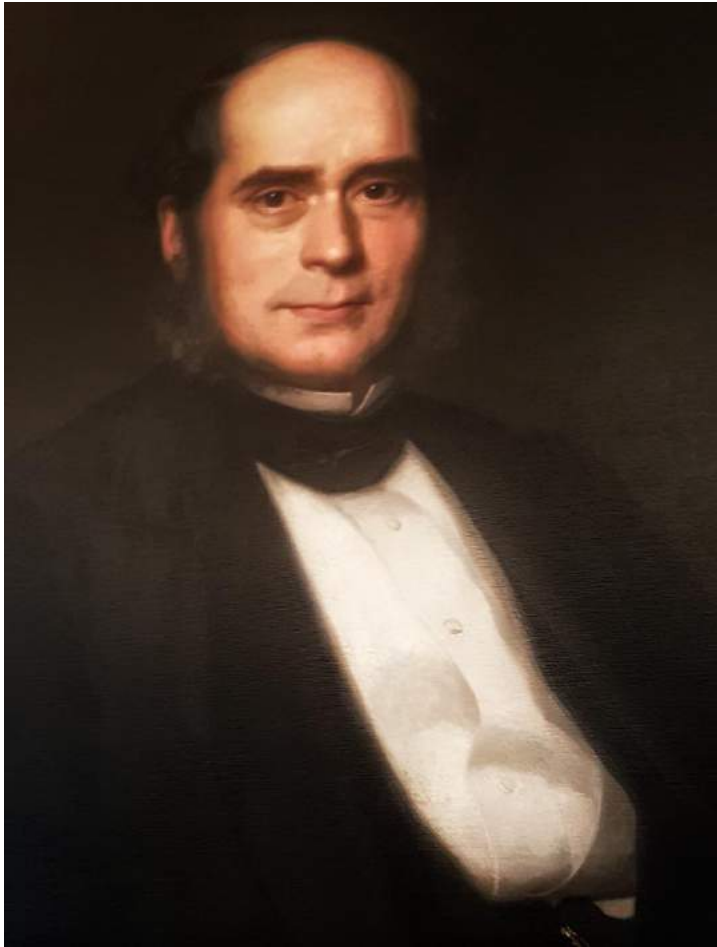
# Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856

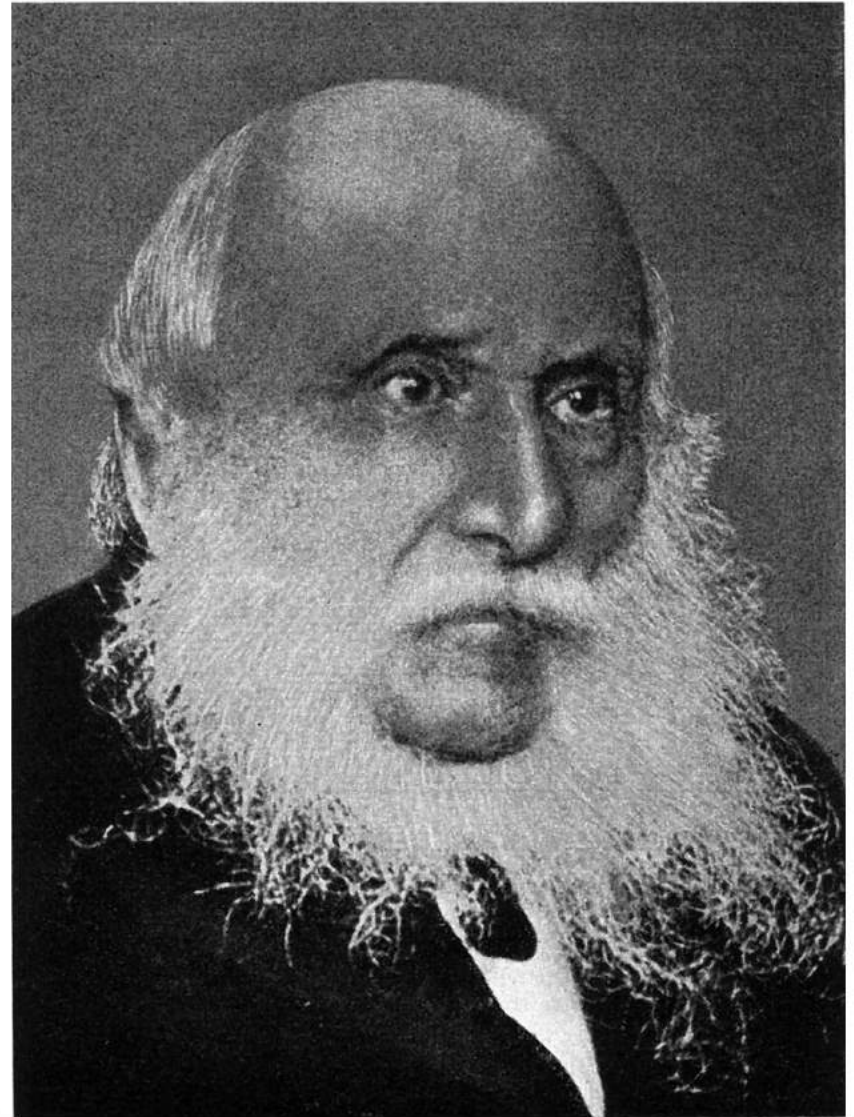


# Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856



# Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856







**Sidney Gilchrist Thomas 1850 – 1885 Elimination of phosphorus – basic converter - 1878**

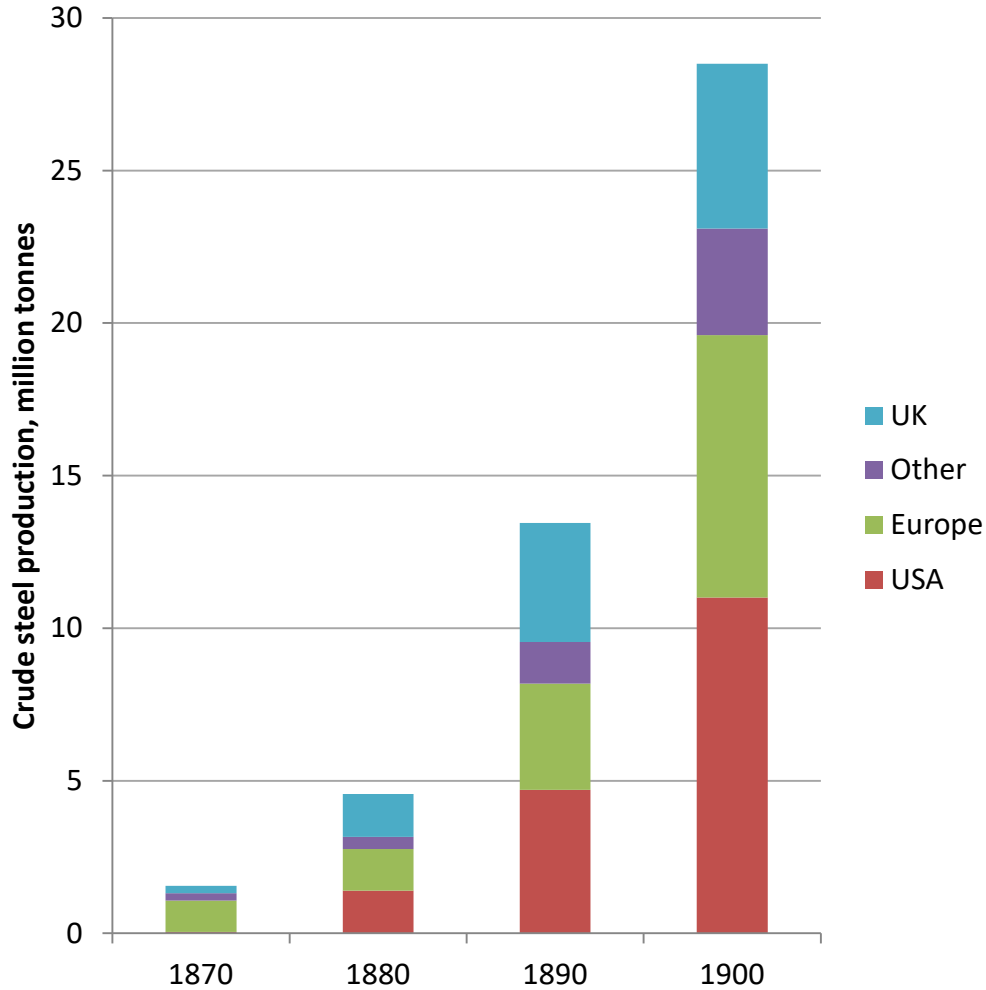


# Brooklyn Bridge 1880 – wrought iron

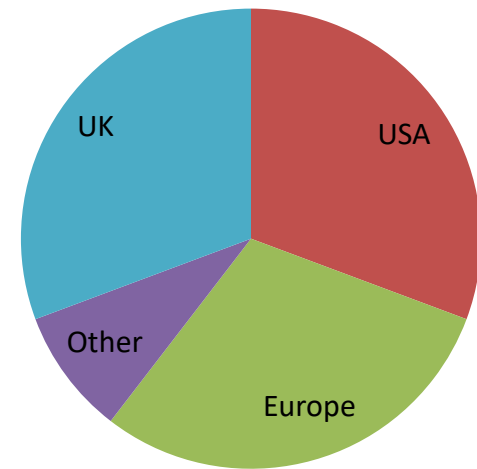


# 1880 steel production worldwide – UK and USA have 31% each

### Growth of steel production by region, 1870 - 1900



### Steel production share by region, 1880



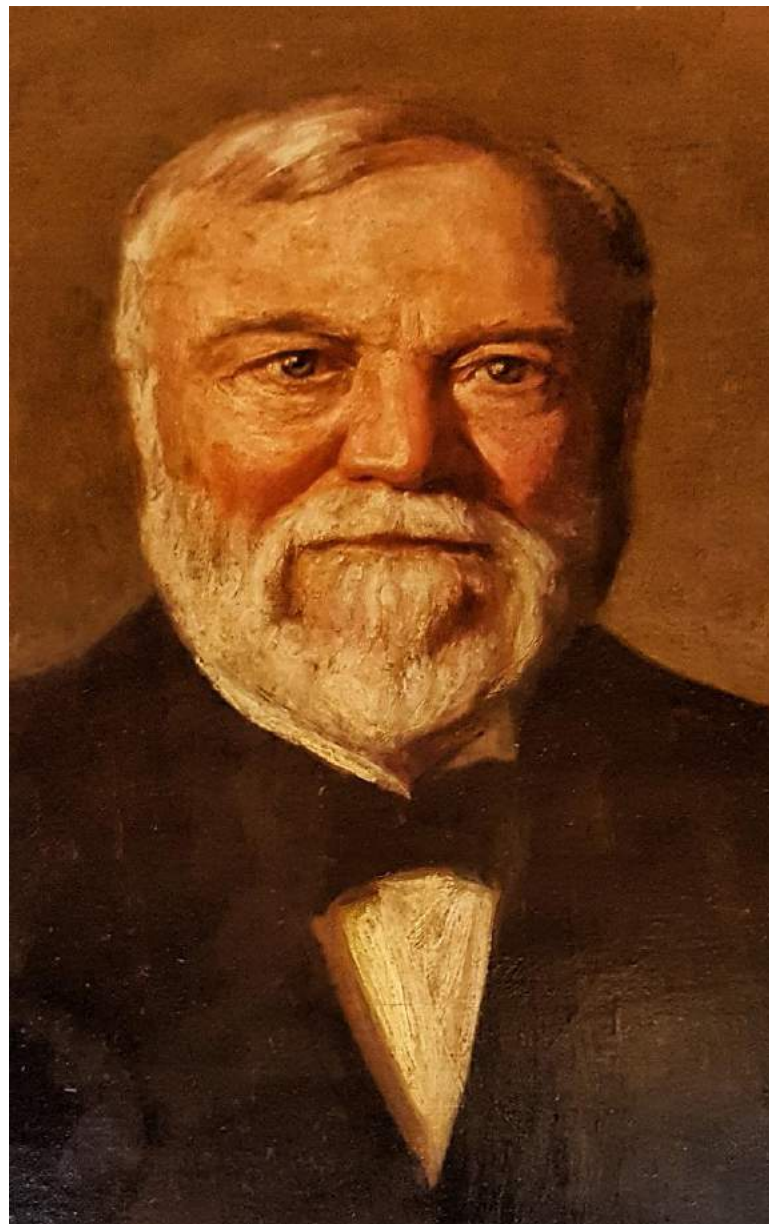
# Dr James Burgess Readman - first operational; EAF - 1888



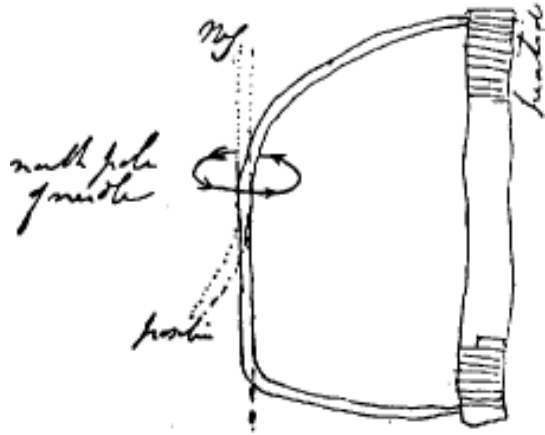
# Eiffel Tower 1889 – wrought iron – 10,000 tonnes



Andrew Carnegie (1835 – 1919) Built Carnegie Steel, forerunner of US Steel. Sold to J P Morgan 1901



# Development of the thermocouple – commercial Pt/Rh by 1900



**Early sketch by Ohm,  
1820s**



**Le Chatelier, uses  
platinum/rhodium  
Thermocouple, 1885**



**Edward Matthey  
commercial version of  
Pt/Rh thermocouple  
1900**

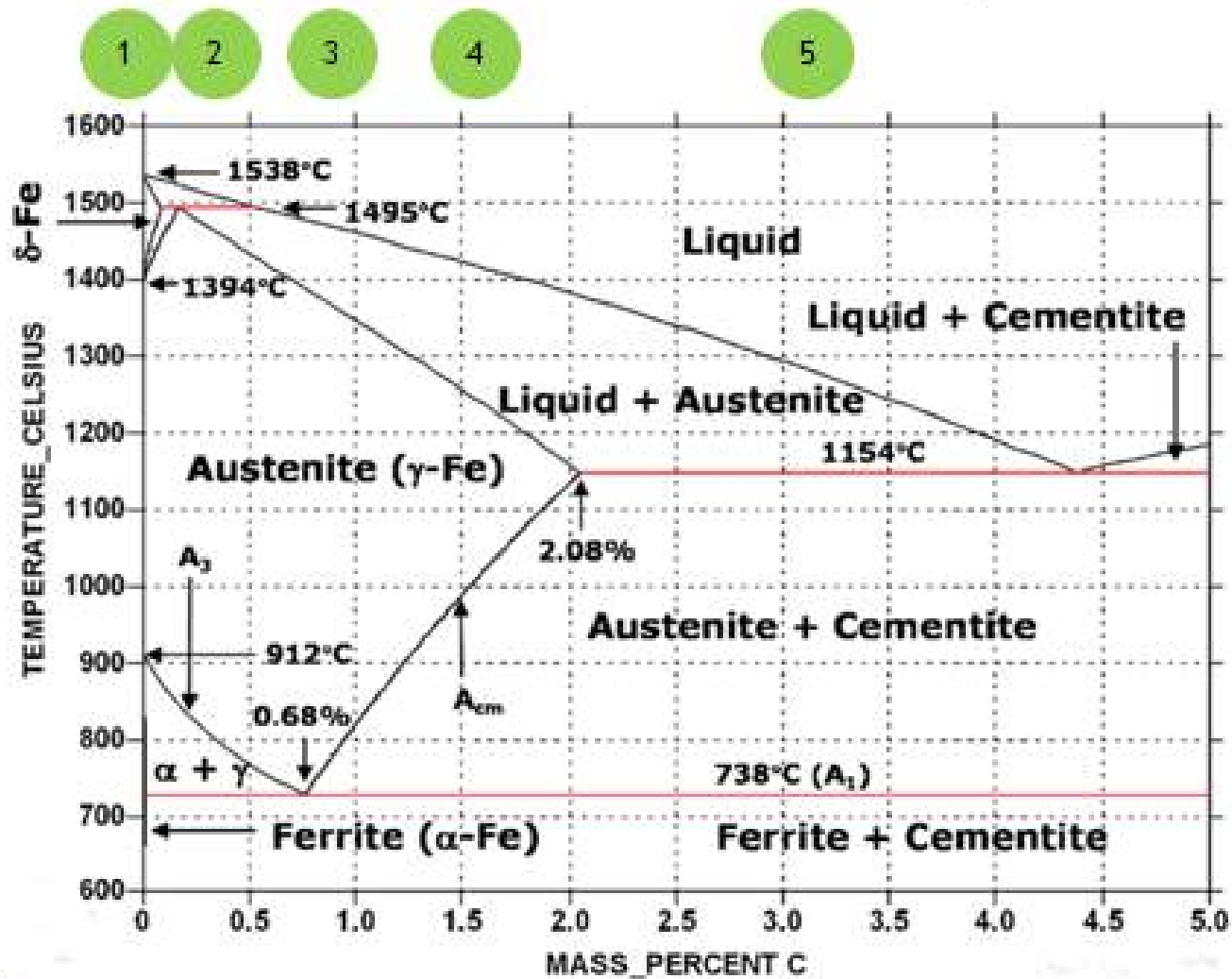
# Taking temperature of Open Hearth Furnace



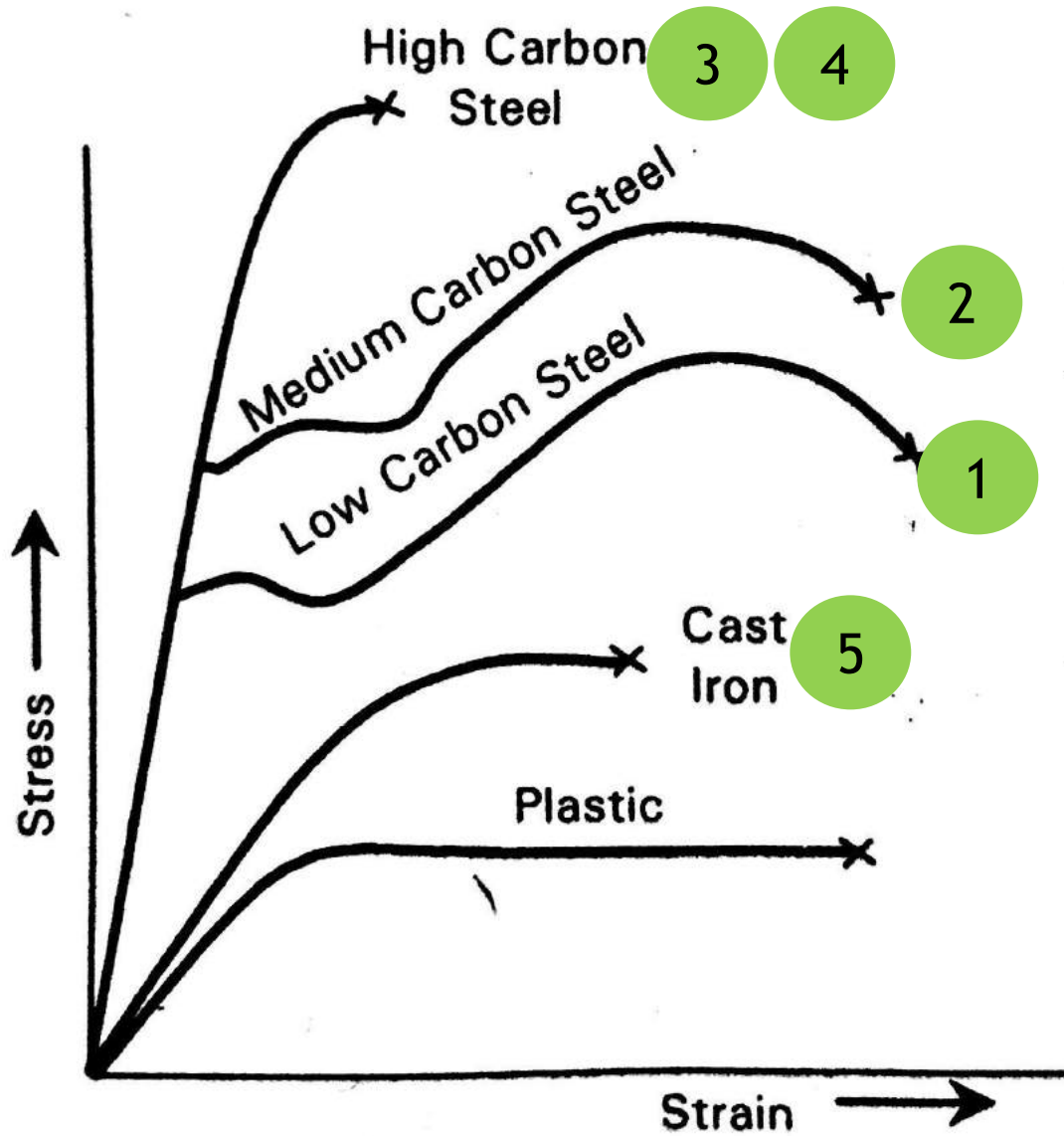


# The Fe/C equilibrium phase diagram – emerges after 1900

steel ← → cast iron



# Stress strain curve for low, medium and high carbon steels



# Steel begins to be understood and classified

**Carbon steel**, or **plain carbon steel**, is steel where the main alloying element is carbon. Manganese must be less than 1.65%, silicon 0.60% and copper 0.60%

