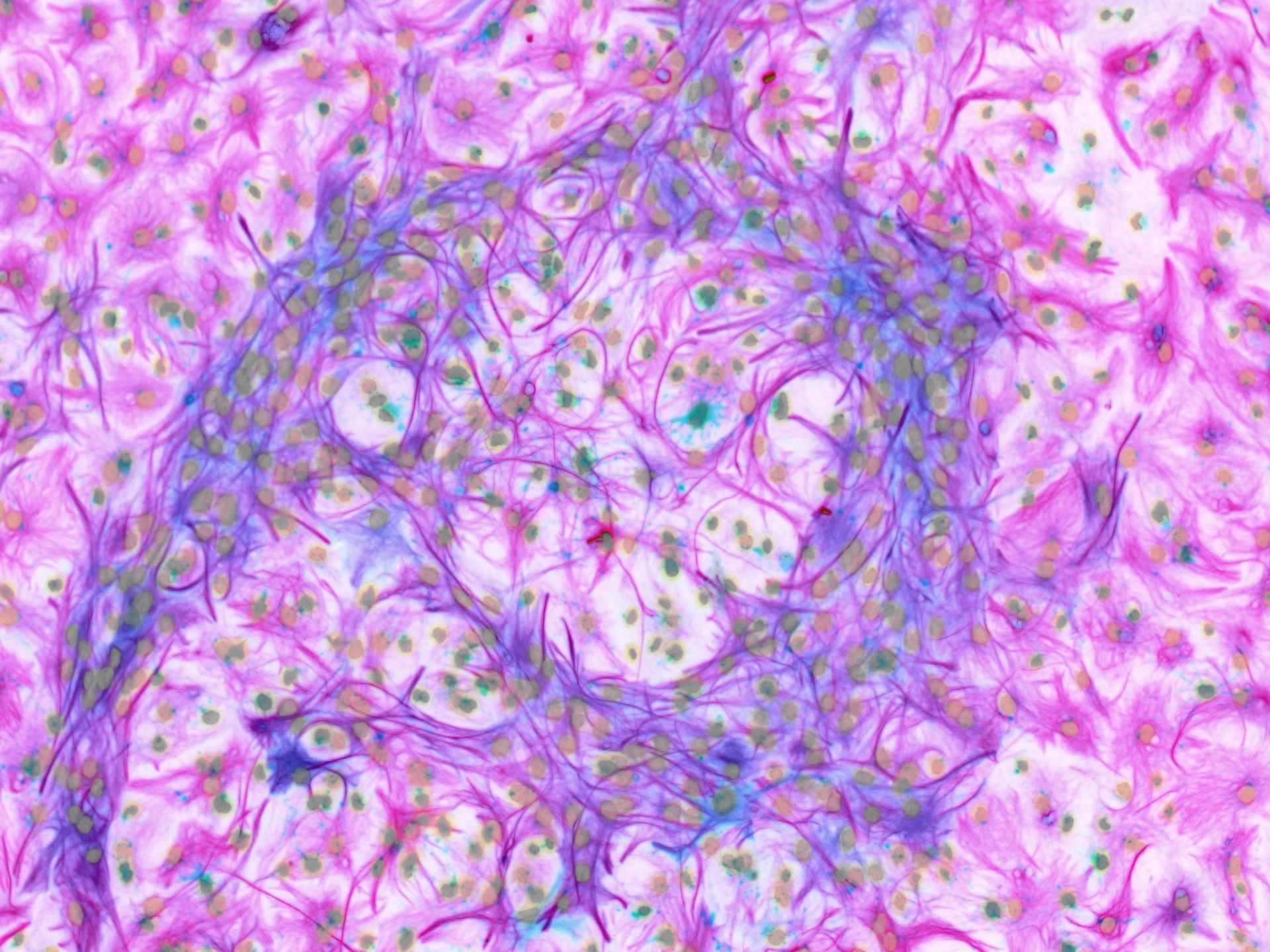
Learning from Stradivarius

Chris Wise
Expedition Engineering
and University College, London

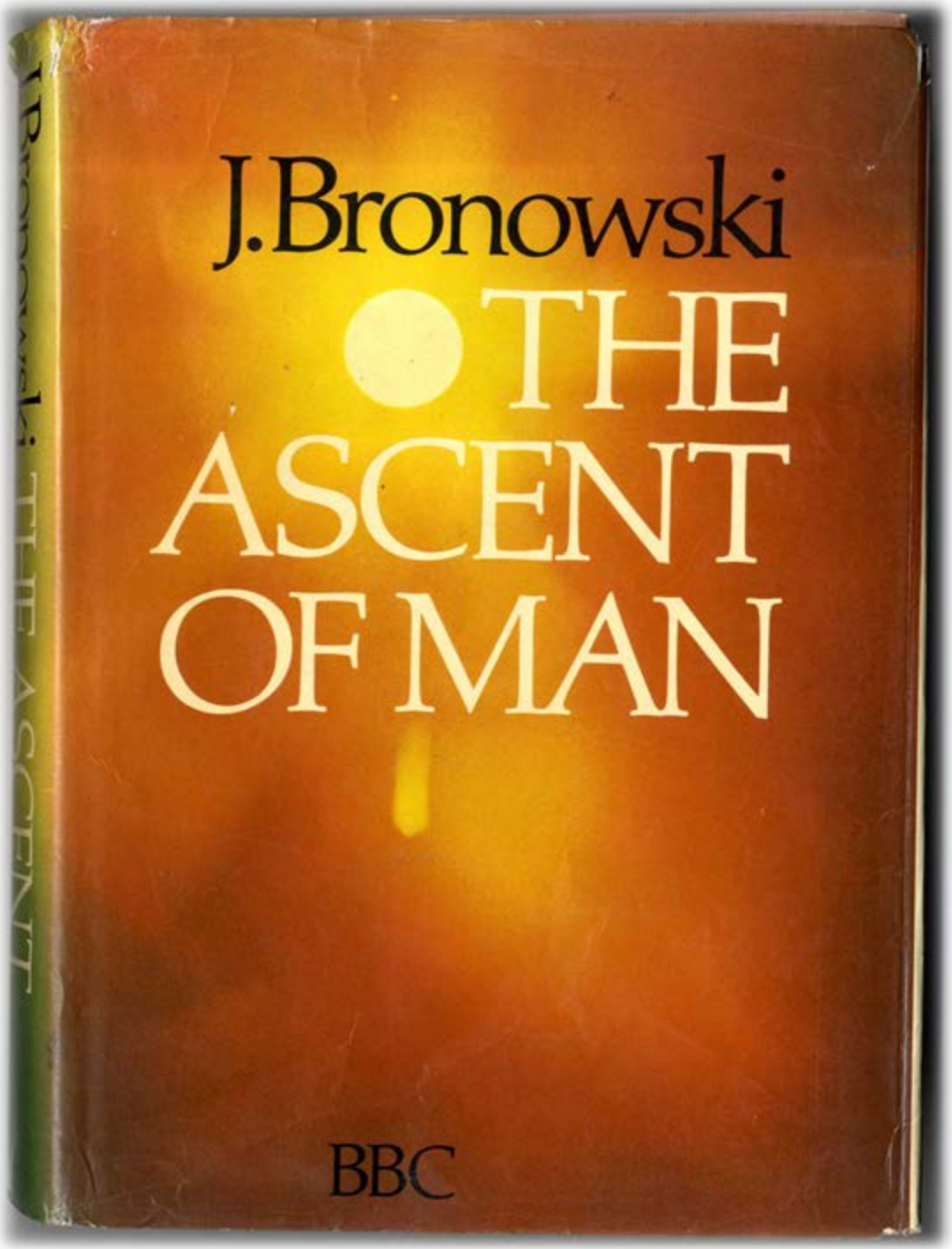
memory foam
catalytic converters
cork
rubber
foam concrete
jet turbine blade
self healing concrete
mica
steel
cloth
glass
brass
bronze
lead
lead
copper
pig iron
brass
bronze
laser sintered nickel
aluminium
steel
coal
flint
bakelite
horn
diamonds
The Periodic Table
reflective cloth
mercury
uranium glass
geiger counter
aerogel
glass
aluminium nitride wafer
two-way mirror
glass
polypropylene
WWII barbed wire
wine glasses
broken bag
sound
nylon
brass
copper
zinc
silver
chrome
stainless steel
tin
zinc
gold
copper

