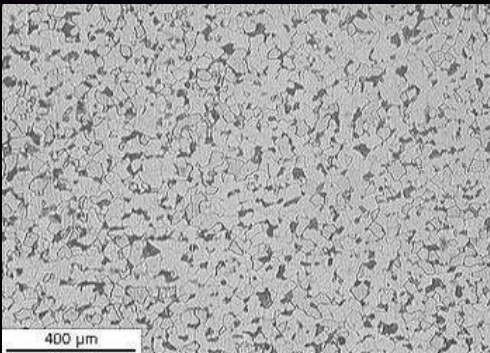


IRON & STEEL INSTITUTE.

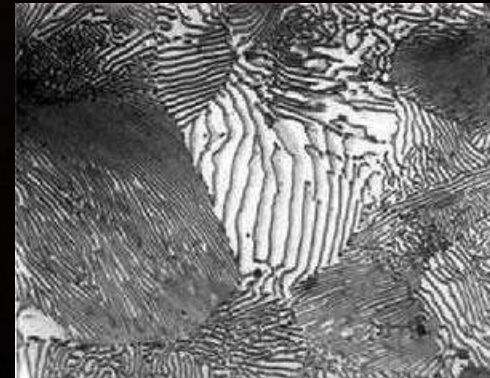


25

Fe



150 years of steel



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1869-71 William Cavendish, 7th Duke of Devonshire

1871-73 Sir Henry Bessemer

1873-75 Sir Lowthian Bell Bt FRS

1875-77 William Menelaus

1877-79 Sir C William Siemens FRS

1879-81 Edward Williams

1881-83 Josiah Timmis Smith

1883-85 Rt Hon Sir Bernard Samuelson Bt FRS

1885-87 John Percy MD FRS

1887-89 Danie Adamson

1889-91 The Rt Hon Lord Airedale of Gledhow DSc

1891-93 Sir Frederick Augustus Abel Bt GVCO KCB FRS

1893-95 Edward Windsor Richards

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1912-14 Arthur Cooper LLD

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1916-18 Rt Hon Lord Invernairn of Strathnairn

1918-20 C P Eurgene Schneider DSc

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1924-25 Sir William Ellis GBE DENG

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1926-27 Sir W Peter Rylands JP

1927-28 Frank William Harbord CBE

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1935-37 Sir Harold Carpenter FRS

1937-38 Alfred Hutchinson MA

1938-40 The Rt Hon The Earl of Dudley DC

1940-42 Sir John Craig CBE DL

1942-44 James Henderson

1869-71 William 1944-46 Arthur Dorman

1946-48 Dr Cecil Henry Desch DSc PhD LLD FRS

1948-50 Sir Andrew McCance LLD DSc FRS

1950-51 James Robert Menzies-Wilson OBE

1951-52 Richard Mather BMet

1952-53 Captain Hector Leighton Davies CBE JP

1953-54 James Mitchell CBE

1954-55 The Hon Richard Glynne Lyttelton

1955-56 Sir Chales Bruce-Gardner Bt

1956-57 Herbert Henry Burton CBE DMet

1957-58 Arnold Hugo Ingen-Housz

1958-59 Charles Reginal Wheeler CBE

1959-60 William Barr OBE

1960-61 William Frederick Cartwright DL

1961-62 Sir Charles Goodeve OBE DSc FRS

1962-63 Maurice Alberic Fiennes

1963-64 Frank Bernard George

1964-65 Frank Henry Saniter OBE DSc (Tech) BEN

1965-66 William Frederick Gilbertson

1966-67 Sir Douglas Bruce-Gardner Bt

1967-68 Norman E Jones CMG DSc ASTC

1968-69 Dr John Hugh Chesters OBE FRS

1969-70 Niall Cambell Macdiarmid

1970-71 Norman Cecil Lake CBE

1971-72 Thomas Rae Craig CBE TD

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:

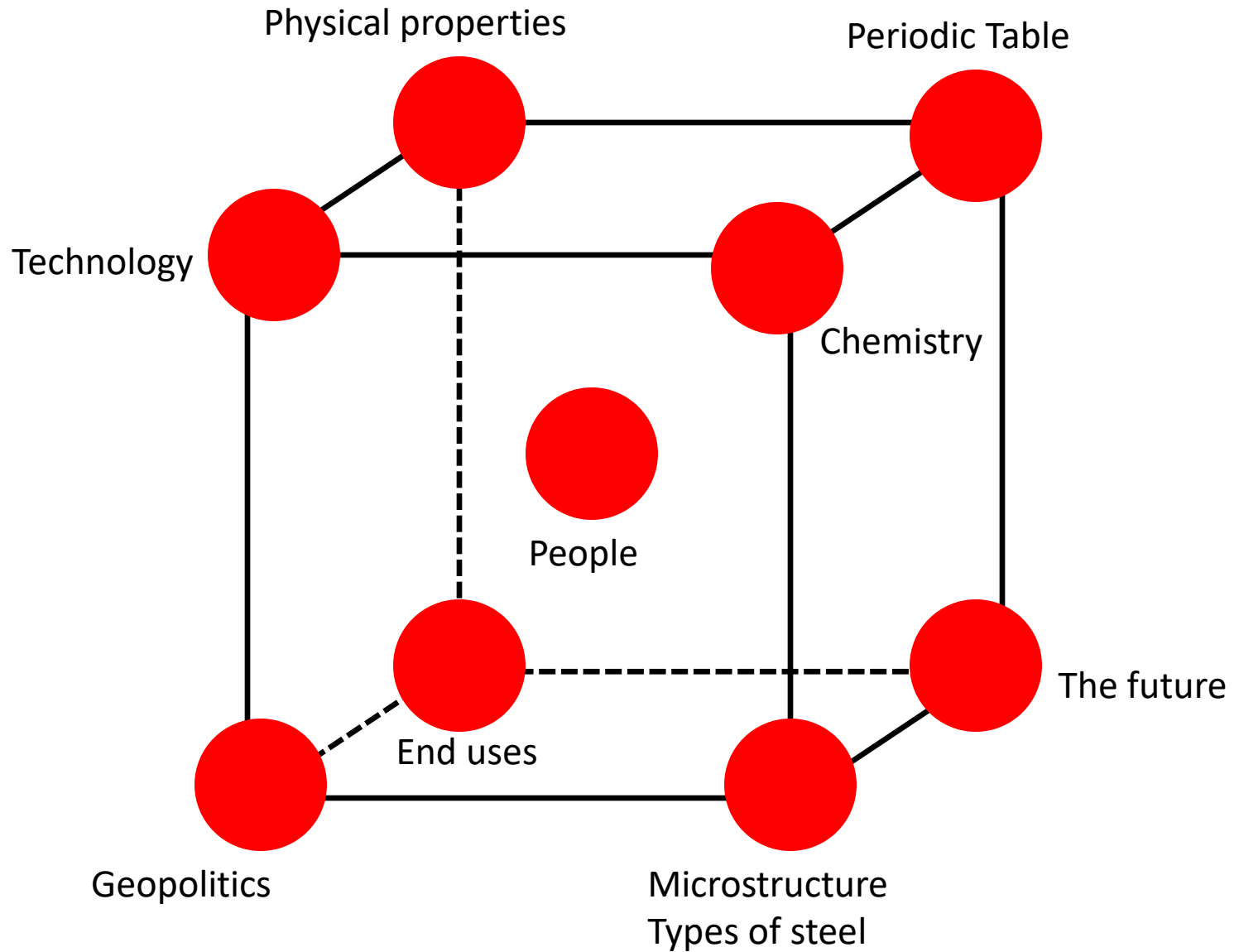
E. & F. N. SPON, 48, CHARING CROSS.

PRICE, SEVEN SHILLINGS AND SIXPENCE.

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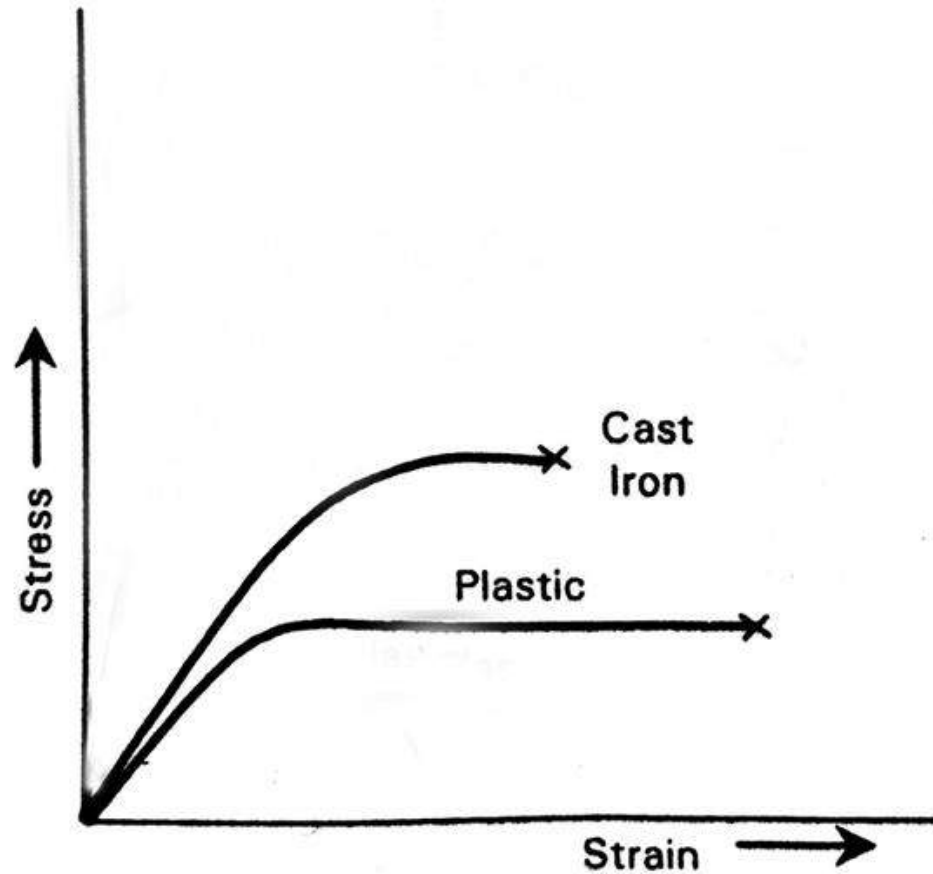
150 years of steel – what this talk is about



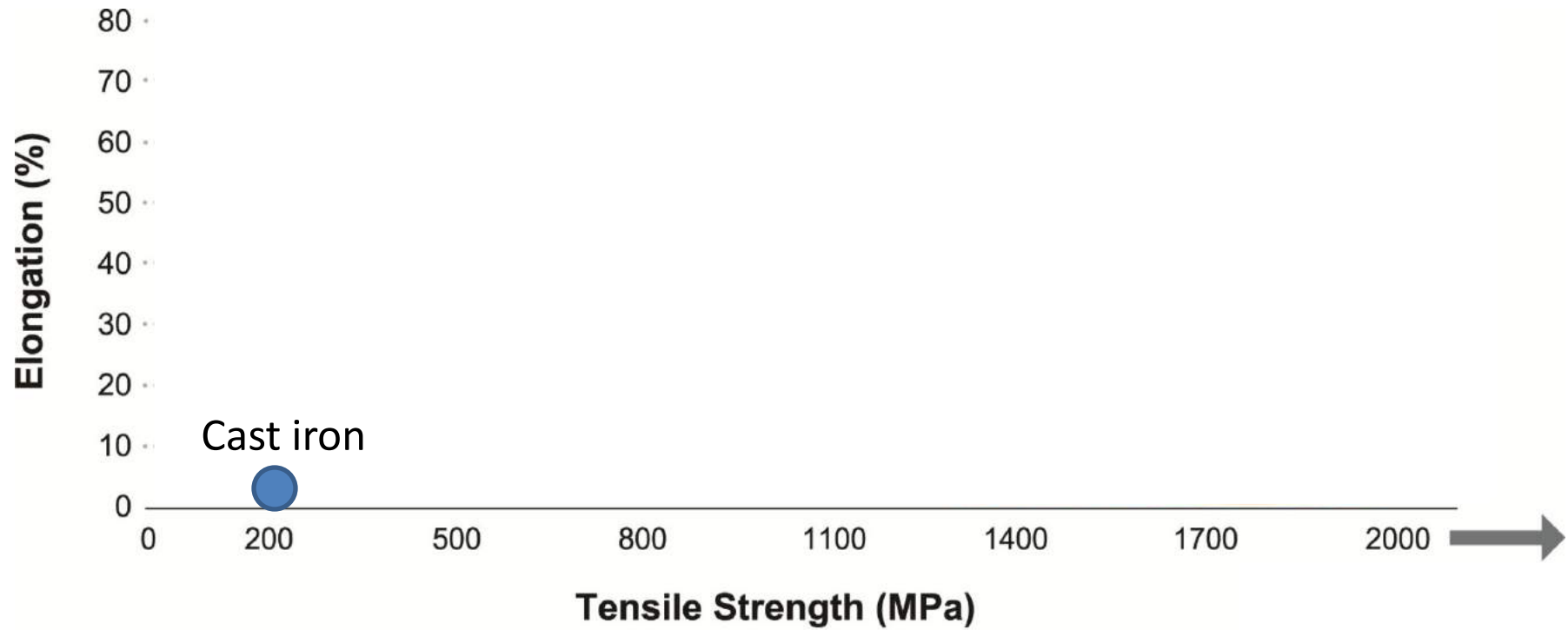
Ironbridge – 1779 – Abraham Darby III – cast iron



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



Position of cast iron



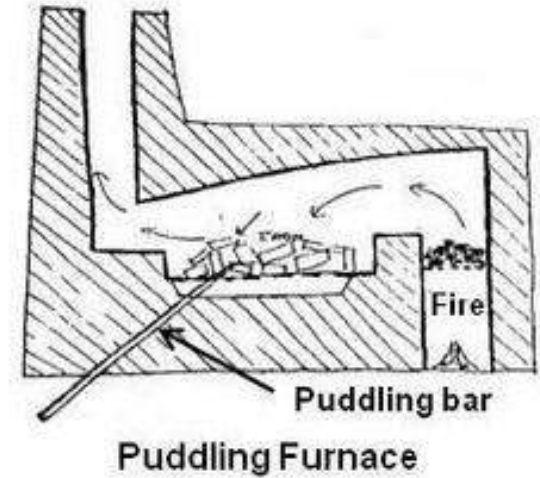
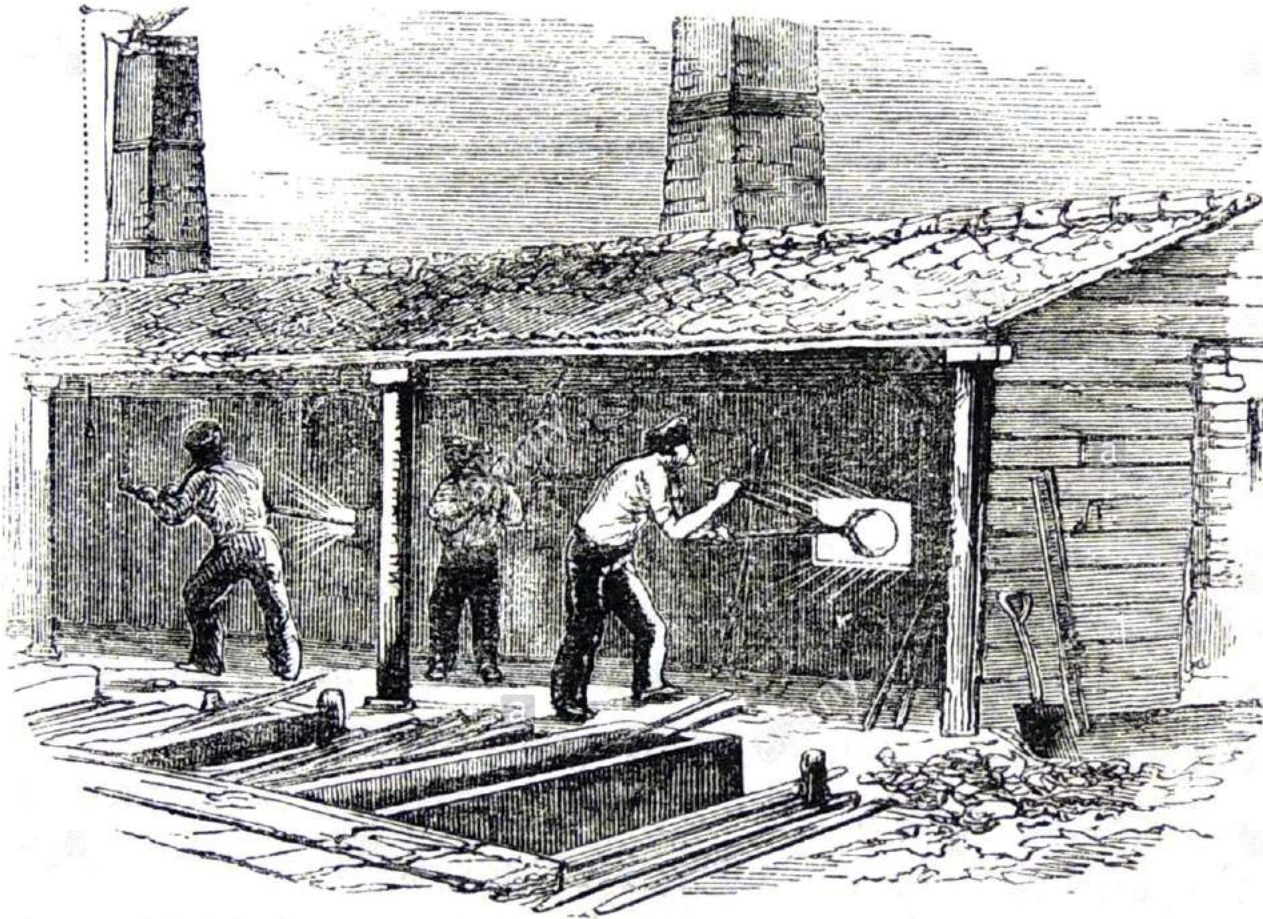
150th anniversary of the Periodic Table – knowledge in 1869

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	67 Tl thallium 204.4	68 Pb lead 207.2	69 Bi bismuth 209.0	70 Po polonium 209	71 At astatine 210	72 Rn radon 222
7	87 Fr francium 223	88 Ra radium 226	89 Lr lawrencium 262	90 Rf rutherfordium 267	91 Db dubnium 268	92 Sg seaborgium 271	93 Bh bohrium 272	94 Hs hassium 270	95 Mt meitnerium 276	96 Ds darmstadtium 281	97 Rg roentgenium 280	98 Cn copernicium 285	99 Nh nihonium 284	100 Fl flerovium 289	101 Mc moscovium 288	102 Lv livermorium 293	103 Ts tennessine 292	104 Og oganesson 294

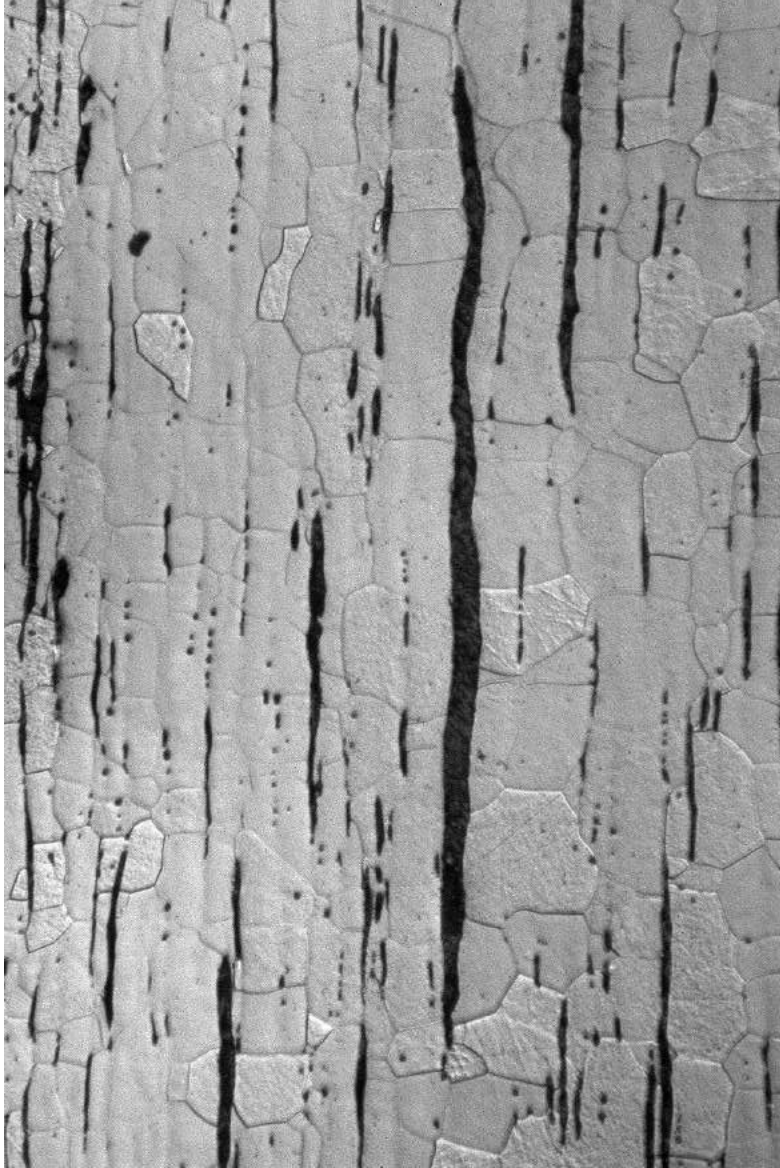
29
Cu
copper
63.55

← ions commonly formed
+2,1
← atomic mass (rounded)