1

**Low carbon** steels have 0.05% - 0.29% carbon. A large proportion of steel has carbon contents within this range

2

**Medium carbon** steels have 0.30% - 0.59% carbon, and often some alloying elements. These are harder, stronger steels, modified by heat treatment

3

**High carbon** steels have 0.60 – 0.99% carbon. These have high strength and good wear resistance – forgings, automotive components

4

**Ultra high carbon** steels have 1.0 – 2.0% carbon. Very hard, sharp (knives)

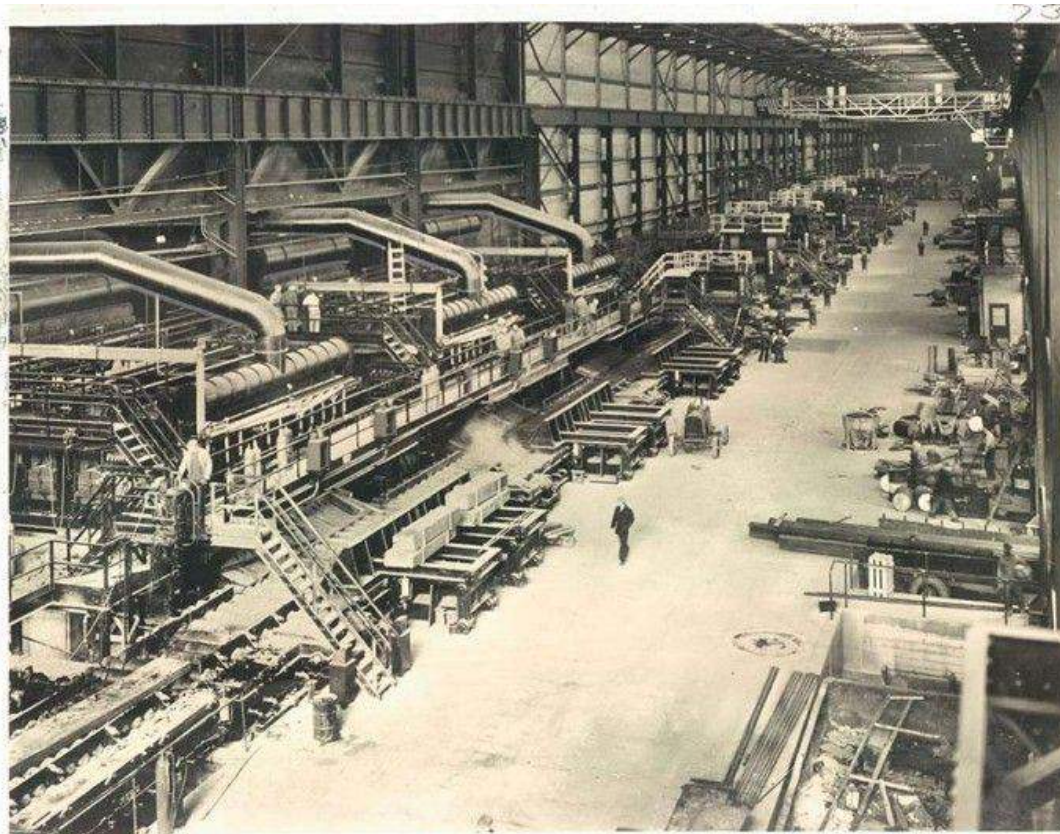
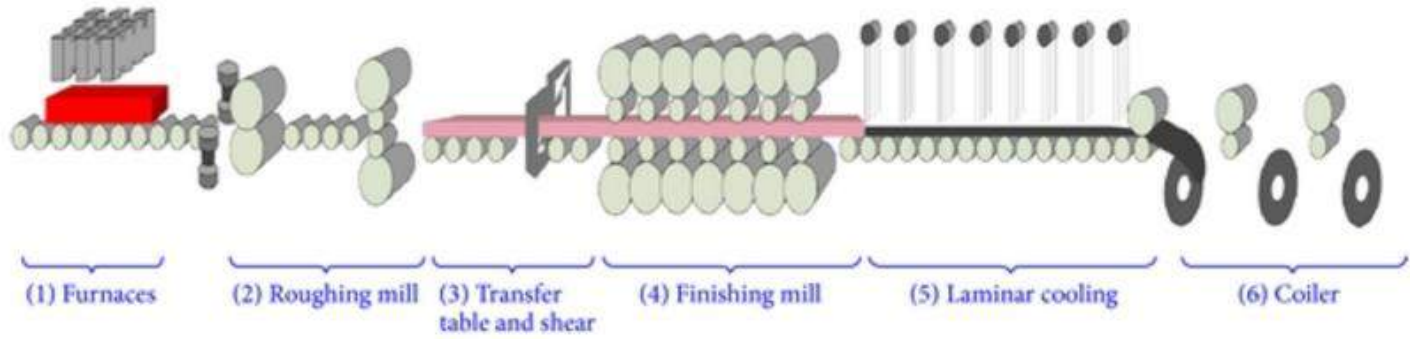
5

**Over 2% carbon** – material becomes **cast iron** not steel

## Steel poured into ingot moulds for subsequent rolling – 1800s onwards



# Hot Strip Mill – developed from 1904



# Empire State Building - 1930



# Empire State Building - 1930



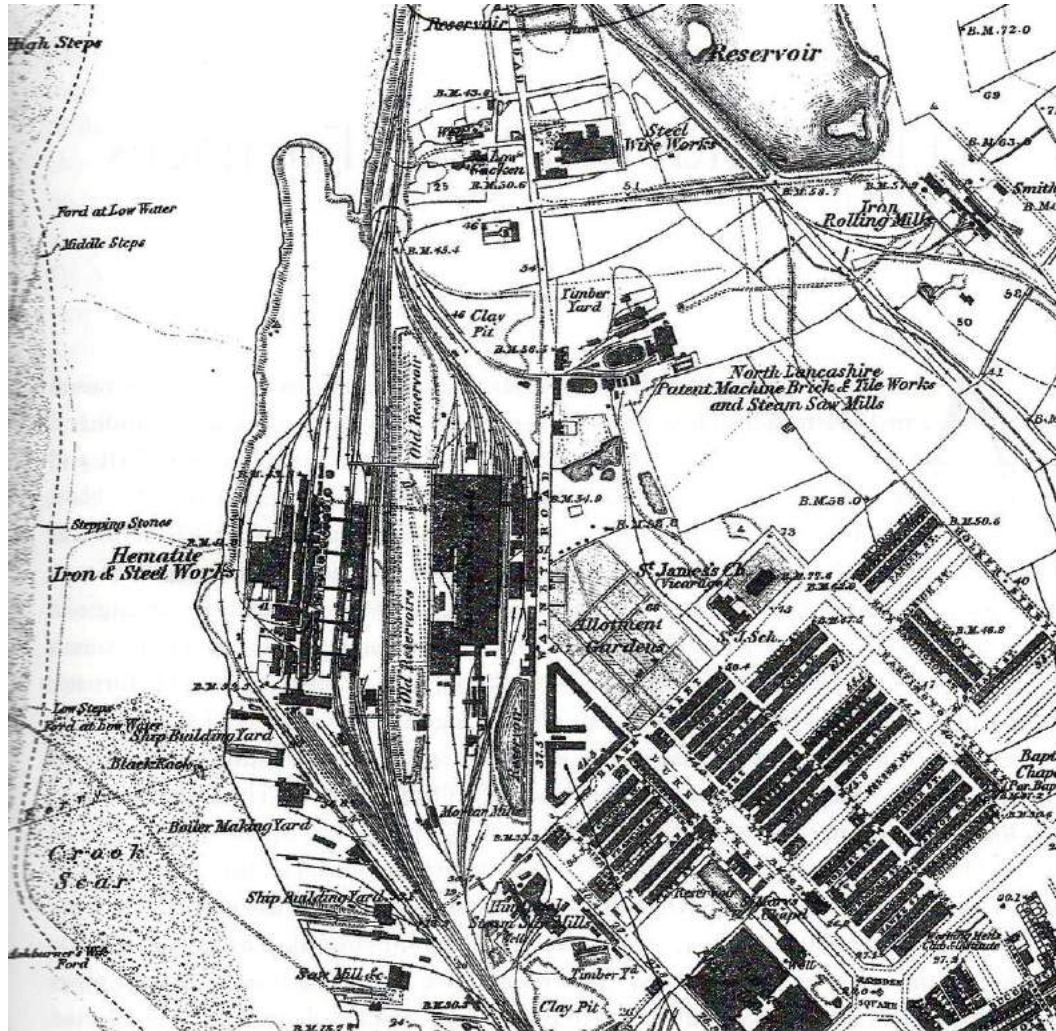
**Sydney Harbour Bridge – 1930 photo – bridge opened 1932 – 86% steel from UK**