Meaning what?…



© AP

7 years later…


J.Bronowski
THE ASCENT OF MAN
BBC
J.Bronowski THE ASCENT

Awarded to

C. M. Wise

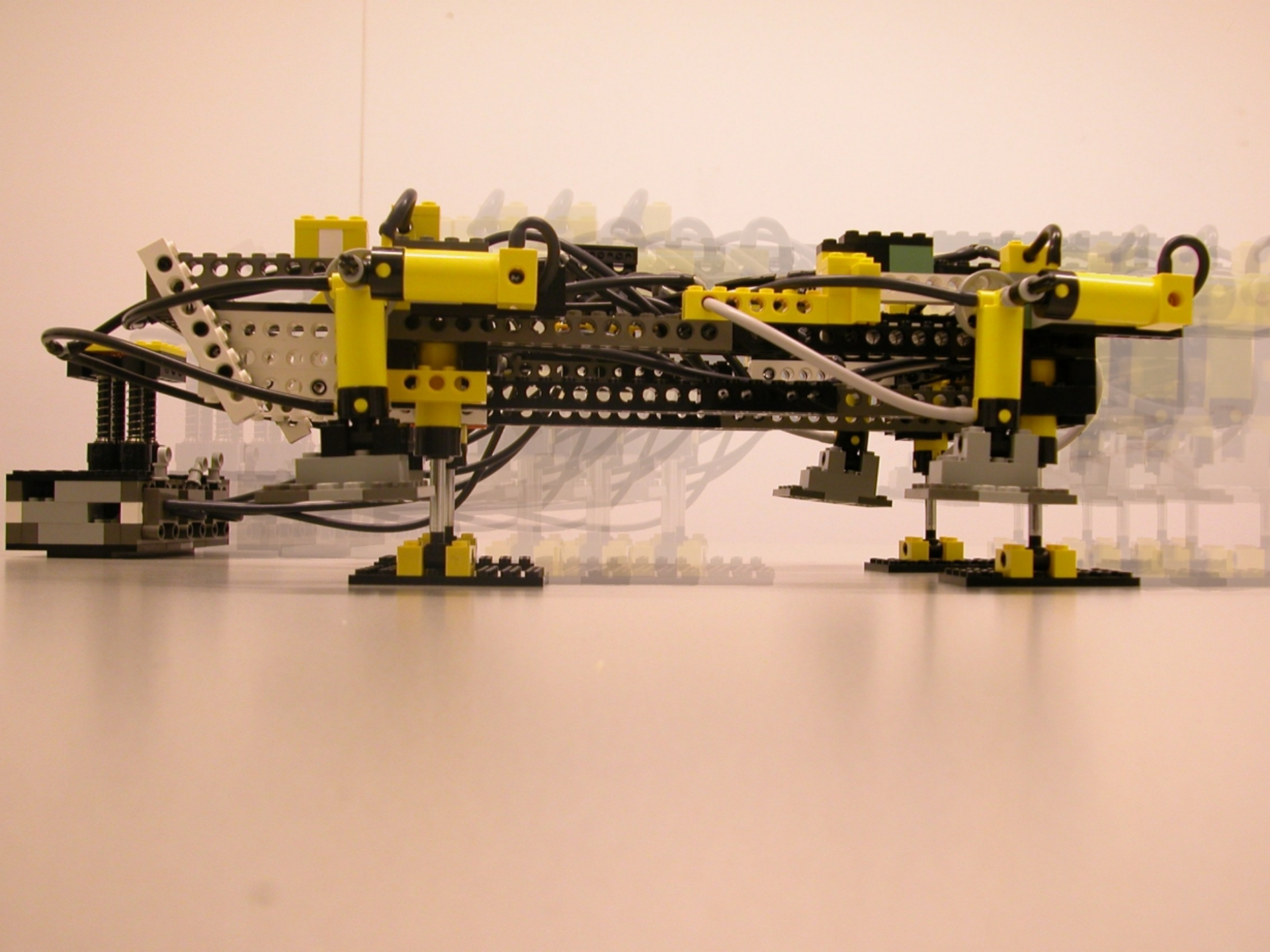
for

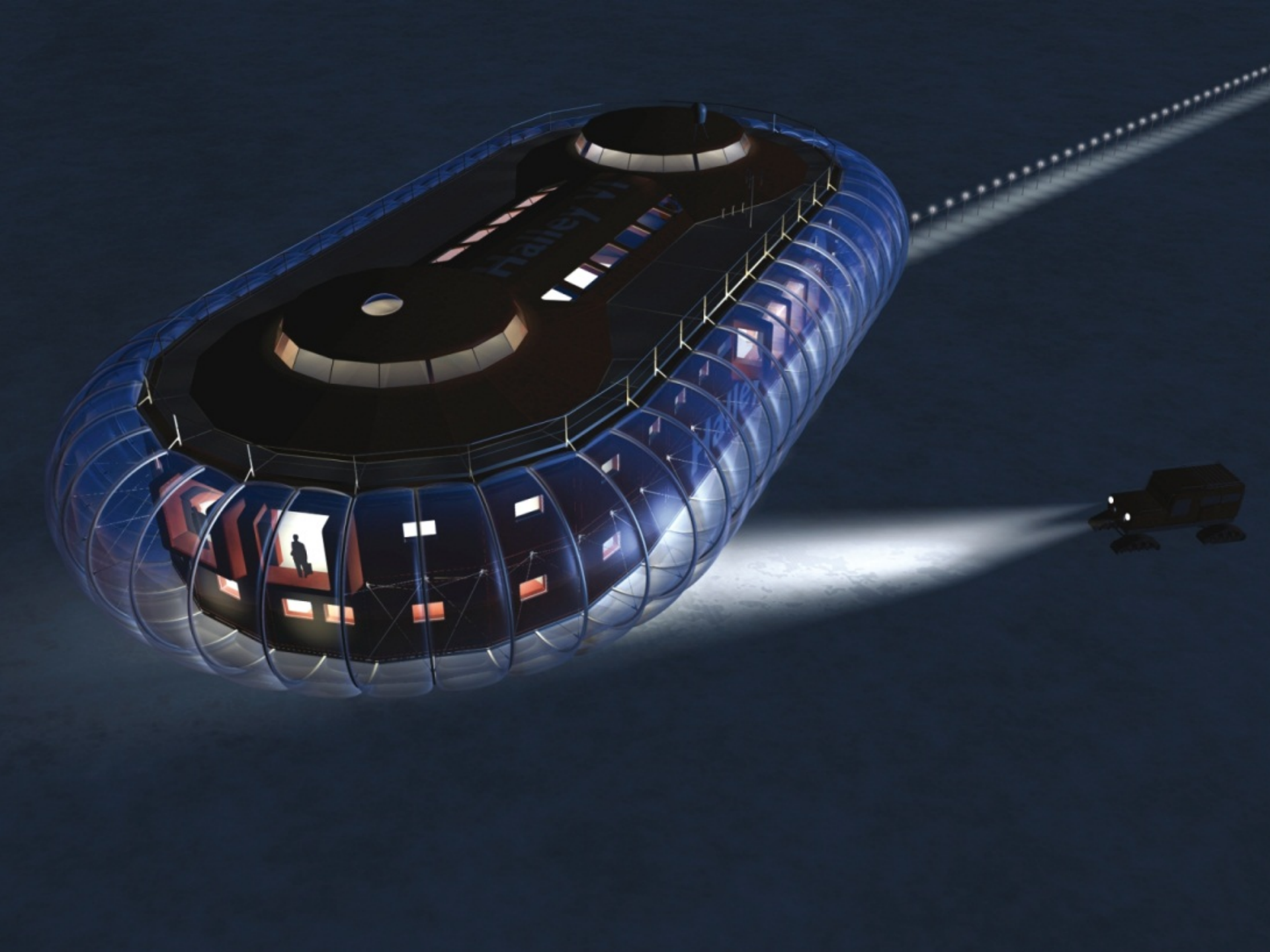
The S. Arbury Prize for Cricket

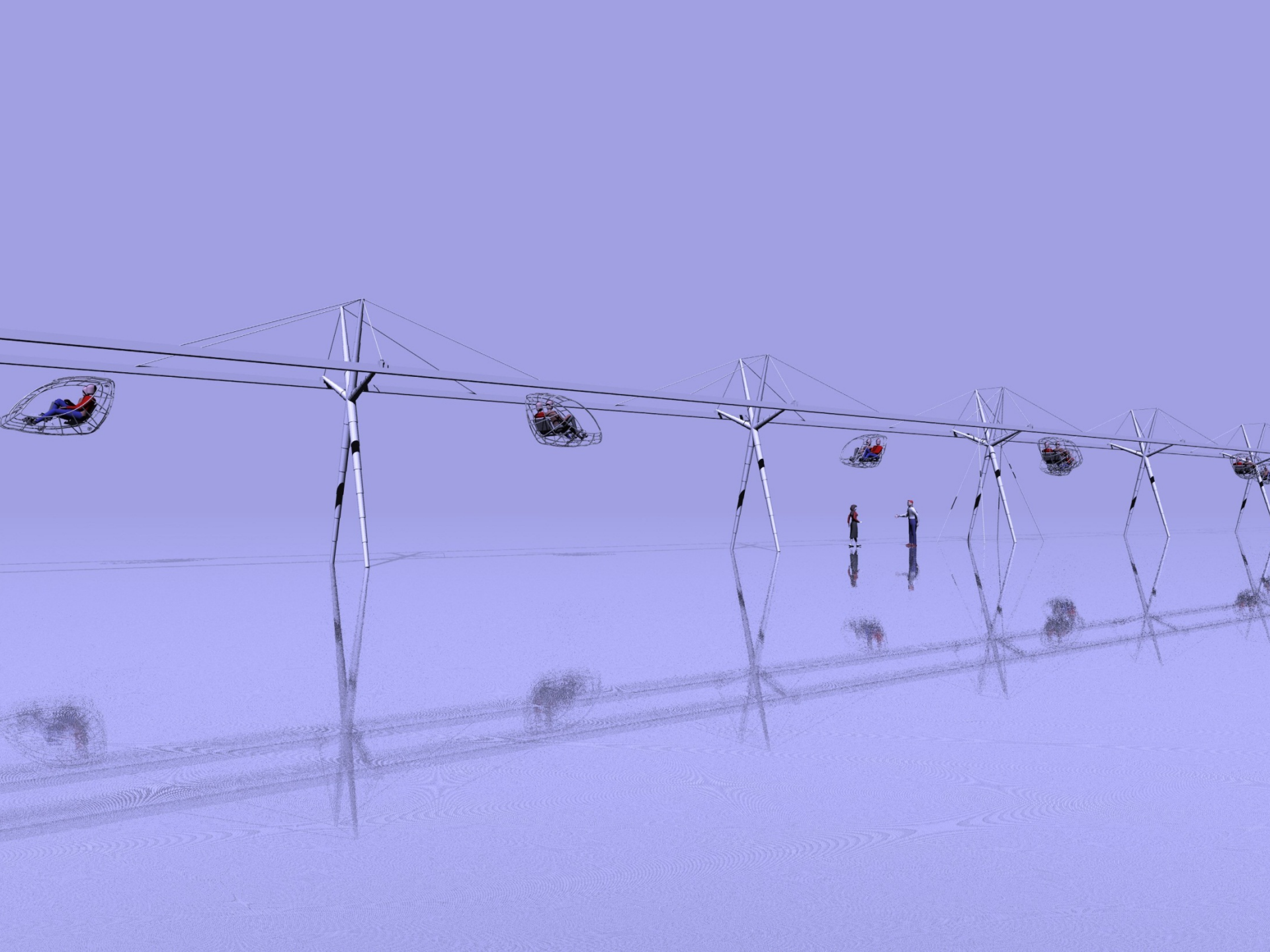
1974

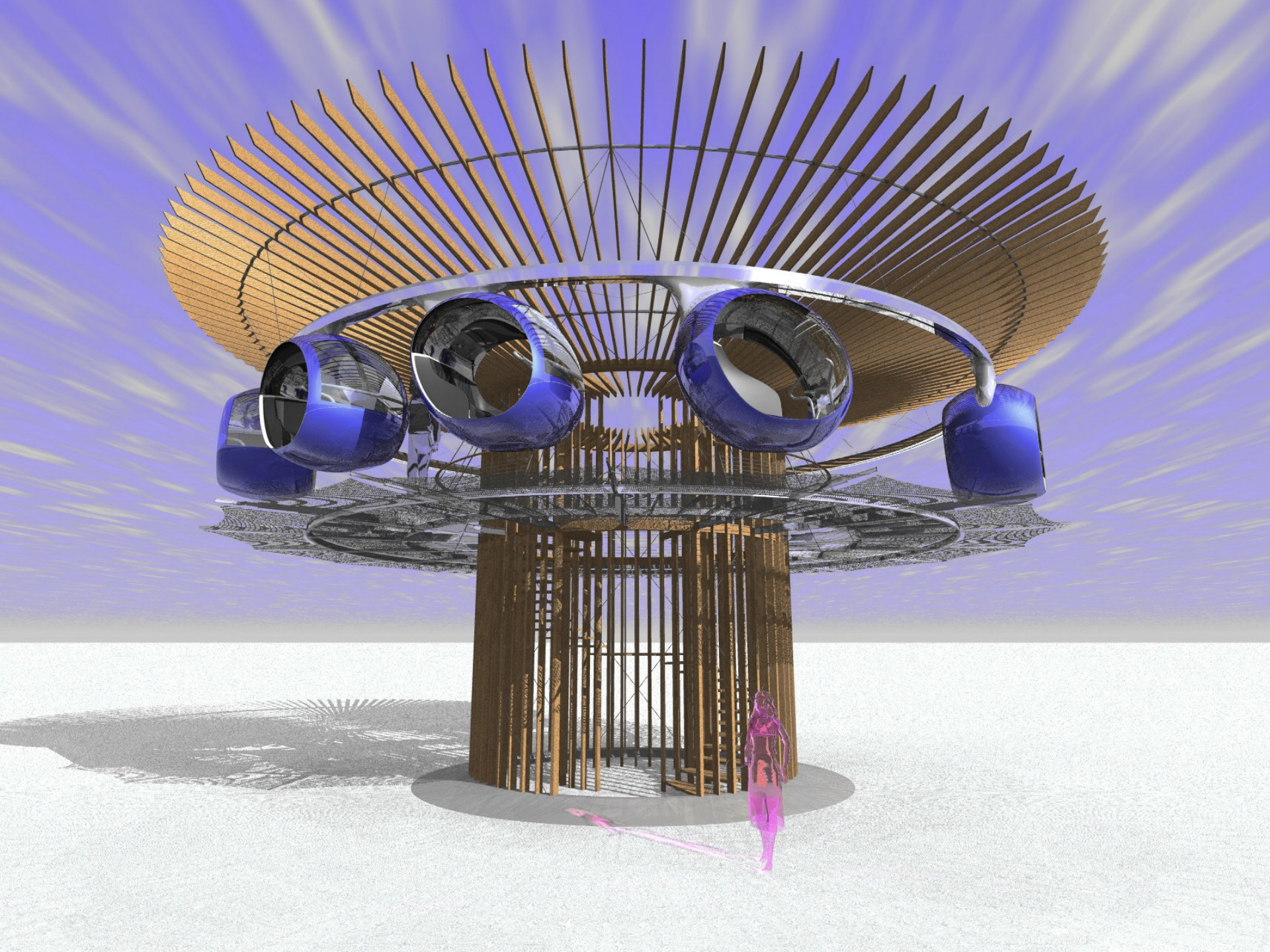
Headmaster

Another 25 years later…





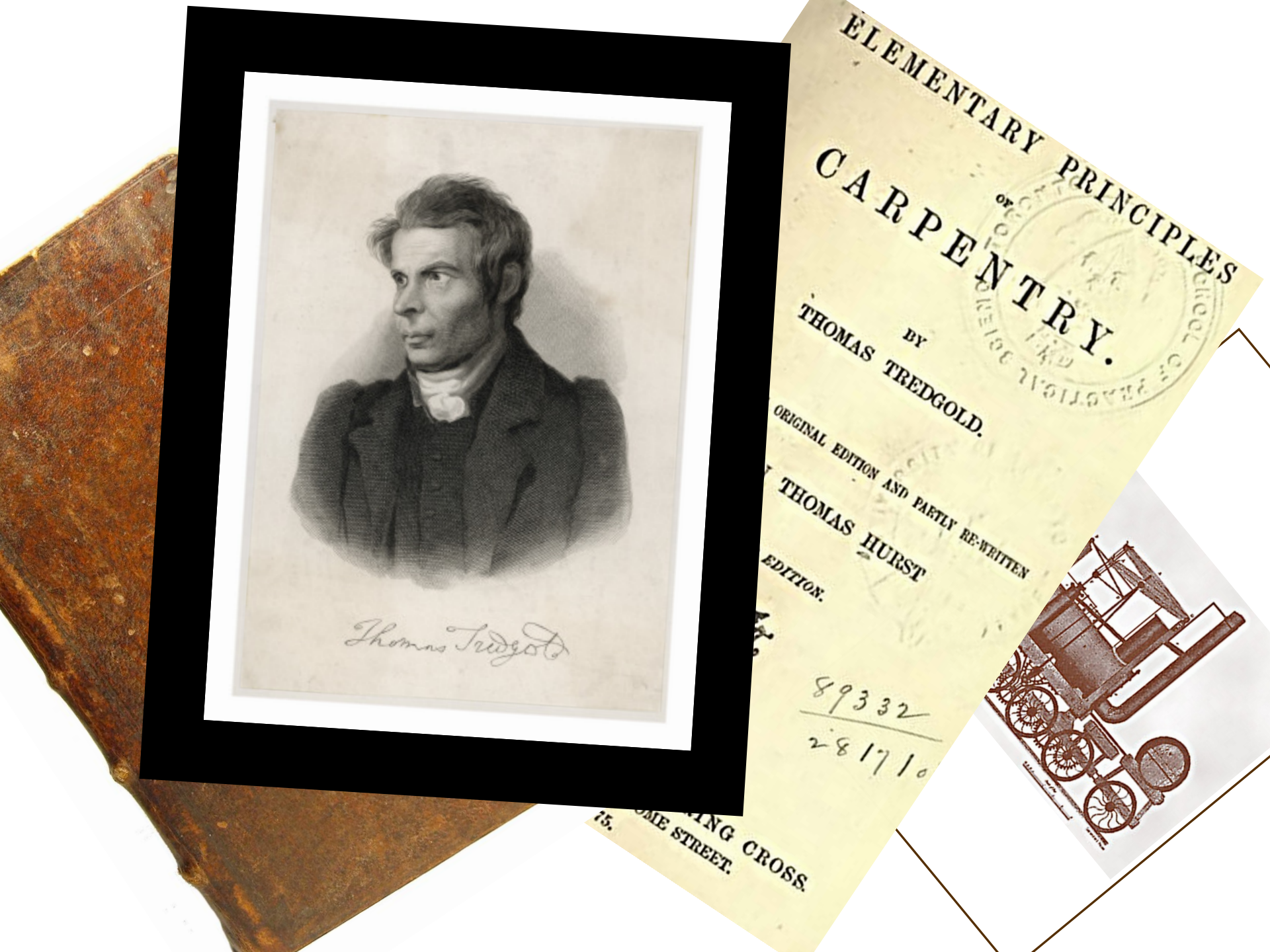




25
Meet the world
at 40,000 feet
A350 Onboard Lounge

via?