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



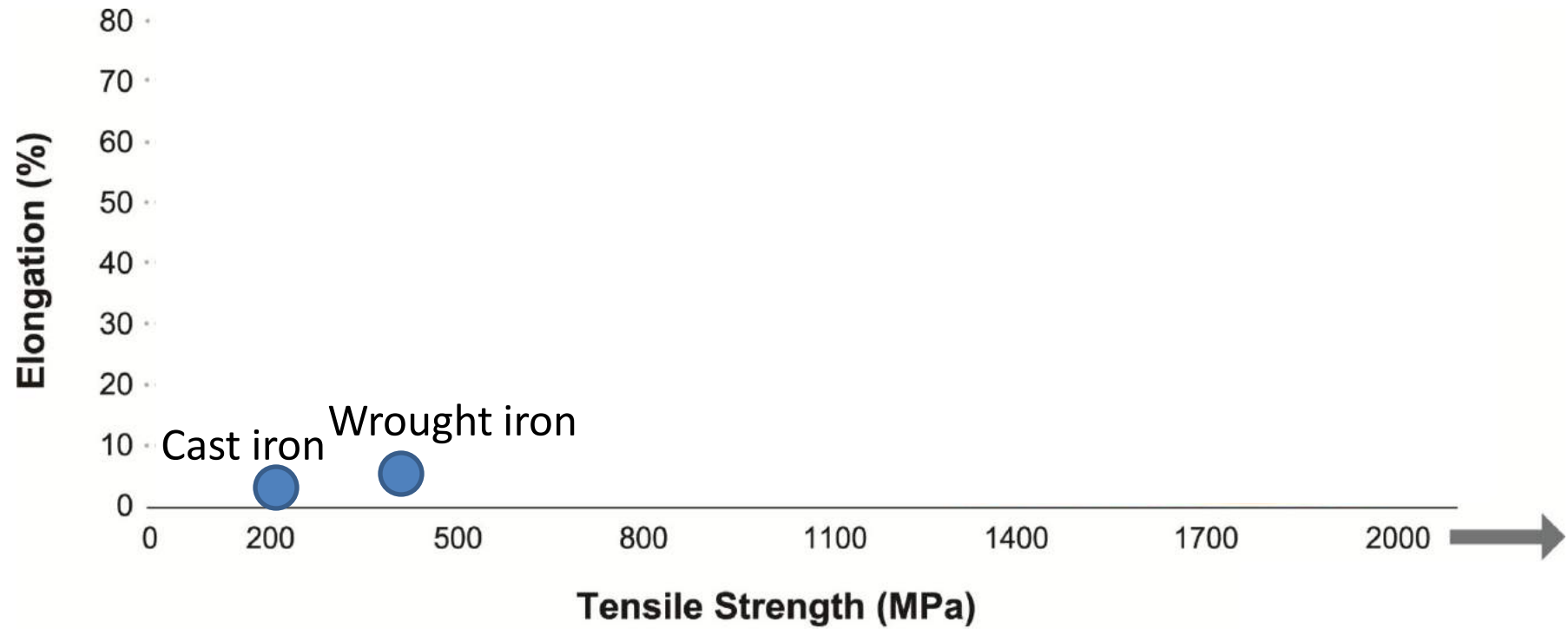
Henry Clifton Sorby – Father of Metallography – 1826 - 1908



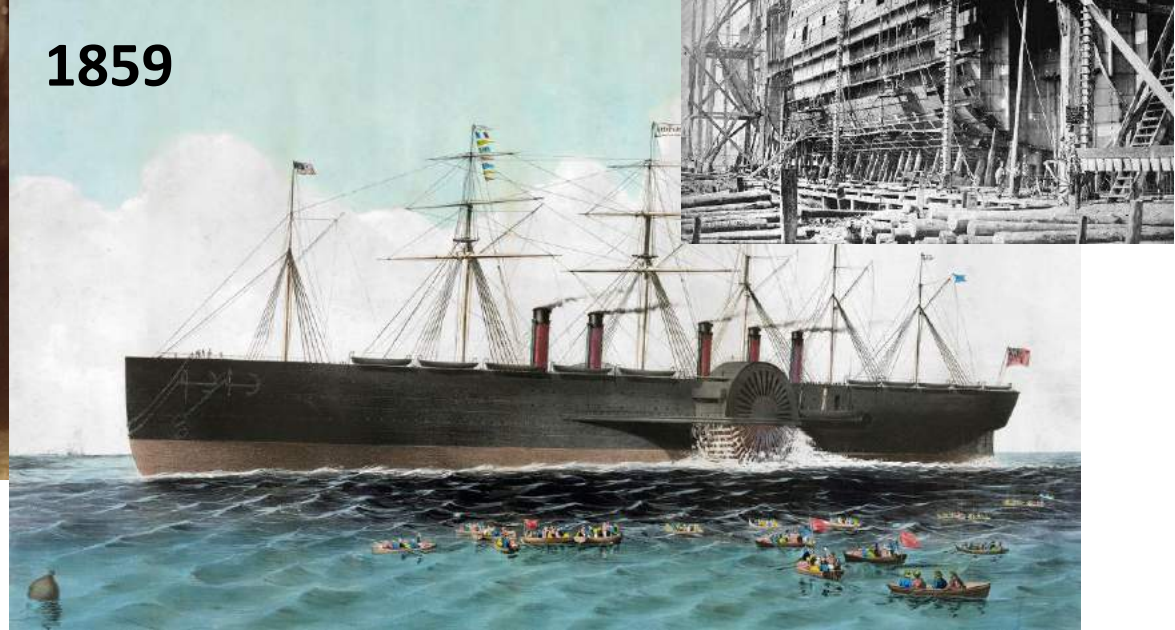
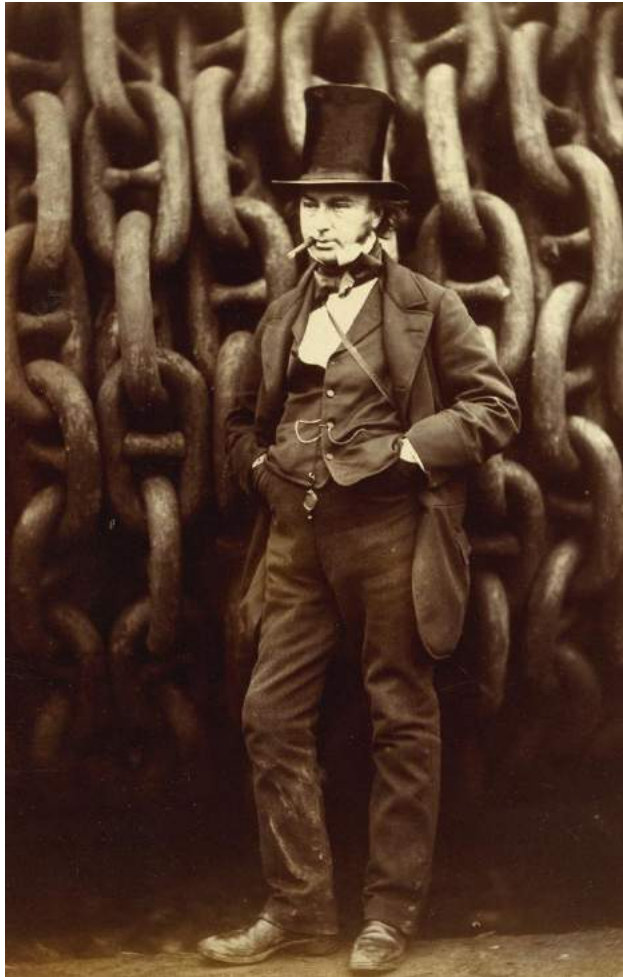
Wrought iron



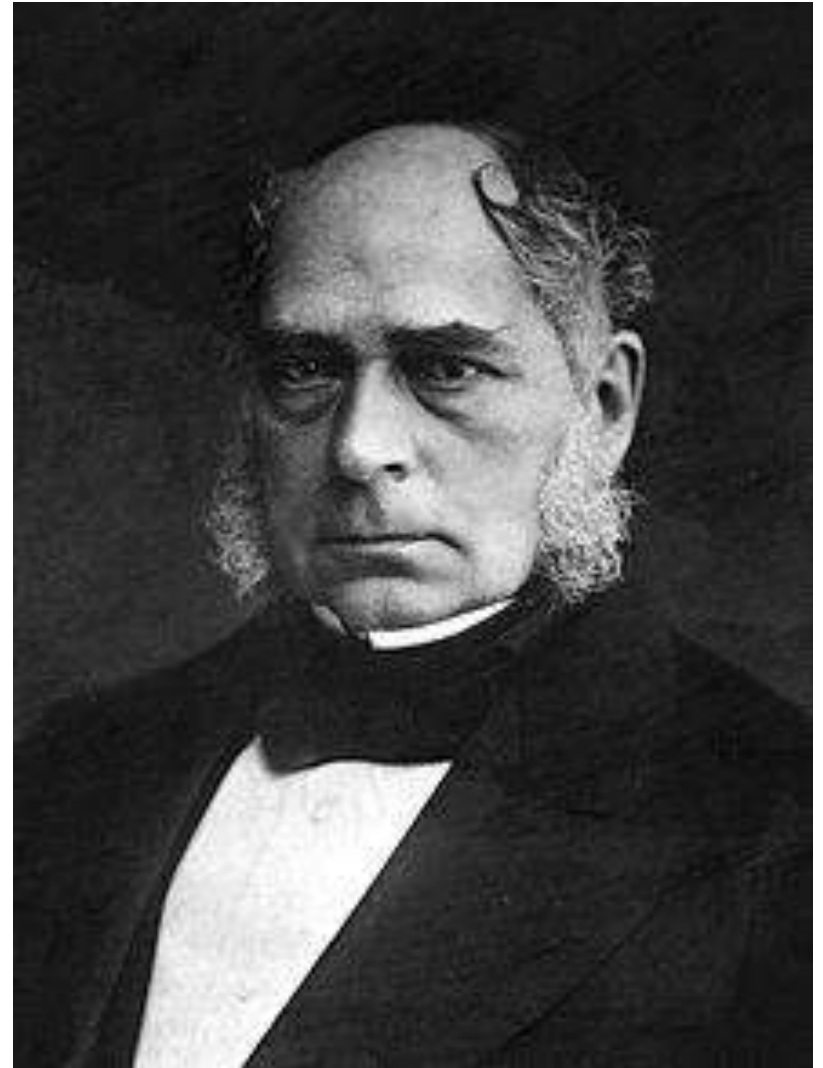
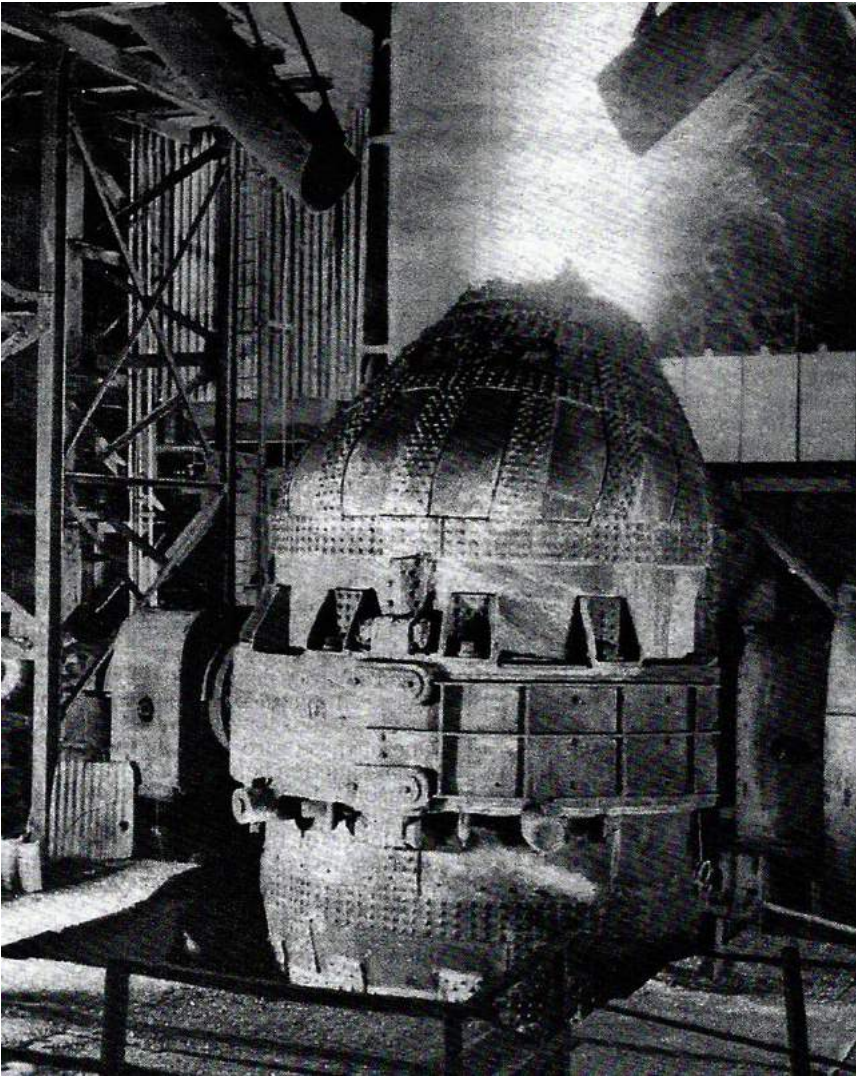
Position of wrought iron



Isambard Kingdom Brunel (1806 – 1859)



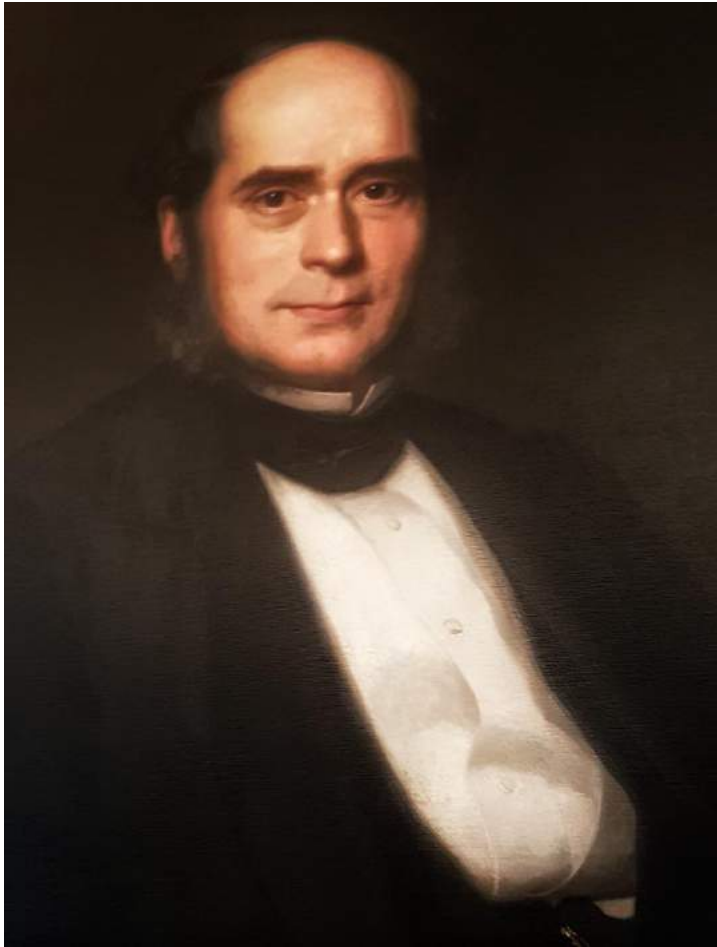
Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856

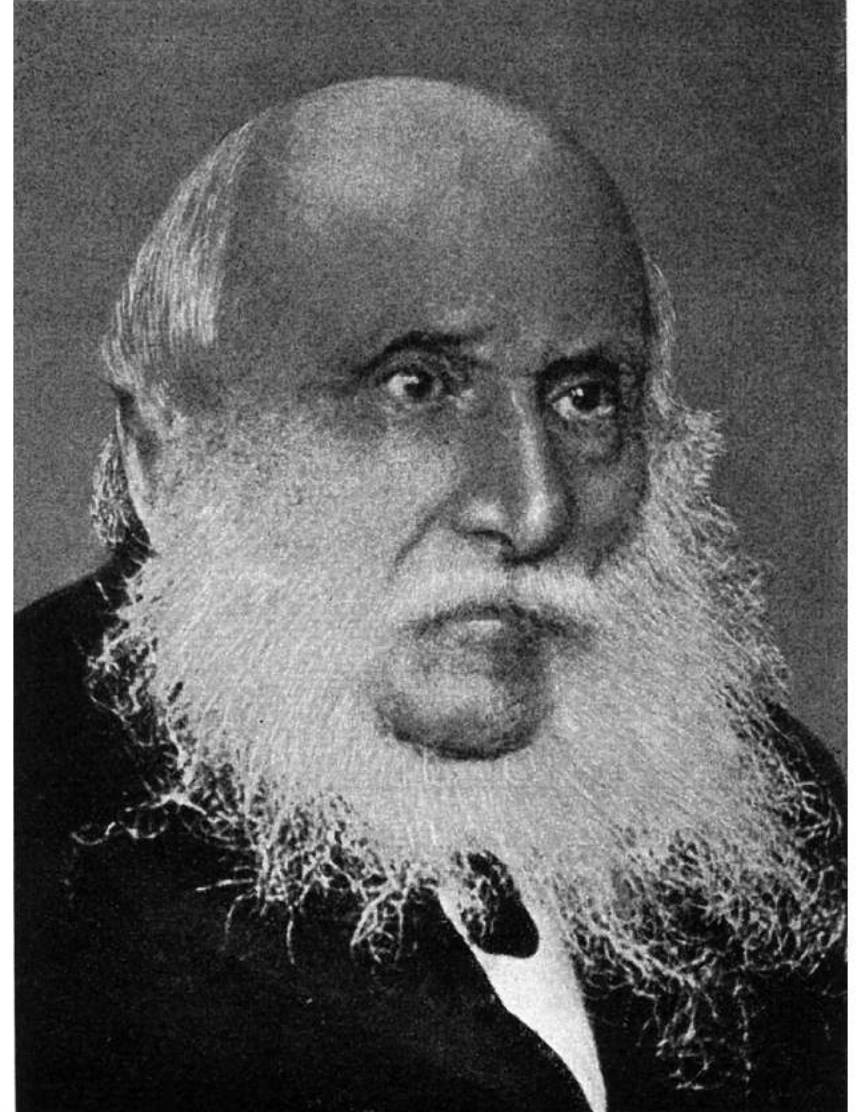


Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856



Henry Bessemer 1813 – 1898 Invention of Bessemer converter, 1856





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

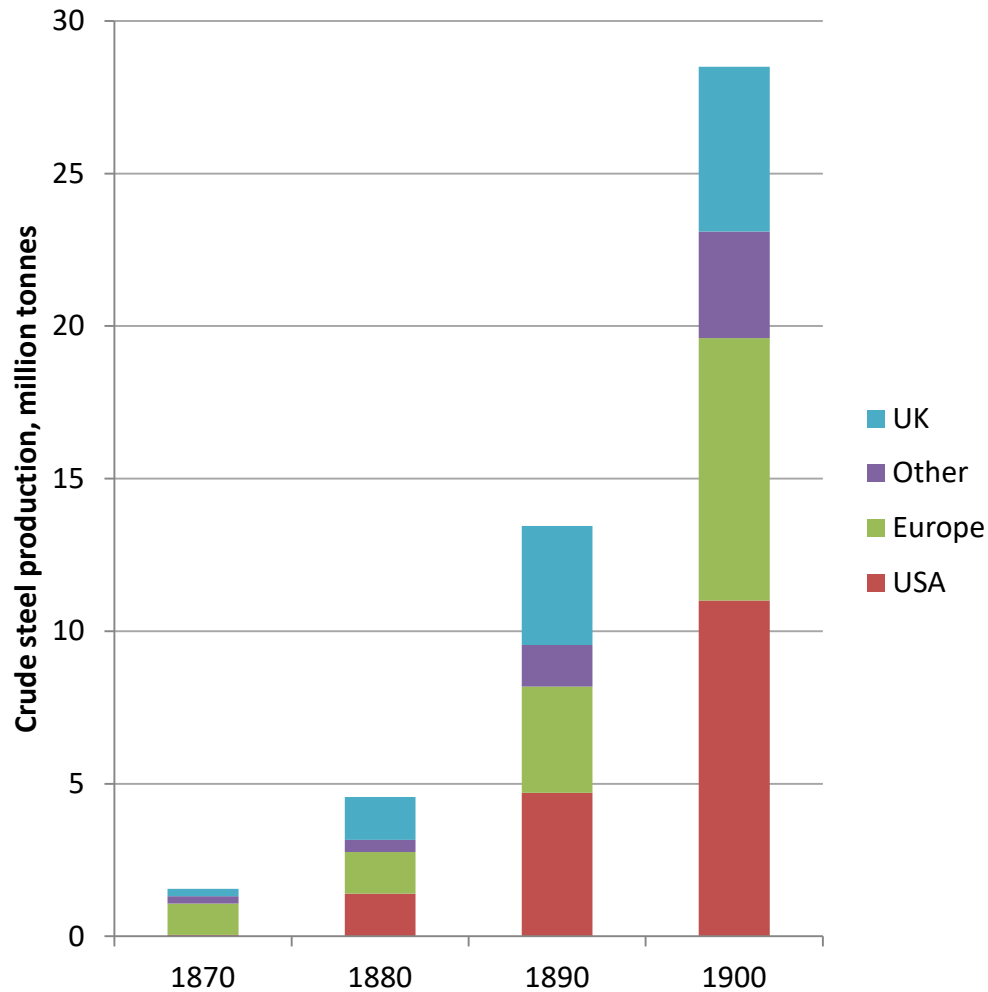


Brooklyn Bridge 1880 – wrought iron

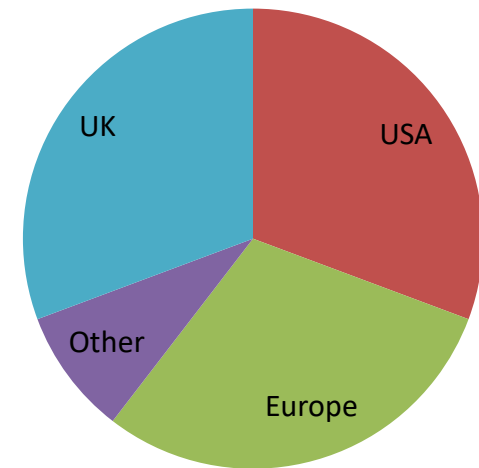


1880 steel production worldwide – UK and USA have 31% each

Growth of steel production by region, 1870 - 1900



Steel production share by region, 1880



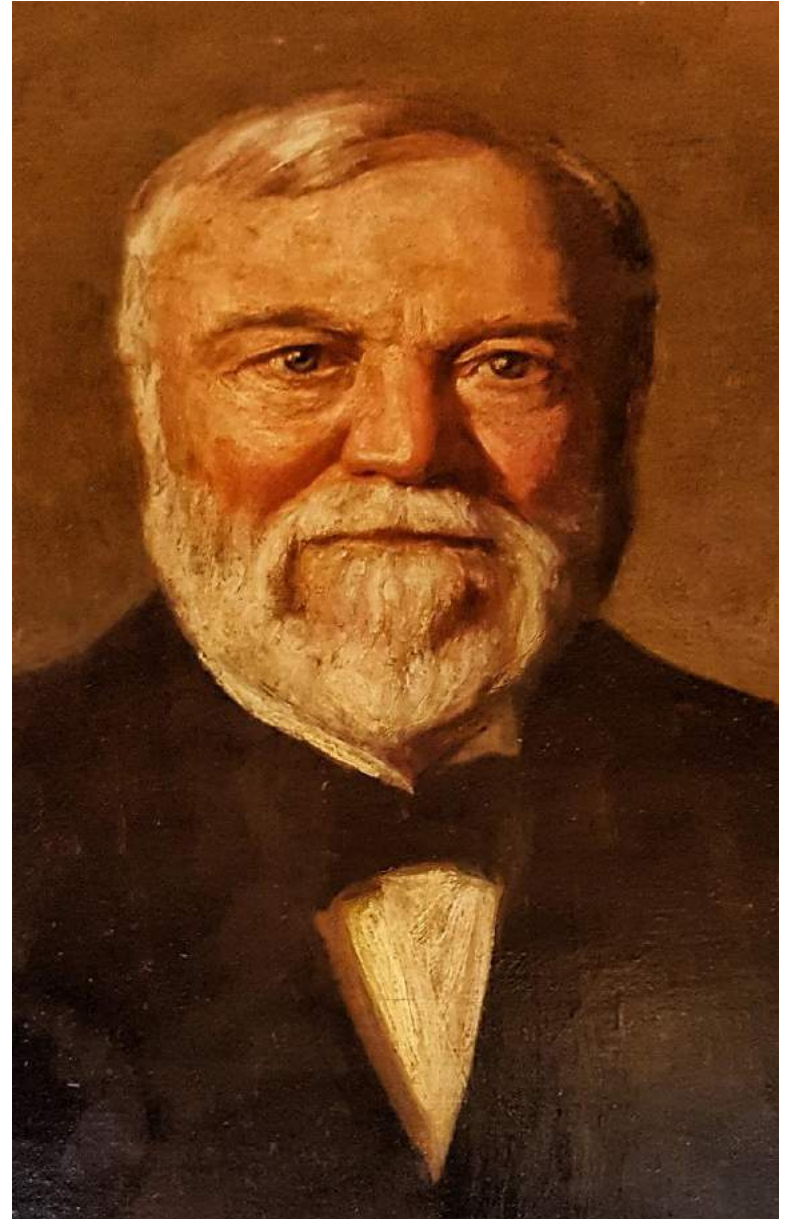
Dr James Burgess Readman - first operational; EAF - 1888