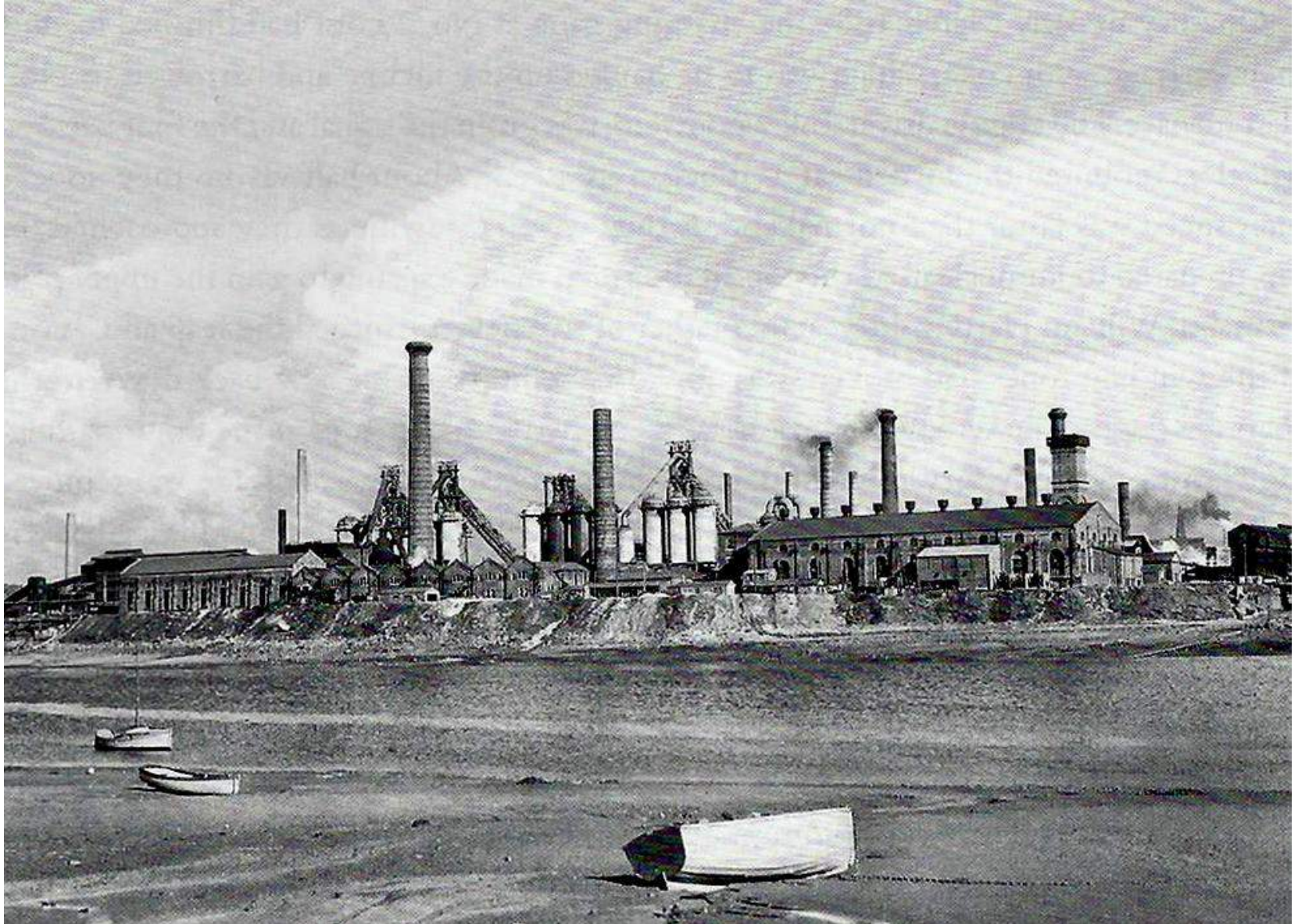
*SYDNEY HARBOUR BRIDGE – JULY, 1930.*



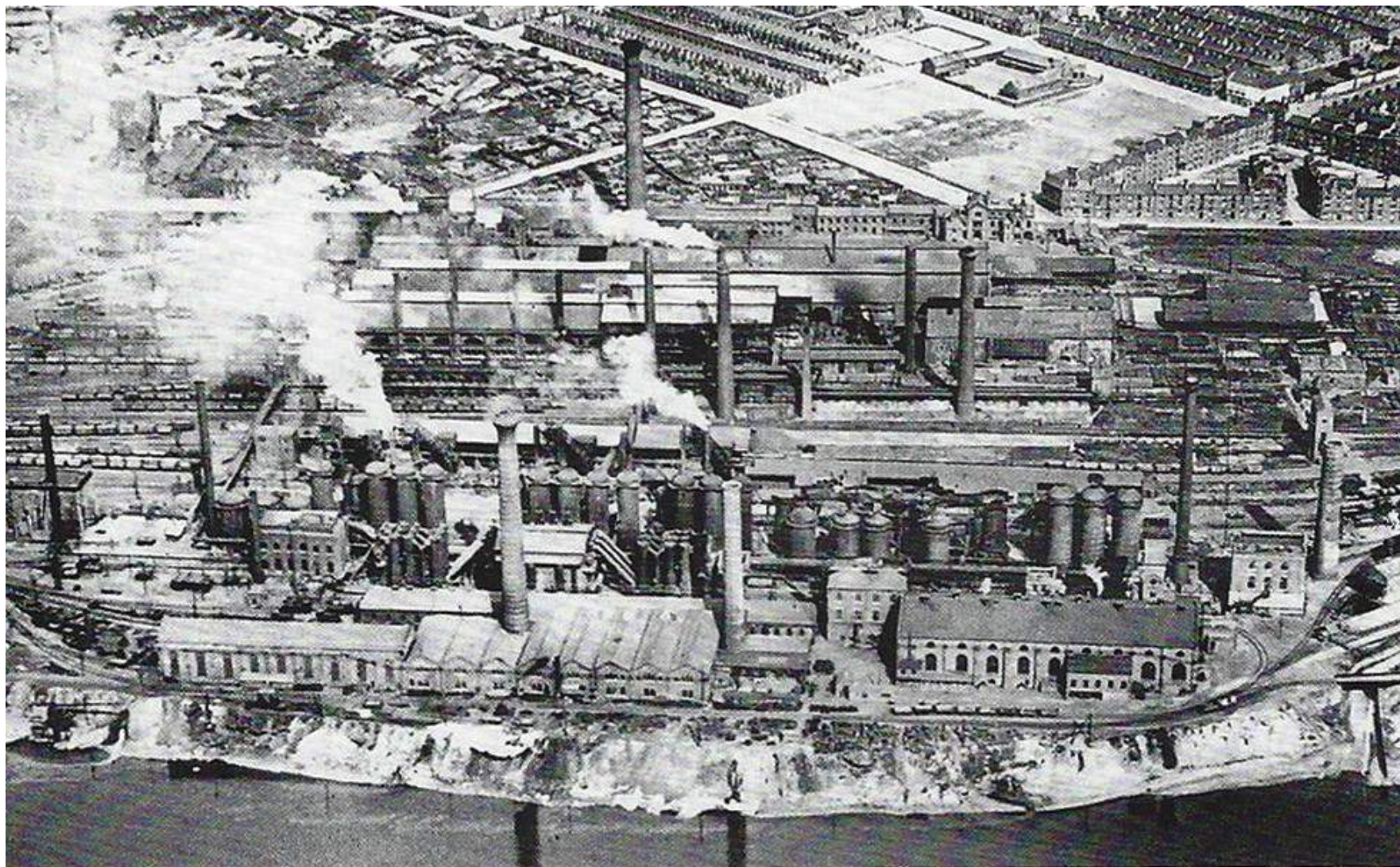
# Barrow Steelworks, 1936



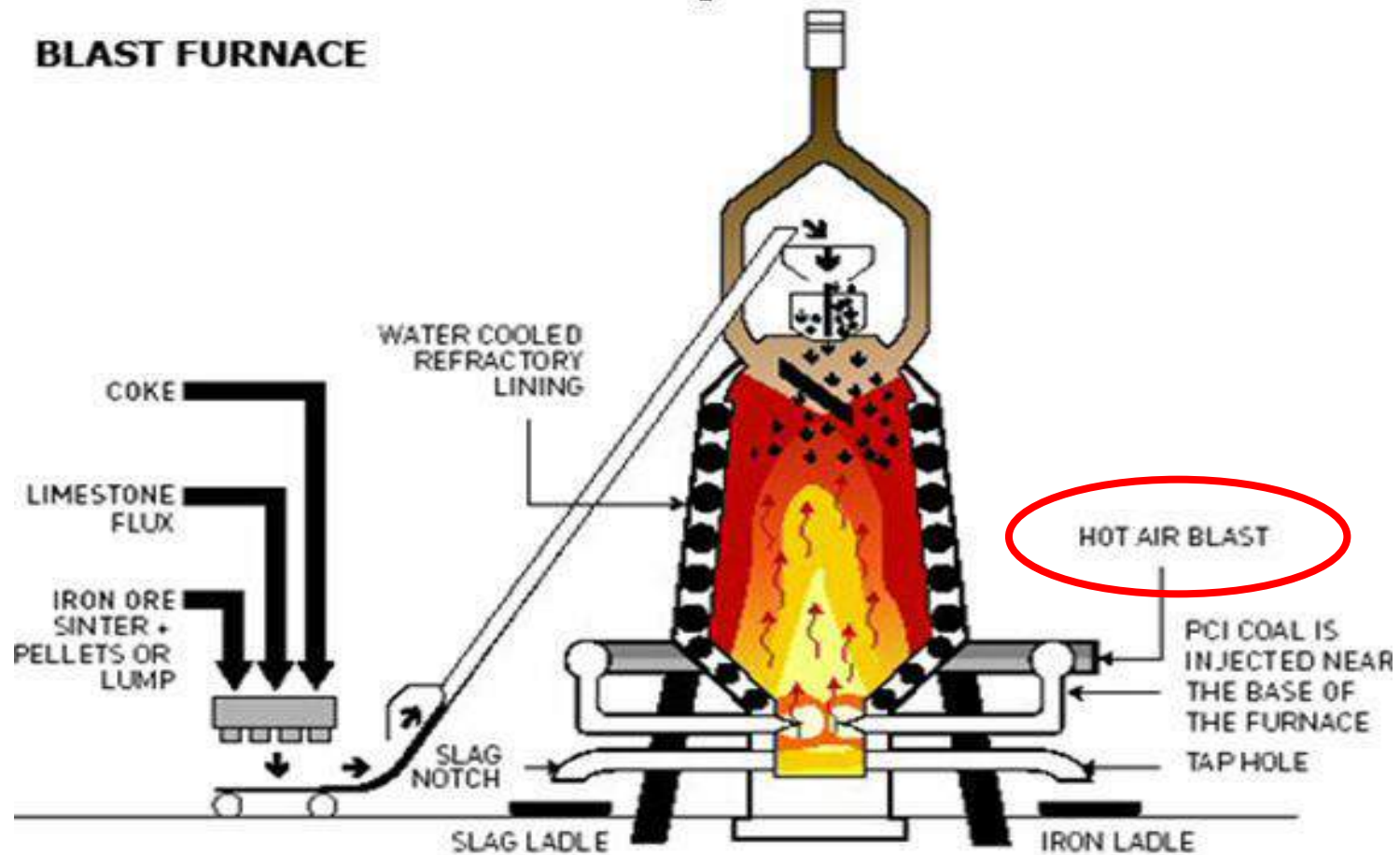
# Barrow steelworks, 1936



# Barrow steelworks, 1936



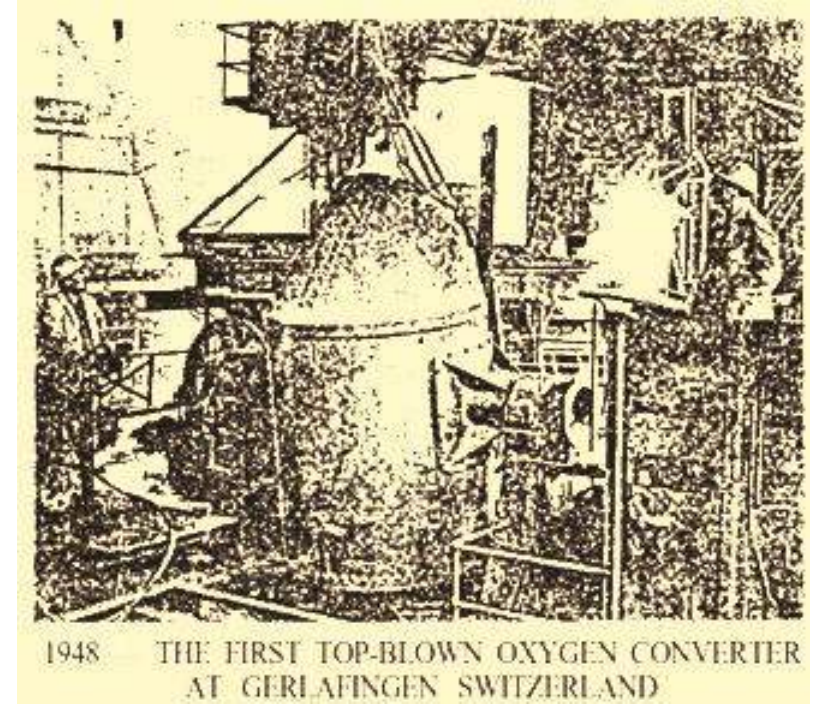
# A blast furnace



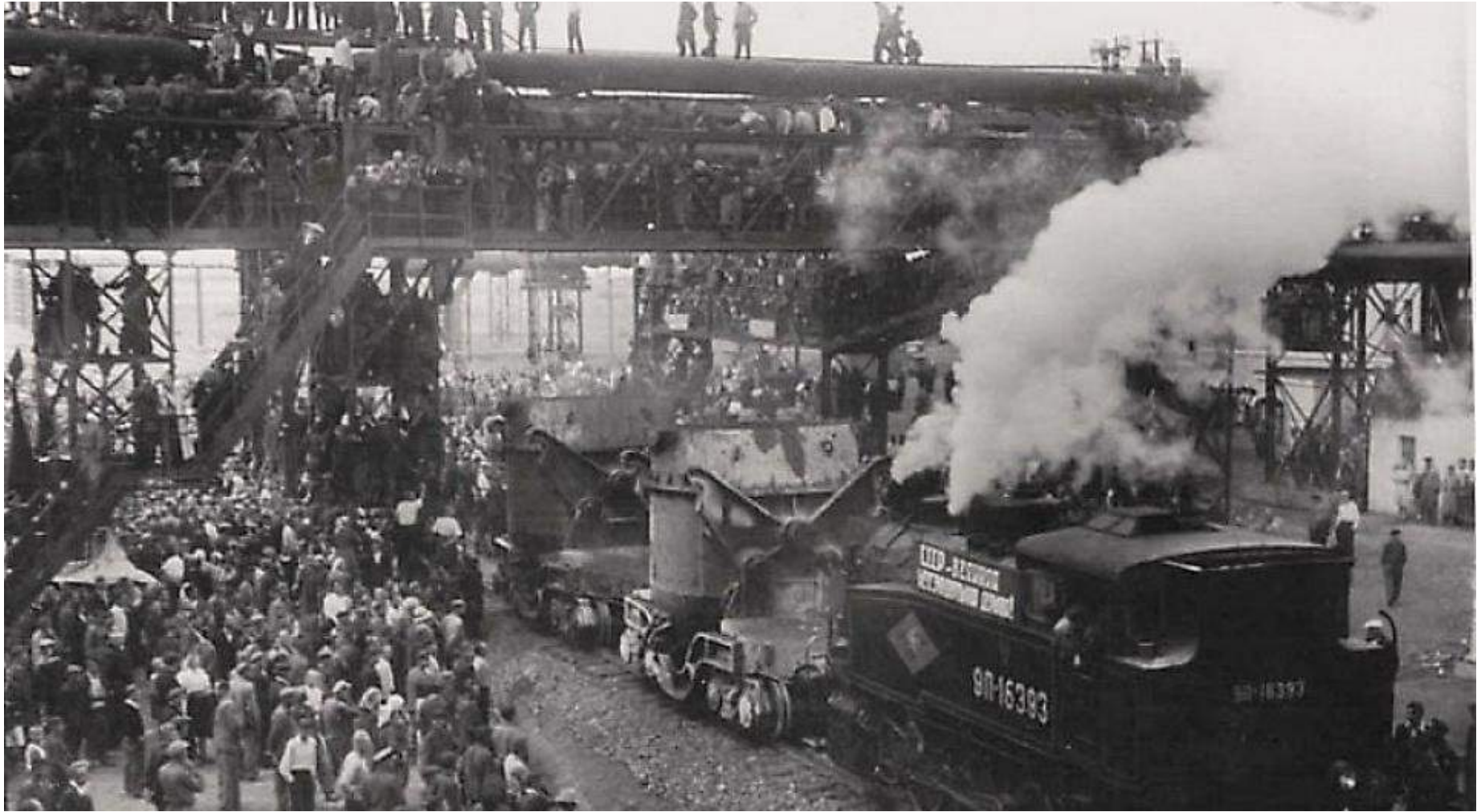
# Tongsman – Barrow - 1936



# Robert Durrer 1890 - 1978 Oxygen blown steel, 1948



# Russia – 1955 – first hot metal produced at Cherepovets (Severstal)





One cannot advance without mistakes... It is necessary to make mistakes.

Chairman Mao, 1956



# China – Great Leap Forward - 1958



## The white heat of this revolution - 1963



“The Britain that is going to be forged in **the white heat of this revolution** will be no place for restrictive practices or for outdated methods on either side of industry.”

Harold Wilson, Labour Party Conference 1963

**British Admiral – built Barrow 1965 – scrapped 1976 in Taiwan**

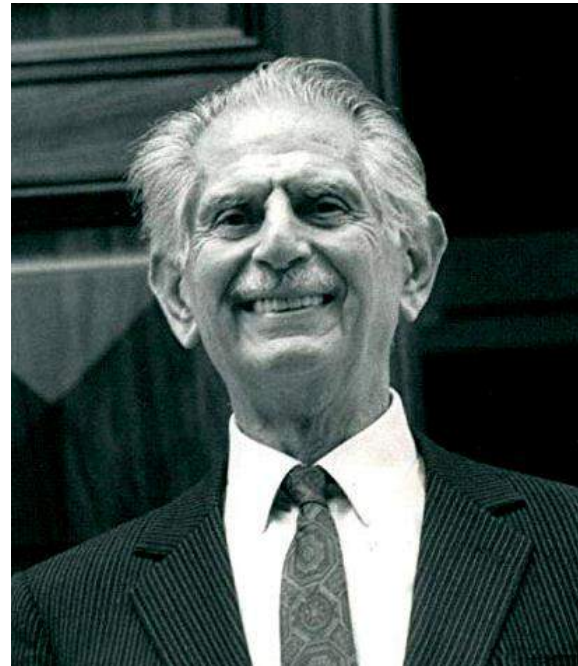


## British Steel Corporation (BSC) – nationalised in 1967

- Key people – Lord Melchett and Sir Monty Finniston
- 269,000 people in the newly formed BSC
- The BSC board had consensus that growth lay ahead
- The plan for growth included an unprecedented £6bn over 10 years



**Lord Melchett - Chairman**



**Sir Monty Finniston - CEO**

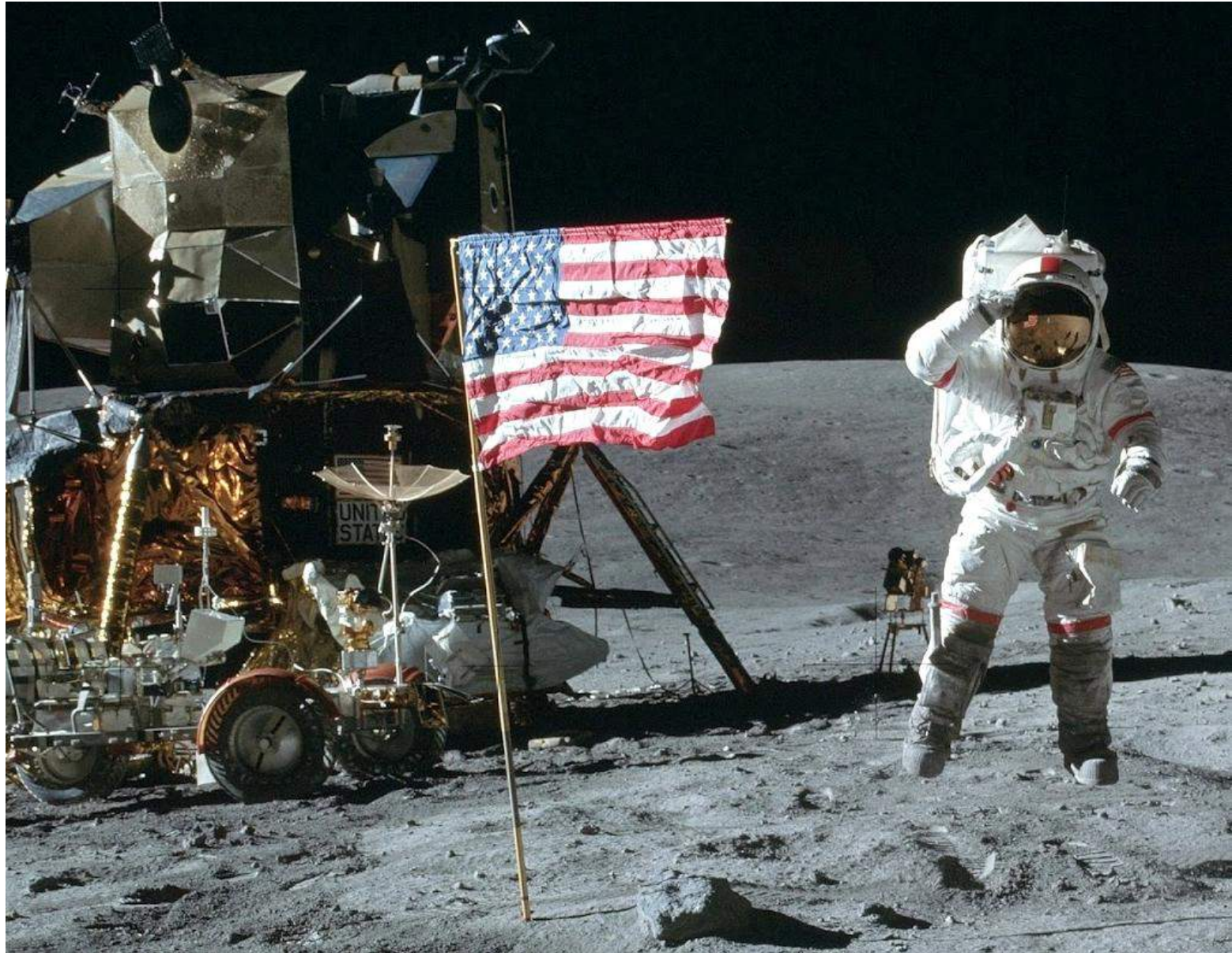
## Revolution – 26 August 1968. B side of Hey Jude.

“You say you want a revolution  
Well, you know  
We all want to change the world  
You tell me that it's evolution  
Well, you know  
We all want to change the world...

...but if you go carrying pictures of  
chairman Mao  
You ain't going to make it with anyone  
anyhow  
Don't you know it's gonna be  
All right, all right, all right...”

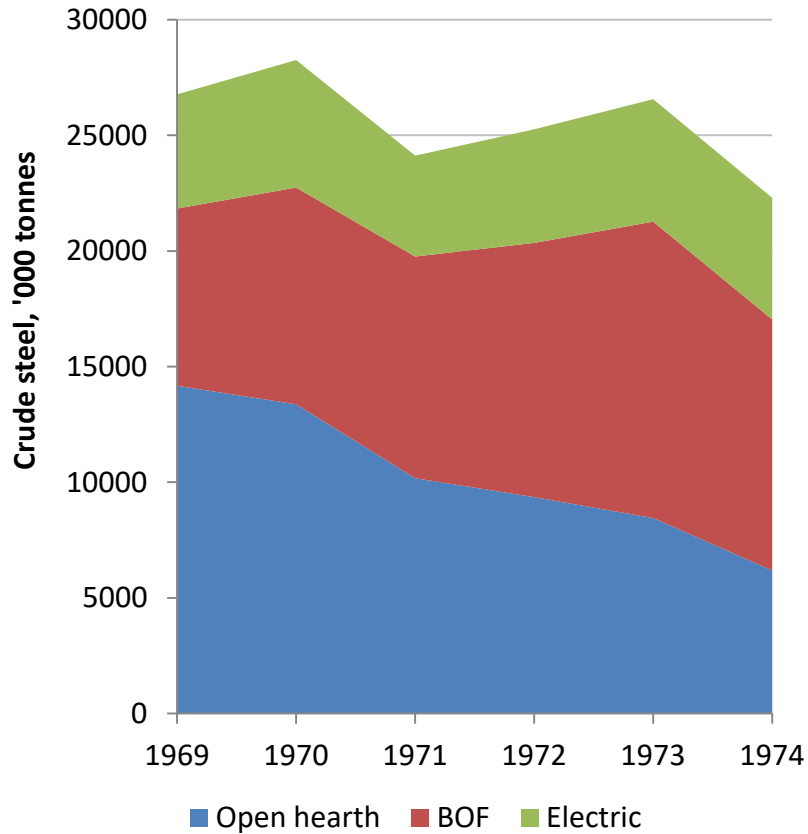
Songwriters: John Lennon / Paul McCartney  
Revolution lyrics © Sony/ATV Music Publishing LLC