1828


Thomas Tredgold
ELEMENTARY PRINCIPLES
OF
CARPENTRY.
BY
THOMAS TREDGOLD.
ORIGINAL EDITION AND PARTLY RE-WRITTEN
THOMAS HURST
EDITION.
89332
28171
CROSS.
STREET.

Description of a Civil Engineer

by Thomas Tredgold, Esqre M.Inst.C.E.

Civil Engineering is the art of directing the great sources of Power in Nature for the use & convenience of man;

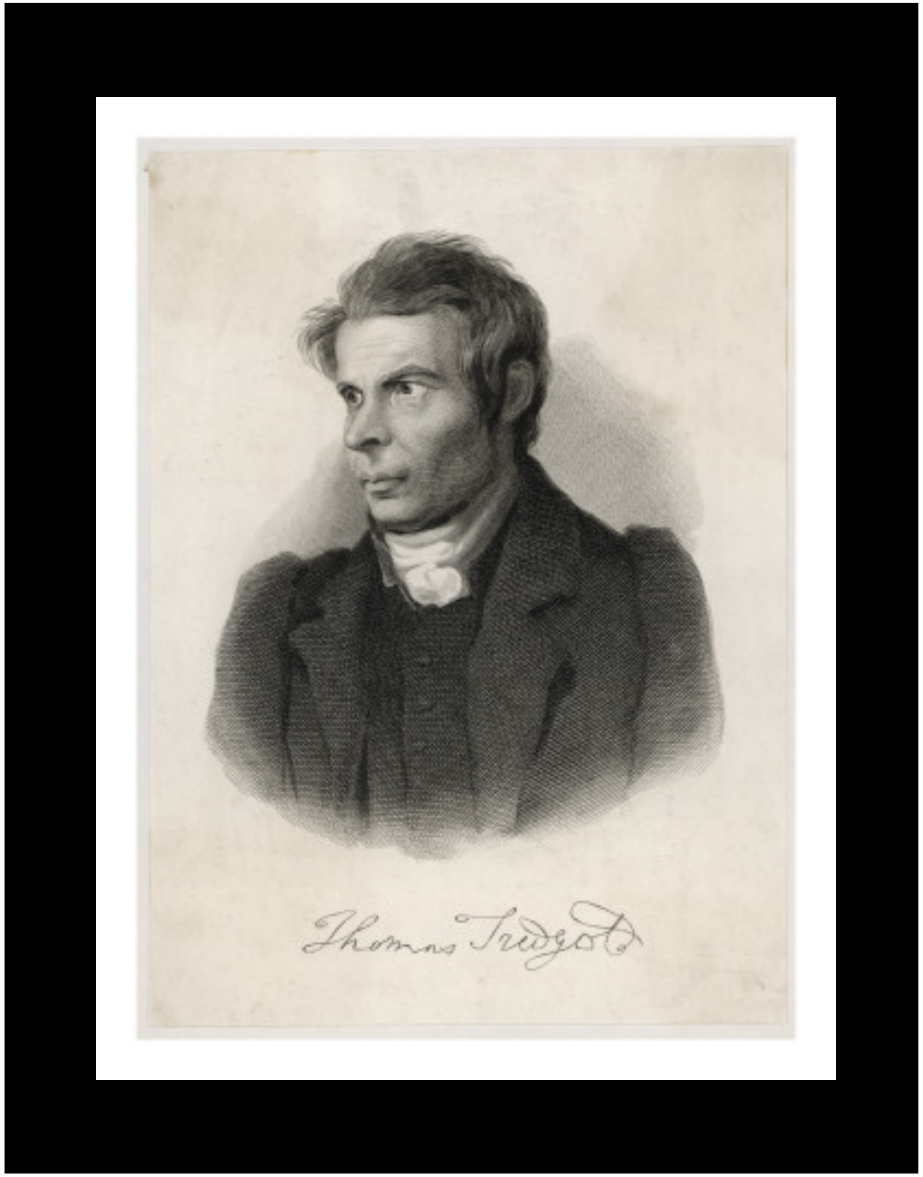
…FORCES OF NATURE….

….FOR THE

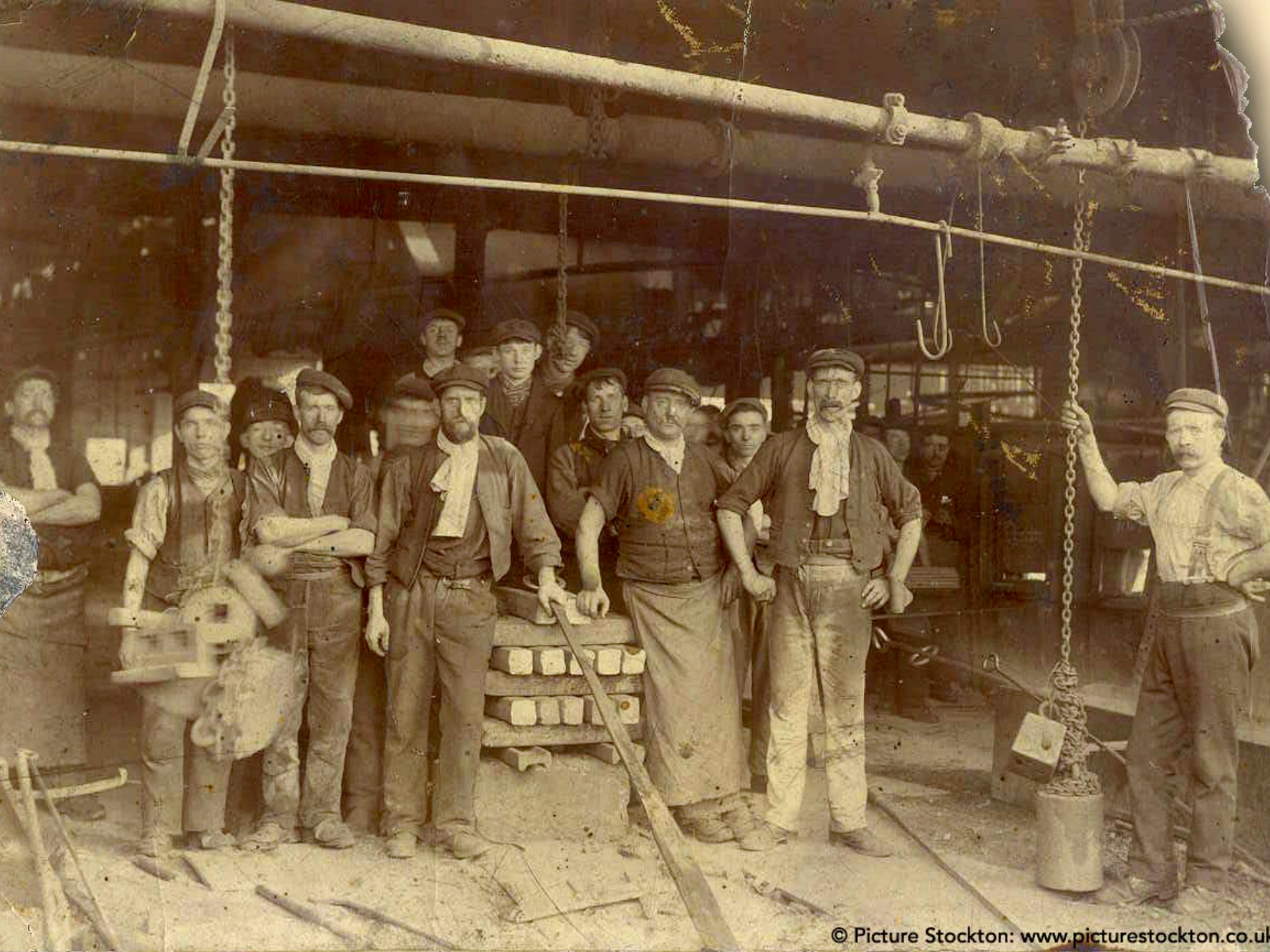
USE AND CONVENIENCE

OF MAN

thank you
Thomas



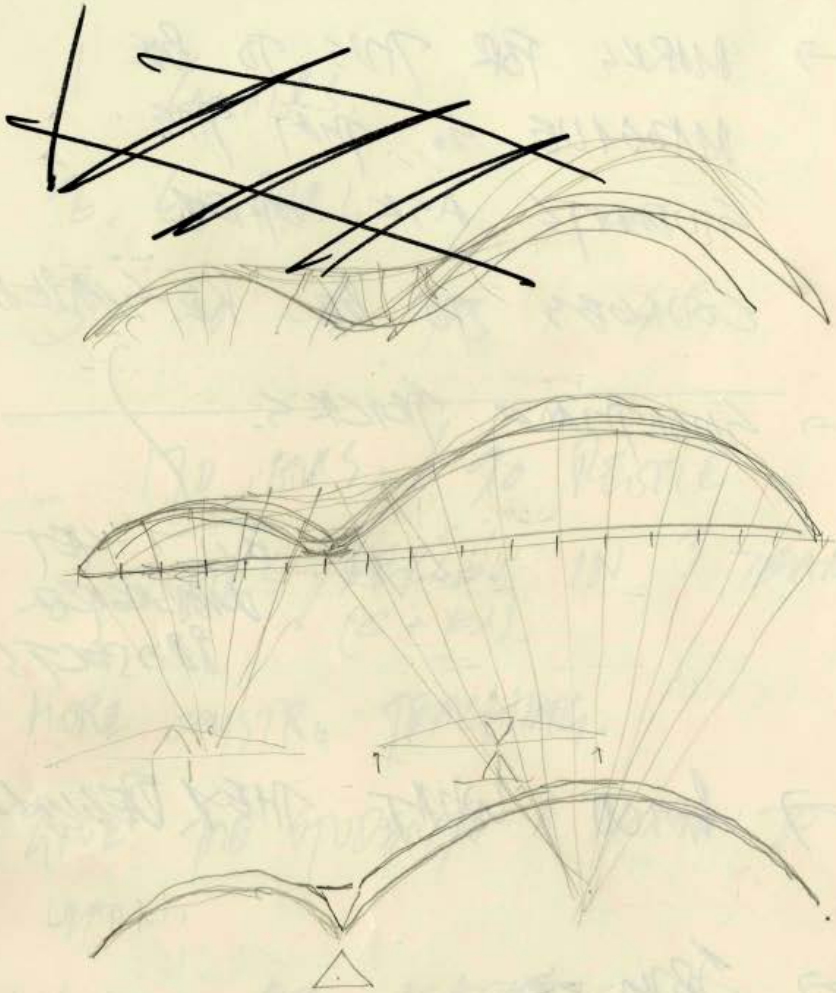
HEAD WRIGHTSON & Co
No 21
TEESDALE IRON WORKS
STOCKTON on TEES
1870