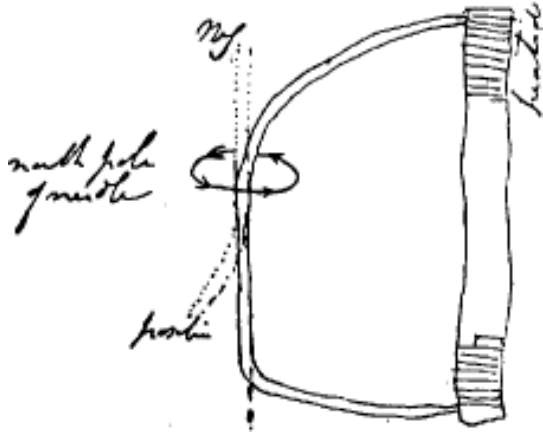
Eiffel Tower 1889 – wrought iron – 10,000 tonnes



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**



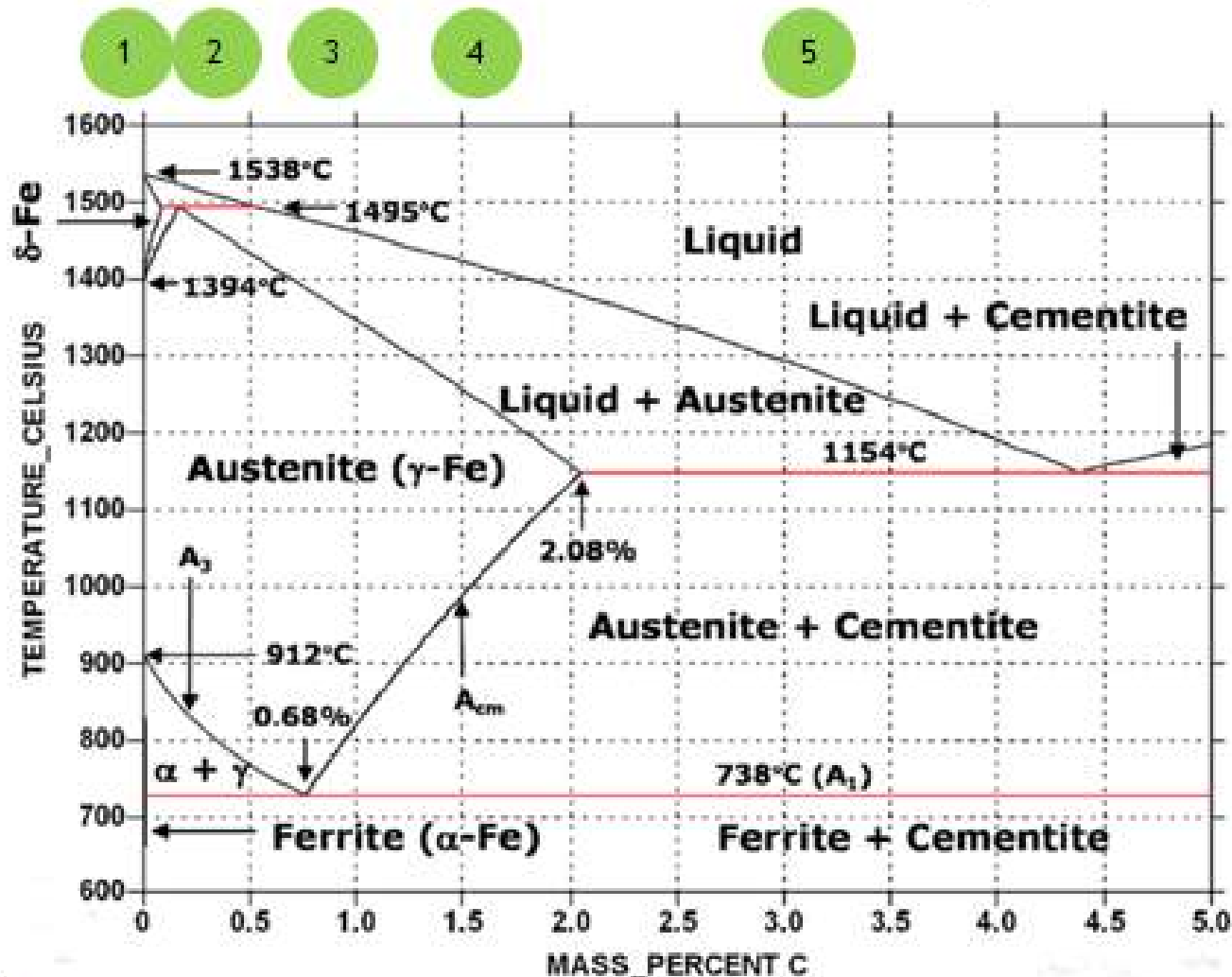
**Edward Matthey
commercial version of
Pt/Rh thermocouple
1900**

Taking temperature of Open Hearth Furnace

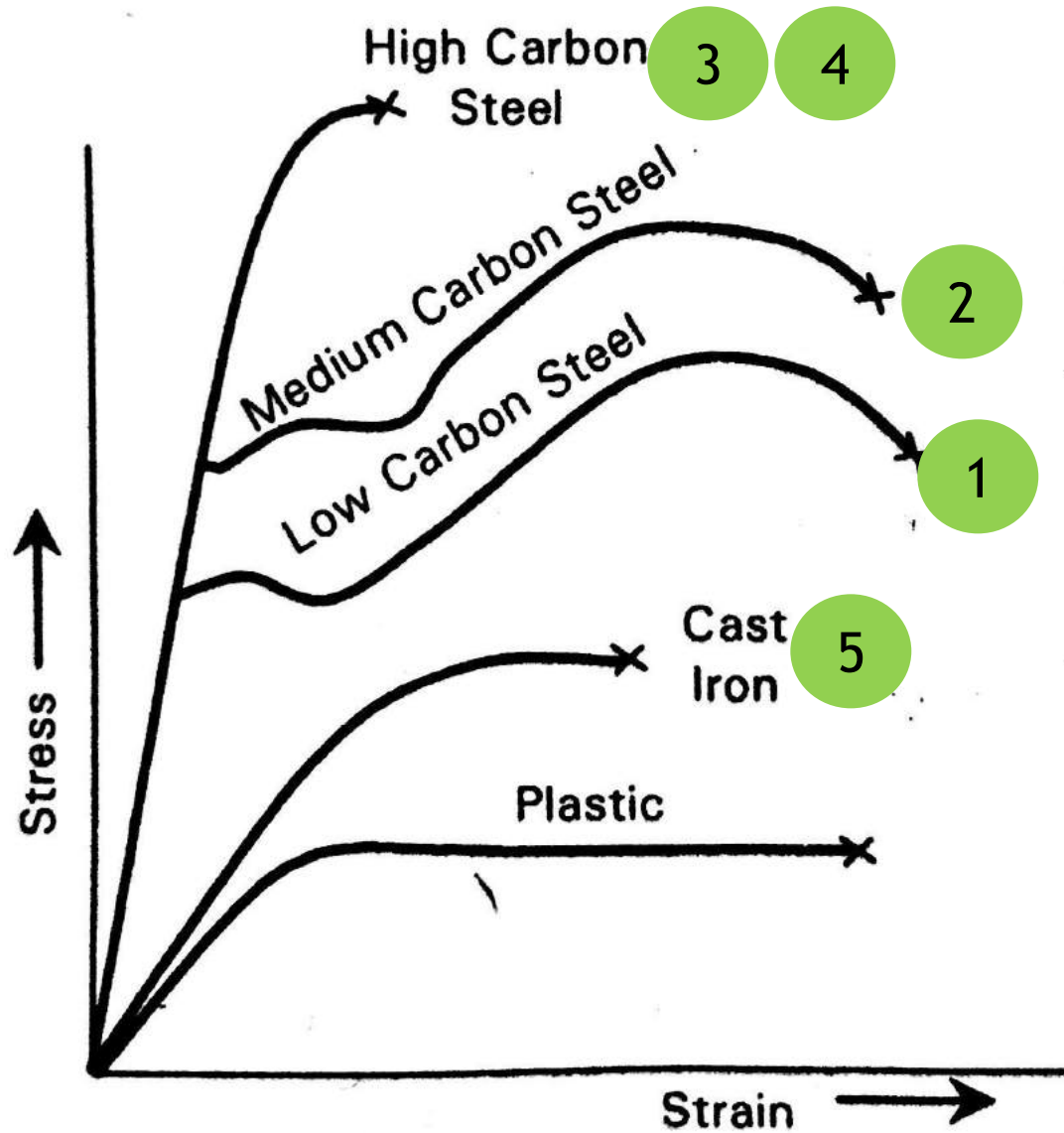


The Fe/C equilibrium phase diagram – emerges after 1900

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)

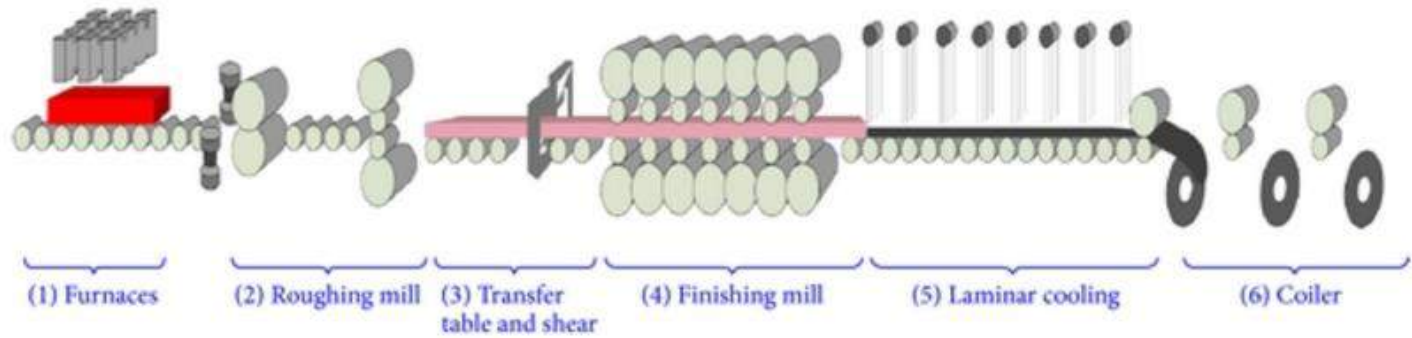
5

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



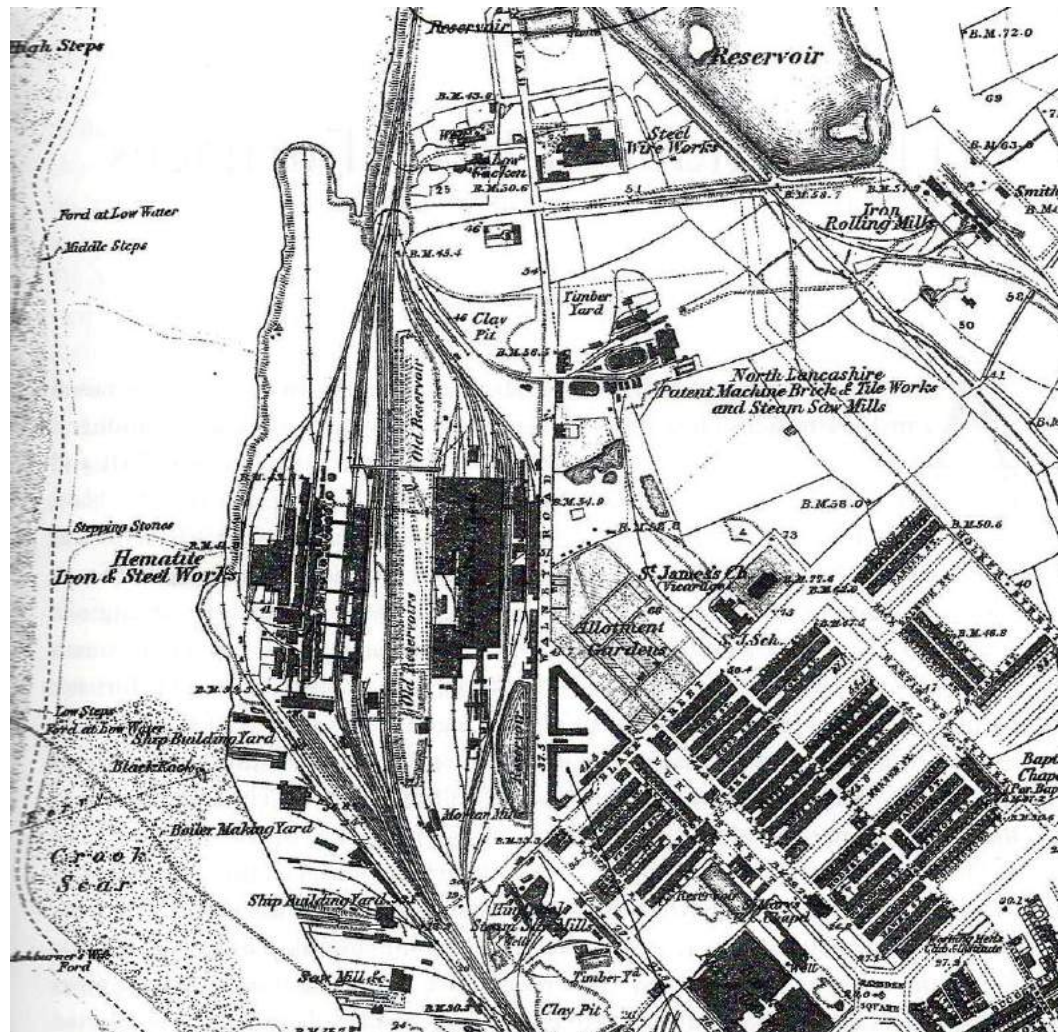
Empire State Building - 1930



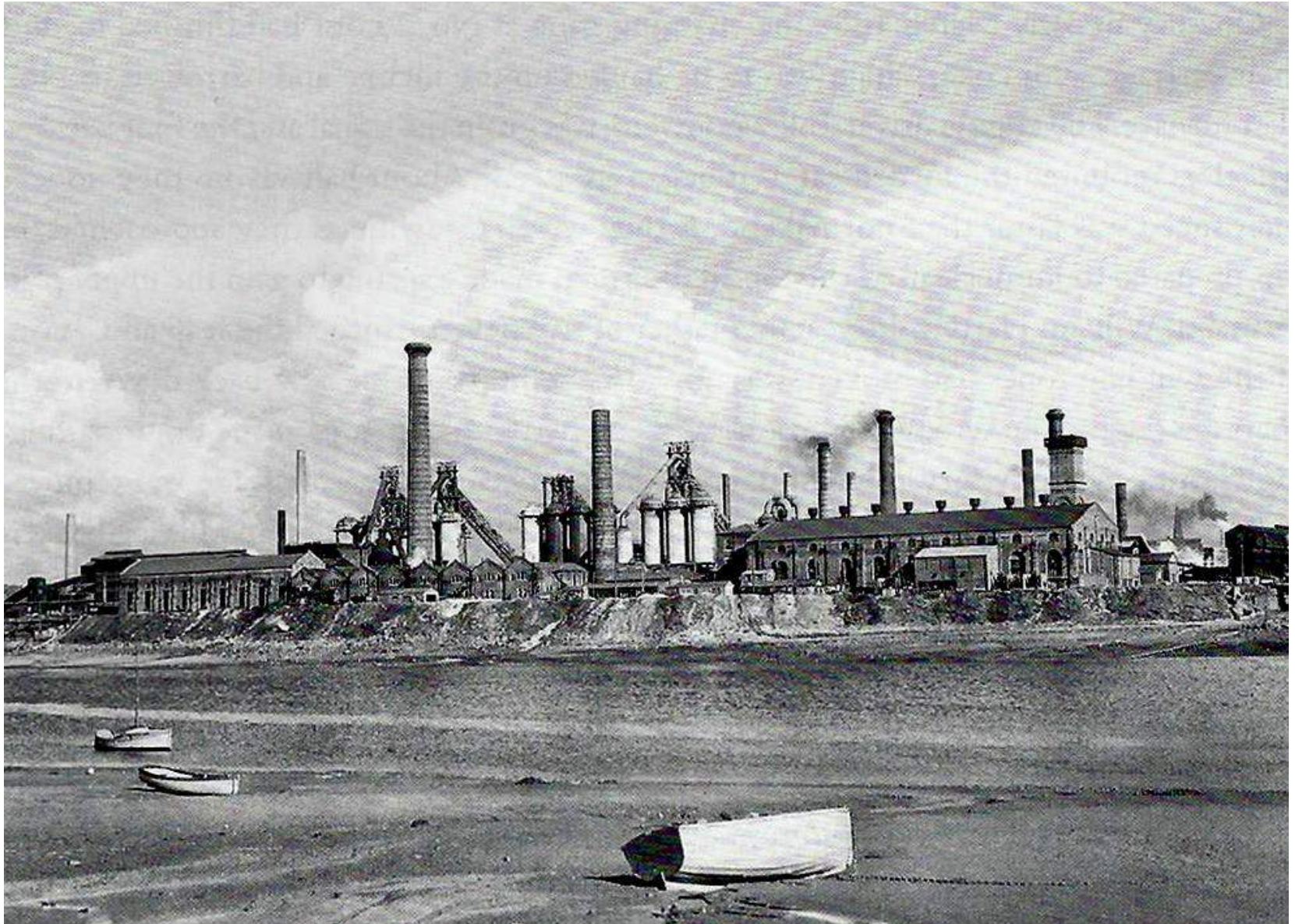
Sydney Harbour Bridge – 1930 photo – bridge opened 1932 – 86% steel from UK