# Moon landing, 20 July 1969

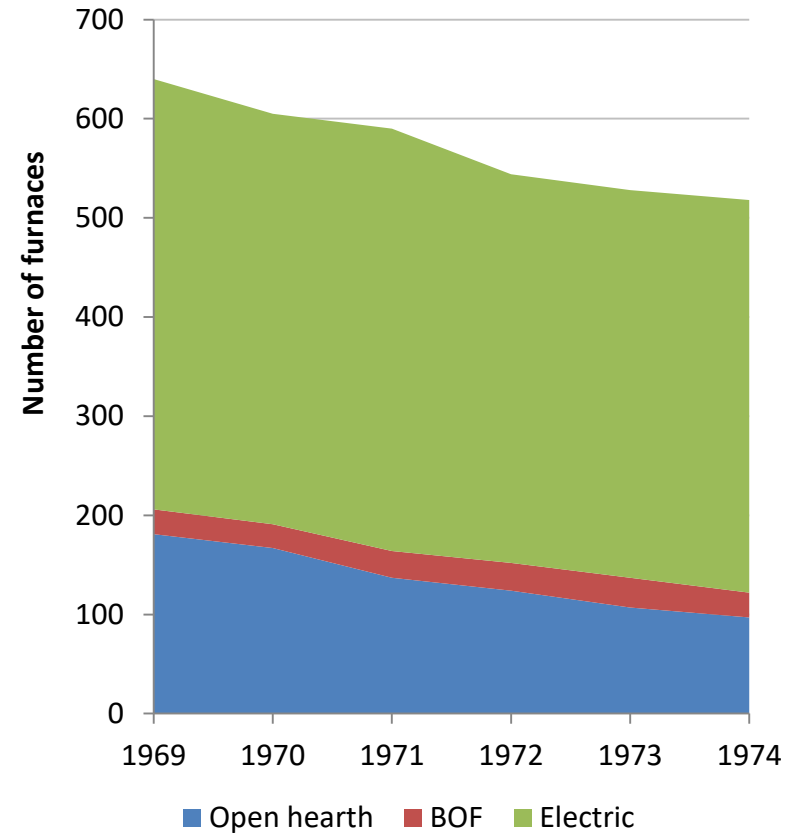


# British Steel 1969 – 1974. A period of revolution. 130,000 people by 1980.

### British Steel - production by process route 1969 - 1974

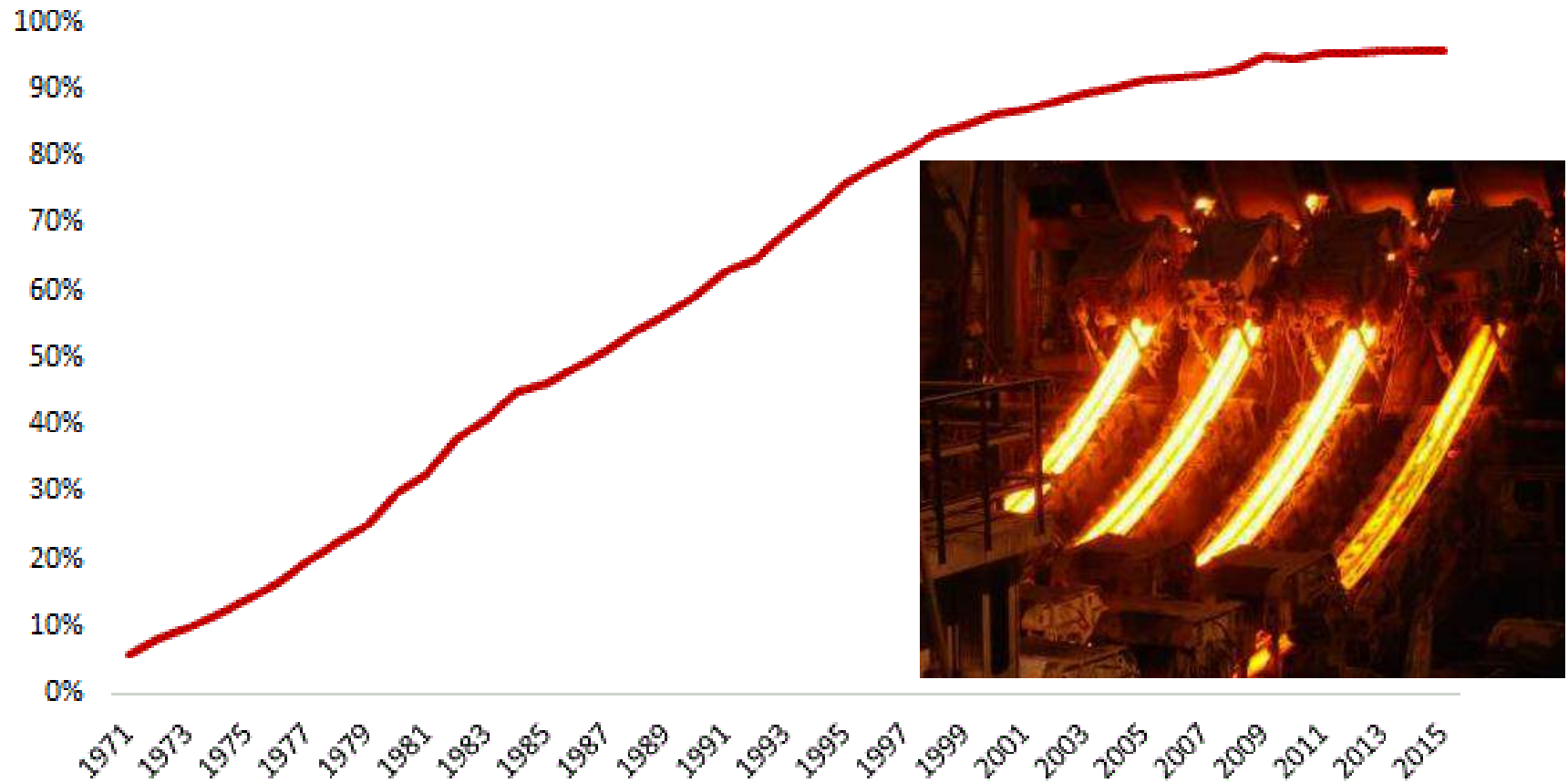


### British Steel – number of furnaces of each type, 1969 - 1974



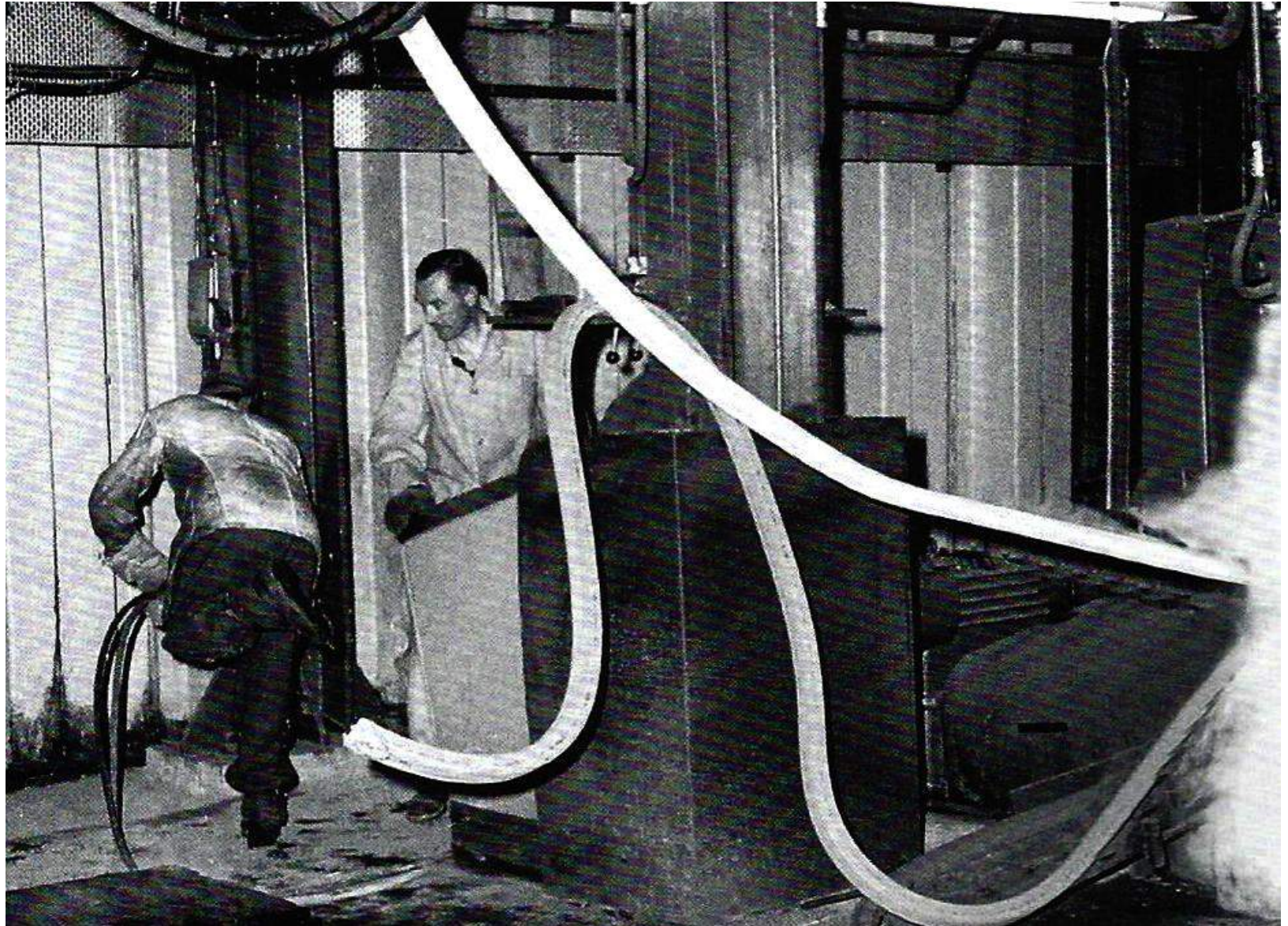
# Evolution of continuous casting

## Share of global crude steel output produced via continuous casting





## Cobble in concast billet – Barrow - 1970



## China – 1970s (Dong Biwu – Acting Chairman, 1972 – 1975)

- China needs to grow
- Needs new technology, larger more modern plants
- Seeks technology from Austria (BOF steelmaking)
- Japan – Baosteel modelled on Nippon Kimitsu
- Target 60mt crude steel by 1990
- \$60bn investment over 2 decades

CIA study (1979)

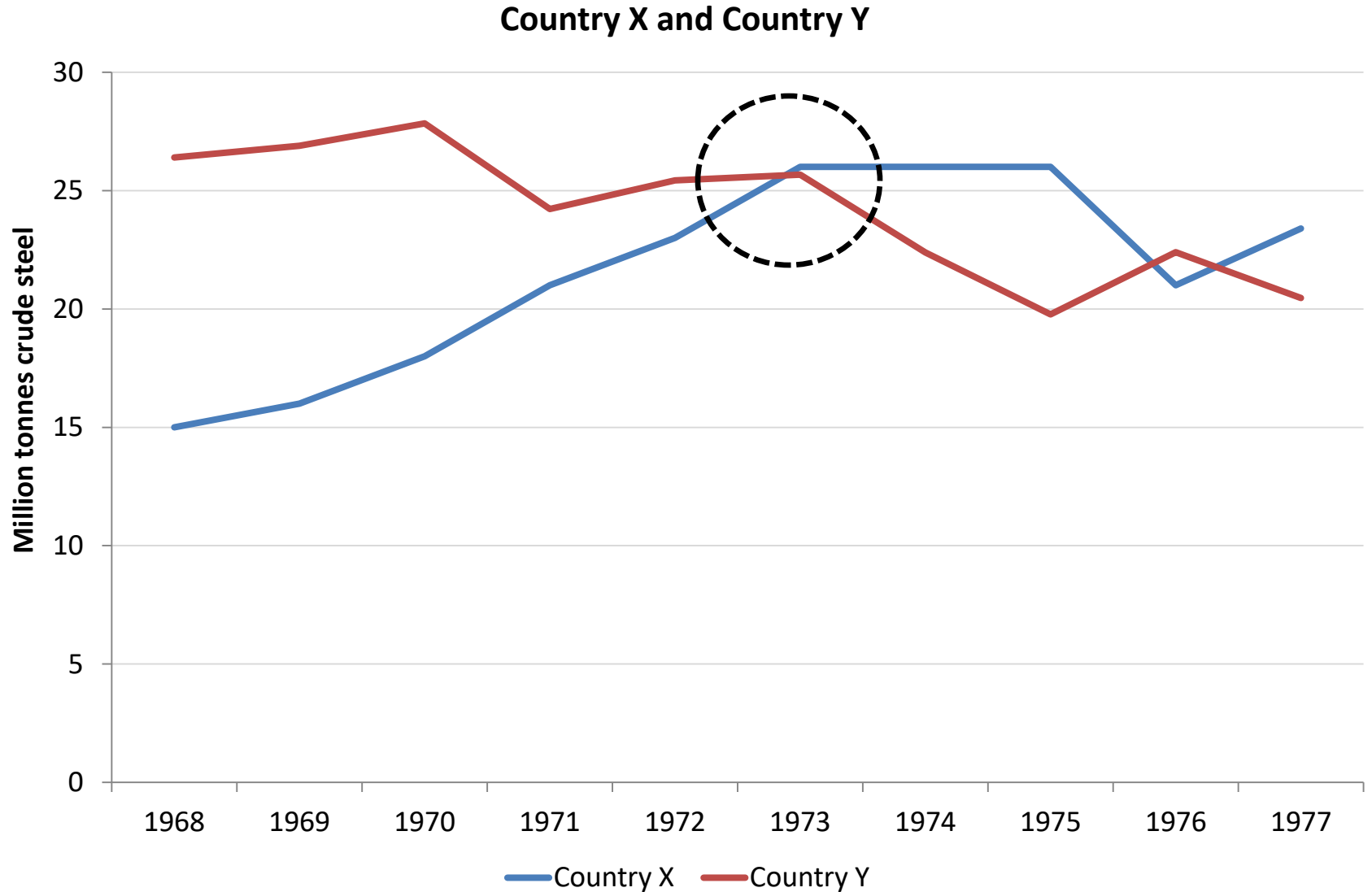
“With its abundant raw materials and the infusion of Western technology,

**China should be able to develop a steel industry comparable in size to the steel industries of the USA, USSR and Japan”.**

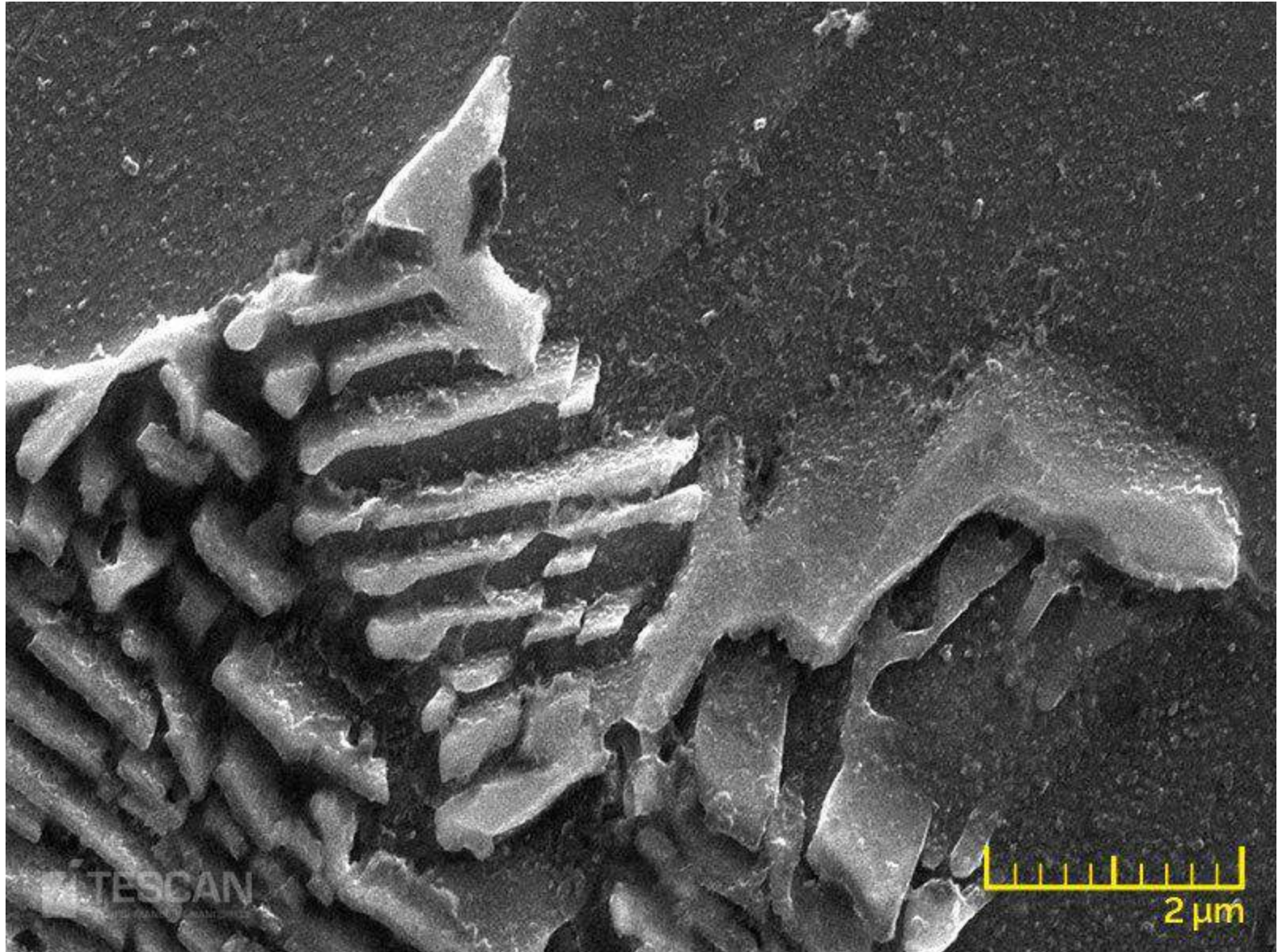
(Embargoed until release in 2000)



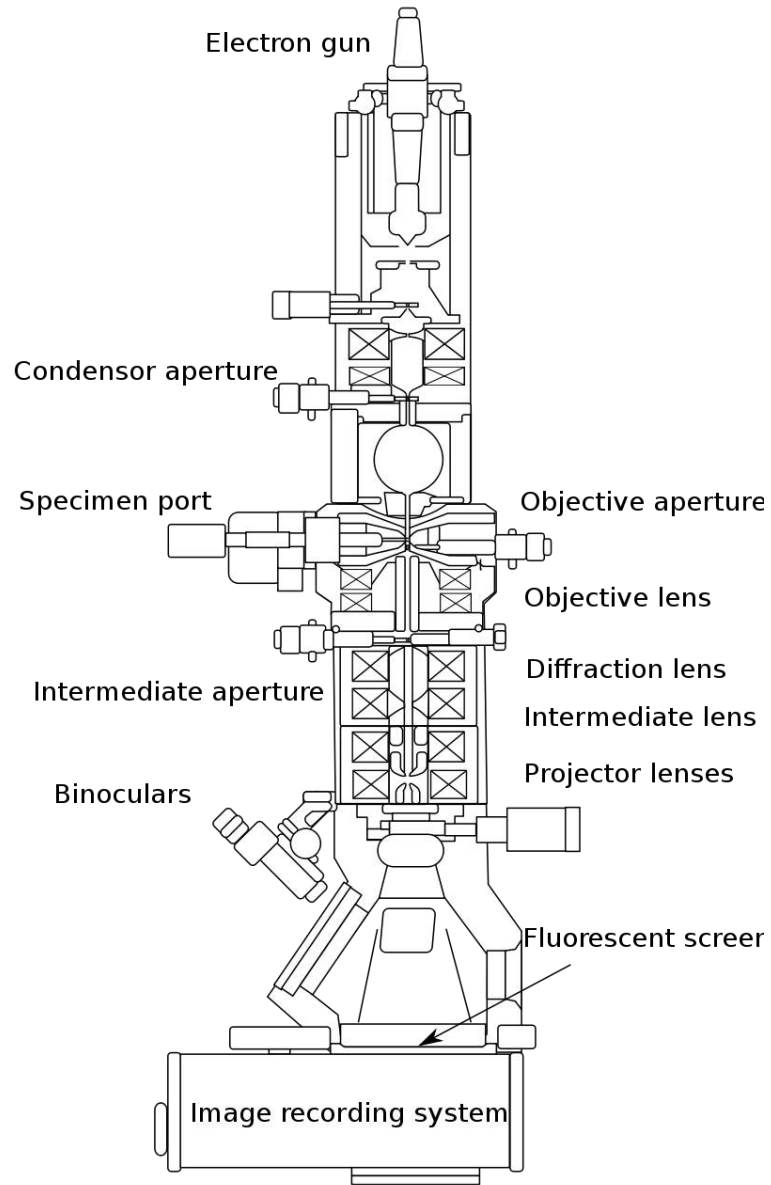
**Country X and Country Y 1968 – 1977. The same crude steel output in 1973.**



# Scanning electron microscope – 1970. Image of pearlite in steel.



# Transmission electron microscope – 1970s onwards



Dislocations in steel

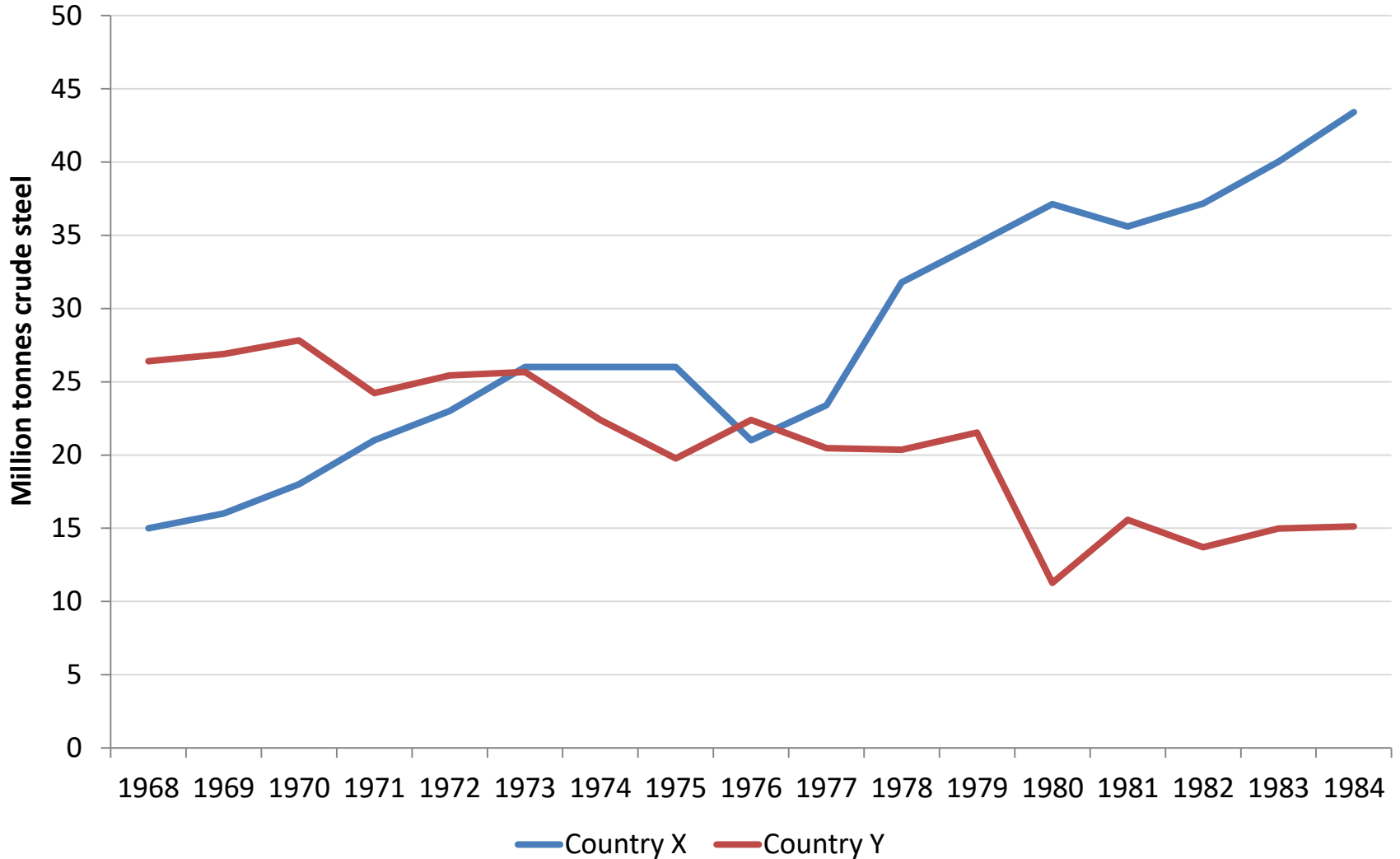
**Lakshmi Mittal (1950 - ) formed his first steel company, PT Ispat Indo, in 1976**