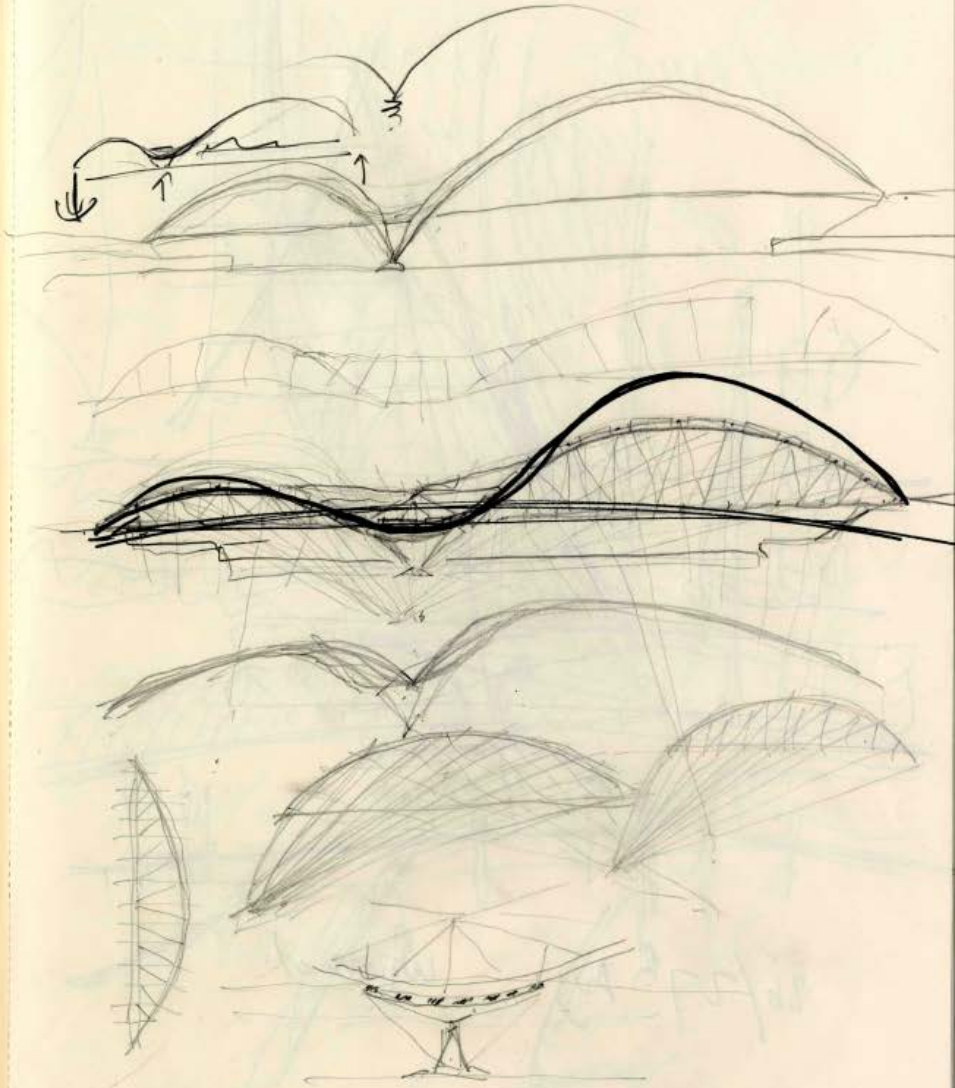


© Picture Stockton: www.picturestockton.co.uk

LONSDALE
TRADING CO

Mr. Dave Riley + Mr. Thomas Douachie + Mr. Gerard Henri
“I remember when all this used to be Wrightson’s Steel,
I worked on it as a lad,
when they had the contract to get the scrap off here,
when they pulled everything out.”





18

The acid test

Slipknot
NO FEAR

Michael Stirling + Chris Hudson

“It’s got better metal than the other bridges.”

Jill Singiglia + Hazel Crocker
“It’s a lovely way to spend your lunchtime.”

NGTON TAXI

“if you’d seen the people,
it says it all.”

10,000 Hours

(Malcolm Gladwell: Outliers)

Five stage model of learning
1980 :
Stuart and Hubert Dreyfus
University of California

Novice:

Competence:

Proficiency:

Expertise:

Mastery

amo
amas
amat

.

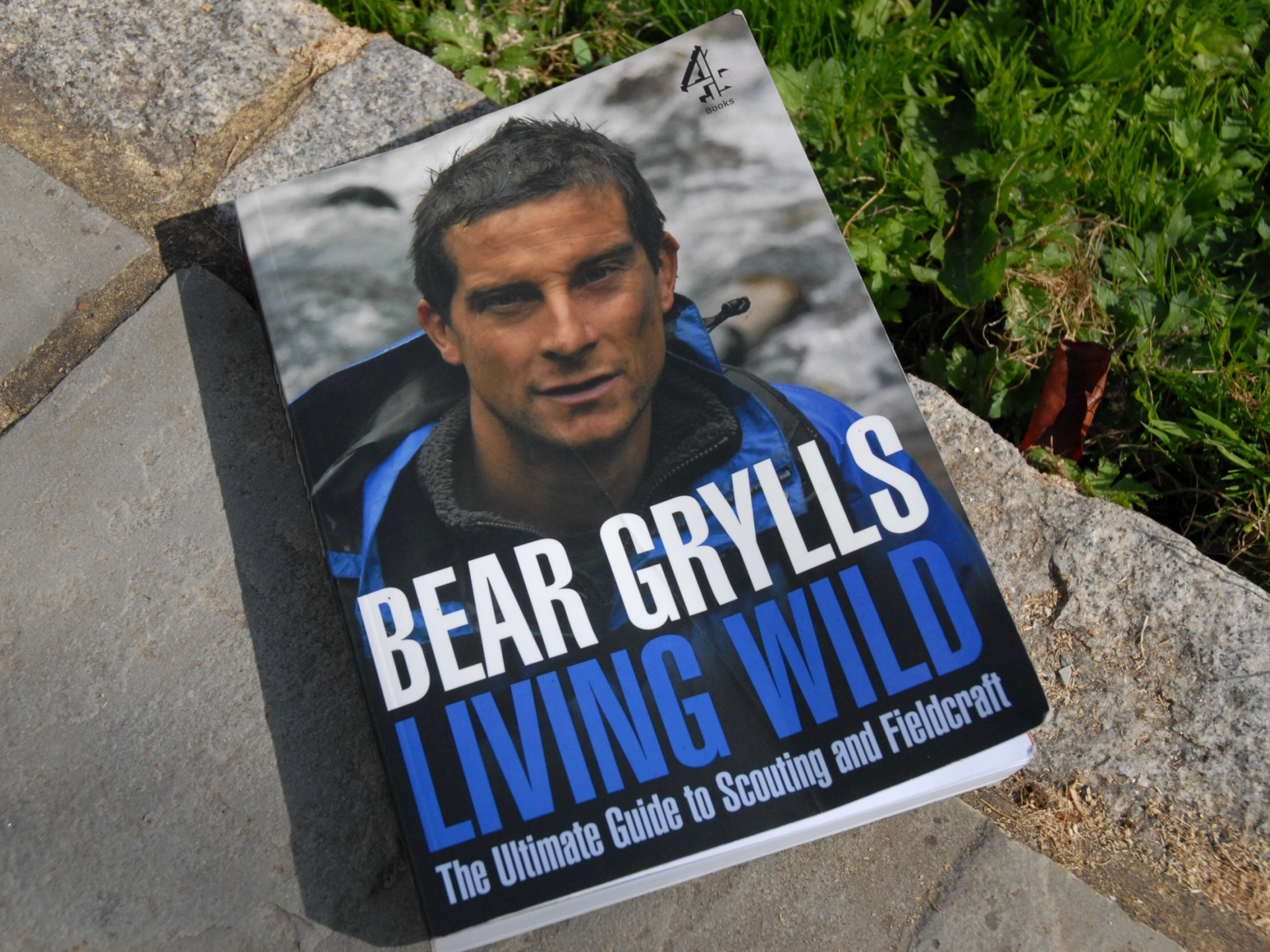
.

.

Aubrey Gerald Scrase

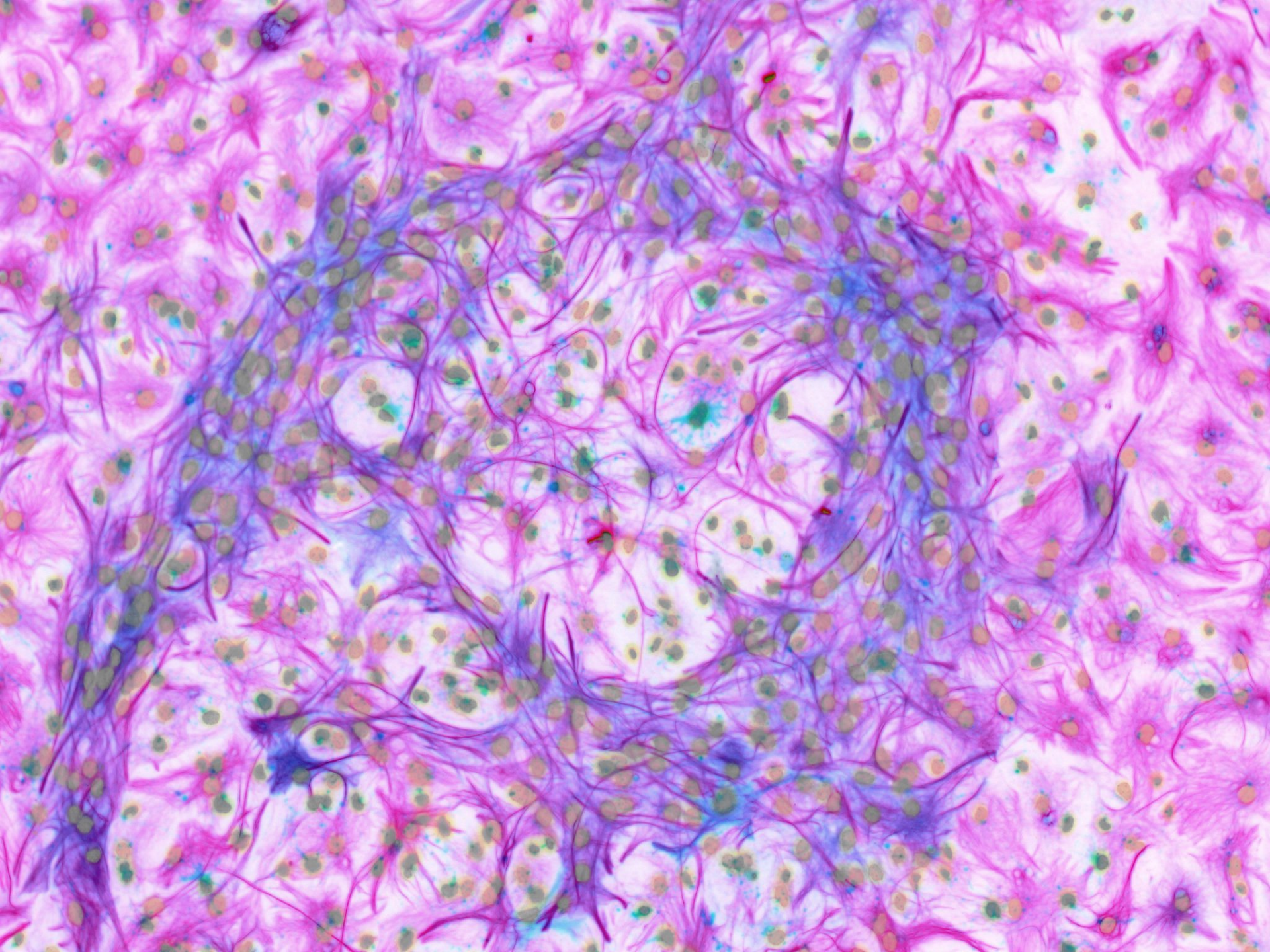
"So by the time they returned to England from Hamburg, they sounded like no one else. It was the making of them."

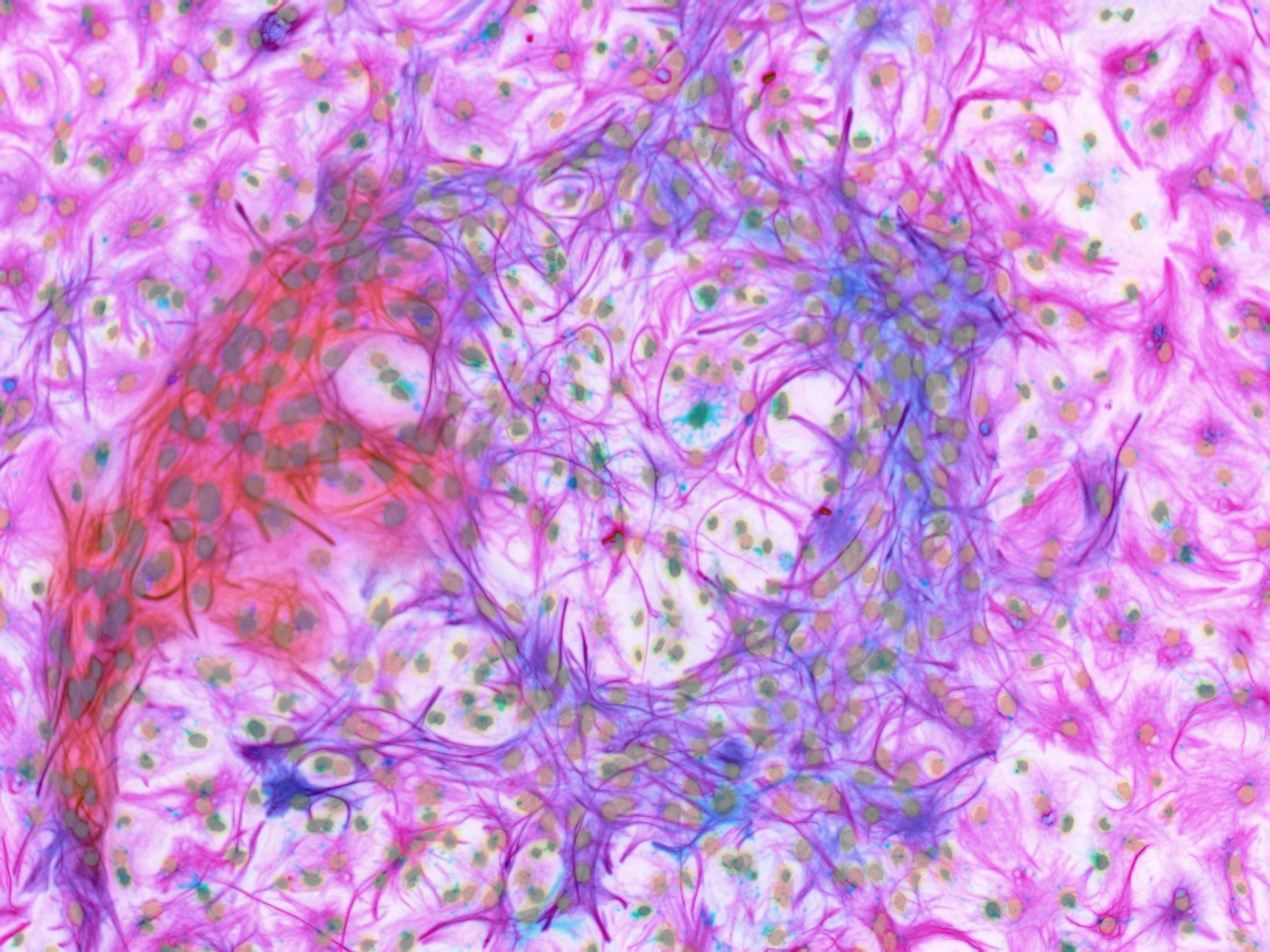
Beatles' biographer Philip Norman


Books
BEAR GRYLLS
LIVING WILD
The Ultimate Guide to Scouting and Fieldcraft

VIVICAM
DIGITAL LENS
f=7mm F=3.0
Vivitar
ViviCam 9114

What are they doing?