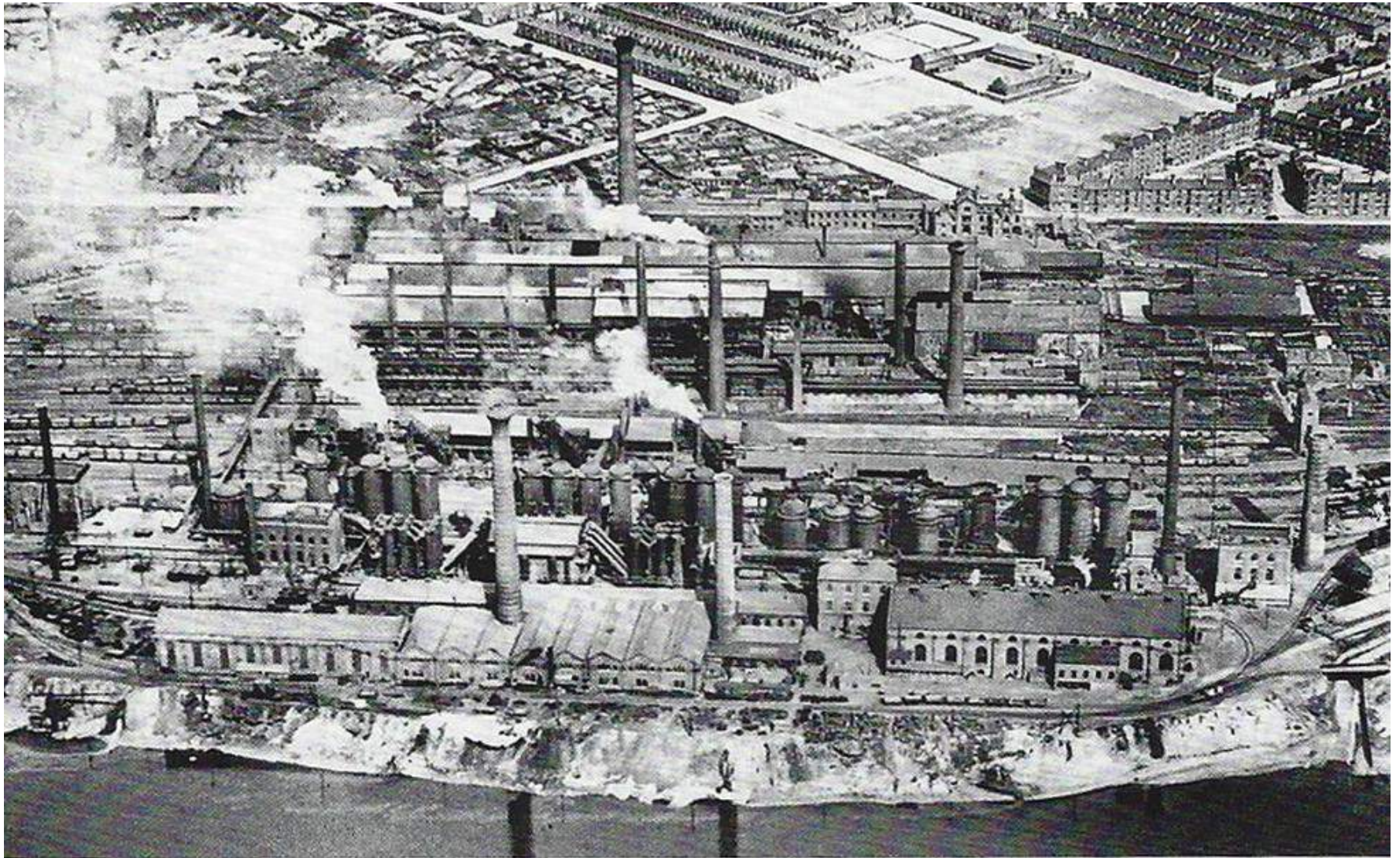
Barrow Steelworks, 1936



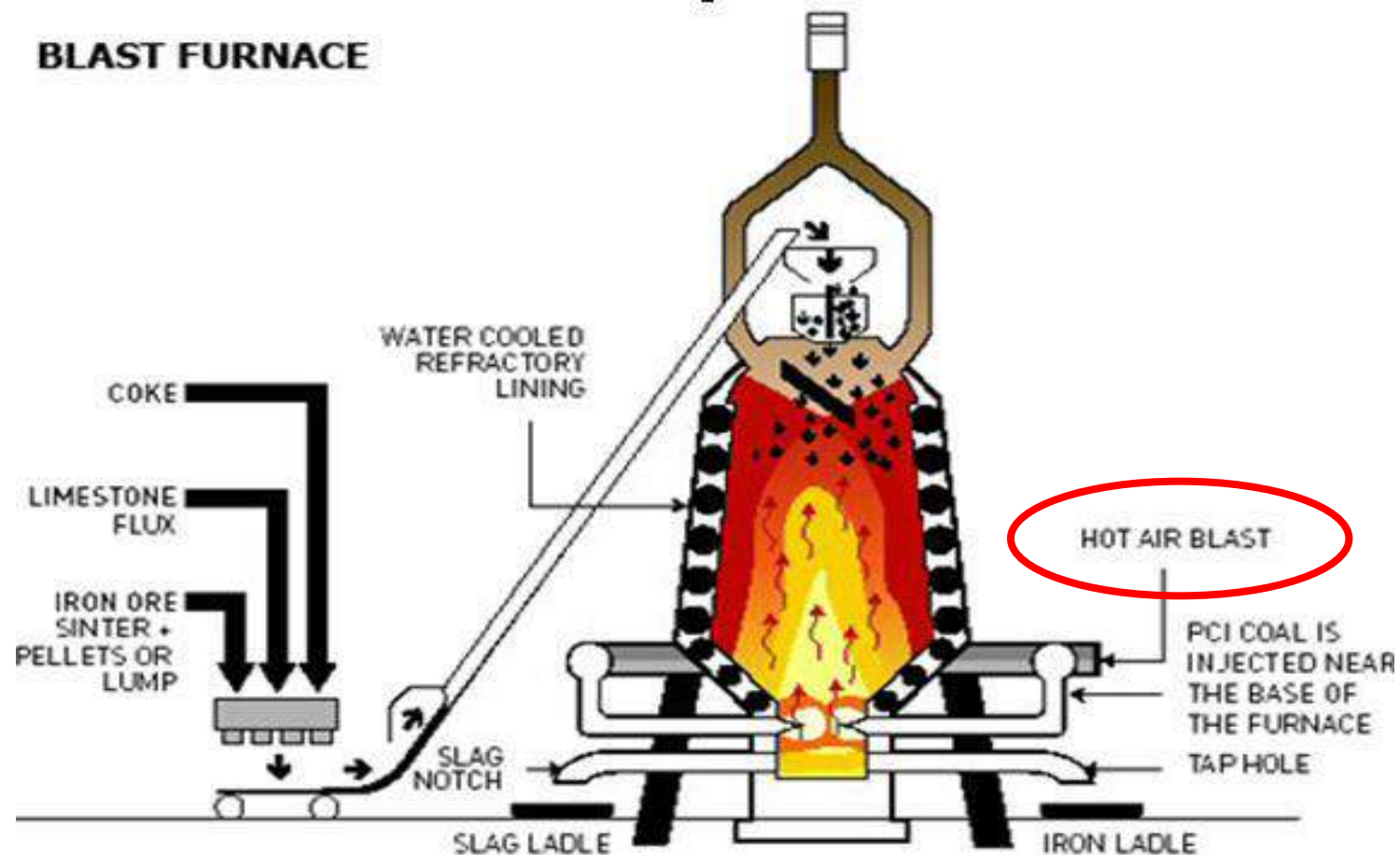
Barrow steelworks, 1936



Barrow steelworks, 1936



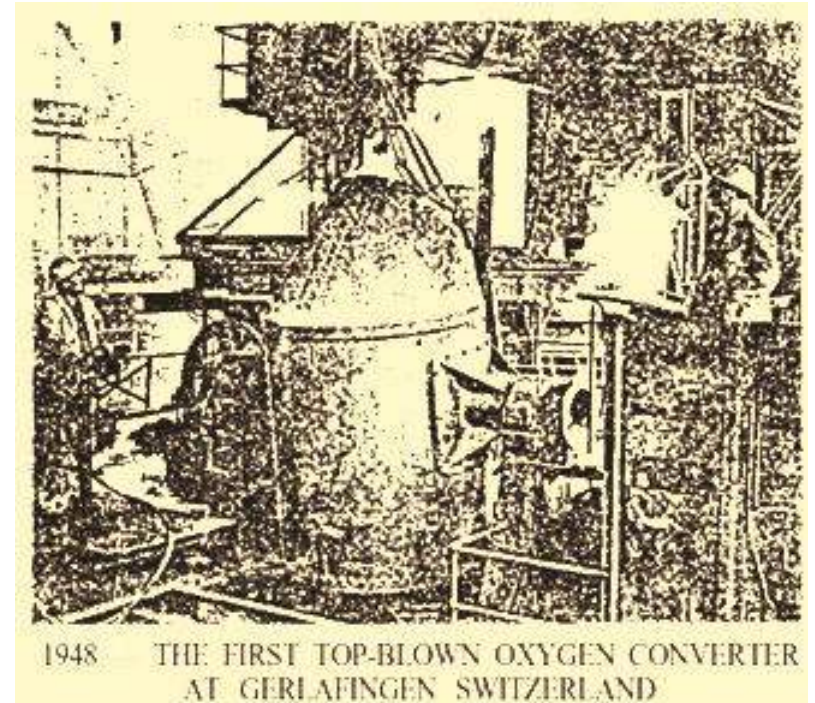
A blast furnace



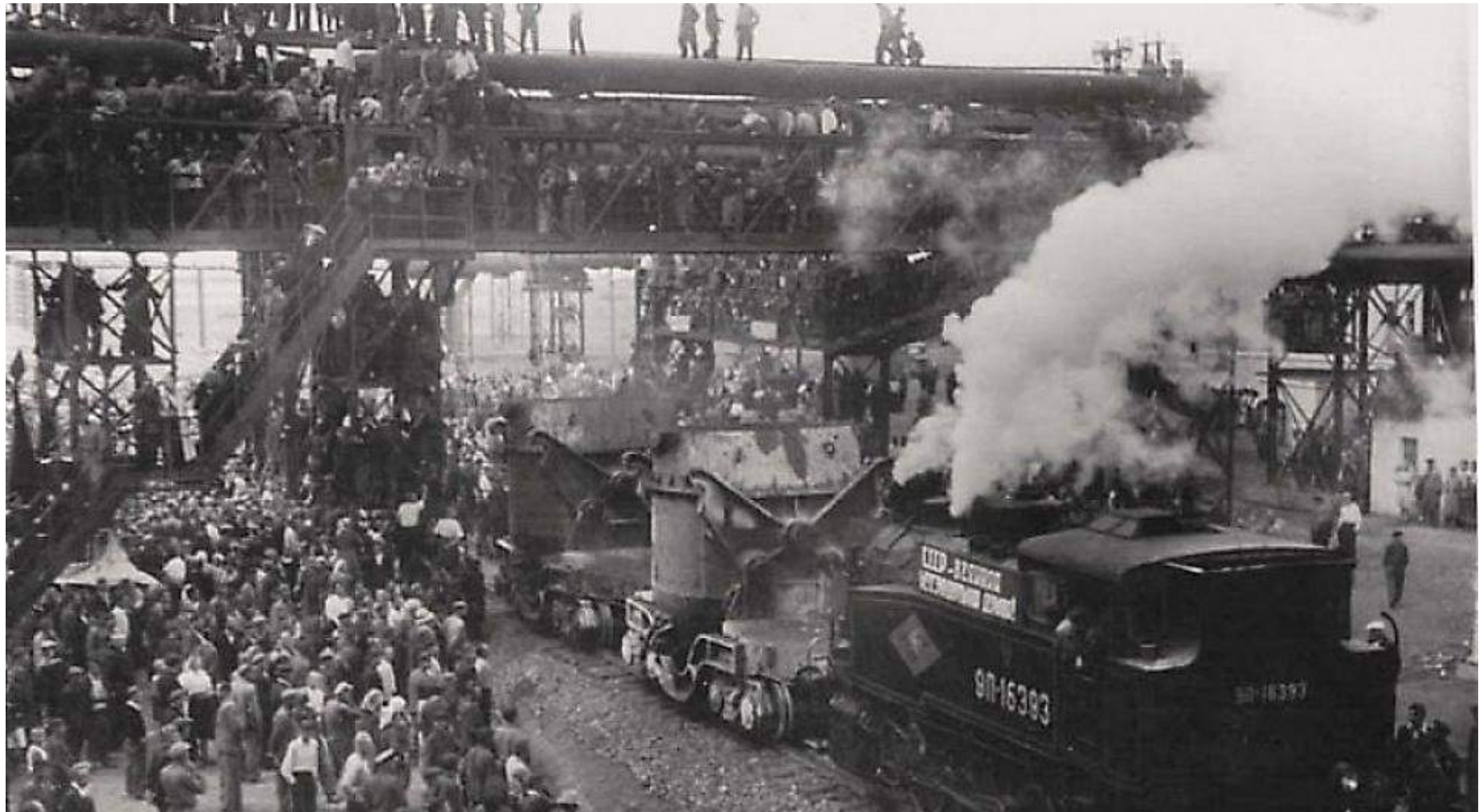
Tongsman – Barrow - 1936



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

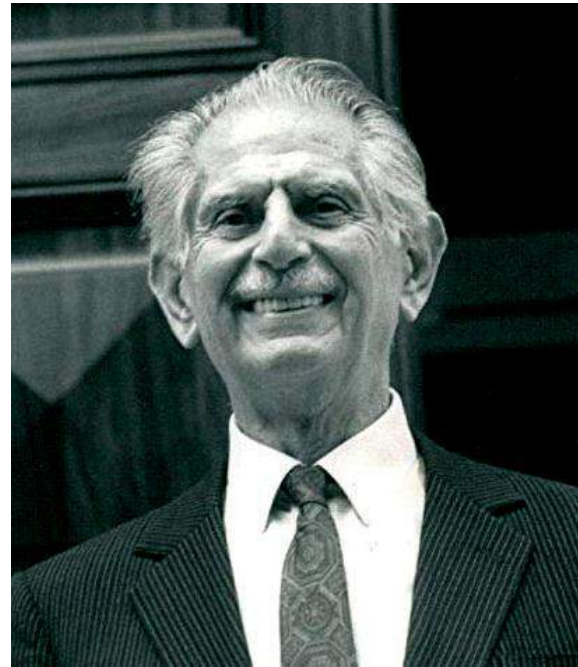


British Steel Corporation (BSC) – nationalised in 1967

- 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

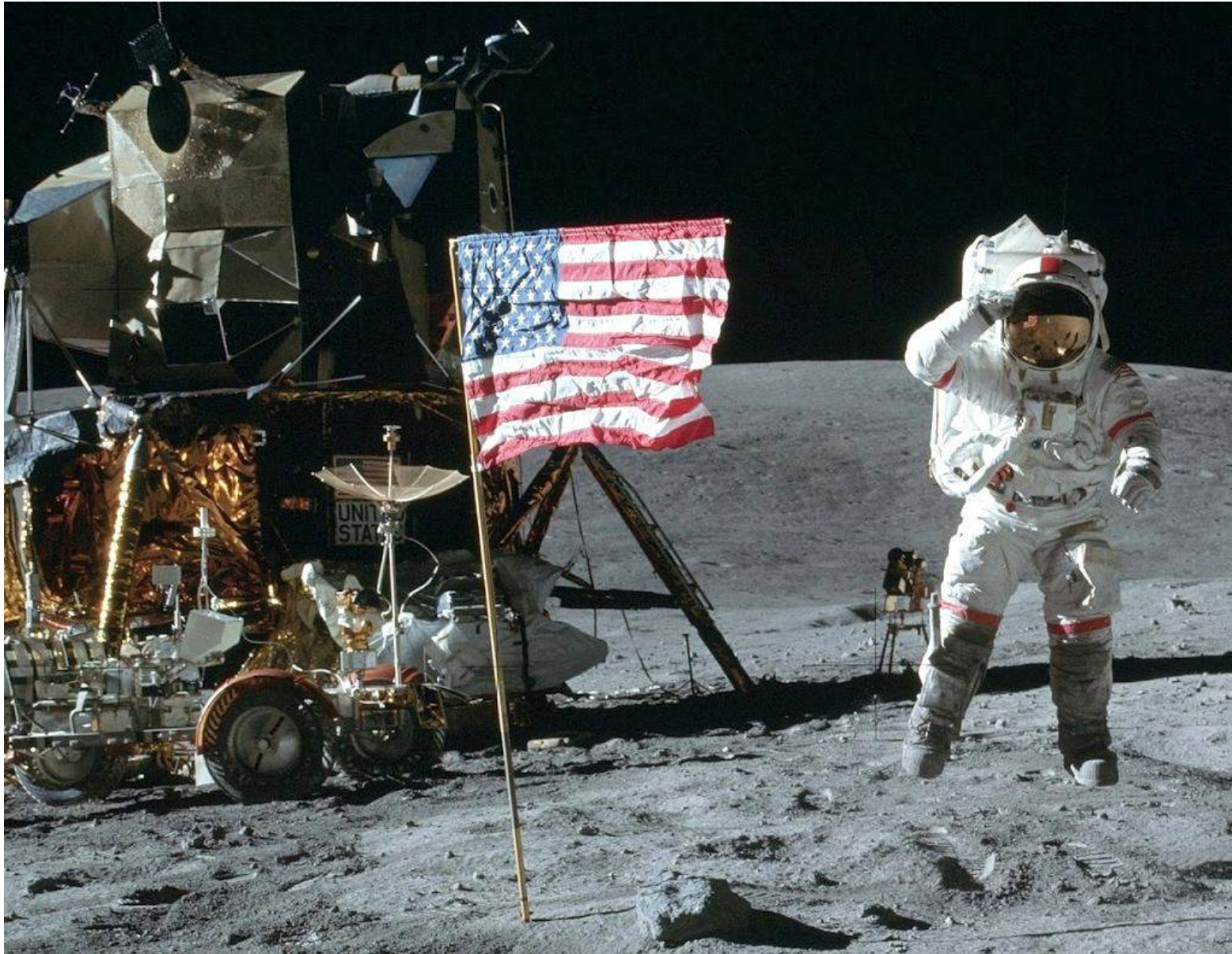
Revolution – 26 August 1968. B side of Hey Jude.

“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...”

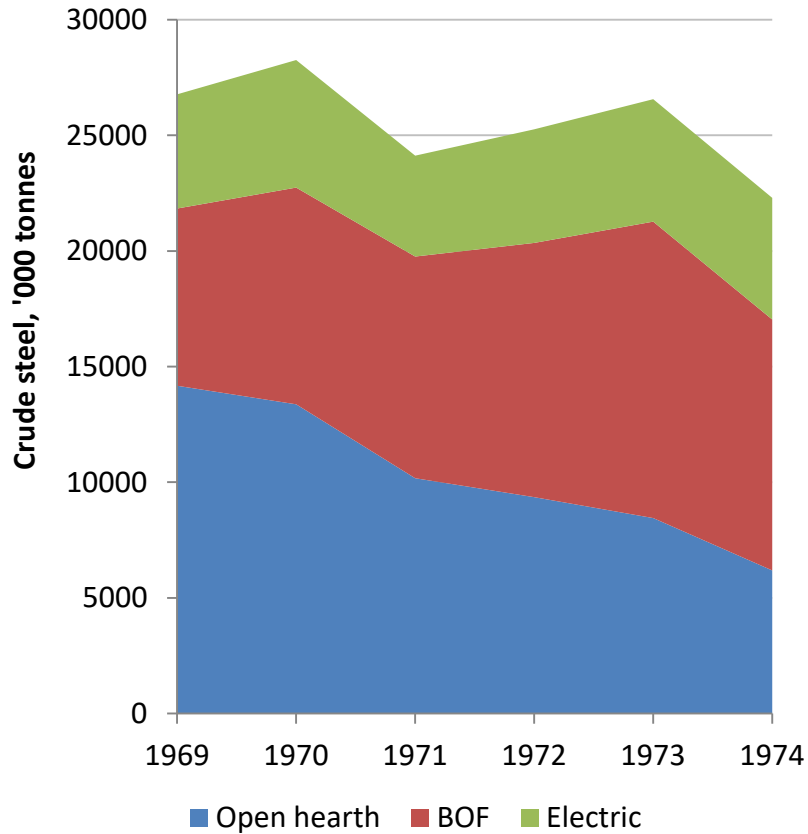
Songwriters: John Lennon / Paul McCartney
Revolution lyrics © Sony/ATV Music Publishing LLC

Moon landing, 20 July 1969

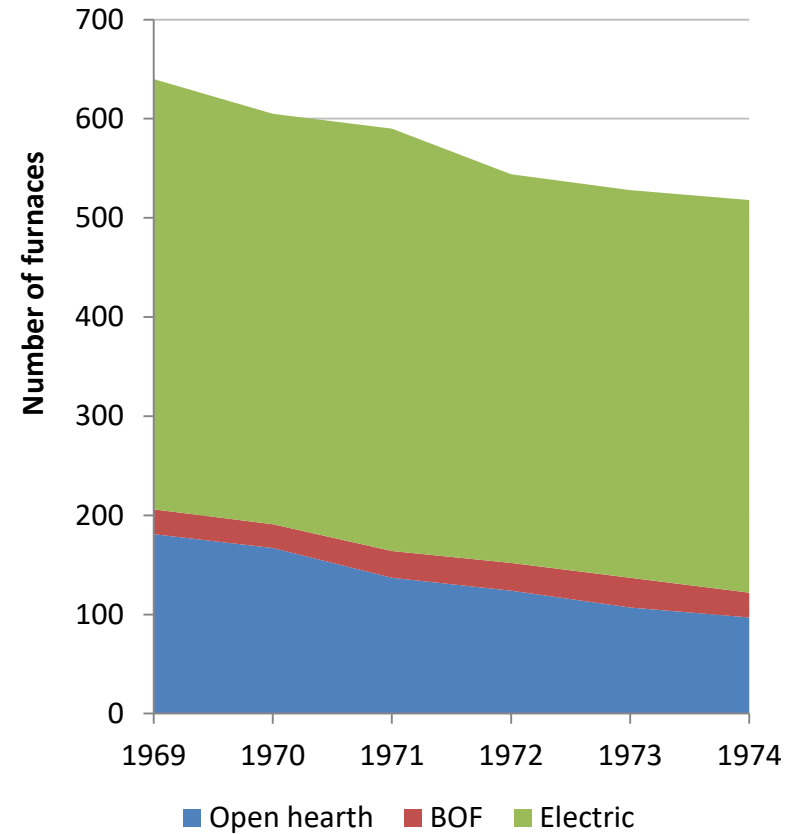


British Steel 1969 – 1974. A period of revolution. 130,000 people by 1980.