# Country X and Country Y by 1984

## Country X and Country Y



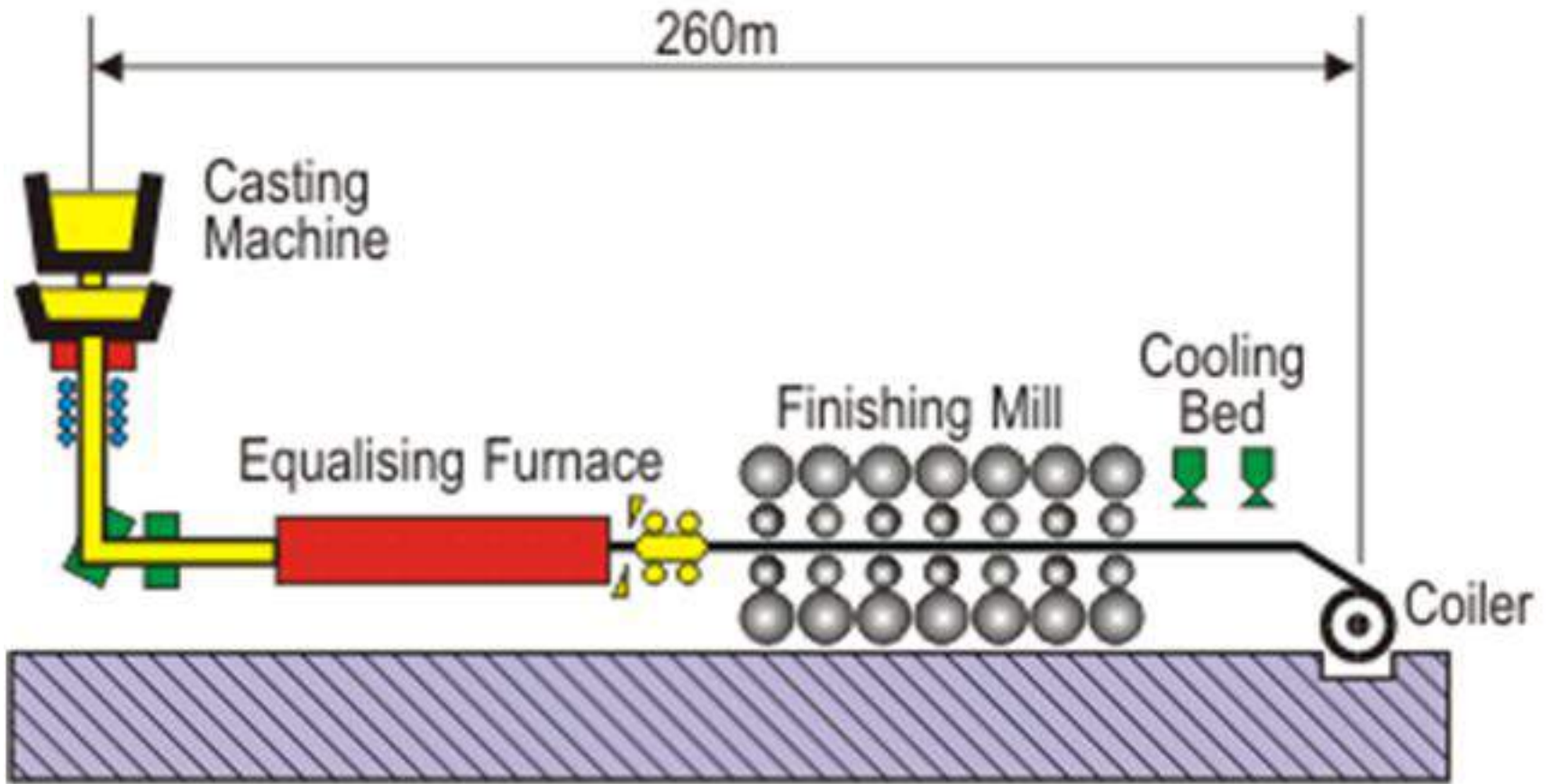


**Ken Iverson (L) (1925 – 2002) and John Correnti of Nucor (R) (1947 – 2015) – commercialisation of thin slab casting, 1989**



# Thin slab casting – commercialised by Nucor, 1989

## Thin Slab Casting

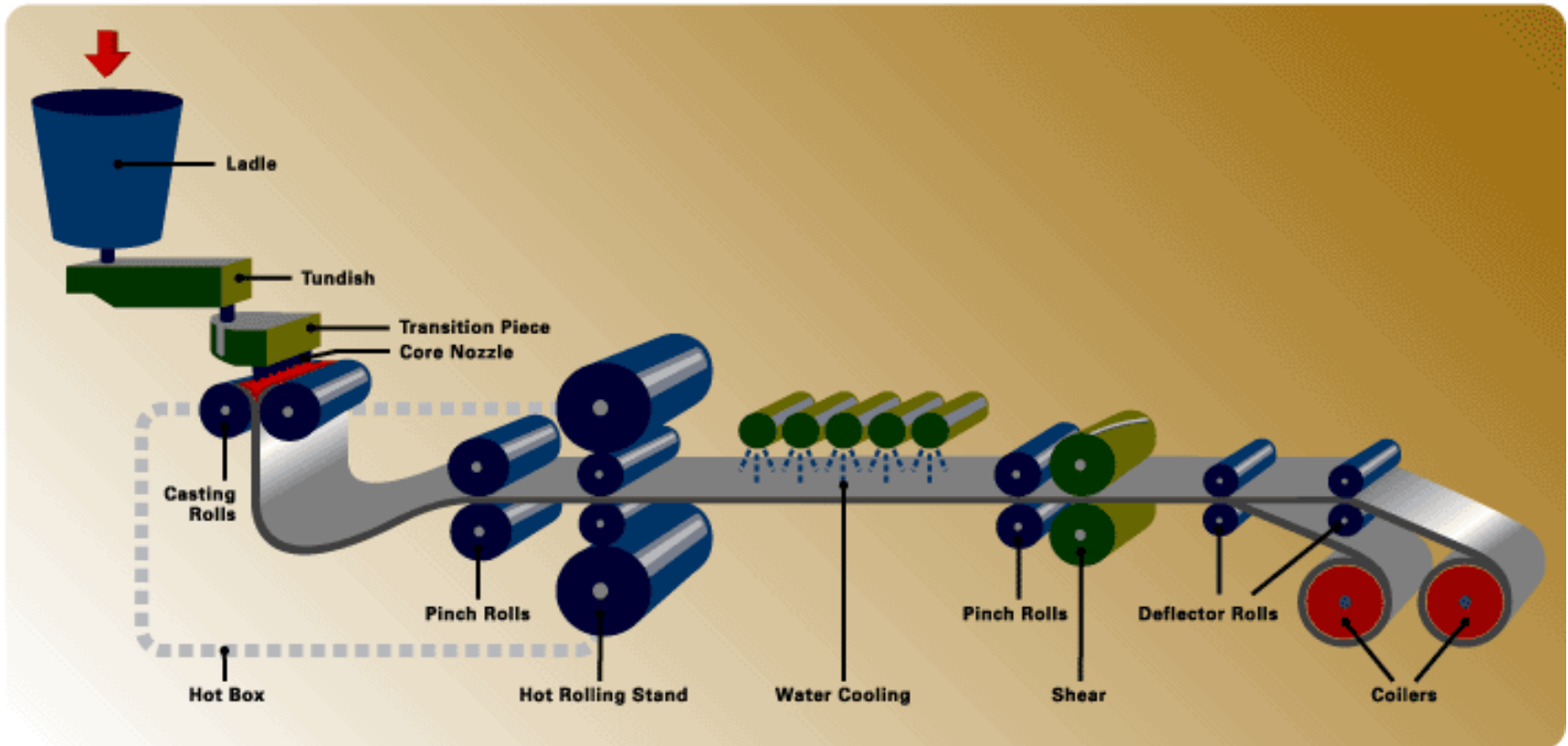


# POSCO Gwangyang works, built 1985 – 1992, capacity 22 million tonnes per annum



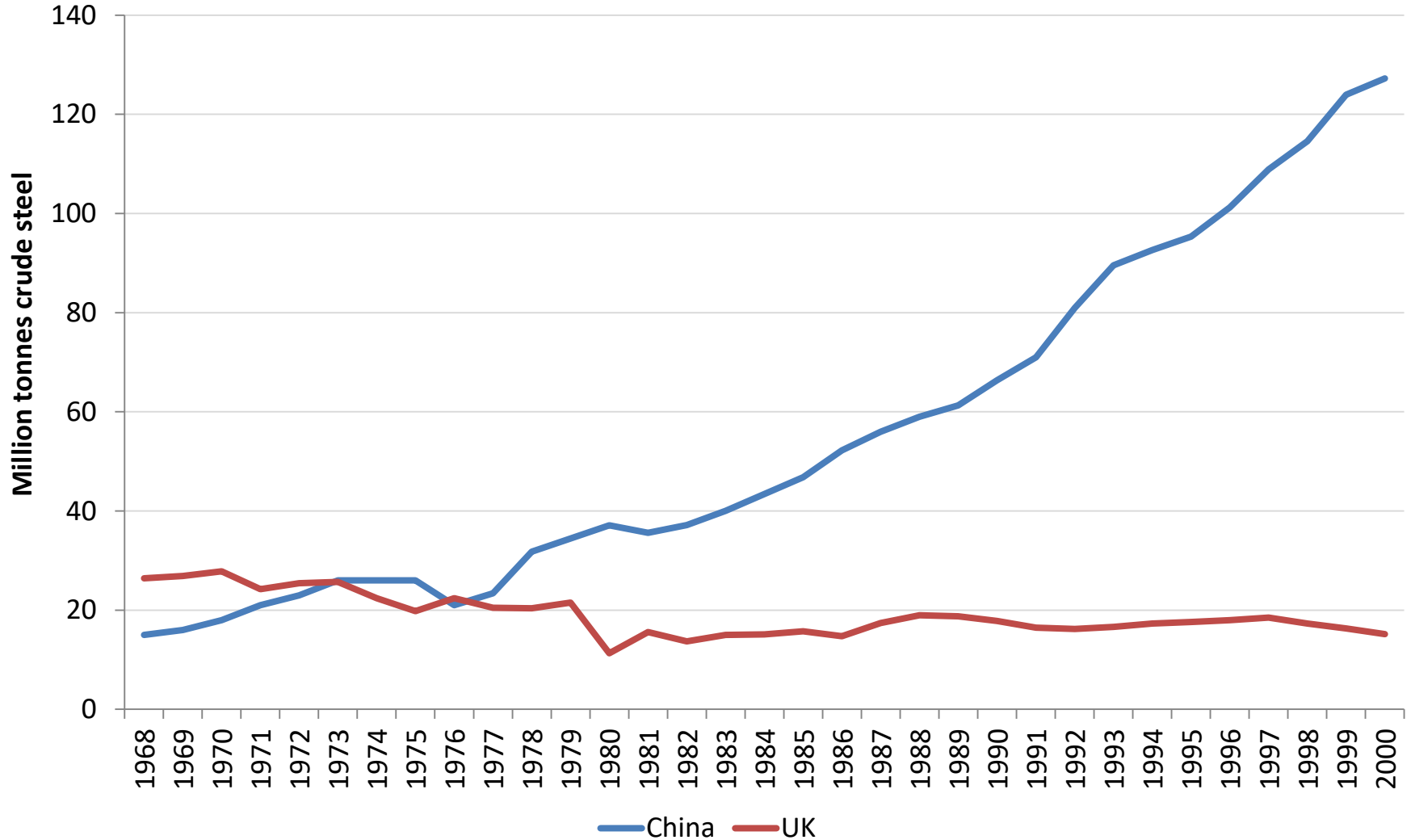
# Castrip – development started in 1988, first commercial plant 2002

The Castrip® Process



# Country X and Country Y revealed – by 2000

## China and UK, production of crude steel



# HMS Bulwark – built Barrow 2001



# Shipyards, China 2000s







# Burj Khlaifa – Adrian Smith – Skidmore Owings & Merrill - 2008



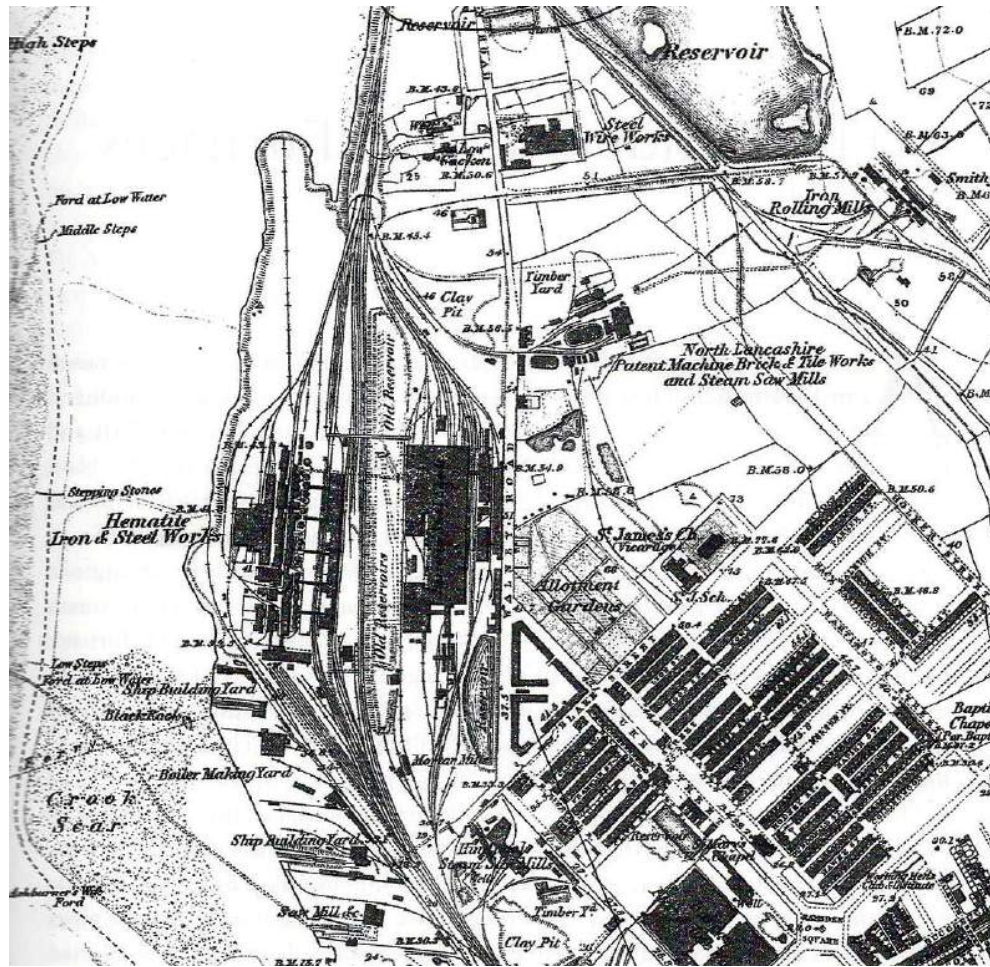
# Blast furnaces at Baosteel, China 2010