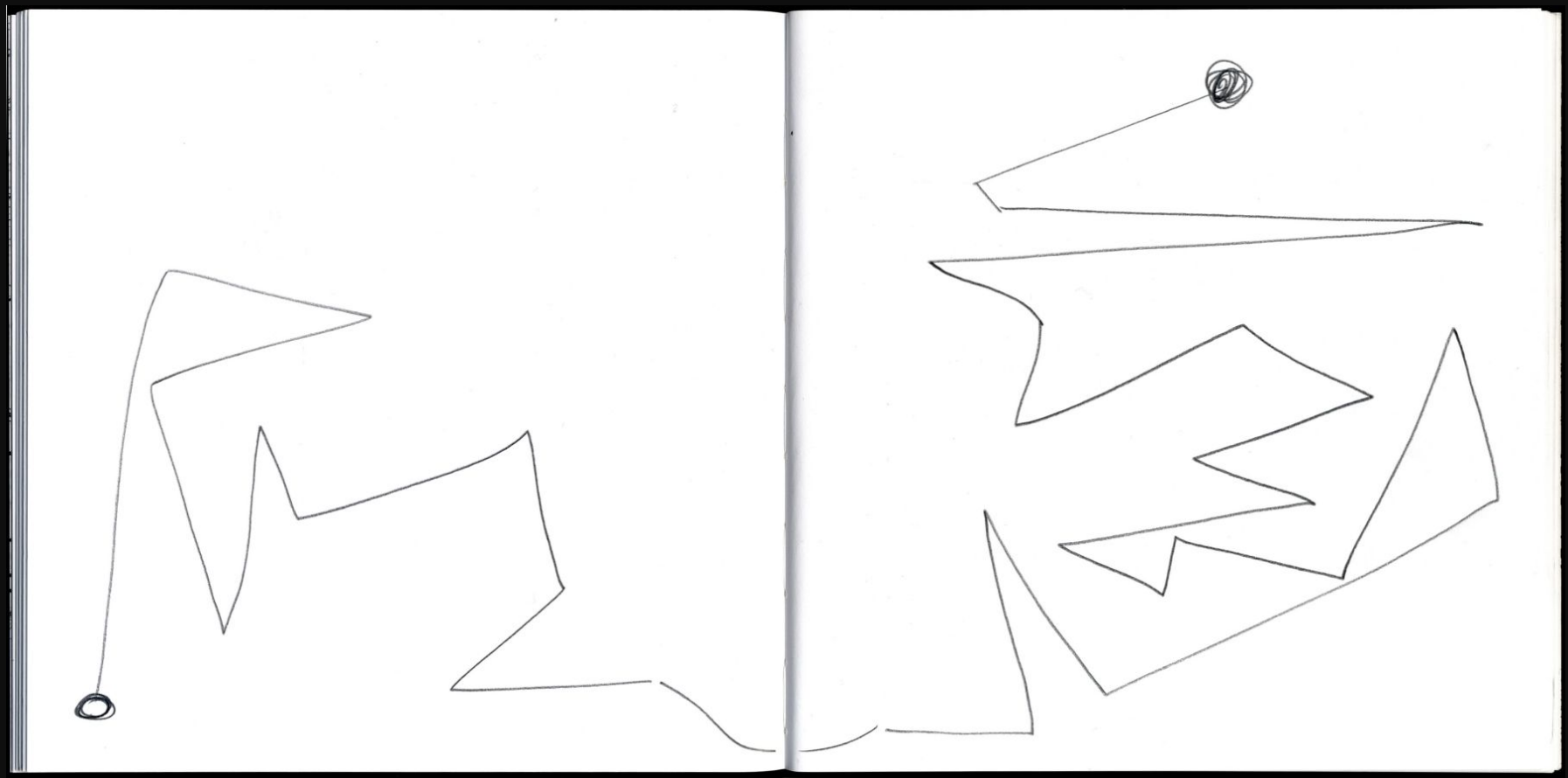


artists,

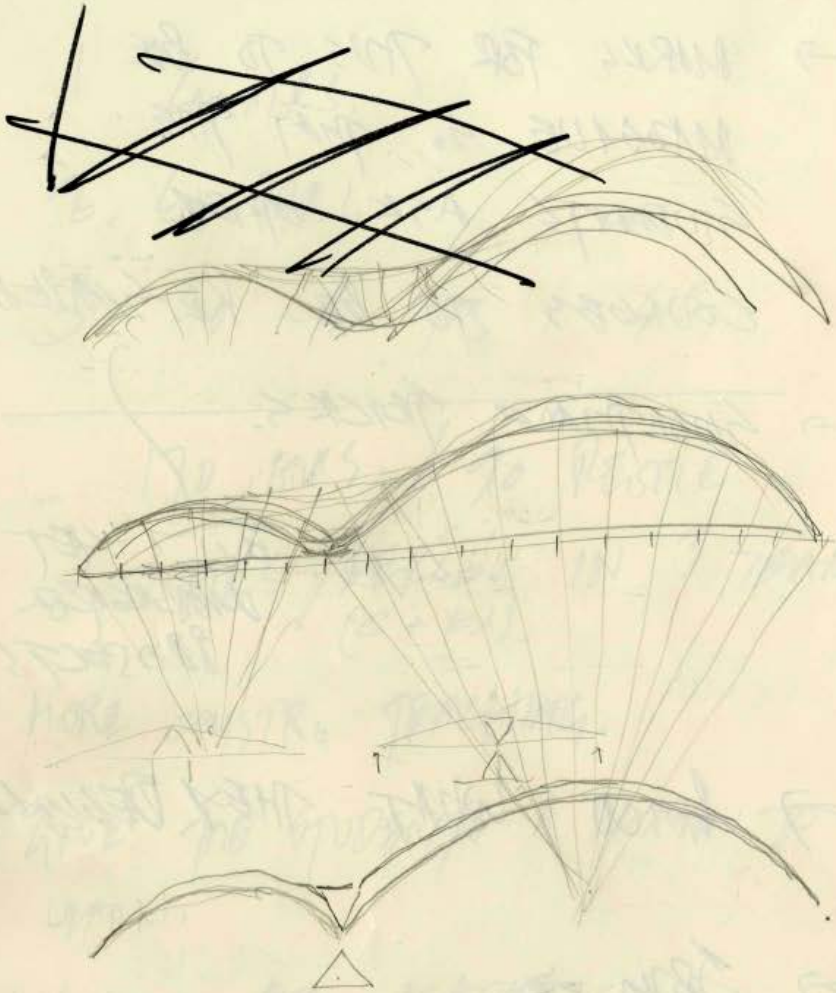
artisans

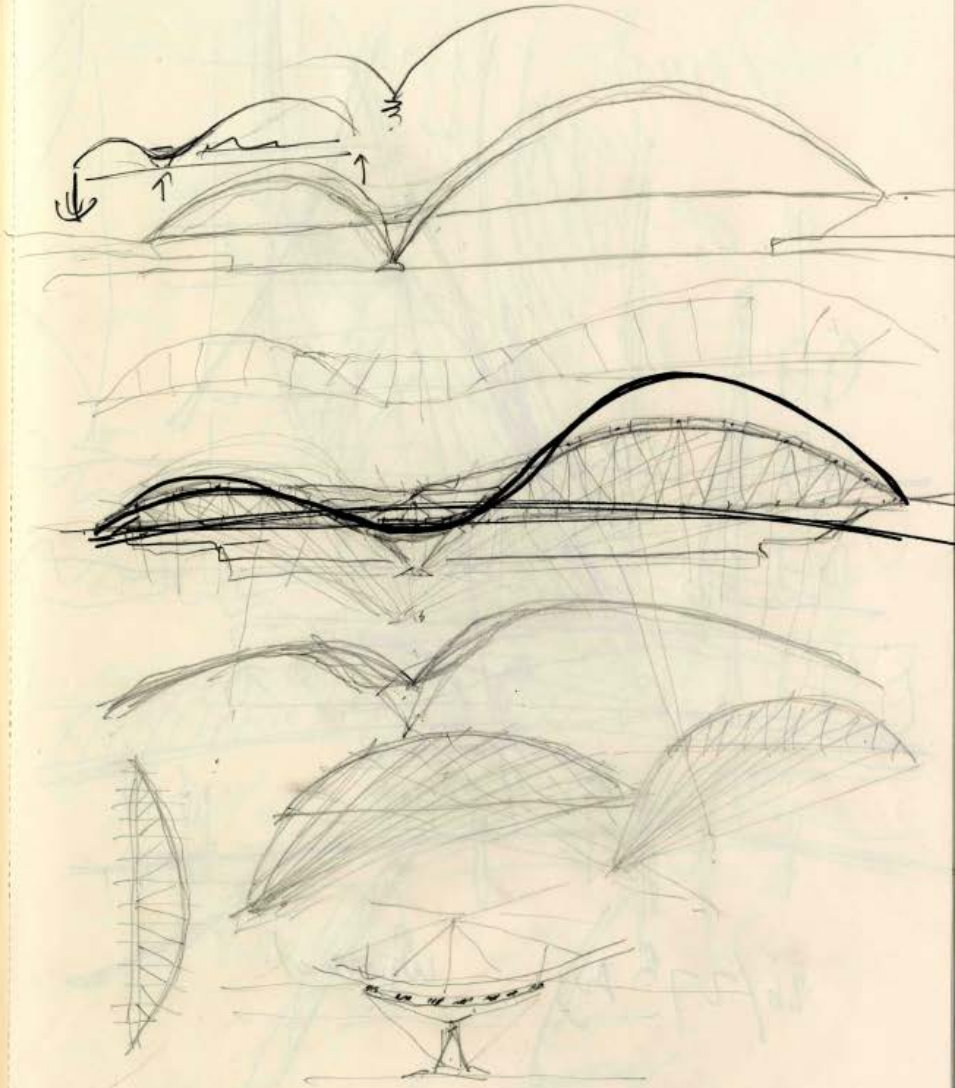
philosophers

An Artist's Strategy

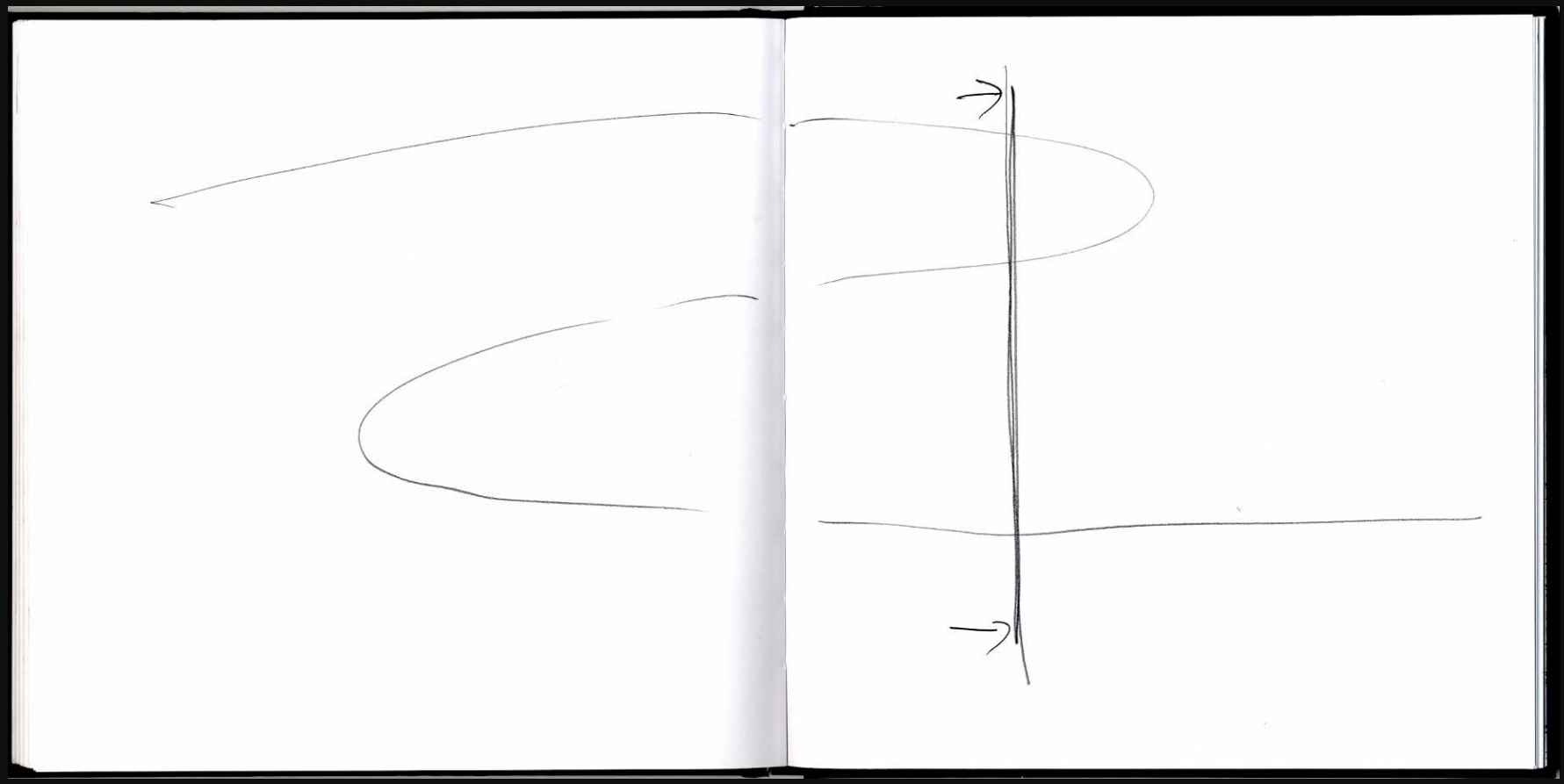


Motivated by interest
Finds it easy to start, hard to stop

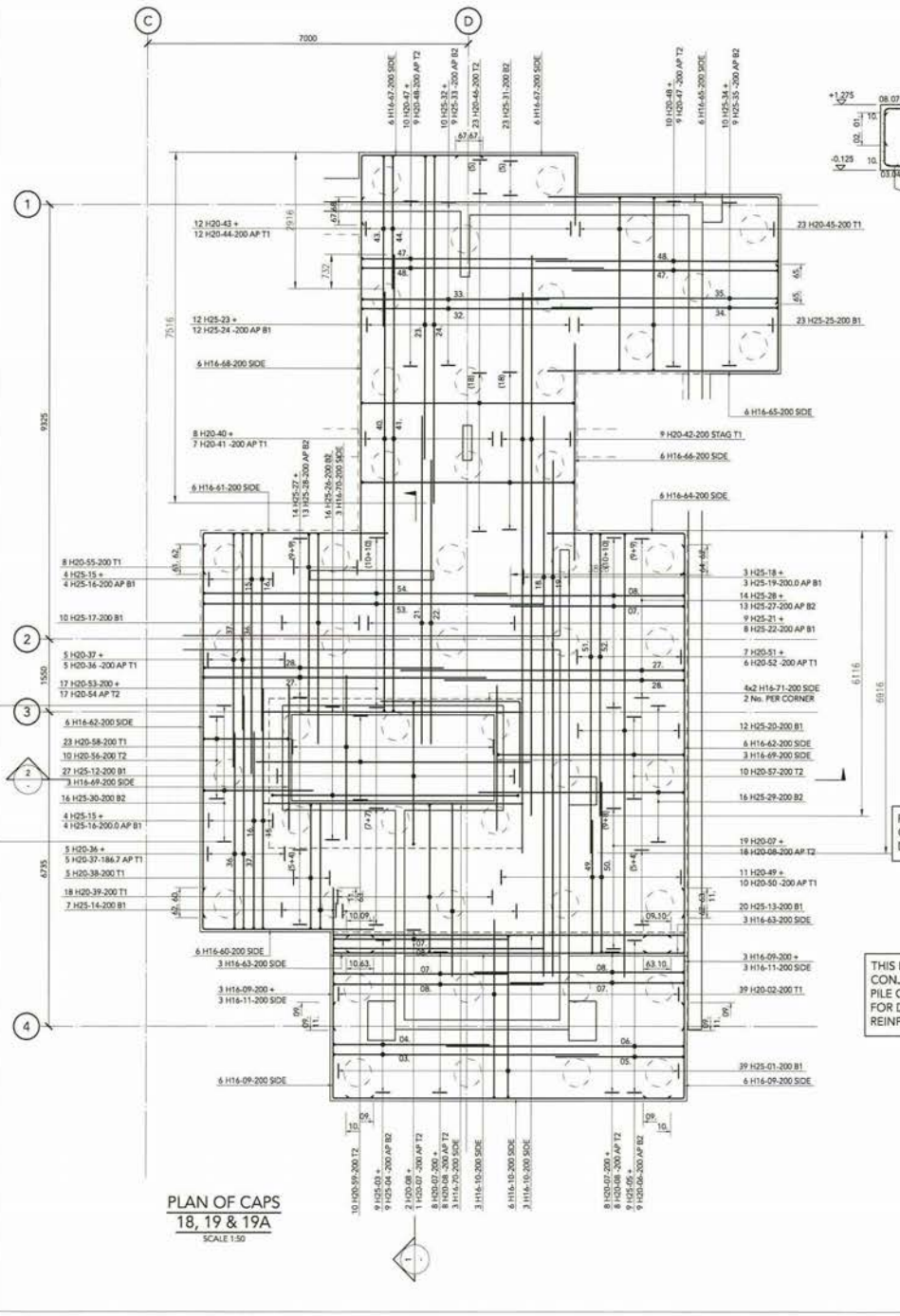




An Artisan's Strategy



Seeks perfection of form
Can't begin without a pre-existing concept
then incrementally seeks improvement.

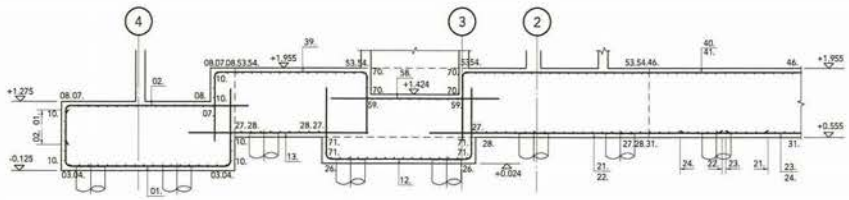


PLAN OF CAPS
18, 19 & 19A
SCALE 1:50

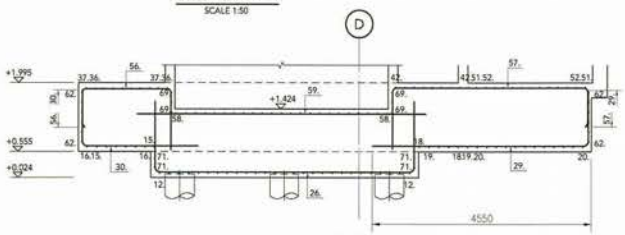
FOR LOCATION OF PILE CAPS & GROUND BEAMS REFER TO DRAWING No. 1B-1A1B-R-0050.

FOR COLUMN & WALL STARTER BARS SEE SEPERATE DRAWINGS.

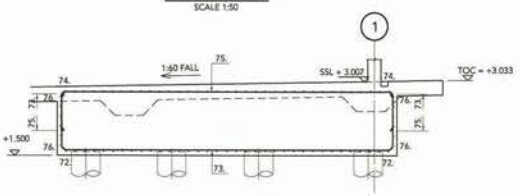
THIS DRAWING TO BE READ IN CONJUNCTION WITH ADJACENT PILE CAP & GROUND BEAM DRAWINGS FOR DETAILS OF CONTINUATION REINFORCEMENT INCLUDING STOOLING.



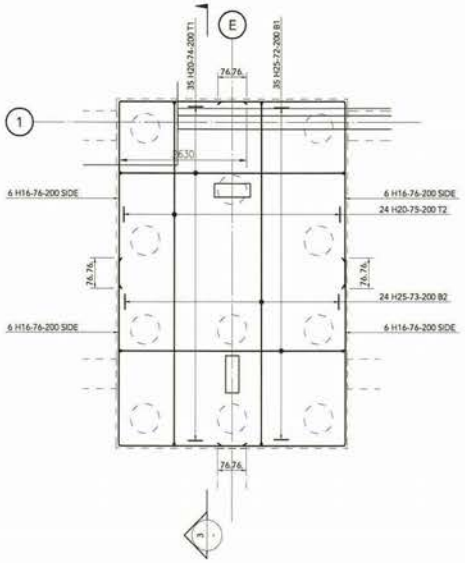
SECTION 1-1
SCALE 1:50



SECTION 2-2
SCALE 1:50



SECTION 3-3
SCALE 1:50



PLAN OF CAP 21
SCALE 1:50

Drawing notes