British Steel - production by process route 1969 - 1974

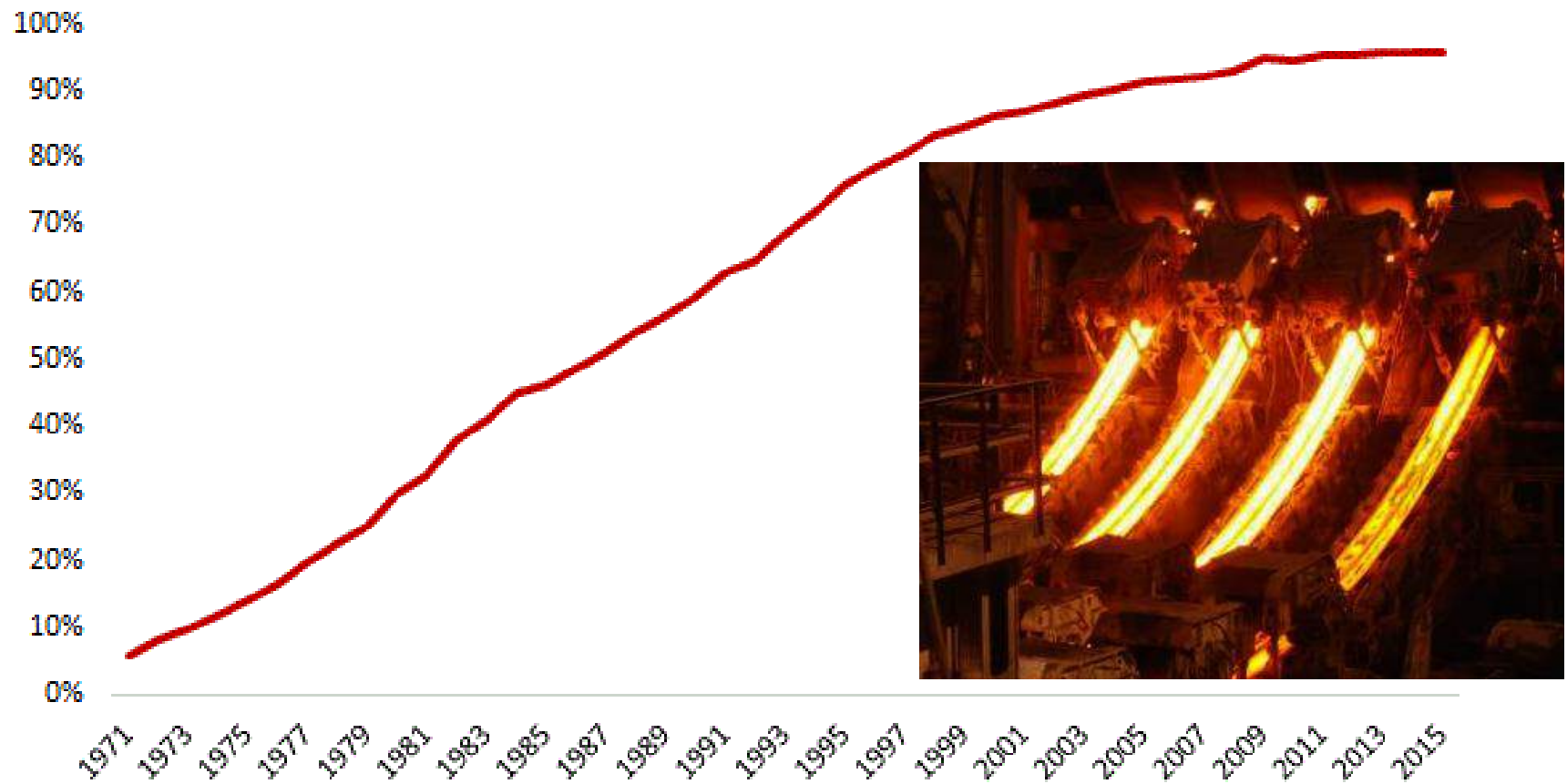


British Steel – number of furnaces of each type, 1969 - 1974

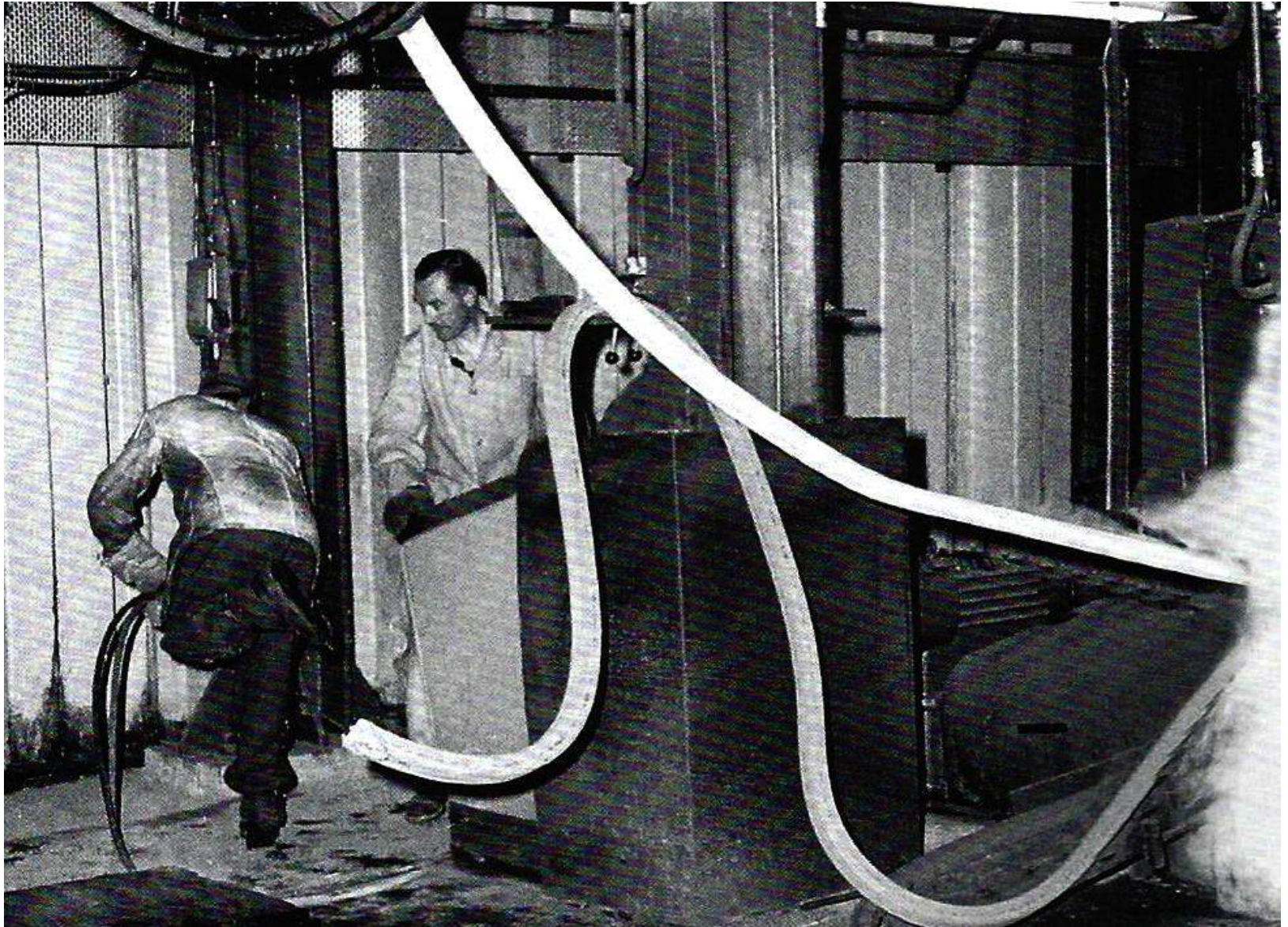


Evolution of continuous casting

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 Kimitoku
- Target 60mt crude steel by 1990
- \$60bn investment over 2 decades

CIA study (1979)

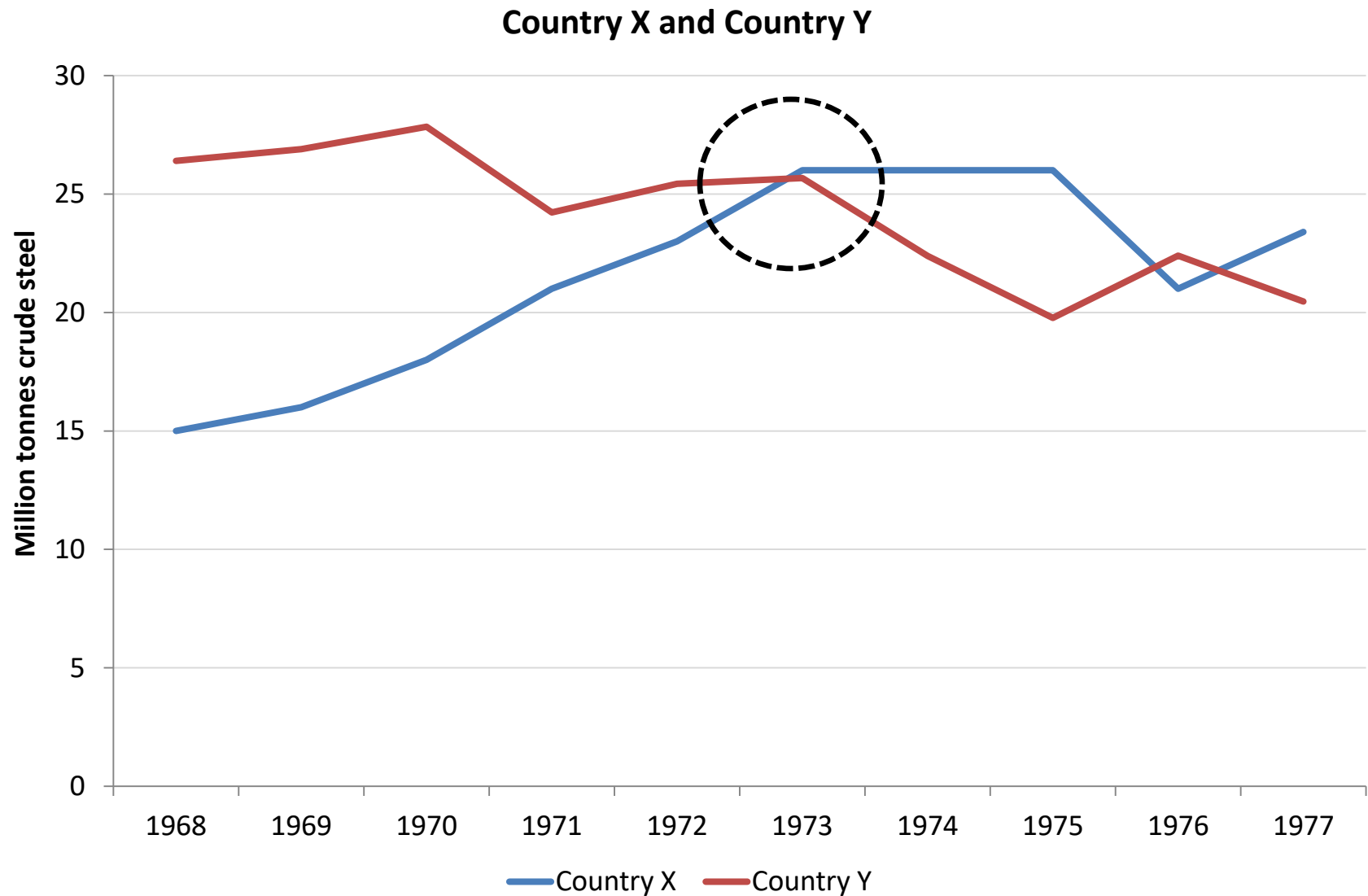
“With its abundant raw materials and the infusion of Western technology,

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

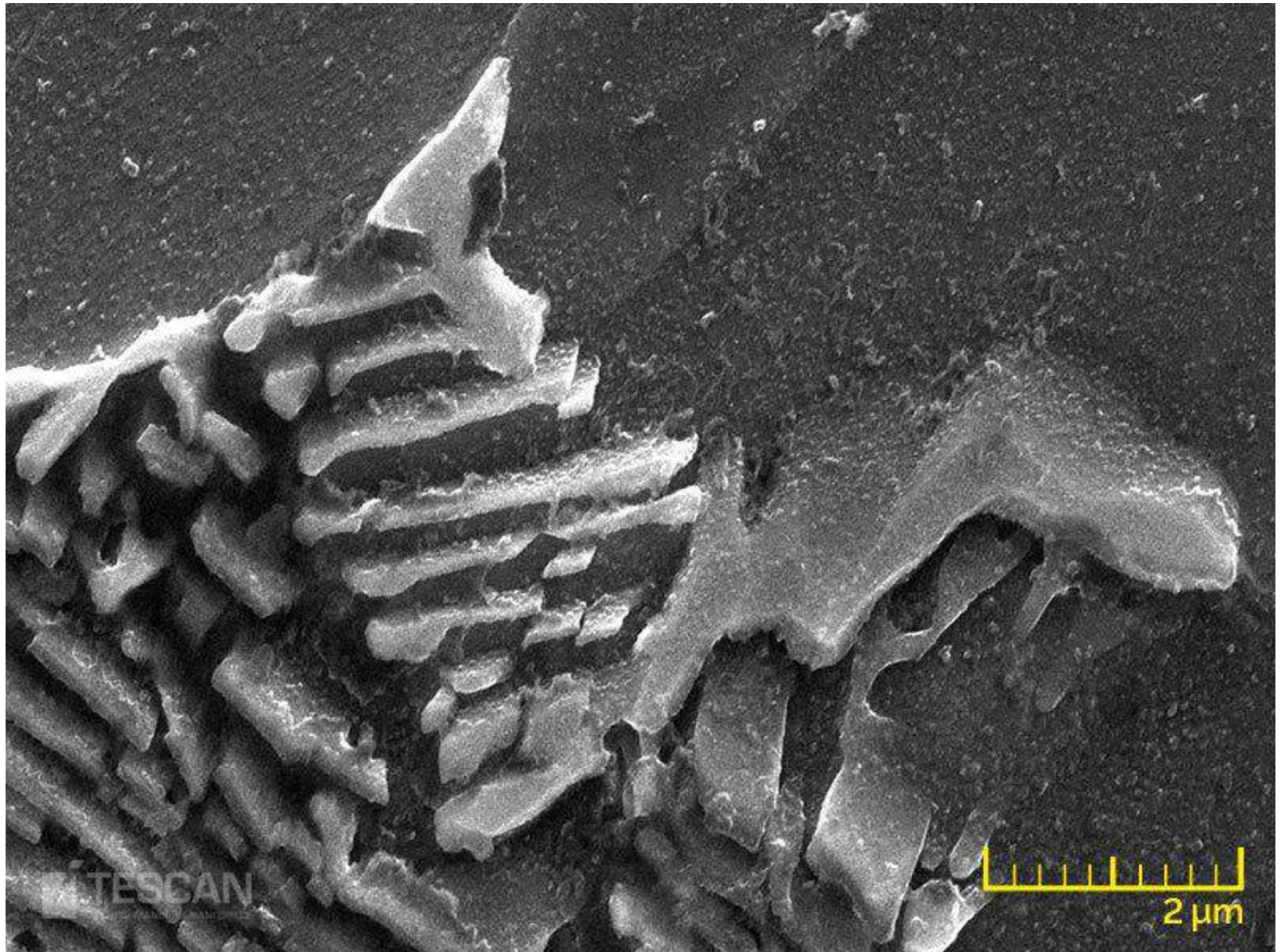
(Embargoed until release in 2000)



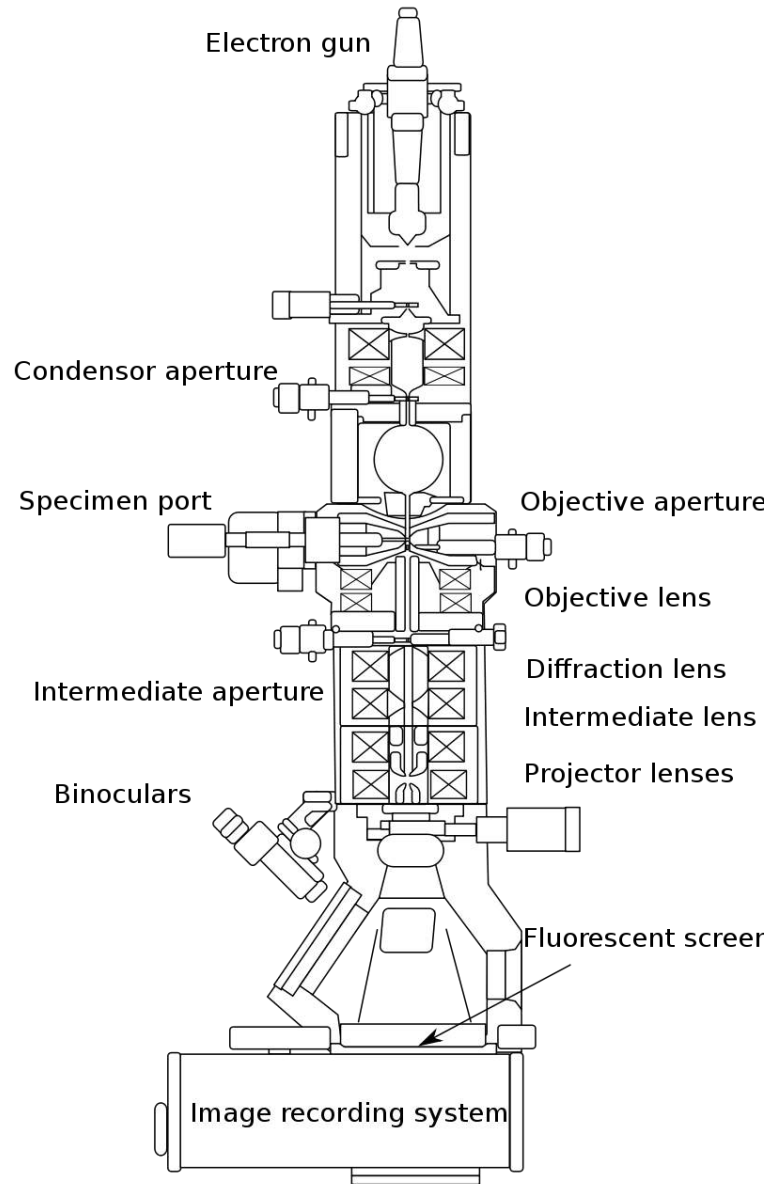
Country X and Country Y 1968 – 1977. The same crude steel output in 1973.