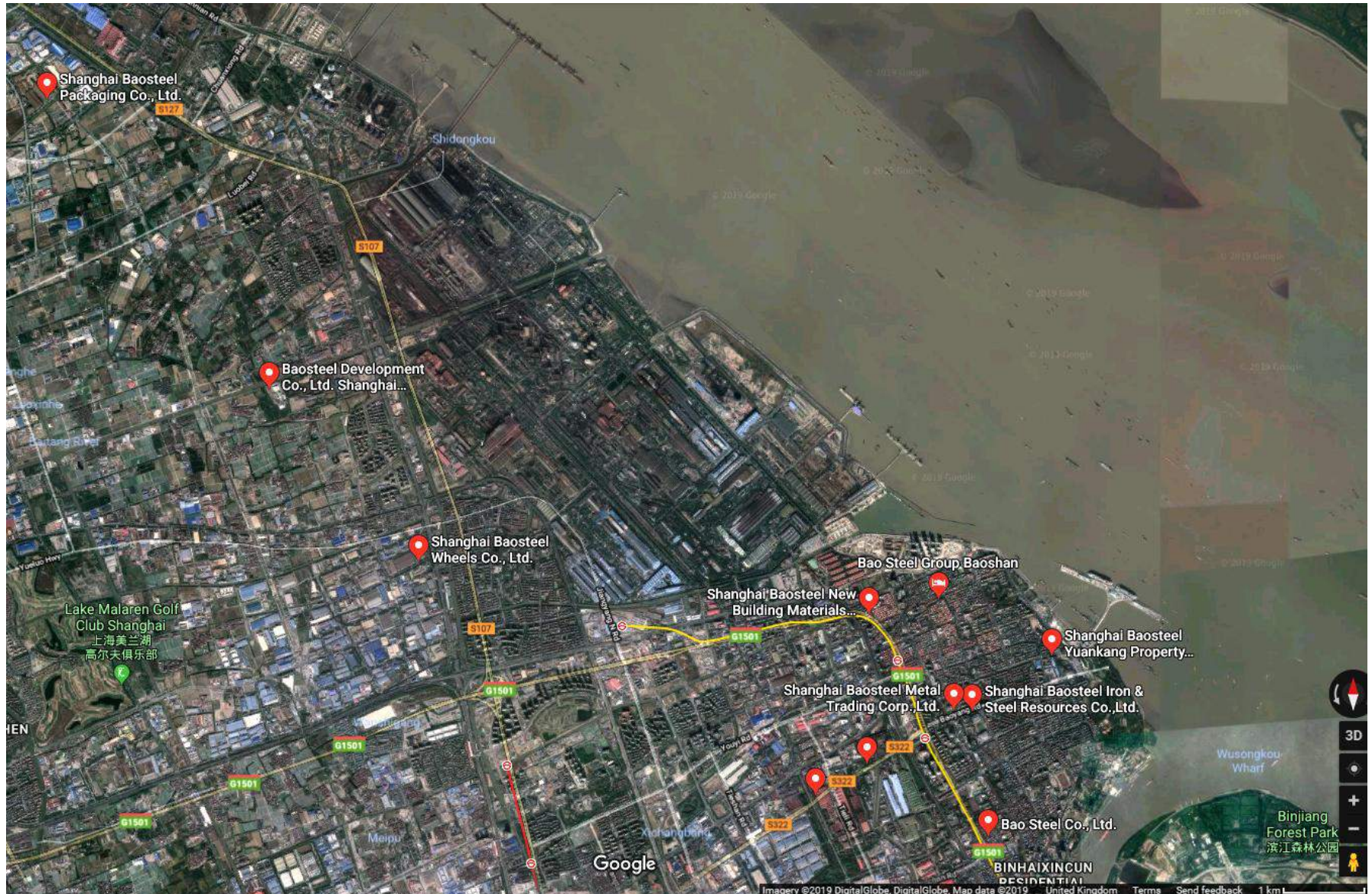
# The Shard – Renzo Piano - 2013



# Barrow steelworks site, 1936 and 2018



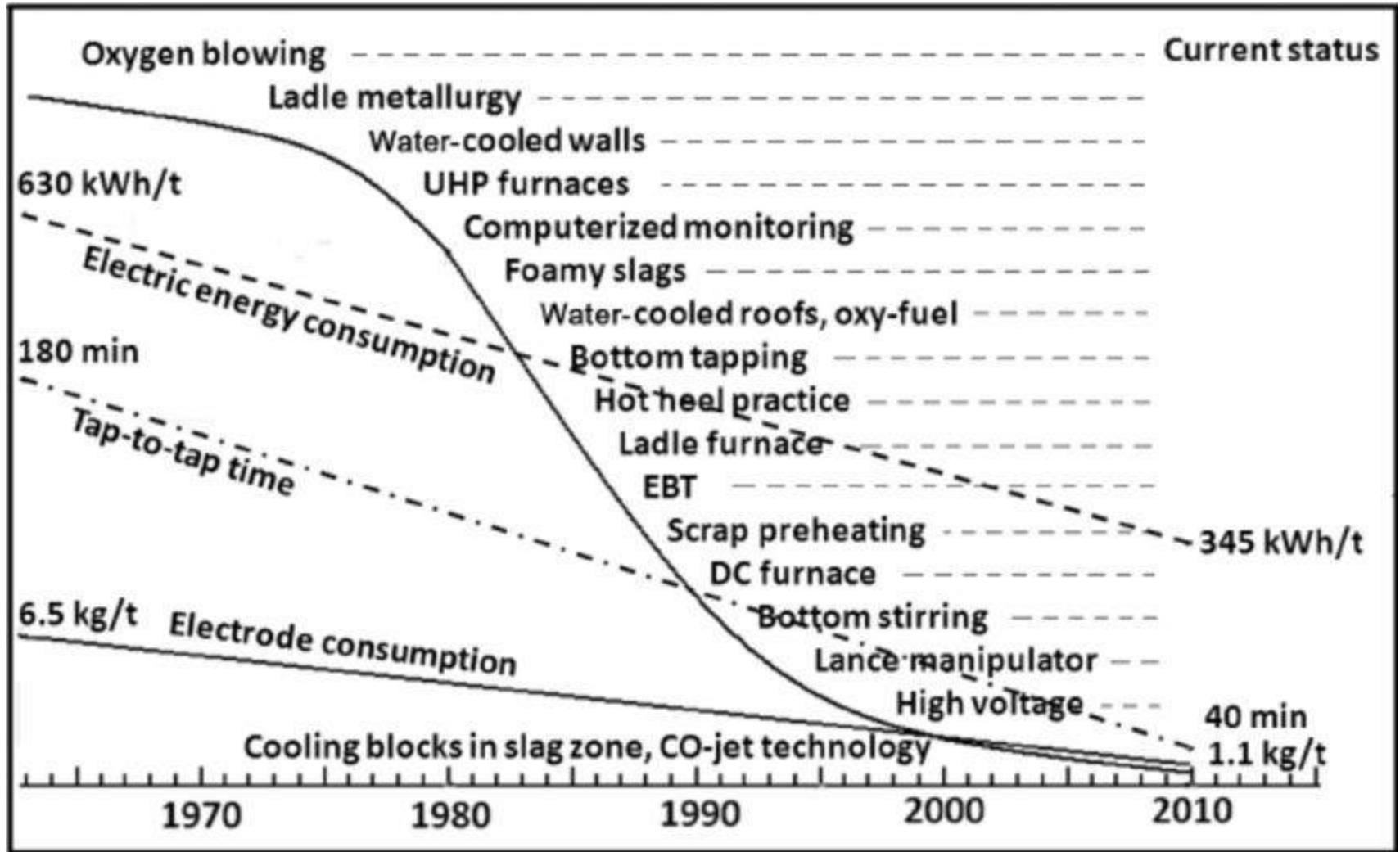
# Shanghai – Baosteel site - 2018



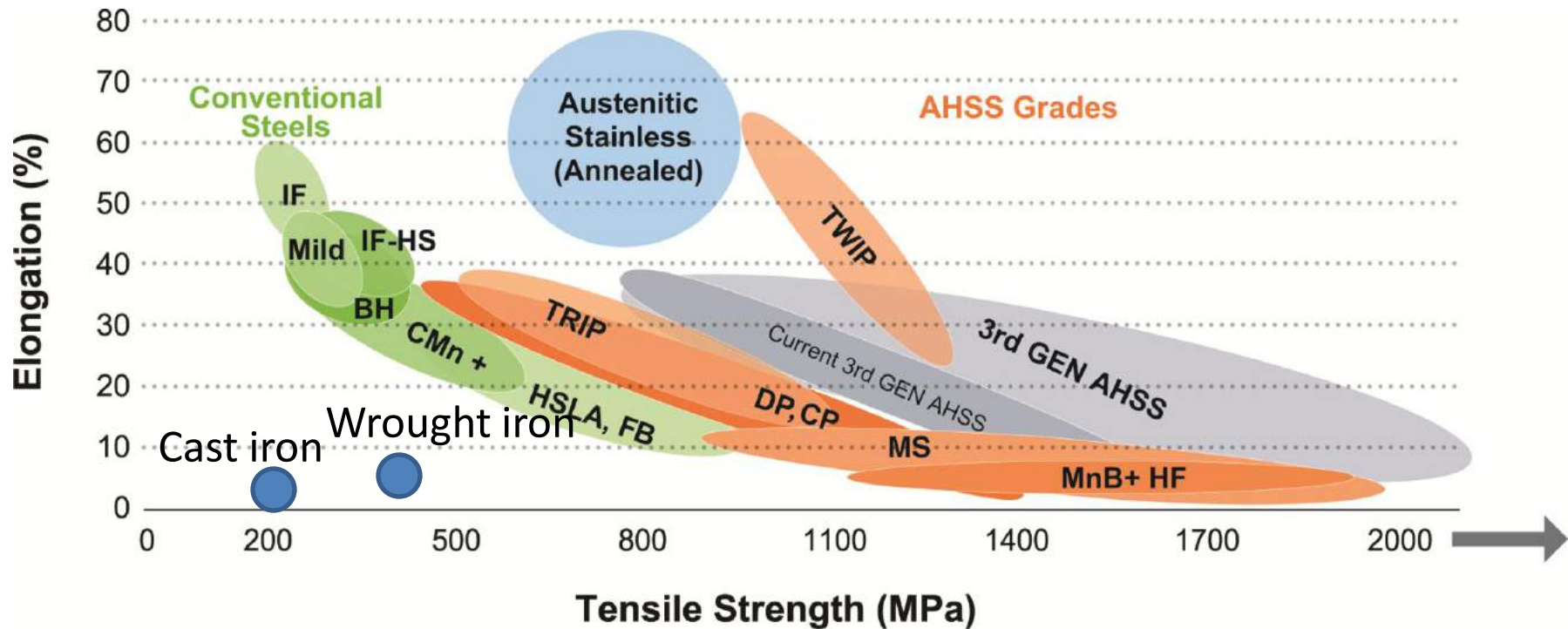
# A modern EAF



# EAF improvements 1965 - 2015



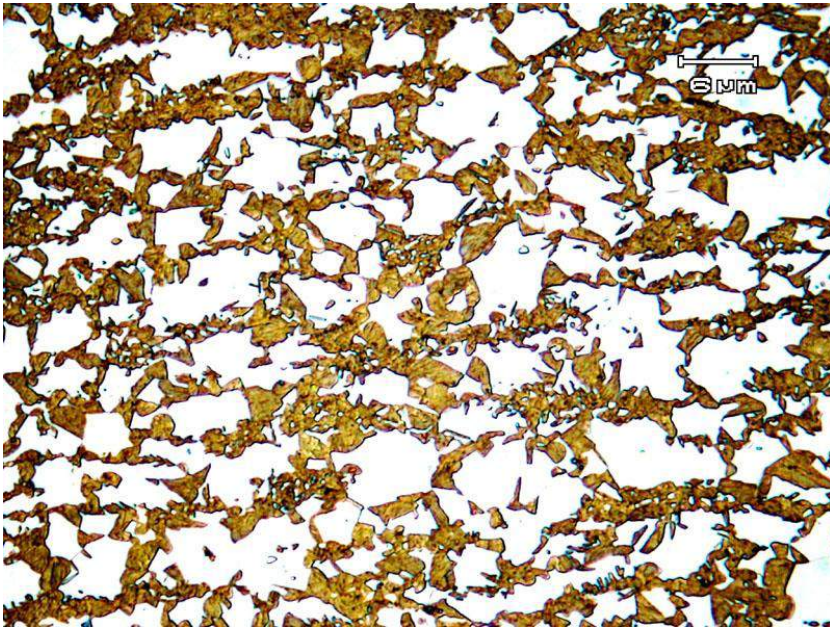
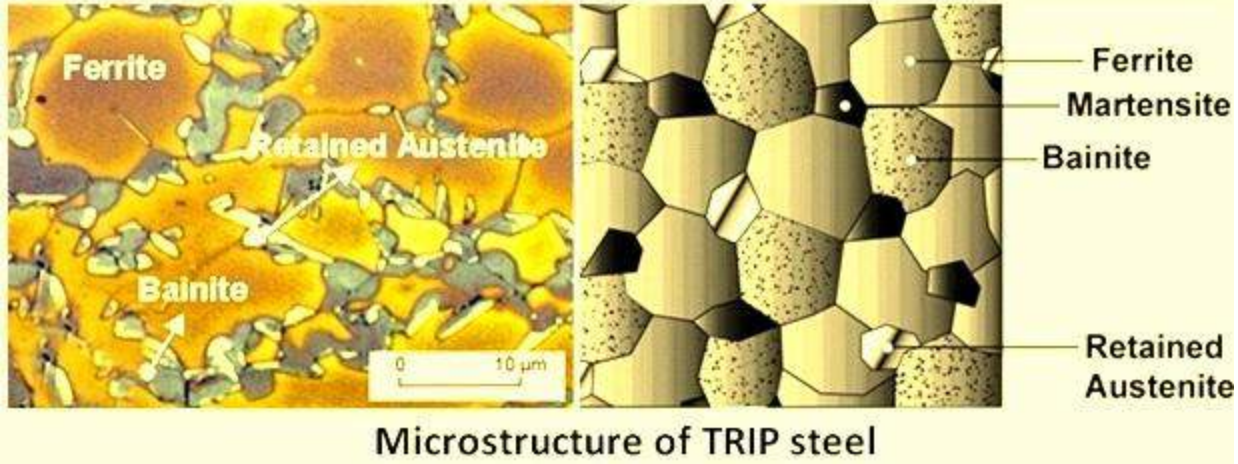
# Development of high strength automotive steels



Source: WorldAutoSteel



# Complex microstructures of high strength steels



Dual phase steel



HSLA steel

# 150<sup>th</sup> anniversary of the Periodic Table

Period	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII B	9 VIII B	10 VIII B	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A
1	1s <b>H</b> hydrogen 1.008																	2 <b>He</b> helium 4.003
2	2s <b>Li</b> lithium 6.968	<b>Be</b> beryllium 9.012											2p <b>B</b> boron 10.81	<b>C</b> carbon 12.01	<b>N</b> nitrogen 14.01	<b>O</b> oxygen 16.00	<b>F</b> fluorine 19.00	<b>Ne</b> neon 20.18
3	3s <b>Na</b> sodium 22.99	<b>Mg</b> magnesium 24.31											3p <b>Al</b> aluminum 26.98	<b>Si</b> silicon 28.09	<b>P</b> phosphorus 30.97	<b>S</b> sulfur 32.07	<b>Cl</b> chlorine 35.45	<b>Ar</b> argon 39.95
4	4s <b>K</b> potassium 39.10	<b>Ca</b> calcium 40.08	3d <b>Sc</b> scandium 44.96	<b>Ti</b> titanium 47.87	<b>V</b> vanadium 50.94	<b>Cr</b> chromium 52.00	<b>Mn</b> manganese 54.94	<b>Fe</b> iron 55.85	<b>Co</b> cobalt 58.93	<b>Ni</b> nickel 58.69	<b>Cu</b> copper 63.55	<b>Zn</b> zinc 65.38	4p <b>Ga</b> gallium 69.72	<b>Ge</b> germanium 72.63	<b>As</b> arsenic 74.92	<b>Se</b> selenium 78.97	<b>Br</b> bromine 79.90	<b>Kr</b> krypton 83.80
5	5s <b>Rb</b> rubidium 85.47	<b>Sr</b> strontium 87.62	4d <b>Y</b> yttrium 88.91	<b>Zr</b> zirconium 91.22	<b>Nb</b> niobium 92.91	<b>Mo</b> molybdenum 95.95	<b>Tc</b> technetium 98	<b>Ru</b> ruthenium 101.1	<b>Rh</b> rhodium 102.9	<b>Pd</b> palladium 106.4	<b>Ag</b> silver 107.9	<b>Cd</b> cadmium 112.4	5p <b>In</b> indium 114.8	<b>Sn</b> tin 118.7	<b>Sb</b> antimony 121.8	<b>Te</b> tellurium 127.6	<b>I</b> iodine 126.9	<b>Xe</b> xenon 131.3
6	6s <b>Cs</b> cesium 132.9	<b>Ba</b> barium 137.3	†5d <b>Lu</b> lutetium 175.0	<b>Hf</b> hafnium 178.5	<b>Ta</b> tantalum 180.9	<b>W</b> tungsten 183.8	<b>Re</b> rhenium 186.2	<b>Os</b> osmium 190.2	<b>Ir</b> iridium 192.2	<b>Pt</b> platinum 195.1	<b>Au</b> gold 197.0	<b>Hg</b> mercury 200.6	6p <b>Tl</b> thallium 204.4	<b>Pb</b> lead 207.2	<b>Bi</b> bismuth 209.0	<b>Po</b> polonium 209	<b>At</b> astatine 210	<b>Rn</b> radon 222
7	7s <b>Fr</b> francium 223	<b>Ra</b> radium 226	†6d <b>Lr</b> lawrencium 262	<b>Rf</b> rutherfordium 267	<b>Db</b> dubnium 268	<b>Sg</b> seaborgium 271	<b>Bh</b> bohrium 272	<b>Hs</b> hassium 270	<b>Mt</b> meitnerium 276	<b>Ds</b> darmstadtium 281	<b>Rg</b> roentgenium 280	<b>Cn</b> copernicium 285	7p <b>Nh</b> nihonium 284	<b>Fl</b> flerovium 289	<b>Mc</b> moscovium 288	<b>Lv</b> livermorium 293	<b>Ts</b> tennessine 292	<b>Og</b> oganesson 294

29	+2, +1	ions commonly formed
<b>Cu</b>		
copper		
63.55		atomic mass (rounded)

# Fazlur Khan 1929 – 1982 “Einstein of structural engineering”

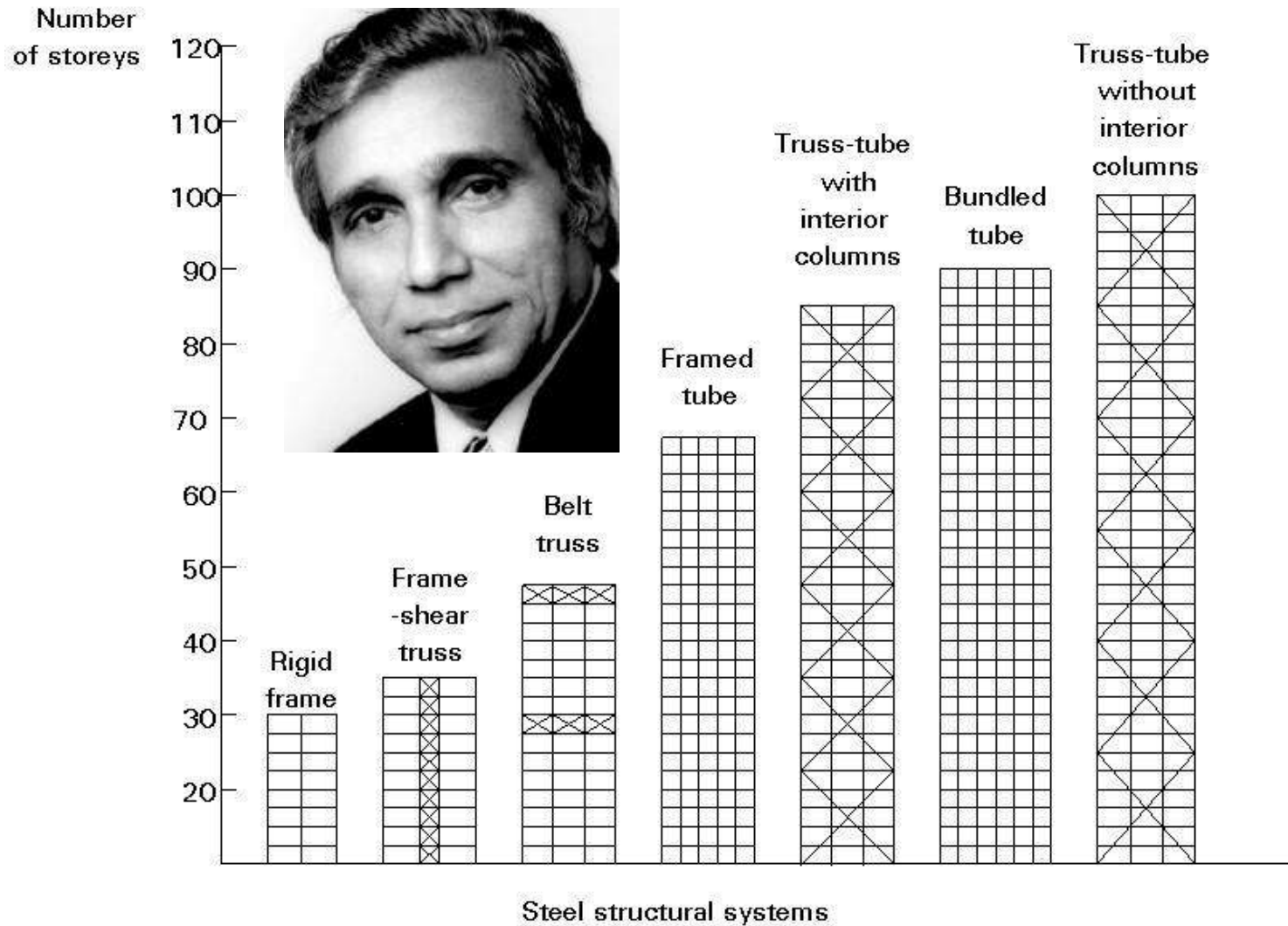
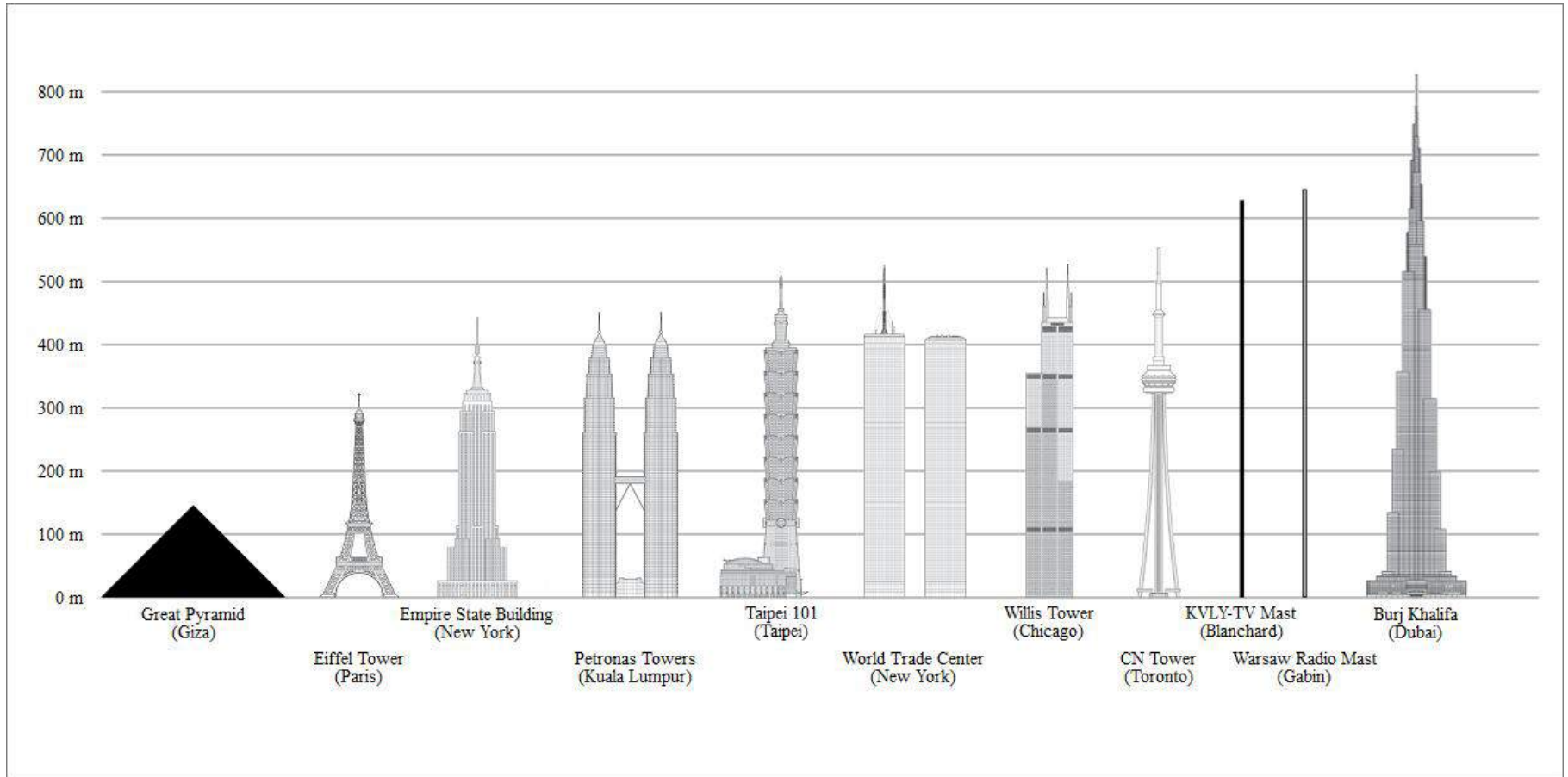