1. THIS DRAWING MUST BE READ IN CONJUNCTION WITH ALL THE RELEVANT DRAWINGS AND THE SPECIFICATION.
2. COVER TO REINFORCEMENT TO BE:
   PILE CAPS: 75mm TOP, 75mm BOTTOM, 50mm SIDES
3. MINIMUM LAPS TO BE:
   T10 - 350mm
   T12 - 425mm
   T16 - 575mm
   T20 - 700mm
   T25 - 875mm
   T32 - 1125mm
4. FOR DETAILS OF REINFORCEMENT SEE BBS, 194-1B/1B-1A1B-R-0051/01-04
5. ALL KICKERS TO BE 75mm
6. ABBREVIATIONS:
   T1 - FIRST LAYER TOP
   T2 - SECOND LAYER TOP
   T3 - THIRD LAYER TOP
   B1 - FIRST LAYER BOTTOM
   B2 - SECOND LAYER BOTTOM
   B3 - THIRD LAYER BOTTOM

issued for purpose indicated | date

Client
L&R
LONDON & REGIONAL PROPERTIES

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320 Regent Street
London, W1B 3BB
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F +44 (0) 20 7307 1001
E info@expedition.uk.com
W www.expedition.uk.com

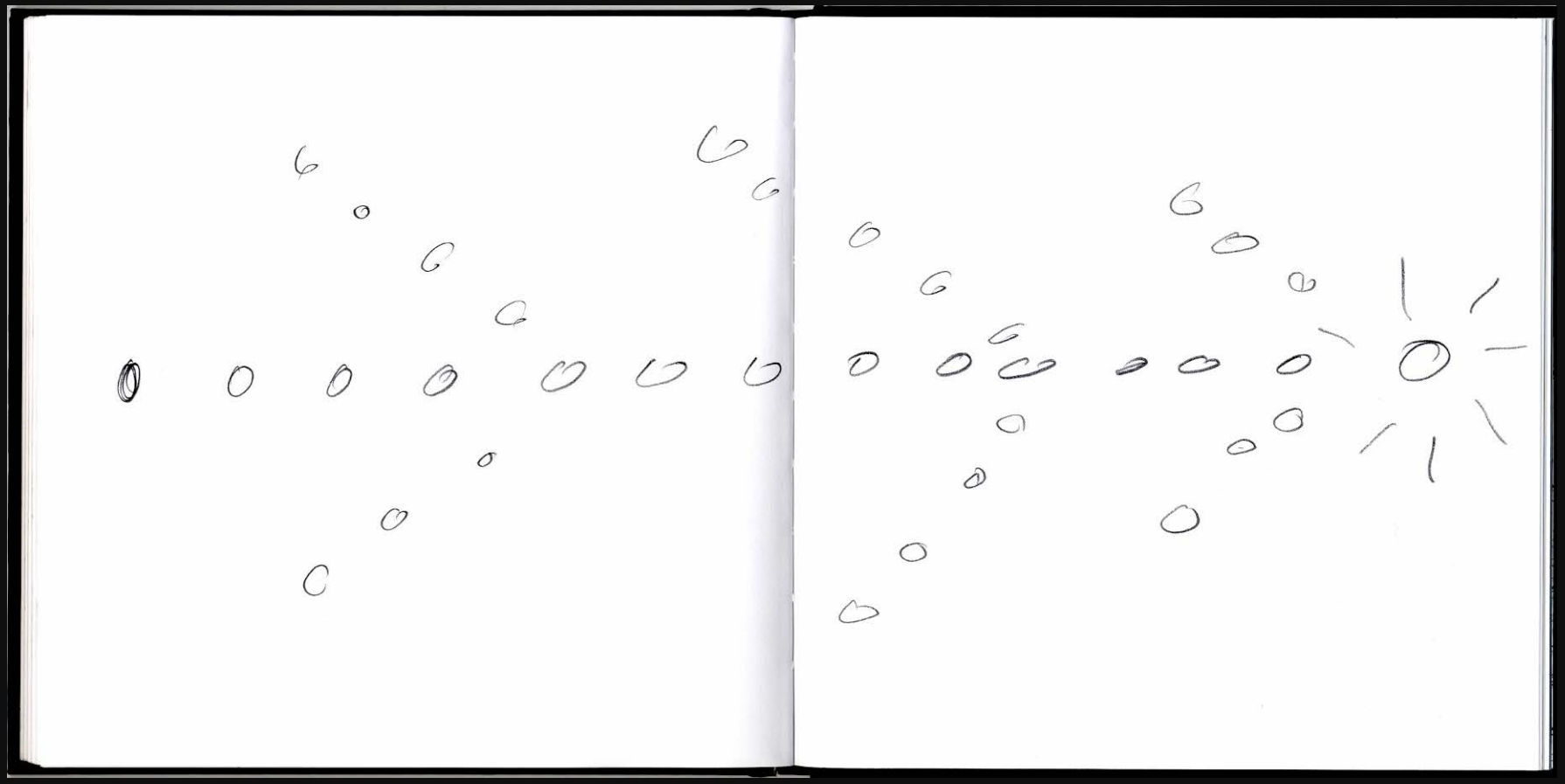
expedition

Project: GREENWICH WHARF

Title: BLOCK 1A/1B
RC DETAILS OF PILE CAPS
SHEET 2

Scales	1:50@A1	Date	Jan 2
Drawn	AJP	Chk'd	BMG
Job No.	194-1B	Rev	-
Drg No.	1B-1A1B-R-0051		