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



Transmission electron microscope – 1970s onwards



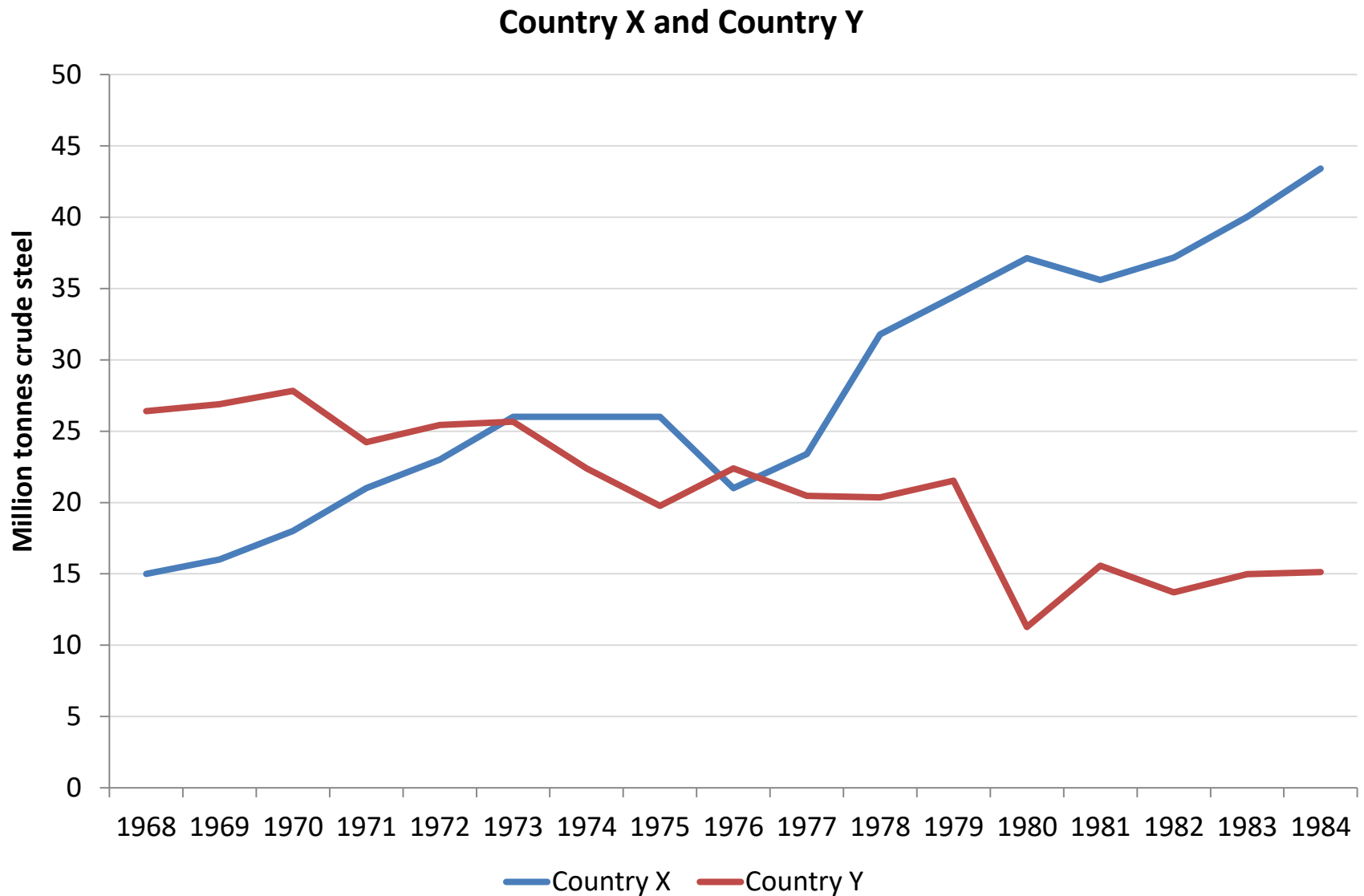
Dislocations in steel

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





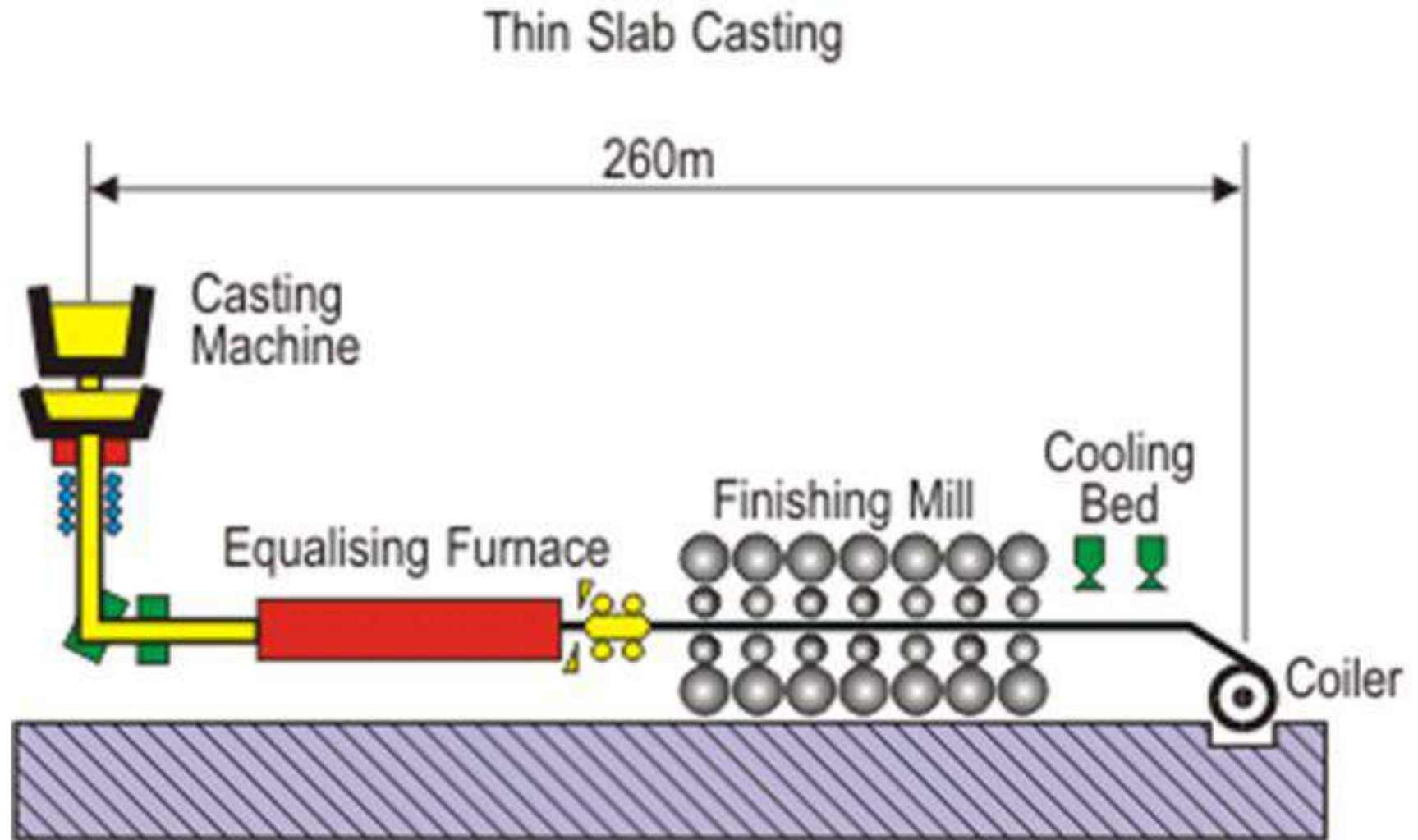
Country X and Country Y by 1984



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

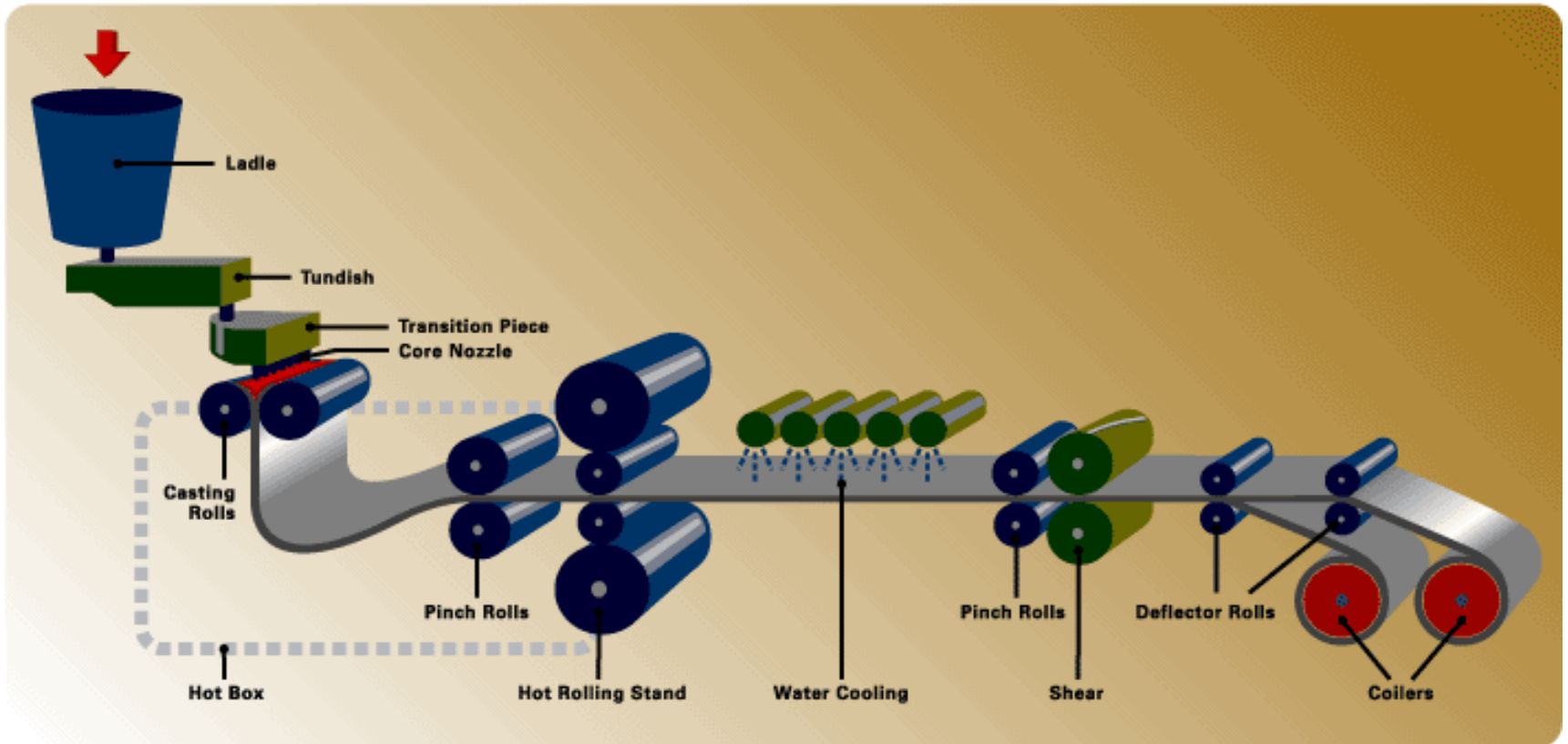


POSCO Gwangyang works, built 1985 – 1992, capacity 22 million tonnes per annum



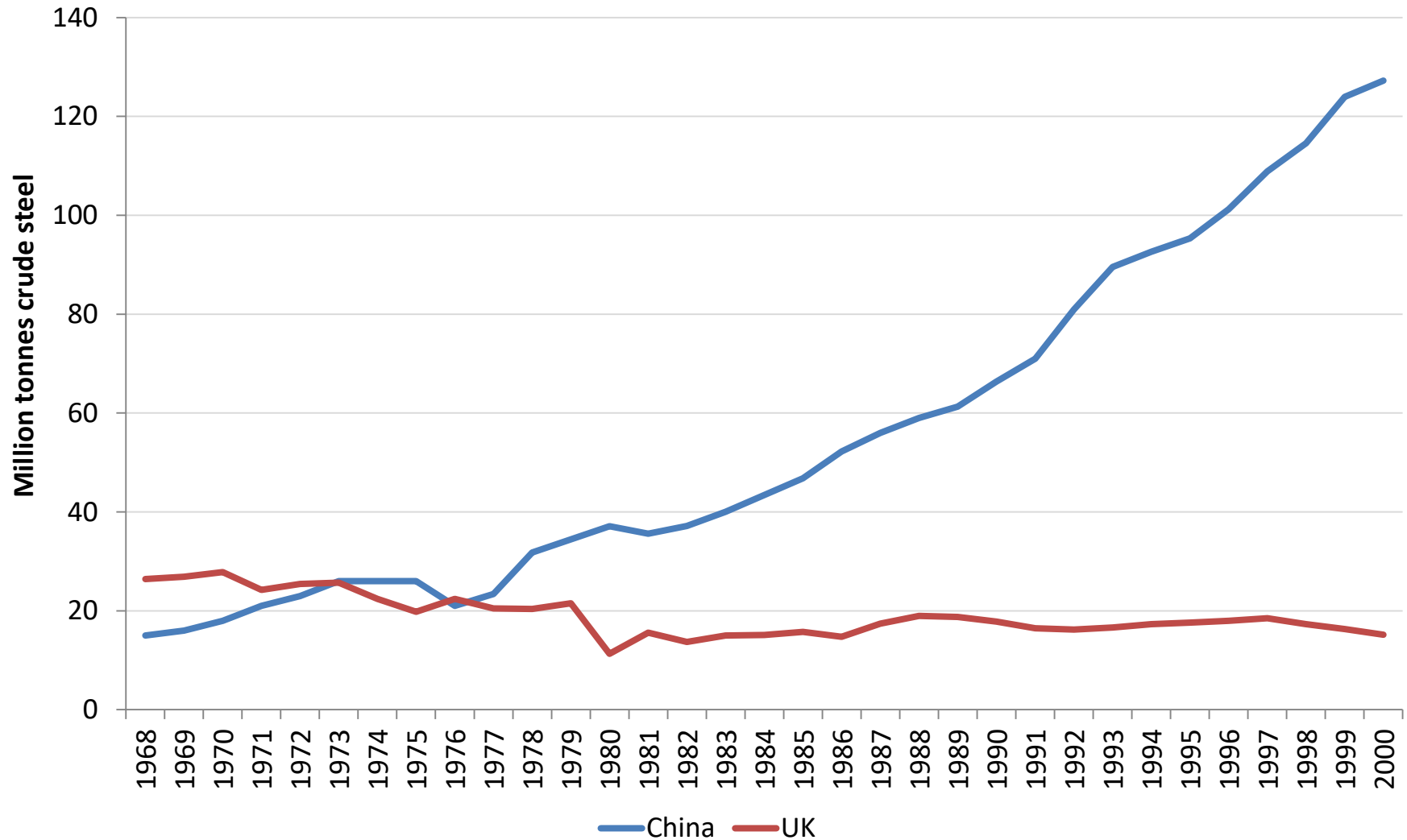
Castrip – development started in 1988, first commercial plant 2002

The Castrip® Process



Country X and Country Y revealed – by 2000

China and UK, production of crude steel



HMS Bulwalk – built Barrow 2001



Shipyard, China 2000s





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



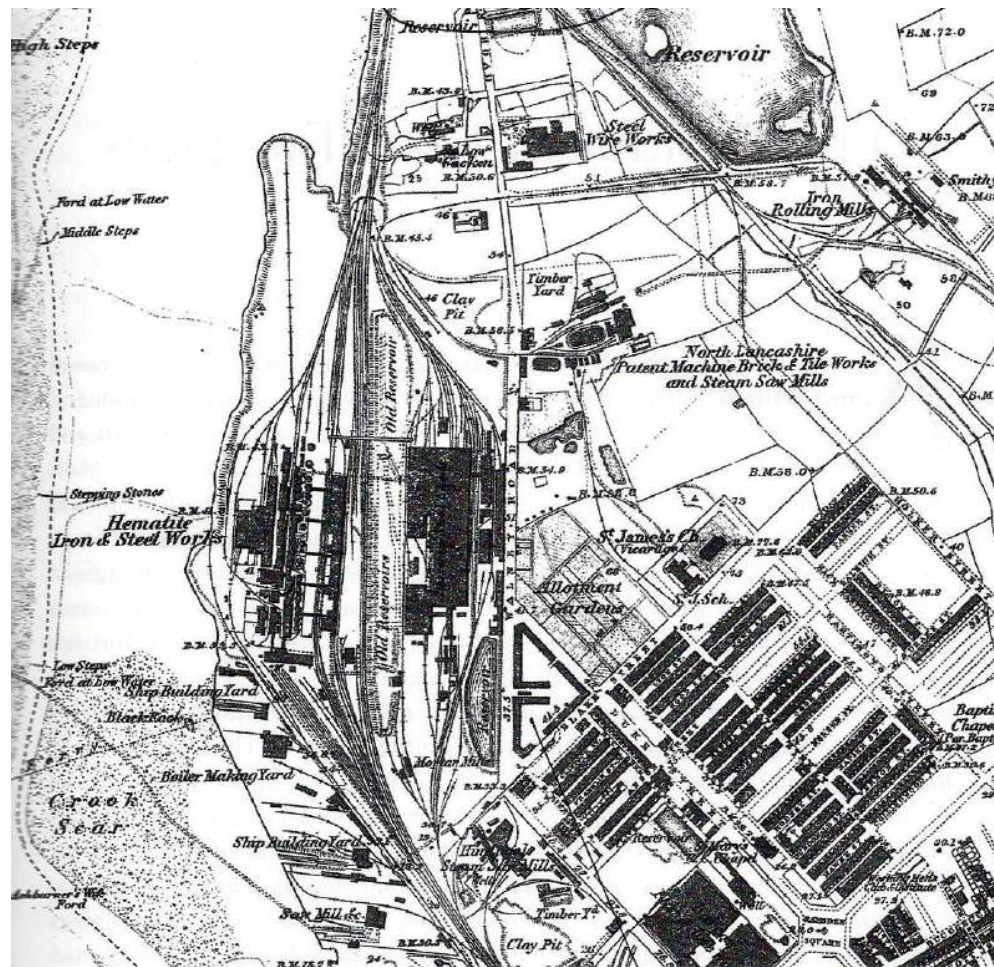
Blast furnaces at Baosteel, China 2010



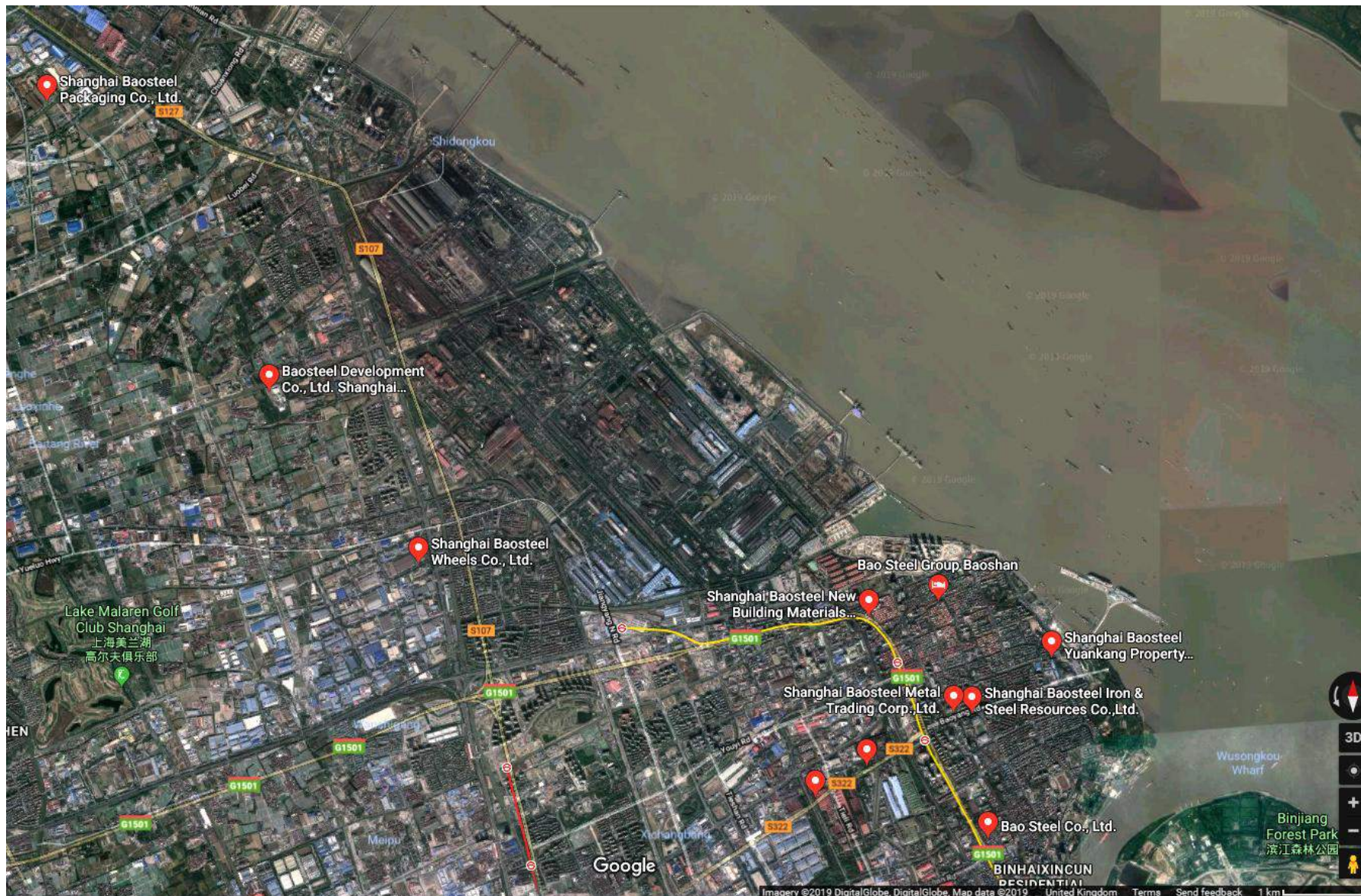
The Shard – Renzo Piano - 2013



Barrow steelworks site, 1936 and 2018



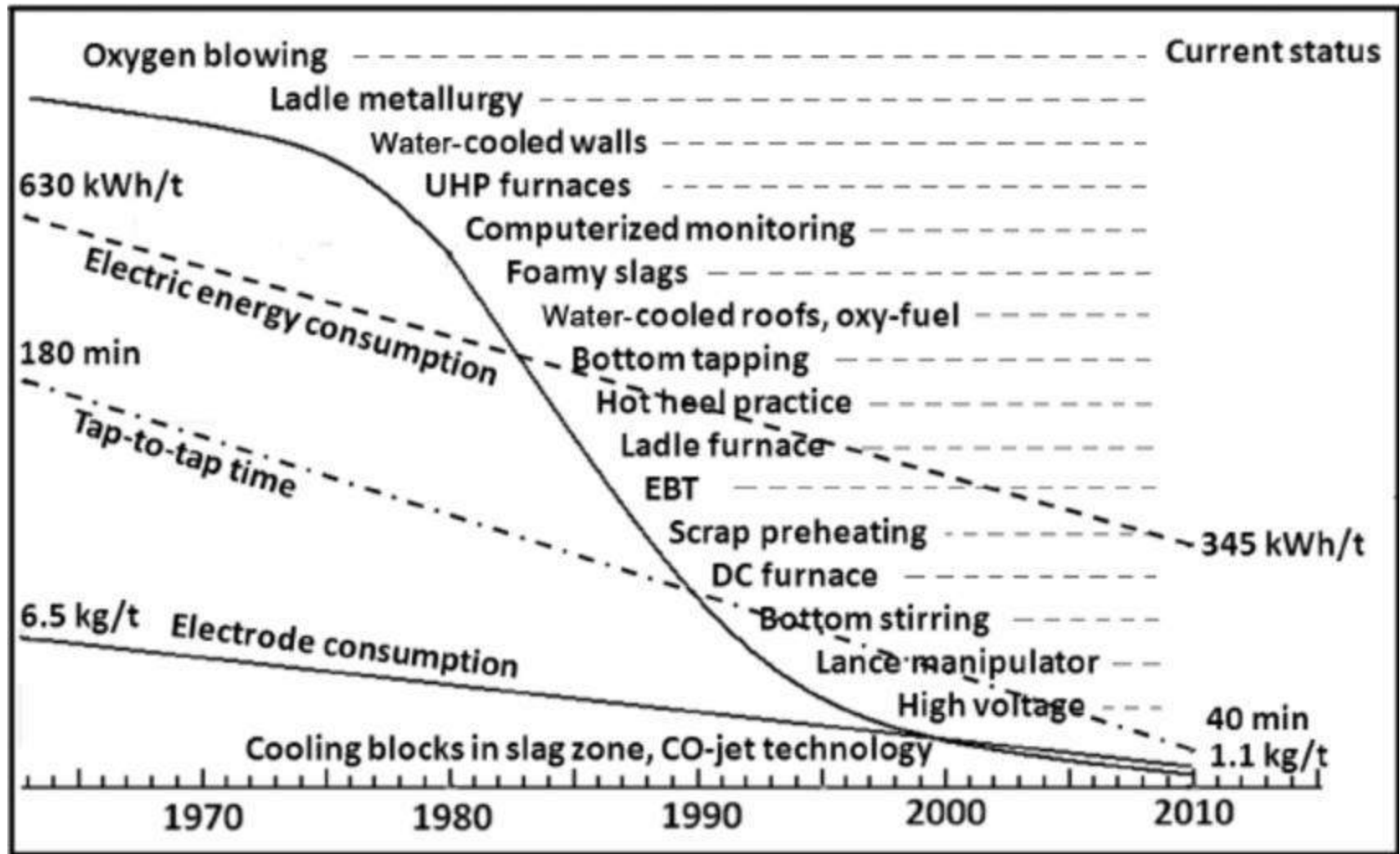
Shanghai – Baosteel site - 2018



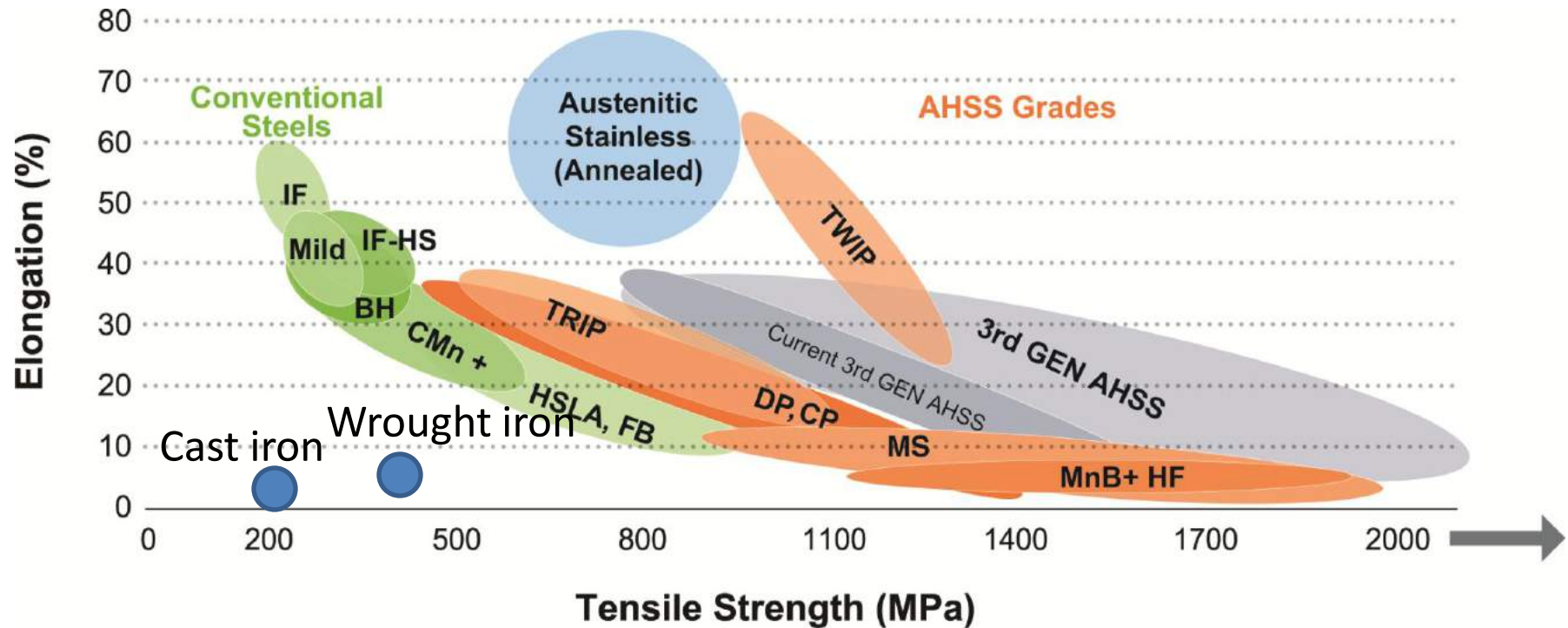
A modern EAF



EAF improvements 1965 - 2015

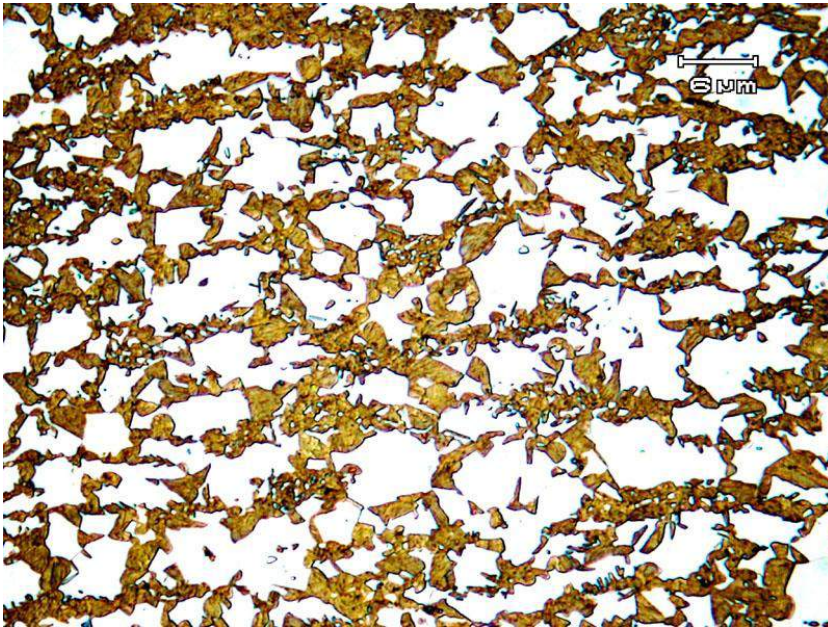
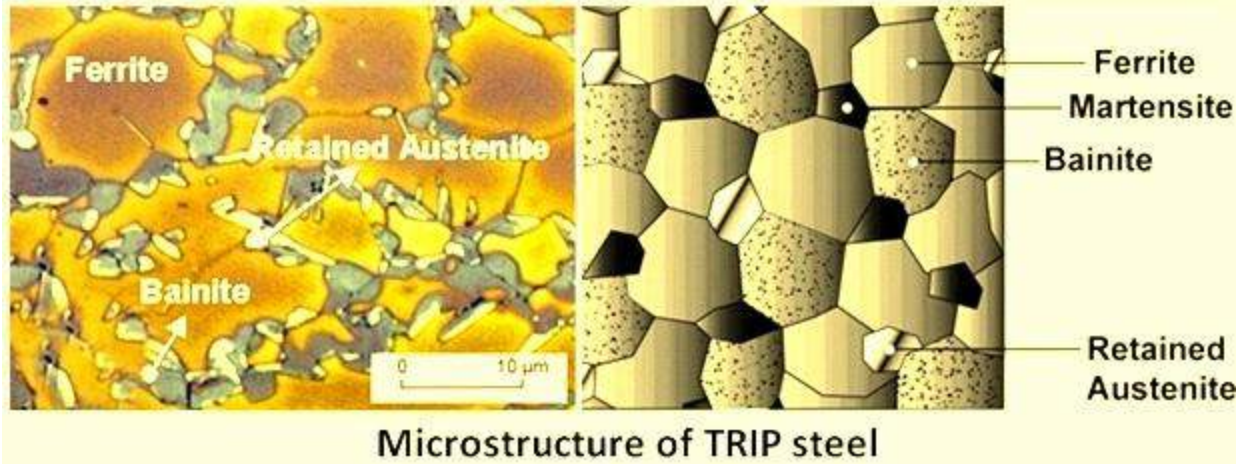