Figure 7 Steel structural systems and the number of storeys

# Height and time



# Bishopsgate 2009



# Bishopsgate 2010



# Bishopsgate 2010



# Bishopsgate 2010

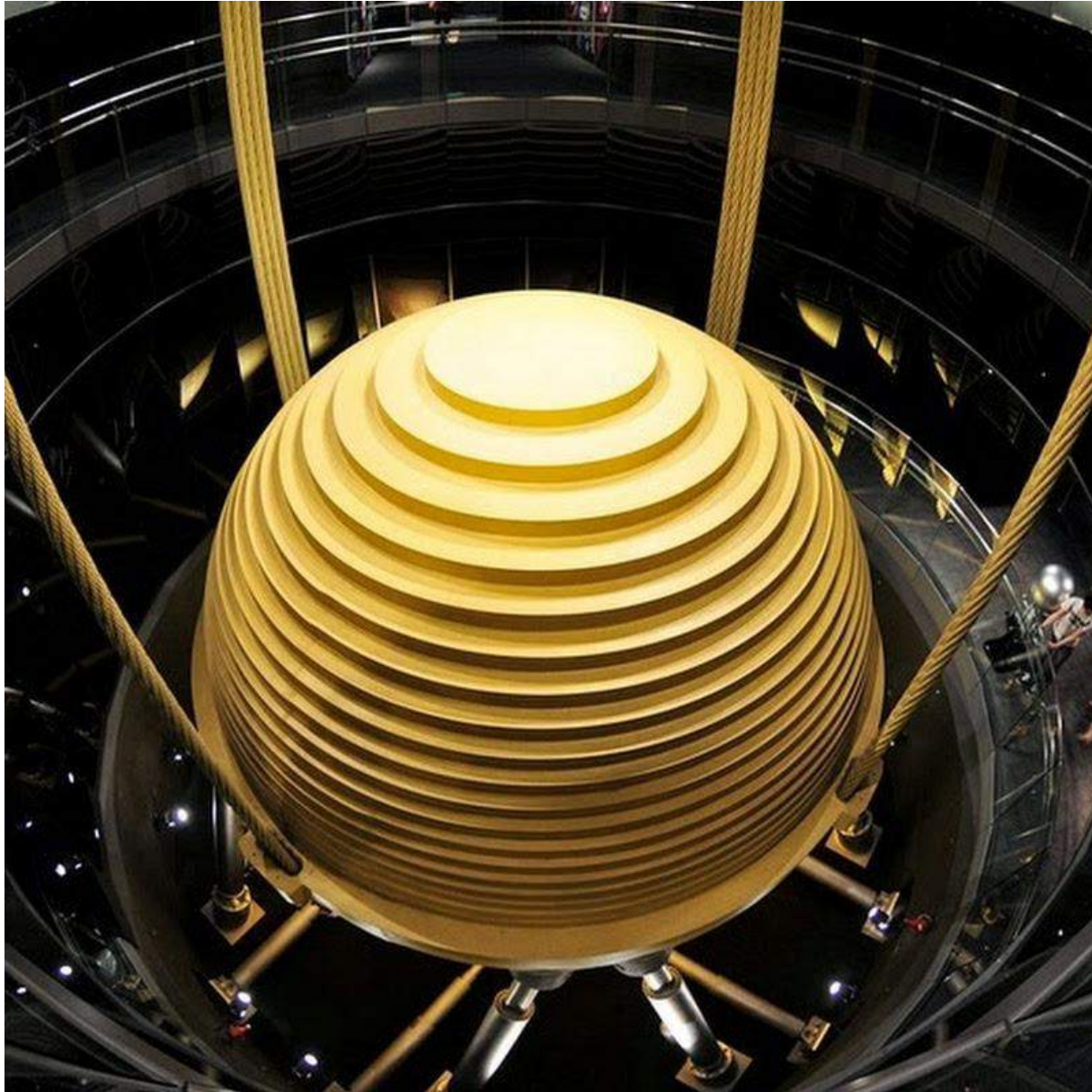




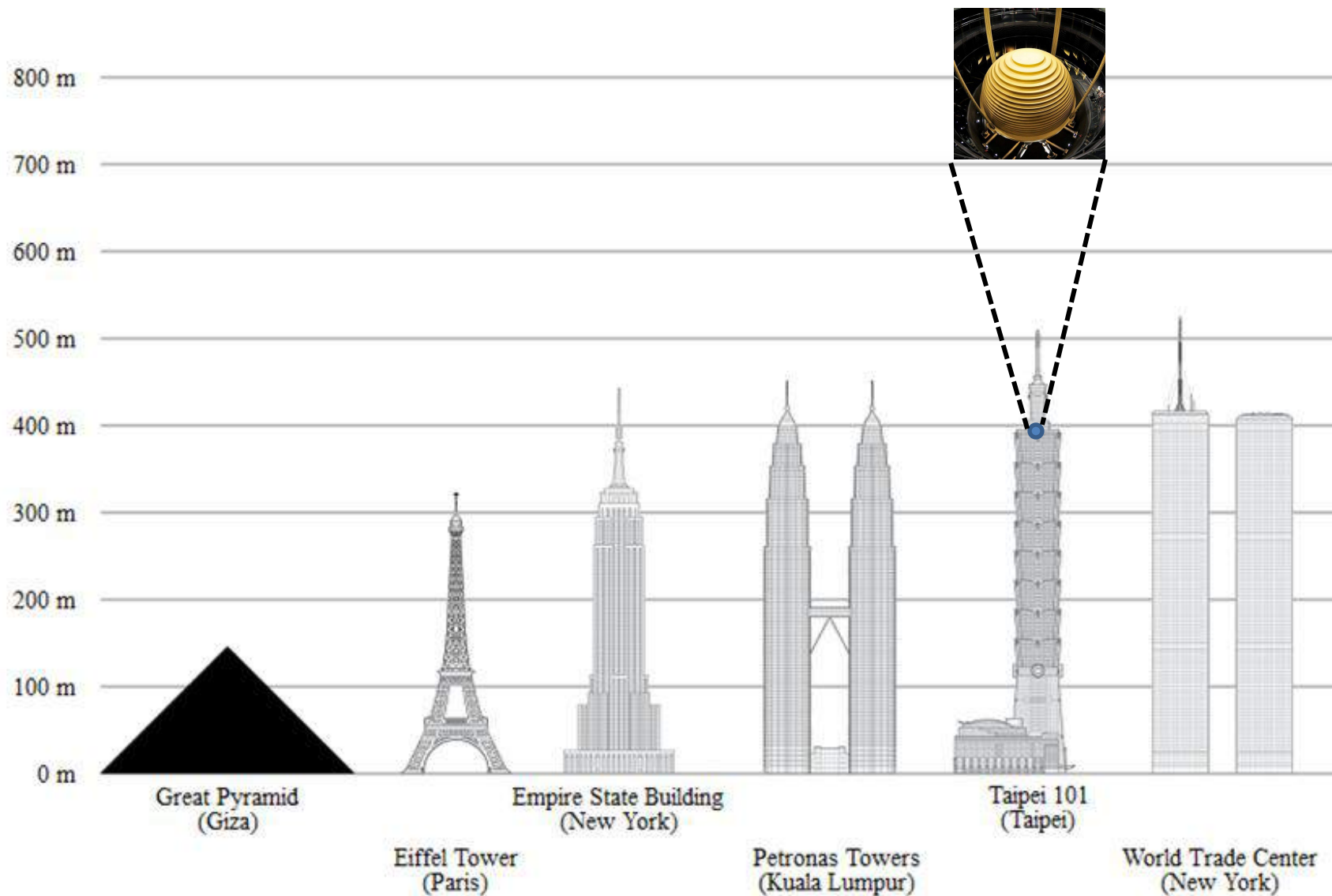
Almost complete, 2019



# What is this?

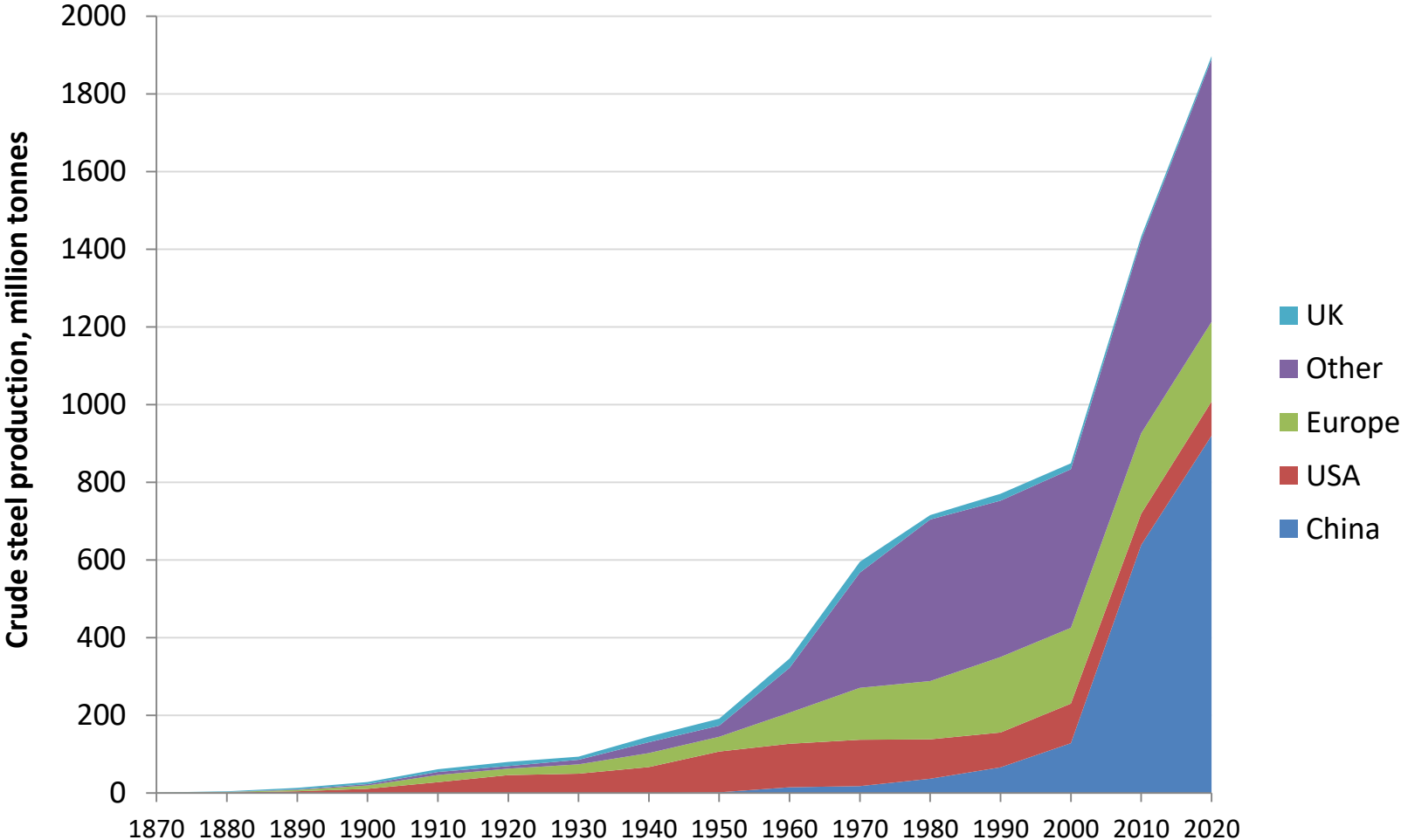


# Tuned mass damper, 700 tonnes of computer controlled steel plates



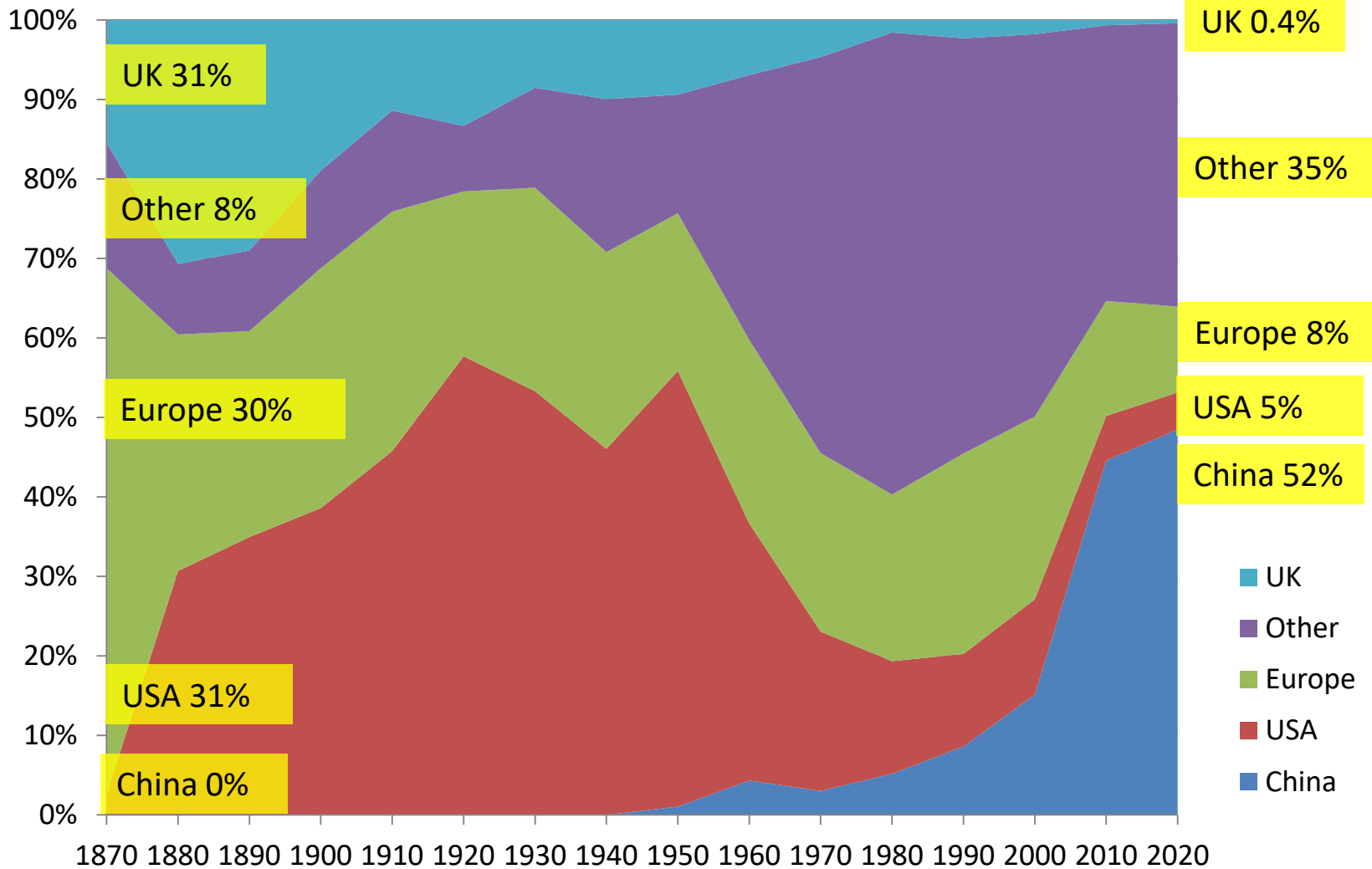
# Crude steel growth by region

## Evolution of world crude steel production tonnage by key region, 1980 - 2020f



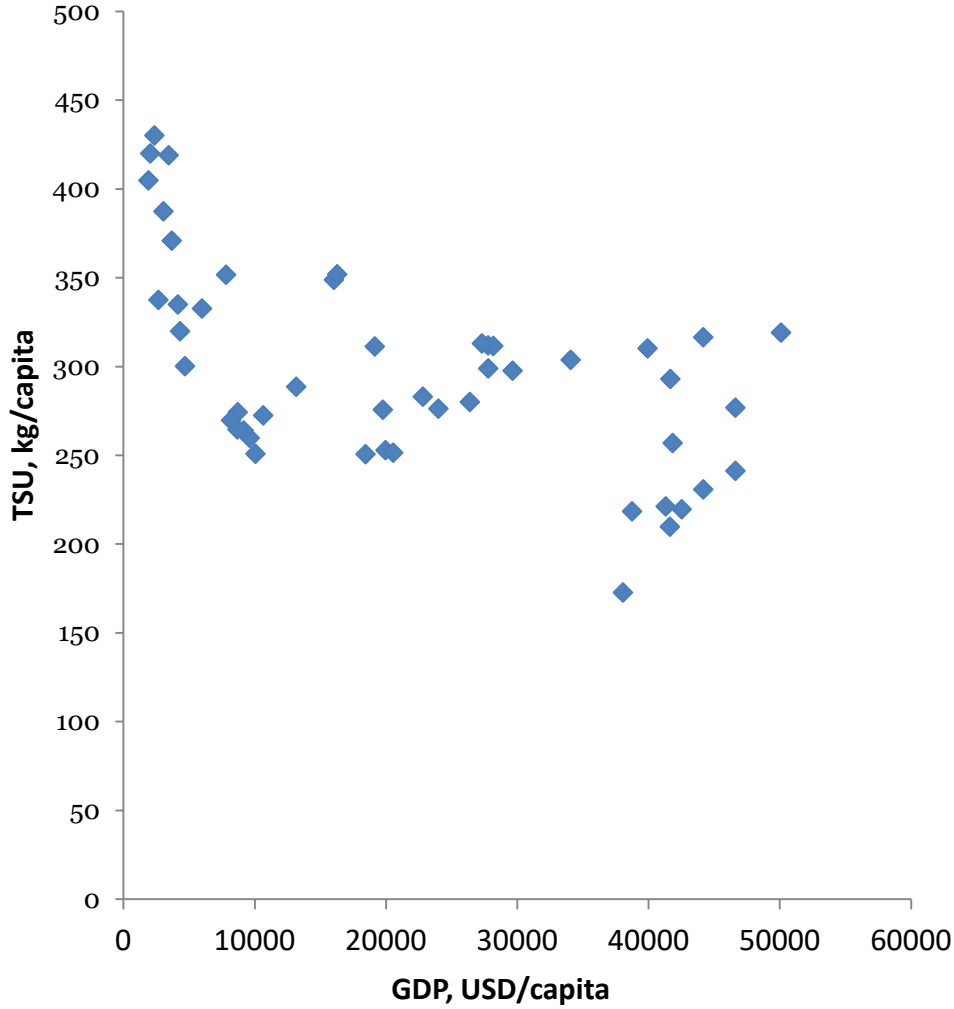
# Evolution of word steel production by region 1870 - 2020