A Philosopher's Strategy



Seeks meaning
Finds it hard to start
because needs perfection of meaning first

Our Velopark proposal is about cycling before all else…… this is not about flights of architectural fantasy or wonders of structural gymnastics……

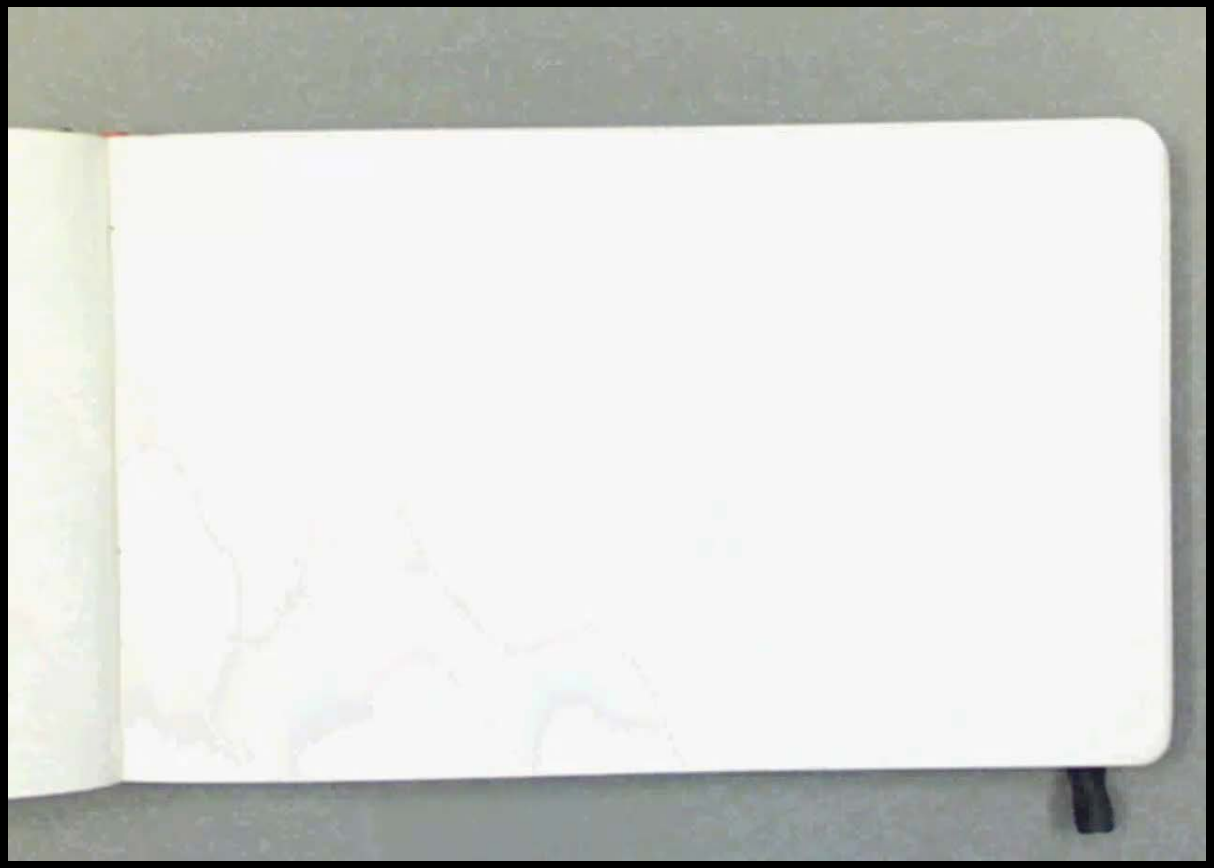
THINKING, FAST AND SLOW

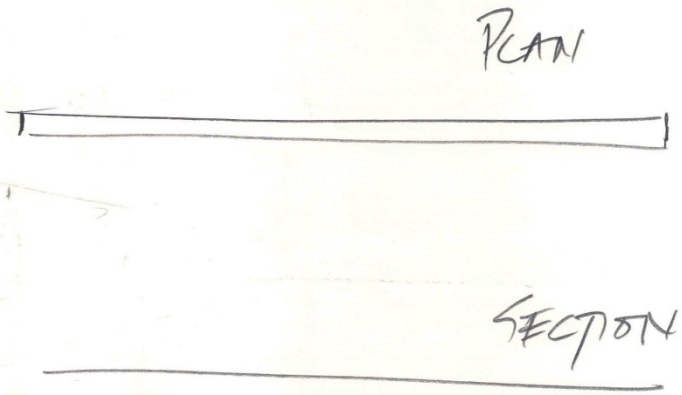
DANIEL KAHNEMAN

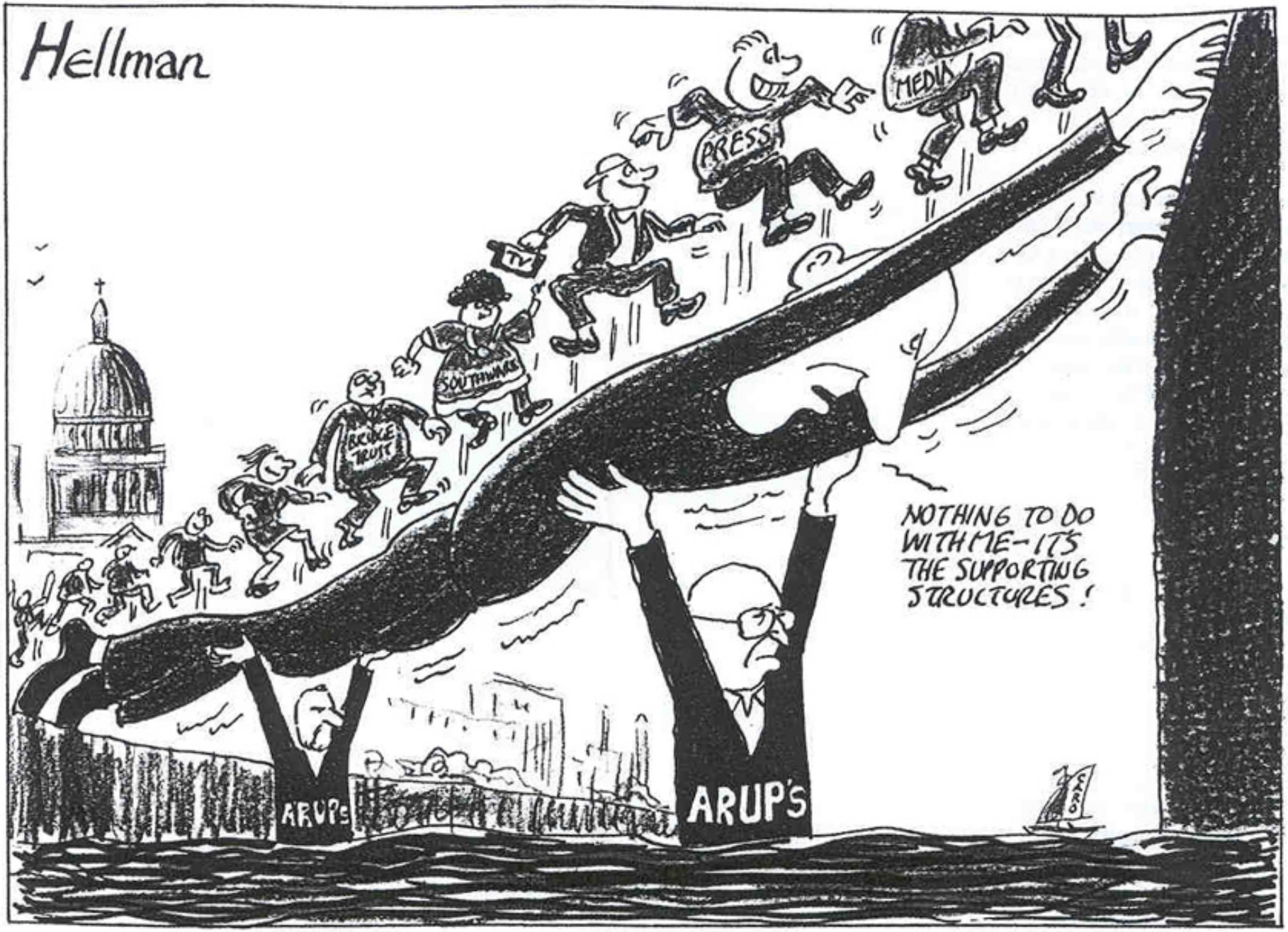
WINNER OF THE NOBEL PRIZE IN ECONOMICS

TIME

“the illusion …
we exaggerate how knowable the world is”




PLAN
SECTION


Hellman
MEDIA
PRESS
TV
SOUTHWARK
BRIDGE TRUST
ARUPs
ARUP'S
NOTHING TO DO WITH ME - IT'S THE SUPPORTING STRUCTURES!

Tony Fitzpatrick: Engineer, Arup, d. 2003

Testing testing

(what are the limits of performance?)

ELSEVIER

Applied Ergonomics 33 (2002) 523–531

APPLIED ERGONOMICS

www.elsevier.com/locate/apergo

An analysis of the forces required to drag sheep over various surfaces

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[b] *VIOSH Australia, University of Ballarat, P.O. Box 663, Ballarat, Victoria 3353, Australia*

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[e] *Wimmera Health Care Group, Physiotherapy Department, Baillie Street, Horsham, Victoria, Australia, 3400*

Received 26 September 2001; accepted 8 July 2002

Abstract

Some occupational health and safety hazards associated with sheep shearing are related to shearing shed design. One aspect is the floor of the catching pen, from which sheep are caught and dragged to the shearing workstation. Floors can be constructed from various materials, and may be level or gently sloping. An experiment was conducted using eight experienced shearers as participants to measure the force exerted by a shearer when dragging a sheep. Results showed that significant changes in mean dragging force occurred with changes in both surface texture and slope. The mean dragging forces for different floor textures and slopes ranged from 359 N (36.6 kg) to 423N (43.2 kg), and were close to the maximum acceptable limits for pulling forces for the most capable of males. The best floor tested was a floor sloped at 1:10 constructed of timber battens oriented parallel to the path of the drag, which resulted in a mean dragging force 63.6N (15%) lower than the worst combination.