Development of high strength automotive steels



Source: WorldAutoSteel

Complex microstructures of high strength steels



Dual phase steel



HSLA steel

150th anniversary of the Periodic Table

Period																																																		
	1 I A												2 II A												3 III A		4 IV A		5 V A		6 VI A		7 VII A		8 VIII A															
1	1s												2s												2p		3p		4p		5p		6p		7p															
	H hydrogen 1.008												He helium 4.003												B boron 10.81		C carbon 12.01		N nitrogen 14.01		O oxygen 16.00		F fluorine 19.00		Ne neon 20.18															
2	Li lithium 6.968												Be beryllium 9.012												Al aluminum 26.98		Si silicon 28.09		P phosphorus 30.97		S sulfur 32.07		Cl chlorine 35.45		Ar argon 39.95															
3	Na sodium 22.99												Mg magnesium 24.31												K potassium 39.10		Ca calcium 40.08												Ga gallium 69.72		Ge germanium 72.63		As arsenic 74.92		Se selenium 78.97		Br bromine 79.90		Kr krypton 83.80	
4	Rb rubidium 85.47												Sr strontium 87.62												Y yttrium 88.91		Zr zirconium 91.22		Nb niobium 92.91		Mo molybdenum 95.95		Tc technetium 98		Ru ruthenium 101.1		Rh rhodium 102.9		Pd palladium 106.4		Ag silver 107.9		Cd cadmium 112.4							
5	Cs cesium 132.9												Ba barium 137.3												La lanthanum 175.0		Hf hafnium 178.5		Ta tantalum 180.9		W tungsten 183.8		Re rhenium 186.2		Os osmium 190.2		Ir iridium 192.2		Pt platinum 195.1		Au gold 197.0		Hg mercury 200.6							
6	Fr francium 223												Ra radium 226												Ac actinium 227		Th thorium 232		Pa protactinium 231		U uranium 238		Np neptunium 237		Pu plutonium 244		Am americium 243		Cm curium 247		Bk berkelium 247		Cf californium 251							
7																																																		

29

Cu

copper

63.55

← ions commonly formed

← atomic mass (rounded)

13 III A	14 IV A	15 V A	16 VI A	17 VII A	18 VIII A
B boron 10.81	C carbon 12.01	N nitrogen 14.01	O oxygen 16.00	F fluorine 19.00	Ne neon 20.18
Al aluminum 26.98	Si silicon 28.09	P phosphorus 30.97	S sulfur 32.07	Cl chlorine 35.45	Ar argon 39.95
Ga gallium 69.72	Ge germanium 72.63	As arsenic 74.92	Se selenium 78.97	Br bromine 79.90	Kr krypton 83.80
In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium 209	At astatine 210	Rn radon 222
Nh nihonium 284	Fl flerovium 289	Mc moscovium 288	Lv livermorium 293	Ts tennessine 292	Og oganesson 294

29

+2, +1

Cu

copper

63.55

← atomic mass (rounded)

← ions commonly formed

Fazlur Khan 1929 – 1982 “Einstein of structural engineering”

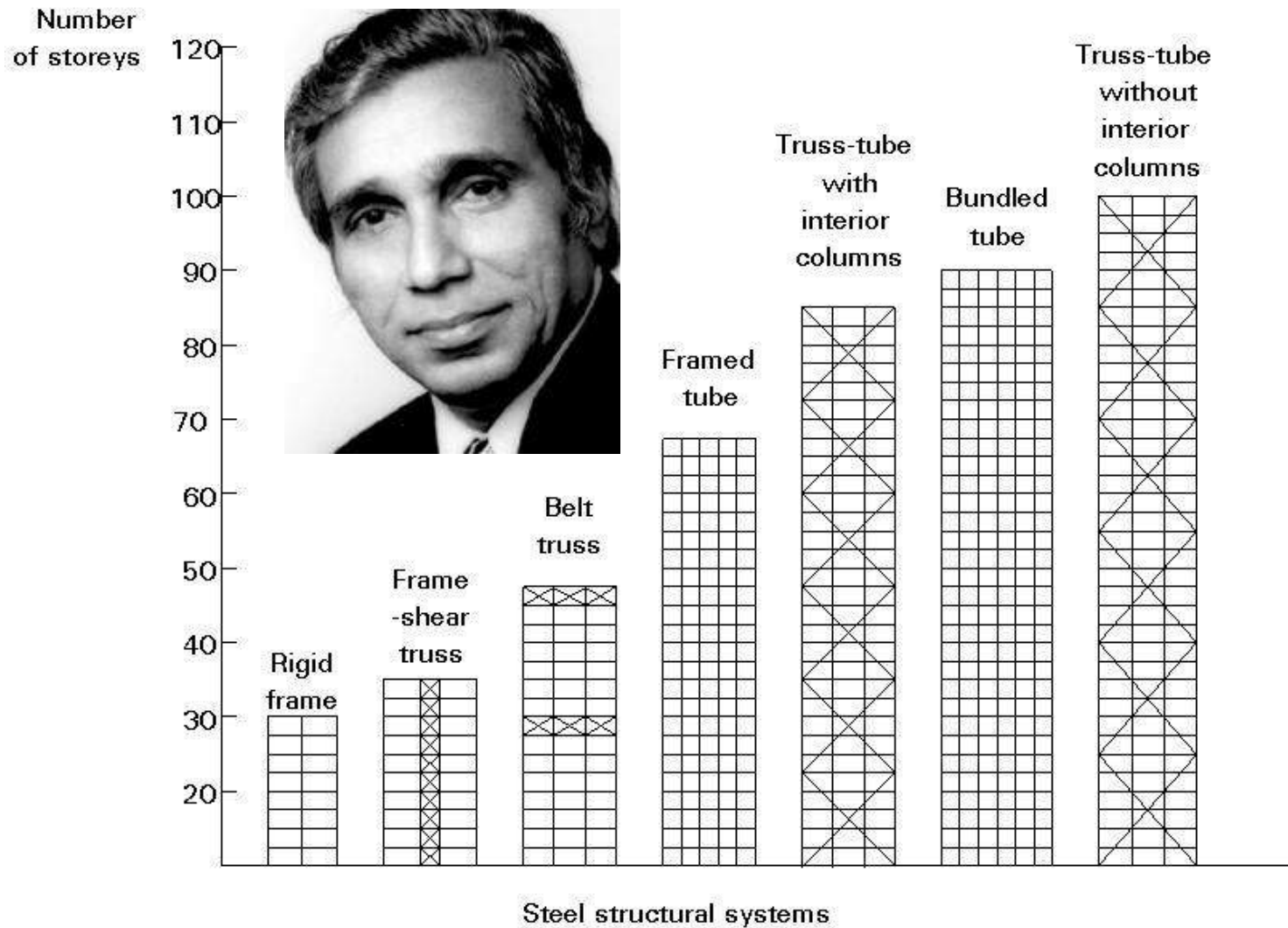
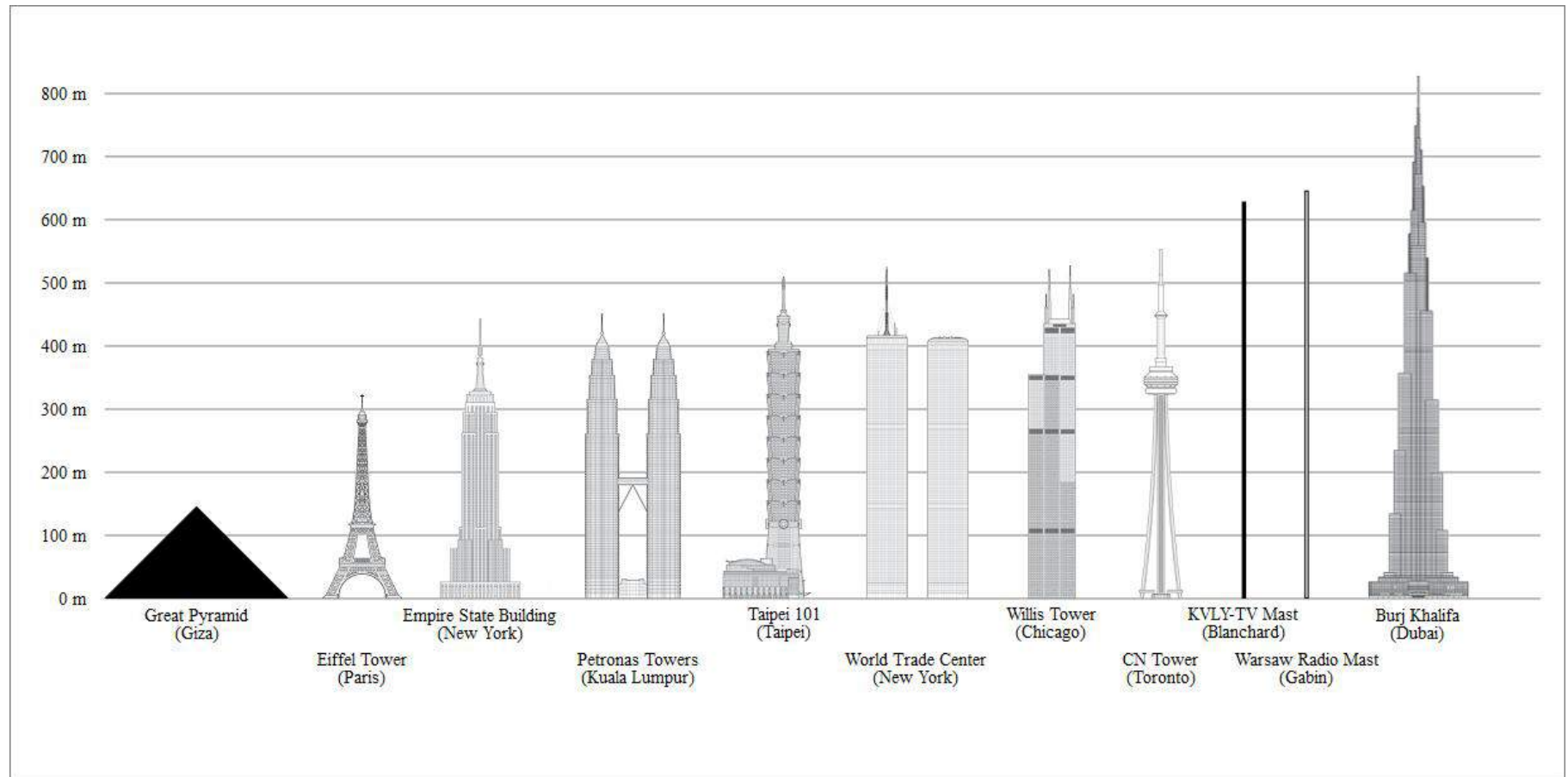


Figure 7 Steel structural systems and the number of storeys

Height and time



Bishopsgate 2009



Bishopsgate 2010



Bishopsgate 2010



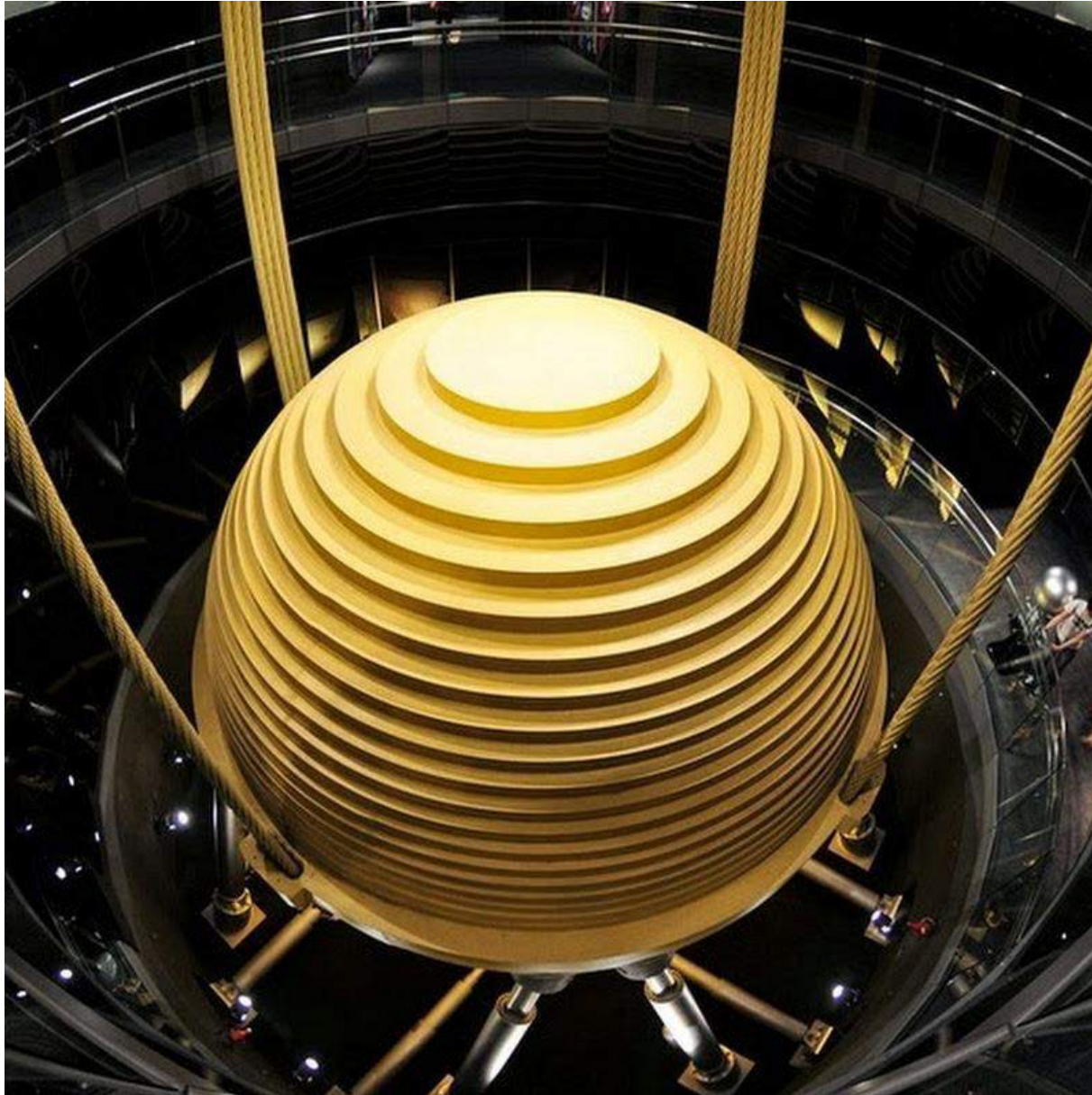
Bishopsgate 2010



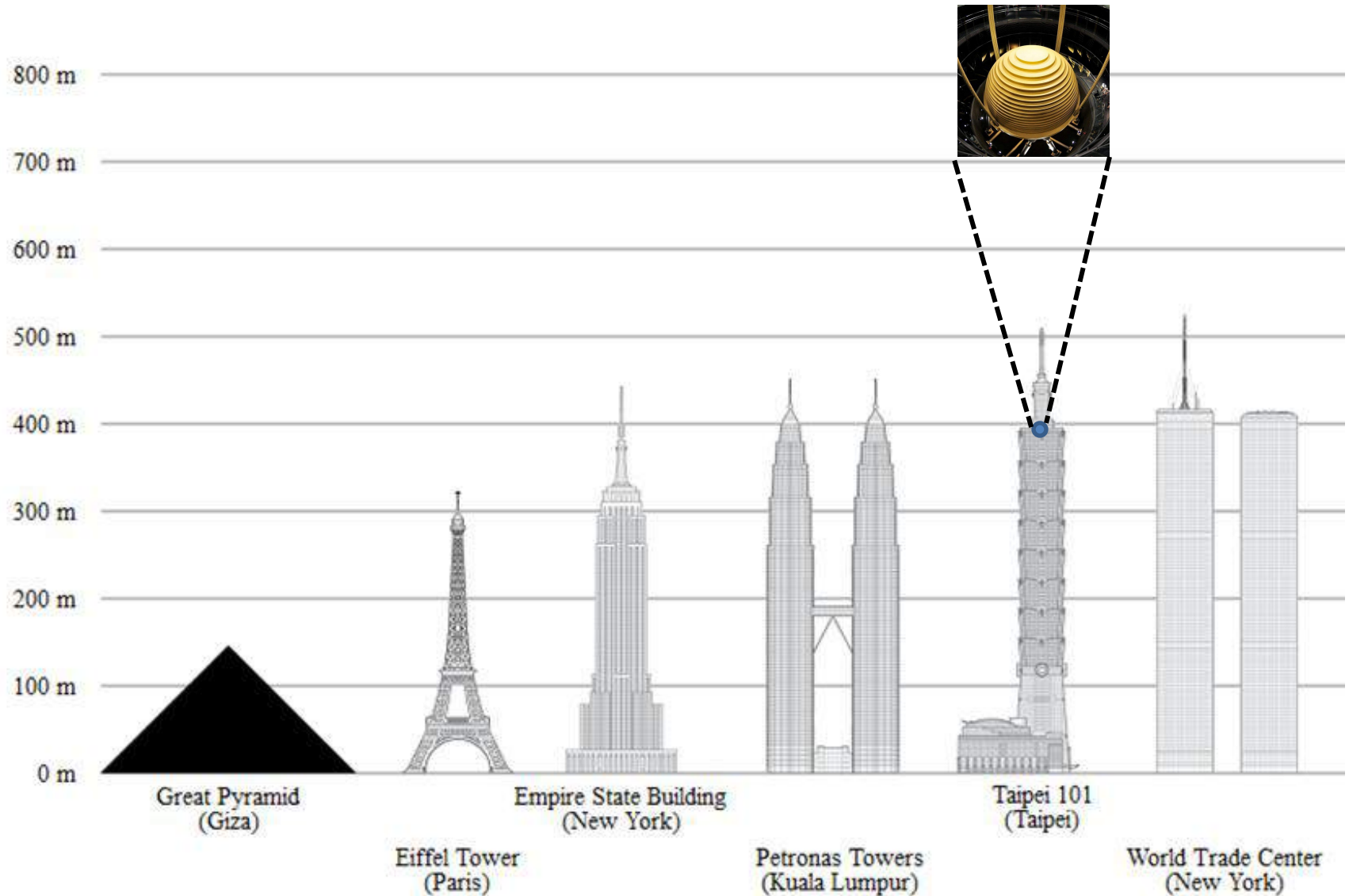
Almost complete, 2019



What is this?