## Evolution of world steel production by key region, 1870 - 2020f

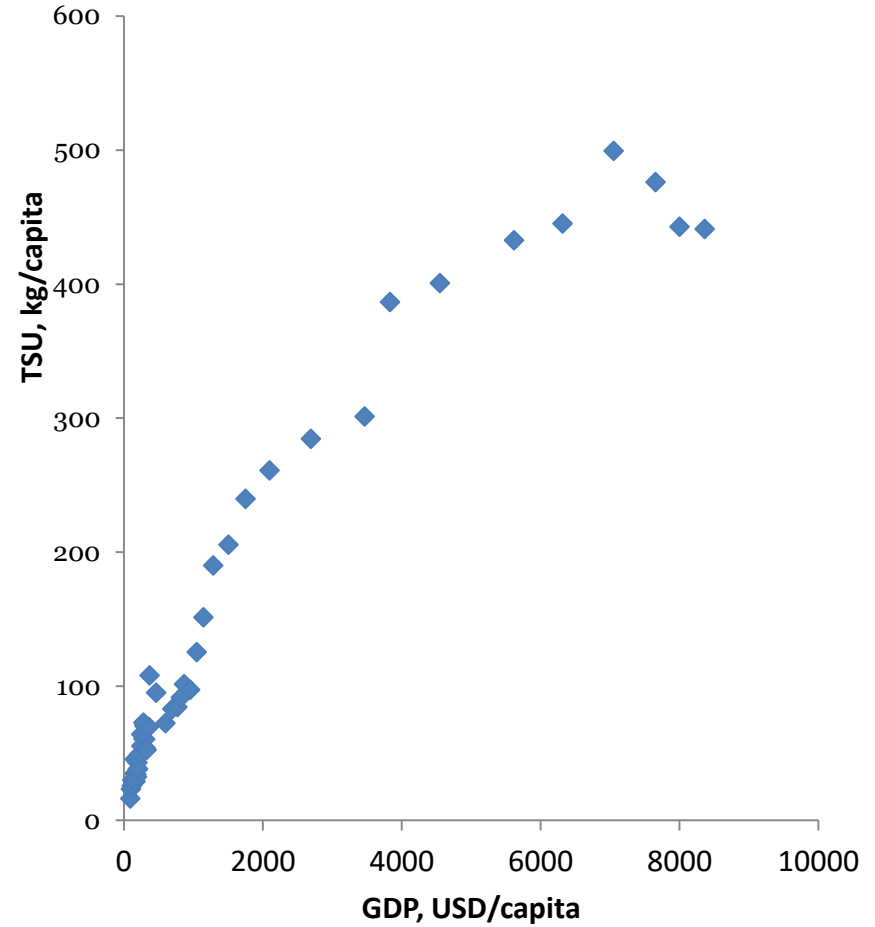


# UK and China – different growth patterns – or are they?

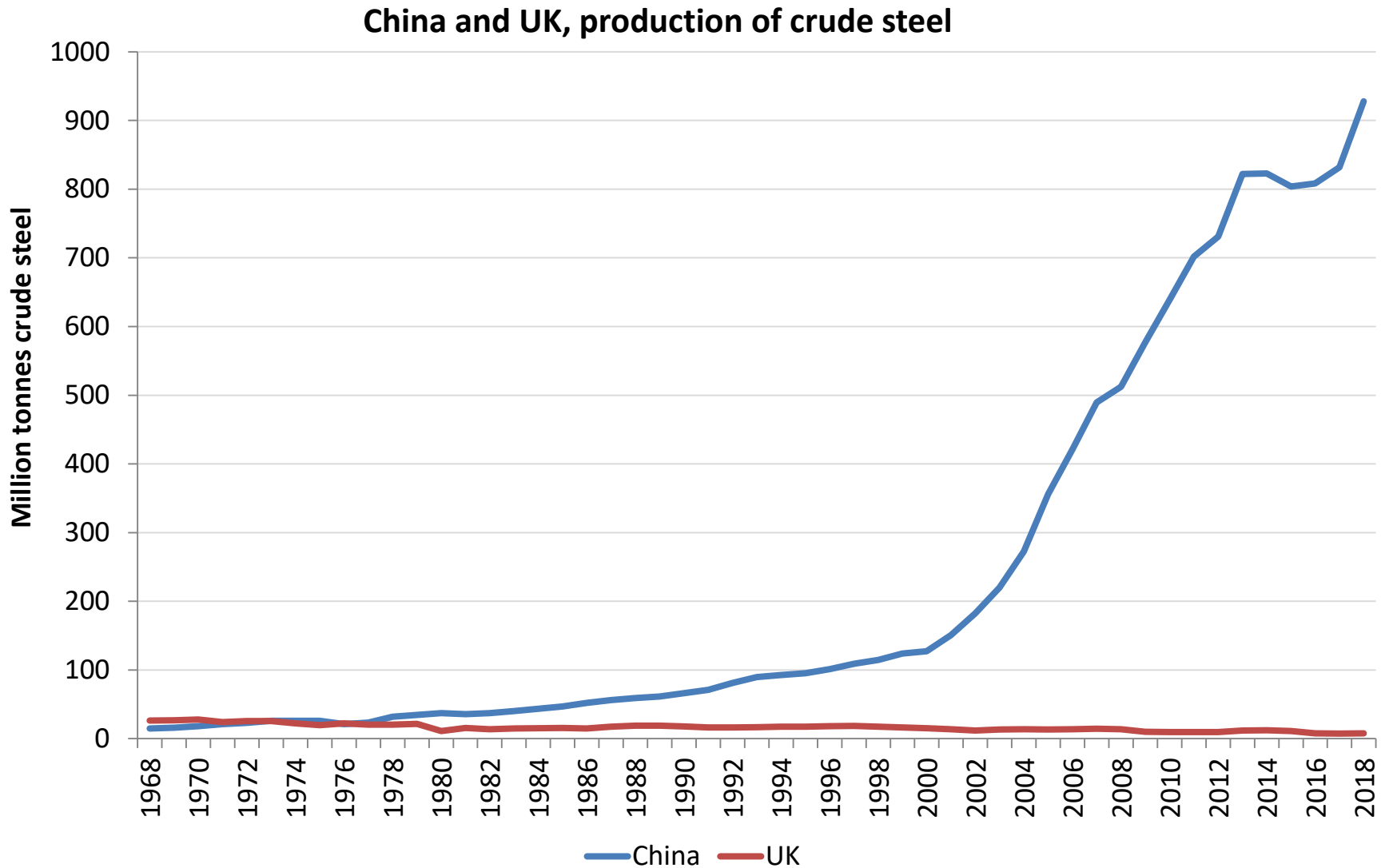
UK: relationship of True Steel Use (TSU) and GDP/capita



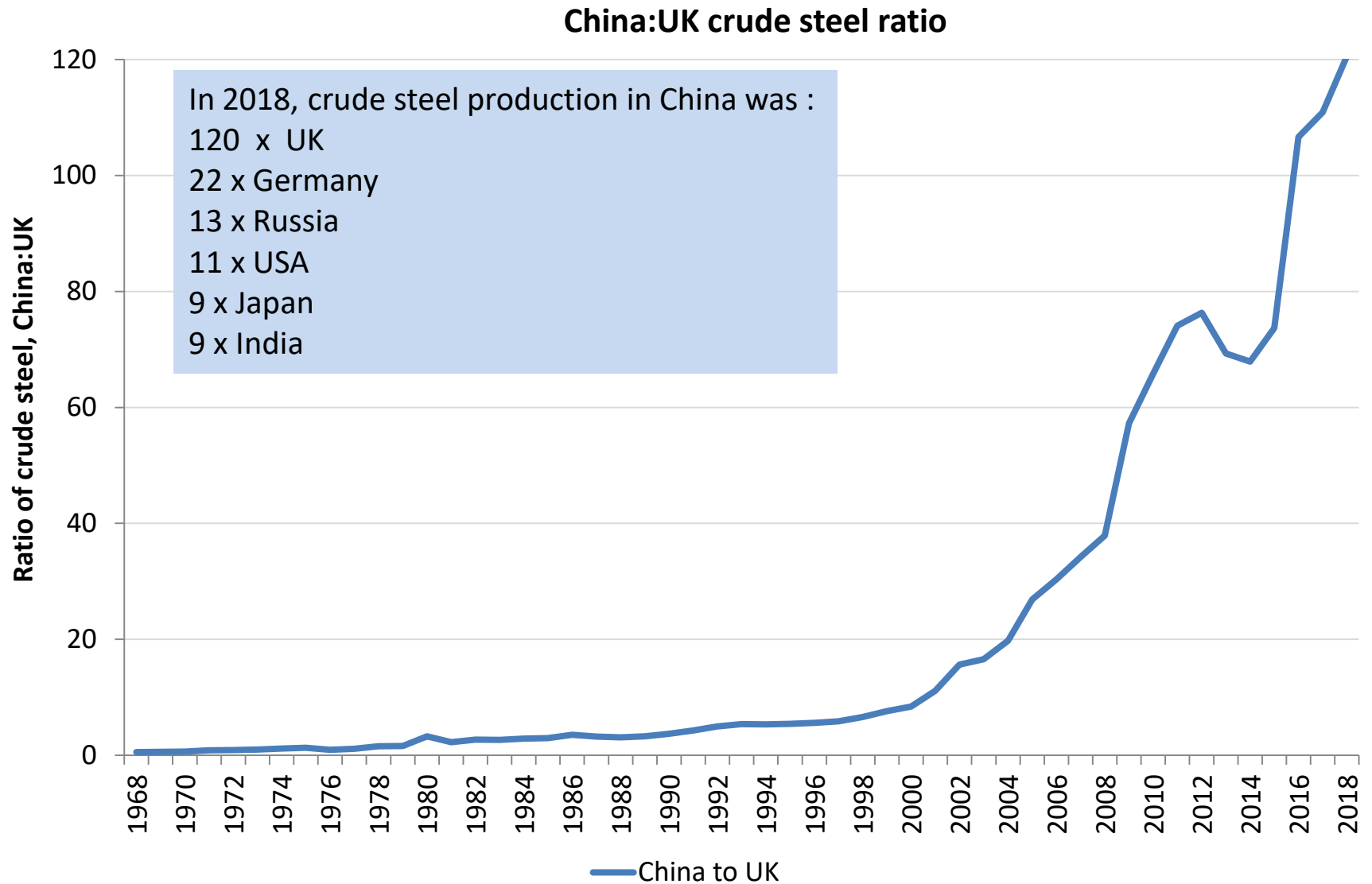
China: relationship of True Steel Use (TSU) and GDP/capita



# Production of crude steel, China and UK, 1968 - 2018

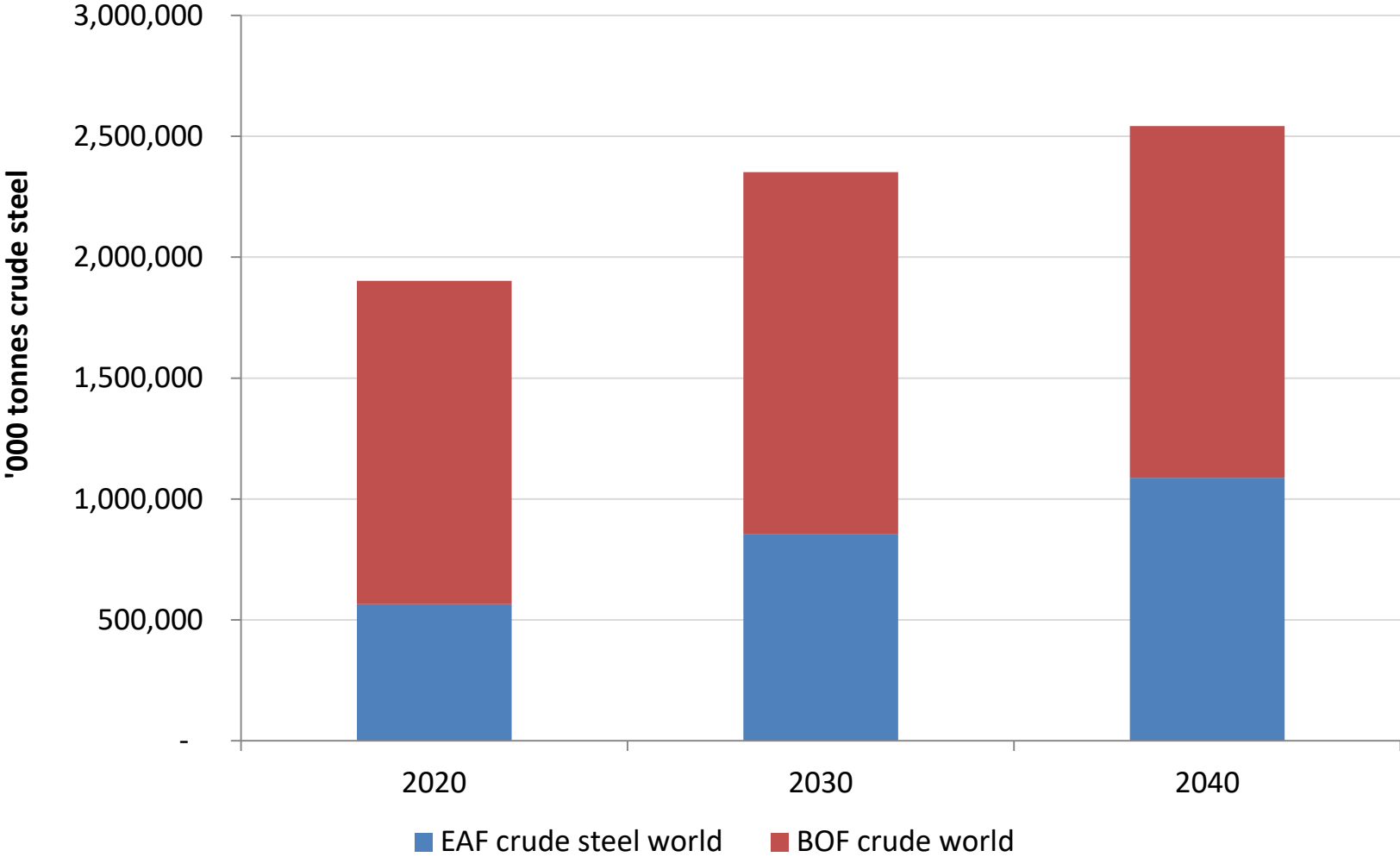


# Ratio of crude steel, China:UK. Ratio was 120:1 in 2018. 1:1 in 1973





World crude steel forecast 2020 - 2040



# Acknowledgements

- **Thanks to MinSouth for inviting me to speak**
- Many sources were used in the preparation of this talk, including:
- <https://archive.org/details/journal187201iron/page/n8> for early details of Iron and Steel Institute
- [https://en.wikipedia.org/wiki/Iron\\_and\\_Steel\\_Institute](https://en.wikipedia.org/wiki/Iron_and_Steel_Institute) for Past Presidents
- [https://en.wikipedia.org/wiki/Abraham\\_Darby\\_III](https://en.wikipedia.org/wiki/Abraham_Darby_III) for images of Ironbridge and Abraham Derby III
- <https://extrudesign.com/how-tensile-test-is-conducted/> for details of cast iron and other stress strain curves
- Mr Bigler for the periodic table
- [http://shropshirehistory.com/iron/iron\\_making.htm](http://shropshirehistory.com/iron/iron_making.htm) for puddling furnaces
- [https://en.wikipedia.org/wiki/Wrought\\_iron](https://en.wikipedia.org/wiki/Wrought_iron) for wrought iron details and microstructure
- [https://en.wikipedia.org/wiki/Isambard\\_Kingdom\\_Brunel](https://en.wikipedia.org/wiki/Isambard_Kingdom_Brunel) for image of Brunel
- <https://www.telegraph.co.uk/travel/destinations/europe/united-kingdom/articles/admire-the-view-from-the-clifton-suspension-bridge-in-this-360-video/> image of Clifton suspension bridge
- [https://en.wikipedia.org/wiki/SS\\_Great\\_Eastern](https://en.wikipedia.org/wiki/SS_Great_Eastern) image of Great Eastern
- [https://en.wikipedia.org/wiki/Henry\\_Bessemer](https://en.wikipedia.org/wiki/Henry_Bessemer) first image of Sir Henry Bessemer. Later image from portrait in Bessemer Room at IOM3
- Bessemer converter image from photo in Bessemer Room at IOM3
- Bessemer steel artefacts from display in Bessemer Room at IOM3
- [https://en.wikipedia.org/wiki/Carl\\_Wilhelm\\_Siemens](https://en.wikipedia.org/wiki/Carl_Wilhelm_Siemens) Image of Carl Wilhelm Siemens
- [https://en.wikipedia.org/wiki/Pierre-%C3%89mile\\_Martin](https://en.wikipedia.org/wiki/Pierre-%C3%89mile_Martin) Image of Carl Emile Martin
- [https://en.wikipedia.org/wiki/Sidney\\_Gilchrist\\_Thomas](https://en.wikipedia.org/wiki/Sidney_Gilchrist_Thomas) Image of Sidney Gilchrist Thomas, also image from portrait in Bessemer Room at IOM3

# Acknowledgements

- Many sources were used in the preparation of this talk, including:
- <https://www.6sqft.com/secrets-and-history-of-the-brooklyn-bridge/> Image of Brooklyn Bridge
- Early steel statistics from Zimmerman, World Resources and industries
- [https://en.wikipedia.org/wiki/Electric\\_arc\\_furnace](https://en.wikipedia.org/wiki/Electric_arc_furnace) Image of first and recent EAFs
- <https://www.livescience.com/29391-eiffel-tower.html> Image of Eiffel Tower
- Portrait of Andrew Carnegie from Bessemer Room at IOM3
- <https://www.technology.matthey.com/article/8/1/23-28/> Images on development of the thermocouple
- Barrow Steelworks, Stan Henderson and Ken Royall, various images and maps of the steelworks
- Iron carbon equilibrium diagram, various sources
- <https://www.pinterest.co.uk/pin/345721708865045232/?autologin=true> Hot Strip Mill, Sparrows Point
- <http://footage.framepool.com/en/shot/696347772-industrialisation-forge-steel-beam-diagram> and [https://en.wikipedia.org/wiki/Empire\\_State\\_Building](https://en.wikipedia.org/wiki/Empire_State_Building) images of Empire State Building
- <https://www.nma.gov.au/defining-moments/resources/sydney-harbour-bridge-opens> Sydney Harbour Bridge
- <https://www.mat.ethz.ch/news-and-events/staudinger-durrer-prize/robert-durrer.html> image of Robert Durrer
- <https://www.scmp.com/news/china-insider/article/1598753/great-leap-forward-commentary-western-hostile-forces-creates> Image of steel production during Great Leap Forward
- <http://www.shipspotting.com/gallery/photo.php?lid=1385454> Image of British Admiral oil tanker
- [https://en.wikipedia.org/wiki/Dong\\_Biwu](https://en.wikipedia.org/wiki/Dong_Biwu) Image of Dong Biwu
- Many steel statistics from WorldSteel, formerly IISI, from 1900 to 2018
- <https://www.forbes.com/profile/lakshmi-mittal/> Image of Lakshmi Mittal

# Acknowledgements

- Many sources were used in the preparation of this talk, including:
- [https://www.dailymail.co.uk/travel/travel\\_news/article-4779070/History-Seawise-Giant-world-s-largest-ship.html](https://www.dailymail.co.uk/travel/travel_news/article-4779070/History-Seawise-Giant-world-s-largest-ship.html) Image of Jahre Viking
- <http://charlottemuseum.org/the-little-steel-company-that-could-ken-iverson-and-nucor-corporation/> Image of Ken Iverson
- <https://www.nytimes.com/2015/08/22/business/john-correnti-steel-industry-executive-dies-at-68.html> Image of John Correnti
- Map of Gwangyang Steelworks, South Korea, Shanghai Baosteel and Barrow in Furness from Google Maps
- <http://www.castrip.com/Process/process.html> Image of Castrip process
- Mr Da Nym – image of HMS Bulwark
- <https://gcaptain.com/china-shipyards-set-to-spark-price-war-among-rigmakers/> Image of China shipyard
- [https://en.wikipedia.org/wiki/Aditya\\_Mittal](https://en.wikipedia.org/wiki/Aditya_Mittal) Image of Aditya Mittal
- [https://en.wikipedia.org/wiki/Burj\\_Khalifa](https://en.wikipedia.org/wiki/Burj_Khalifa) Image of Burj Khalifa
- Various photos (China blast furnaces, Harold Wilson, rebuilding 22 Bishopsgate by Roger Emmott)
- [https://www.researchgate.net/figure/Basic-innovations-and-improvement-in-the-120-t-EAF-performances\\_fig3\\_221911830](https://www.researchgate.net/figure/Basic-innovations-and-improvement-in-the-120-t-EAF-performances_fig3_221911830) EAF improvements
- <https://www.worldautosteel.org/why-steel/steel-your-strength/>
- <https://www.cia.gov/library/readingroom/docs/CIA-RDP86B00985R000300040017-8.pdf> CIA paper on China written 1979 embargoed until release in 2000
- Engineering Architecture: The Vision of Fazlur R. Khan by Yasmin Sabina Khan (his daughter) – details of his work with structural steels and high rise buildings
- <https://www.amusingplanet.com/2014/08/the-728-ton-tuned-mass-damper-of-taipei.html> image of tuned mass damper in Taipei 101
- Crude steel forecasts by MCI/James F King [www.steelonthenet.com](http://www.steelonthenet.com)