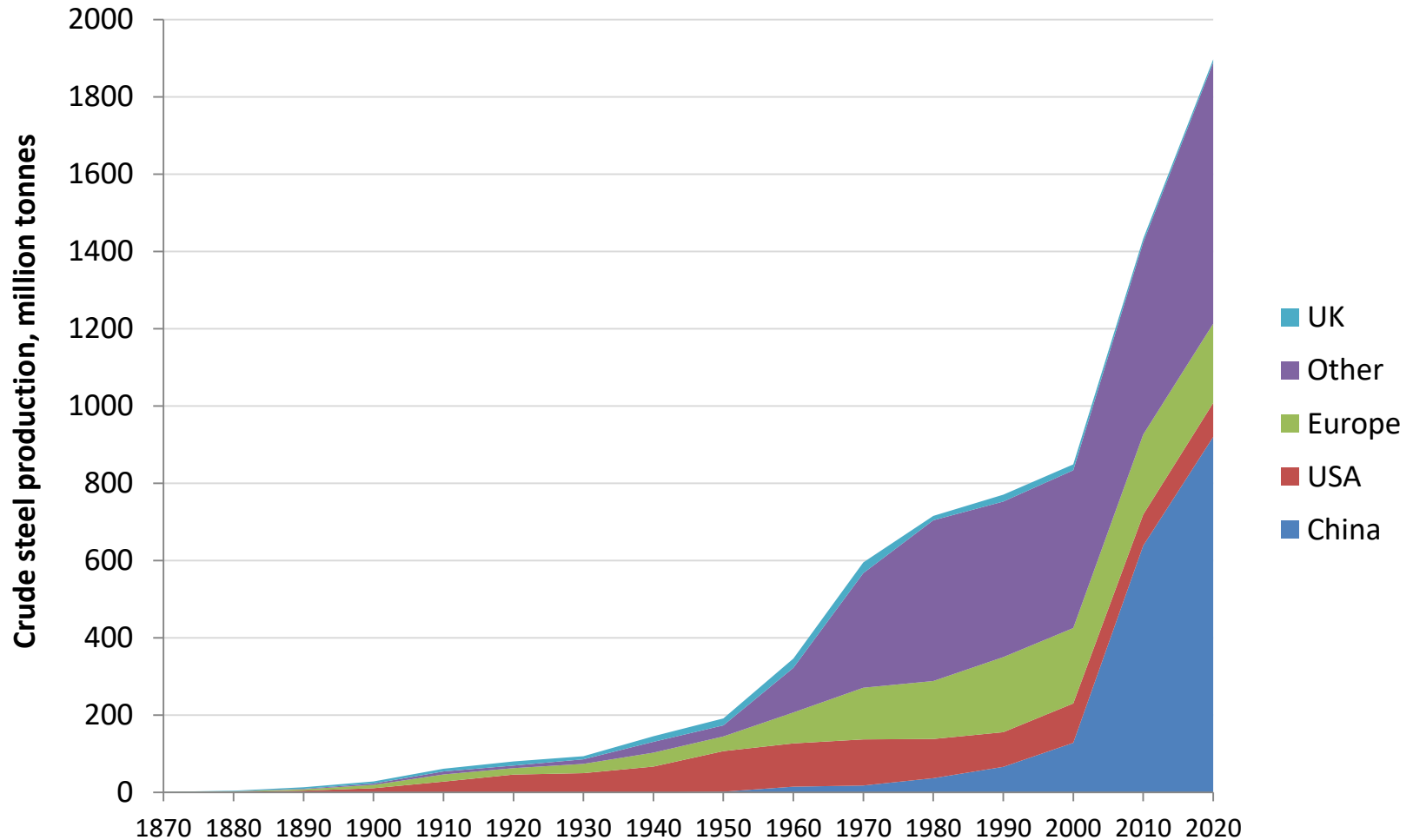


Tuned mass damper, 700 tonnes of computer controlled steel plates

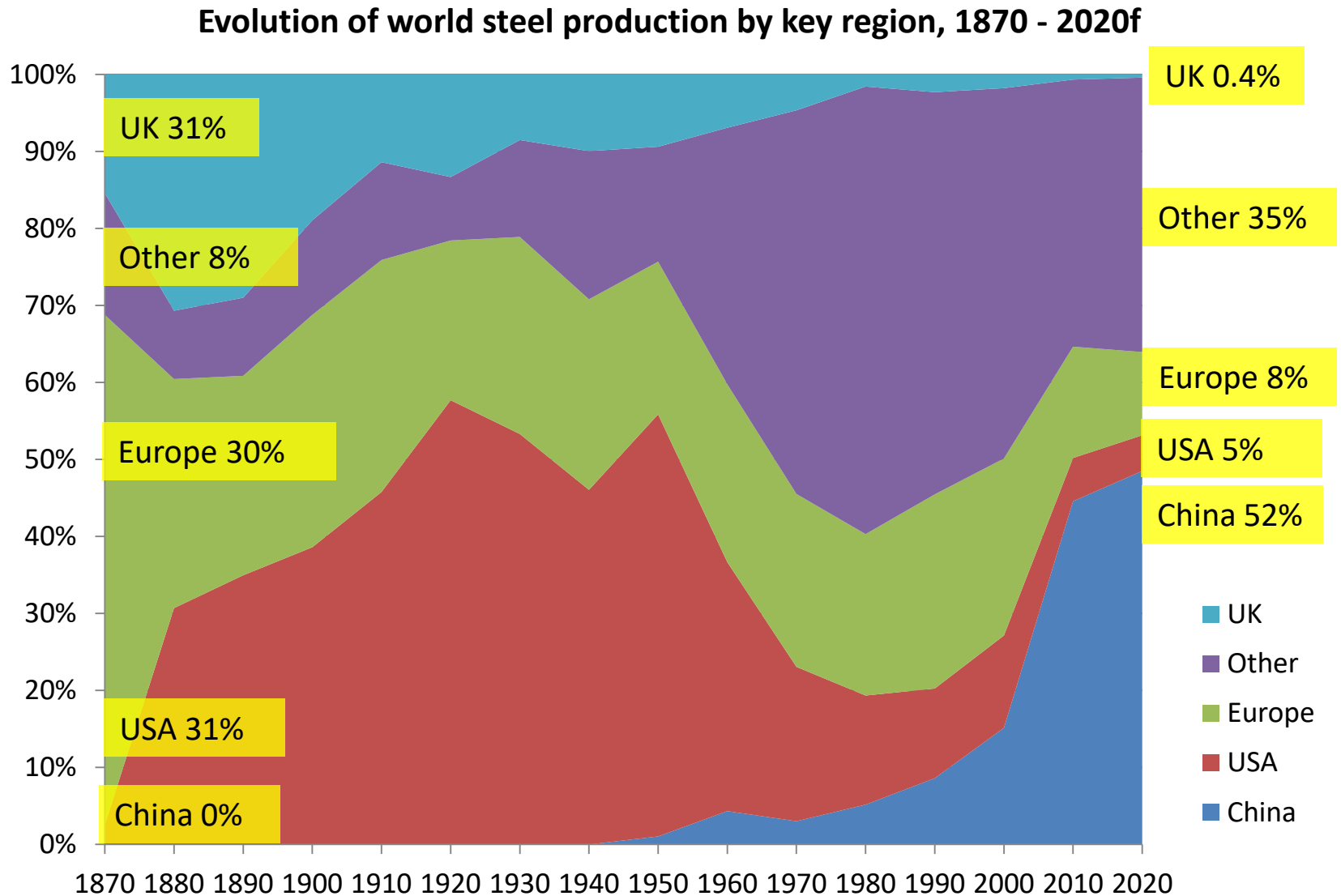


Crude steel growth by region

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

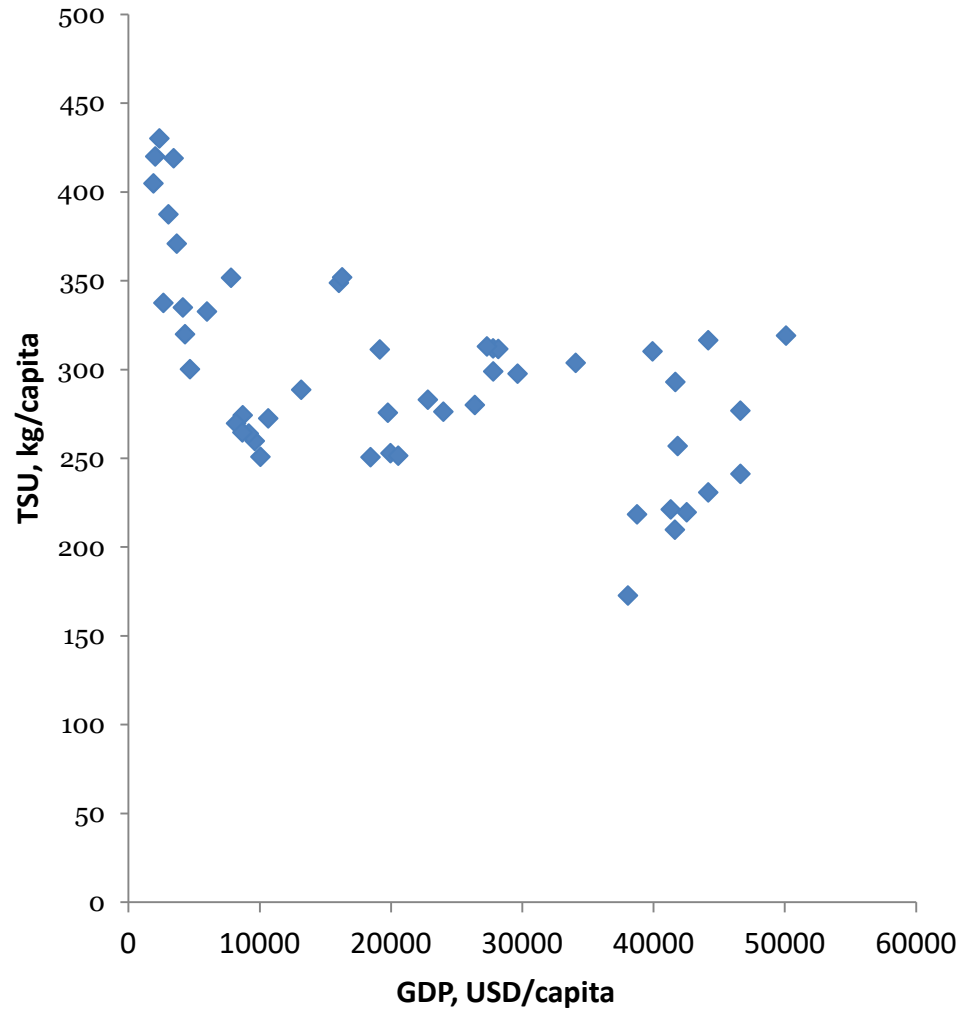


Evolution of word steel production by region 1870 - 2020

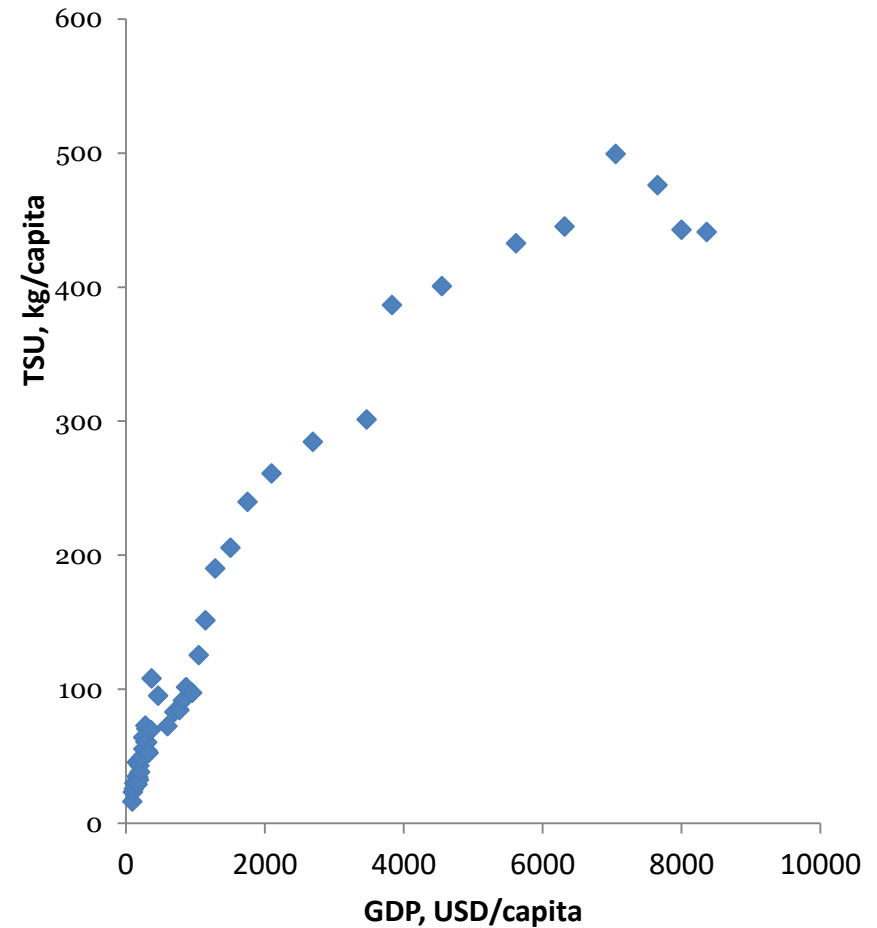


UK and China – different growth patterns – or are they?

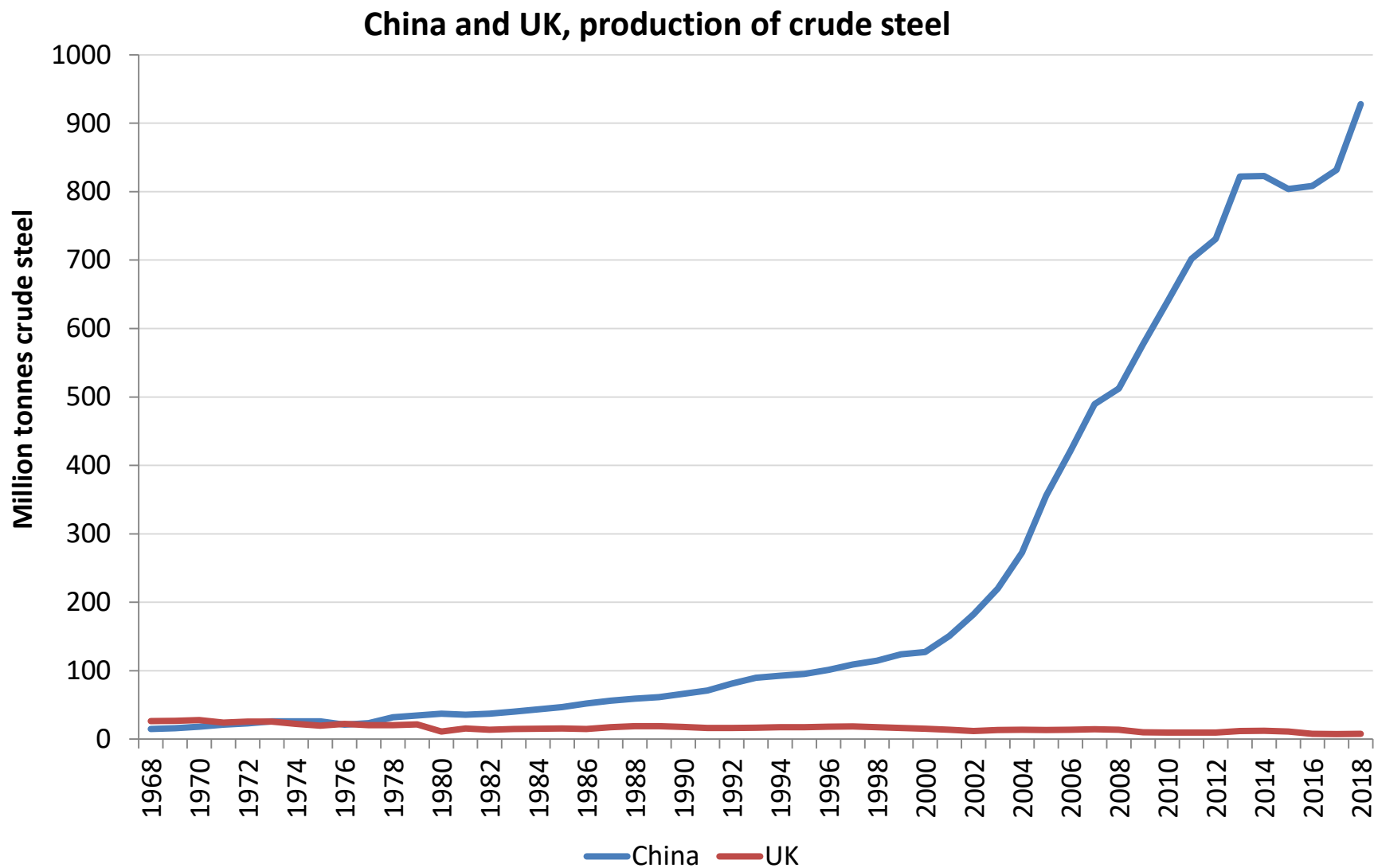
UK: relationship of True Steel Use (TSU) and GDP/capita



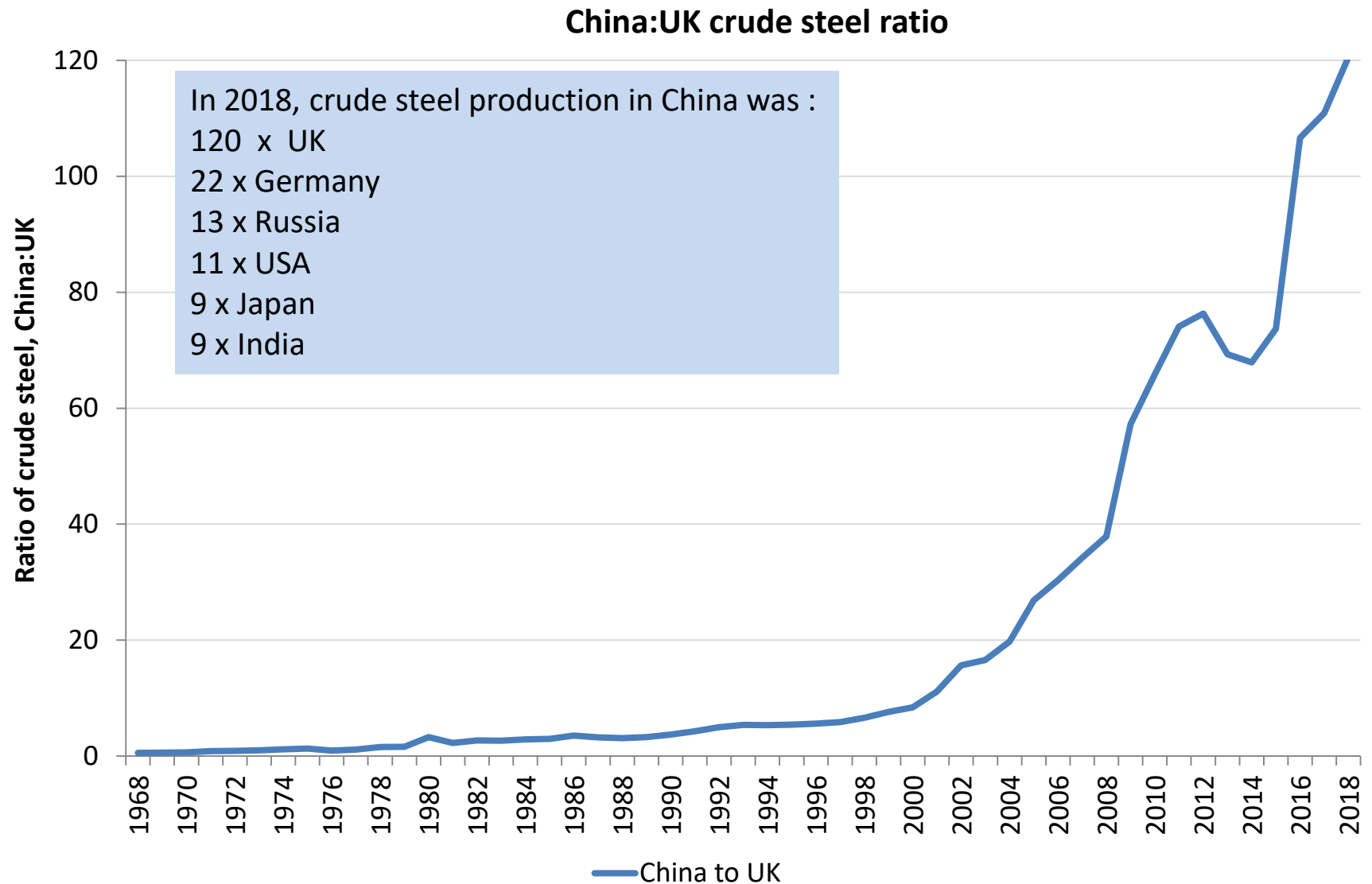
China: relationship of True Steel Use (TSU) and GDP/capita



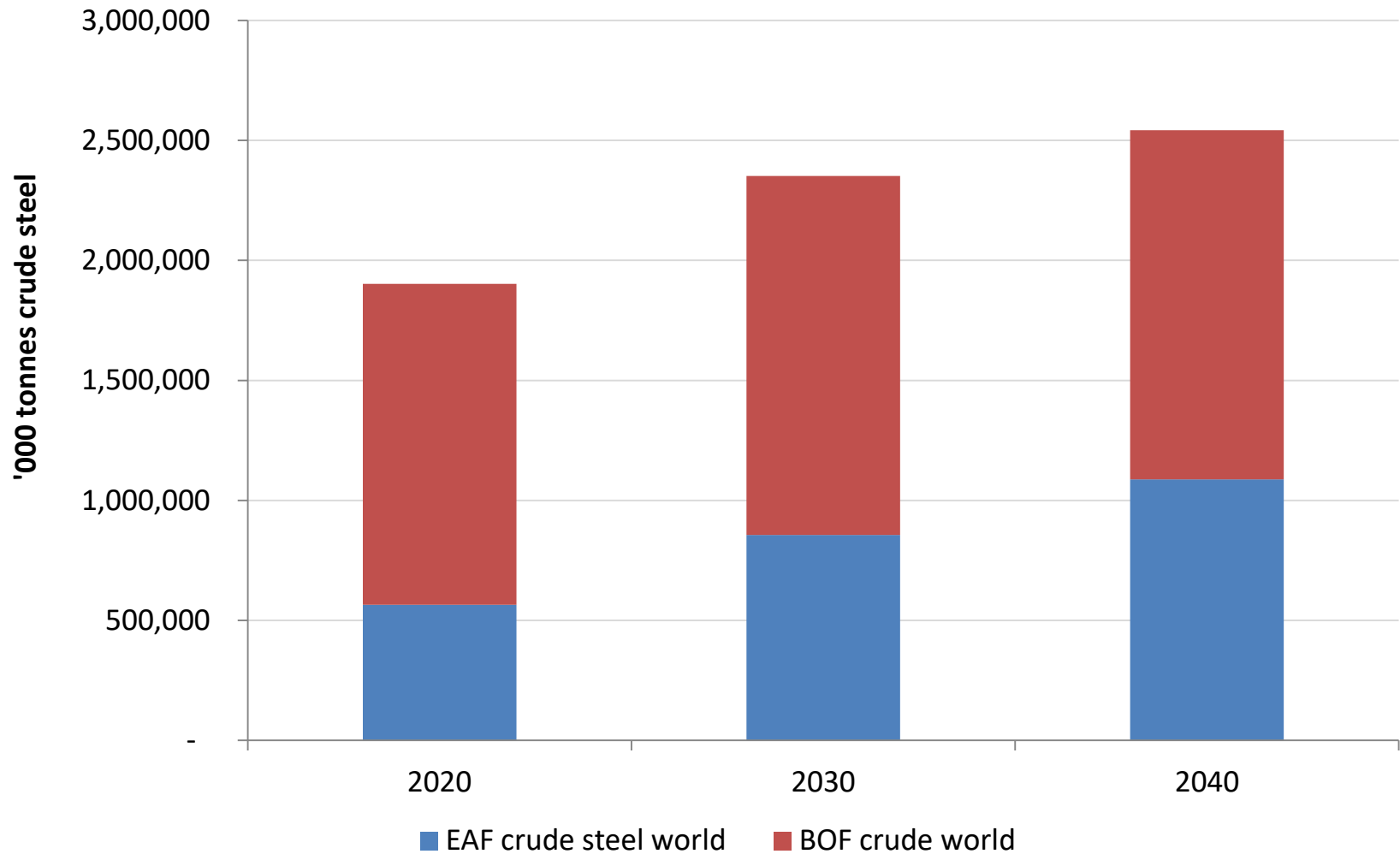
Production of crude steel, China and UK, 1968 - 2018



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 for Past Presidents
- 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 for puddling furnaces
- https://en.wikipedia.org/wiki/Wrought_iron for wrought iron details and microstructure
- 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 image of Great Eastern
- 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 Image of Carl Wilhelm Siemens
- https://en.wikipedia.org/wiki/Pierre-%C3%89mile_Martin Image of Carl Emile Martin
- 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 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-industralisation-forge-steel-beam-diagram> and 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 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 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 Image of Aditya Mittal
- 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 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