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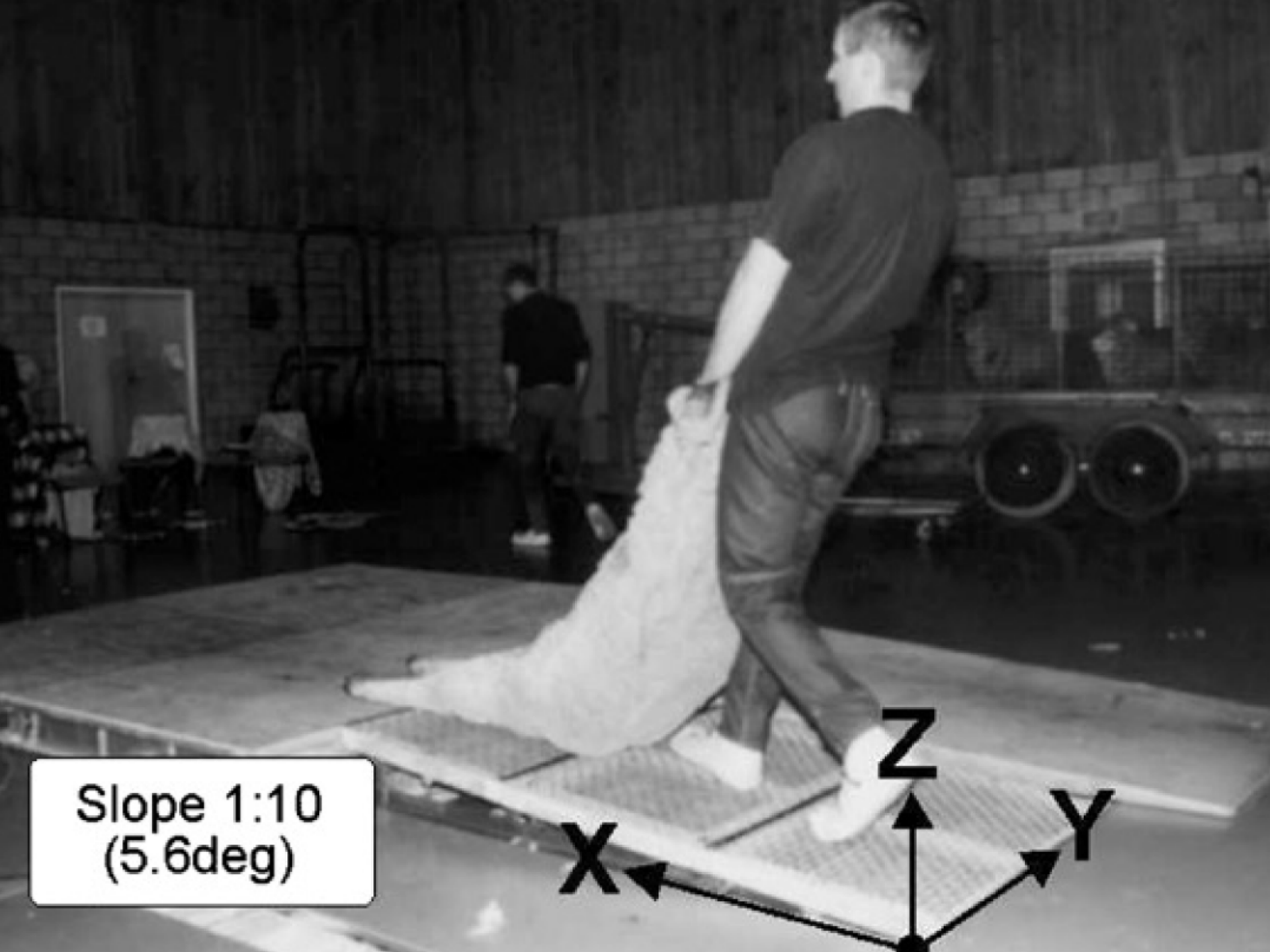
Slope 1:10
(5.6deg)
Z
X
Y

XI

1 CATAPULTARUM rationes, e quibus membris ex portionibus conponantur, dixi. Ballistarum autem rationes variae sunt et differentes unius effectus causa conparatae. Aliae enim vectibus suculis, nonnullae polyspastis, aliae ergastis, quaedam etiam tympanorum torquentur rationibus. Sed tamen nulla ballista perficitur nisi ad propositam magnitudinem ponderis saxi, quod id organum mittere debet. Igitur de ratione earum non est omnibus expeditum, nisi qui geometricis rationibus numeros et multiplicationes habent notas.

2 Nam quae[1] fiunt in capitibus foramina, per quorum spatia contenduntur capillo maxime muliebri vel nervo funes, magnitudine ponderis lapidis, quem debet ea ballista mittere, ex ratione gravitatis proportione sumuntur, quemadmodum catapultis de longitudinibus sagittarum. Itaque ut etiam qui geometrice[2] non noverunt, habeant[3] expeditum, ne in periculo bellico cogitationibus detineantur, quae ipse faciundo certa cognovi quaeque ex parte accepta praeceptoribus, finita exponam, et quibus rebus Graecorum pensiones ad modulos habeant rationem,

[1] namq *H*.
[2] geometrice e_2 (*cf.* nosse Graece *Aug*) : -ce *H*.
[3] habeant *ed* : habent *H*.

[1] *mittere* first means 'to let go.' The vernacular phrase *mitte*, 'chuck it,' is illuminating. Hence the solemn name of the mass, *missa* : 'the assemblage is dismissed, *ite*; *missa est*.'

[2] Euclid treats numbers geometrically, Books VII–X. It has been said of Newton that he could treat geometrically

CHAPTER XI

ON BALISTAE

1. I HAVE described the design of a catapult and the details which are combined in accordance with proportion. The design of the balista varies and its differences are adjusted for the purpose of a single effect. For some are worked by levers and windlasses, some by many pulleys, some by capstans, some by wheels. Yet all balistae are constructed with a view to the proposed amount of the weight of the stone which such a machine is to let fly.[1] Therefore only those craftsmen can deal with the design who are familiar with the geometrical[2] treatment of numbers and their multiples.

2. For the holes which are made in the frames (through the openings of which ropes are stretched, made especially of woman's hair or of the sinews of animals) are taken proportionately to the amount of the weight of the stone which the balista is to shoot, in accordance with gravity,[3] just as in the case of catapults the *length of the arrows* furnishes the module. Therefore in order that persons who are ignorant of geometry may be equipped and may not be delayed by calculation amid the perils of war, I will specify in accordance with my own knowledge gained in practice and also in accordance with the instructions of my teachers. Further, I will set forth in detail the manner in which the Greek

problems which other mathematicians could only solve by analysis of a numerical character.

[3] Specific gravity was discovered by Archimedes, Book IX., *pref.* 9 ff. The phrase 'centre of gravity,' κέντρον βάρους, was known before his time. Gow, *Greek Maths.* 238.

the details which are combined in accordance with proportion. The design of the balista varies and its differences are adjusted for the purpose of a single effect. For some are worked by levers and windlasses, some by many pulleys, some by capstans, some by wheels. Yet all balistae are constructed with a view to the proposed amount of the weight of the stone which such a machine is to let fly.[1] Therefore only those craftsmen can deal with the design who are familiar with the geometrical [2] treatment of numbers and their multiples.

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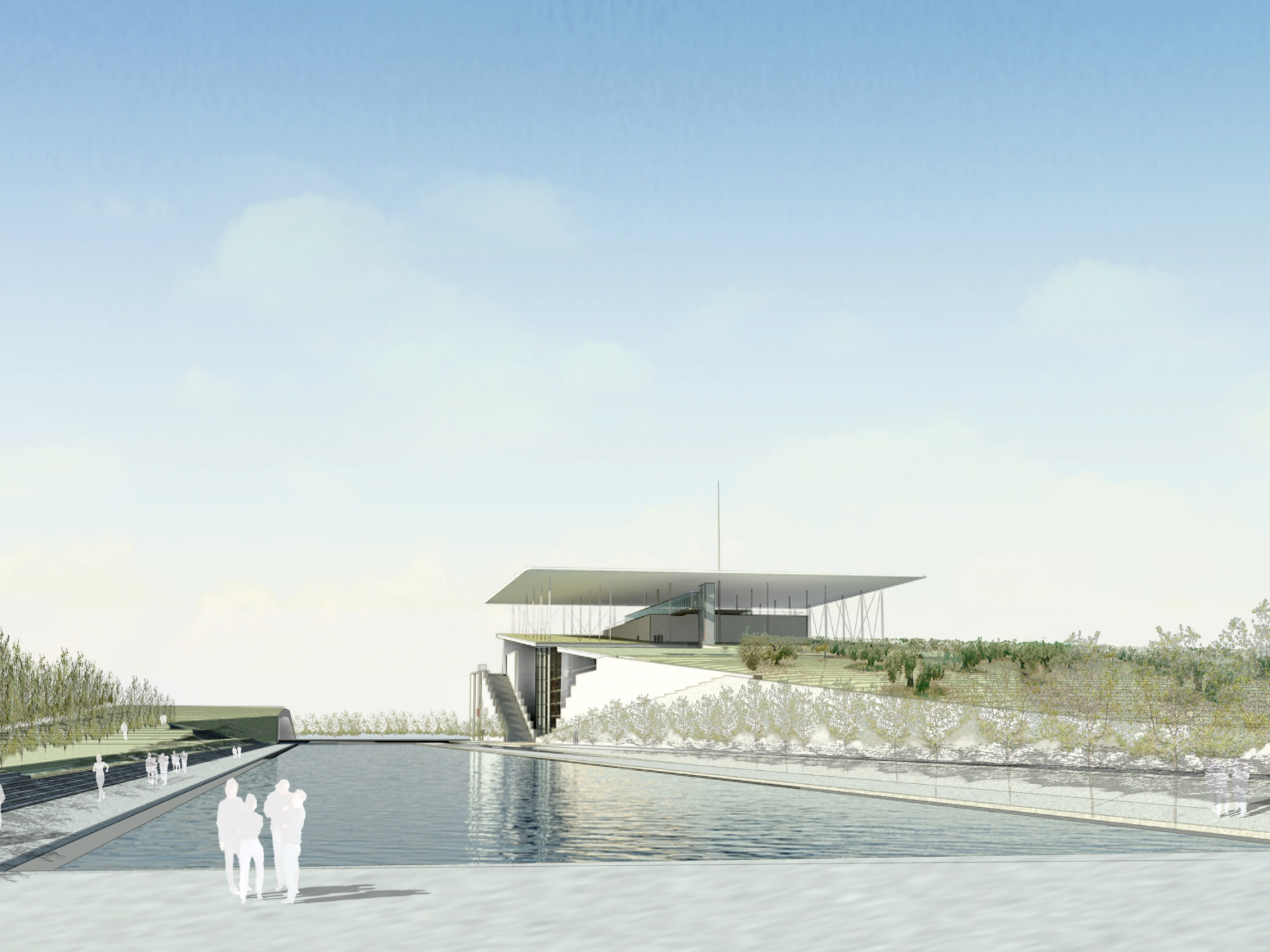
problems which other mathematicians could only solve by analysis of a numerical character.

LITTER

LITTER



Intermission:
a cautionary tale which would shock Stradivarius

…as we all know:
Energy is getting more expensive….
Materials have to go further to meet rising populations and standards of living….
Labour is comparatively cheaper
(or we're replaced by robots)….

….and designers, engineers, scientists from 20 countries

each find ways
to use materials better to design
out the embodied carbon
equivalent to driving

50 billion car miles

20 countries together could save the carbon equivalent of not driving

a Trillion Miles

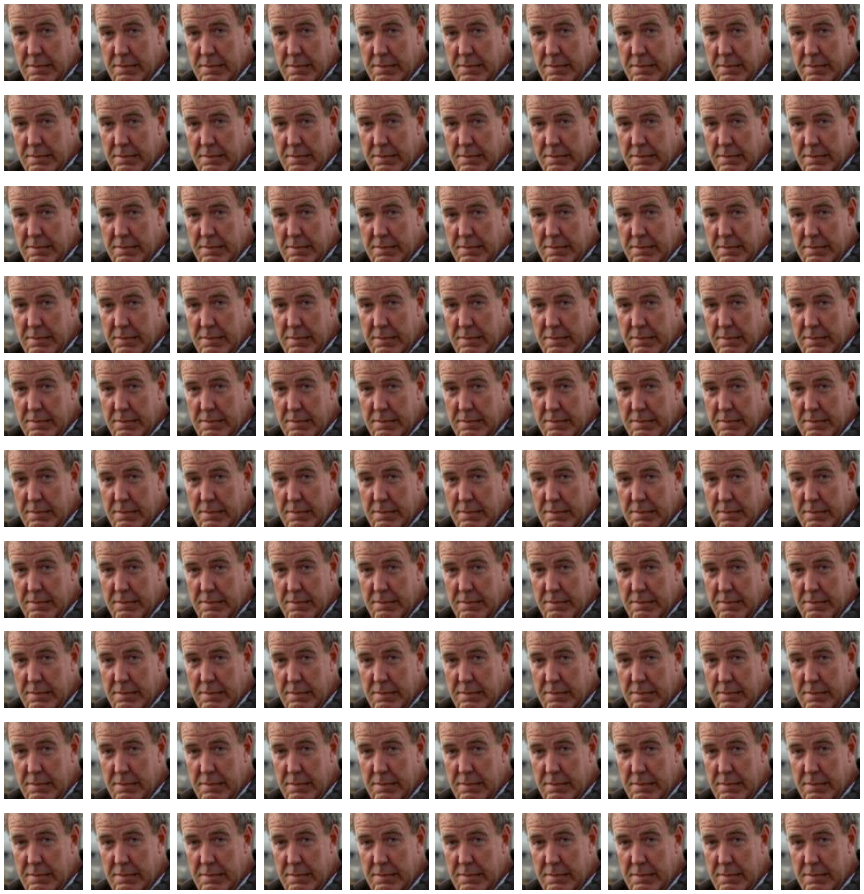
Suggested Units:

10 billion car miles = 1 Clarkson

100 Clarksons = 1 Trump

= 1 Trillion car miles

(a mind-bogglingly extravagant quantity of energy)



100 Clarksons = 1 Trump

Saving a Trillion miles of embodied carbon:

Wouldn’t that be something

??

…but, a Trillion miles?

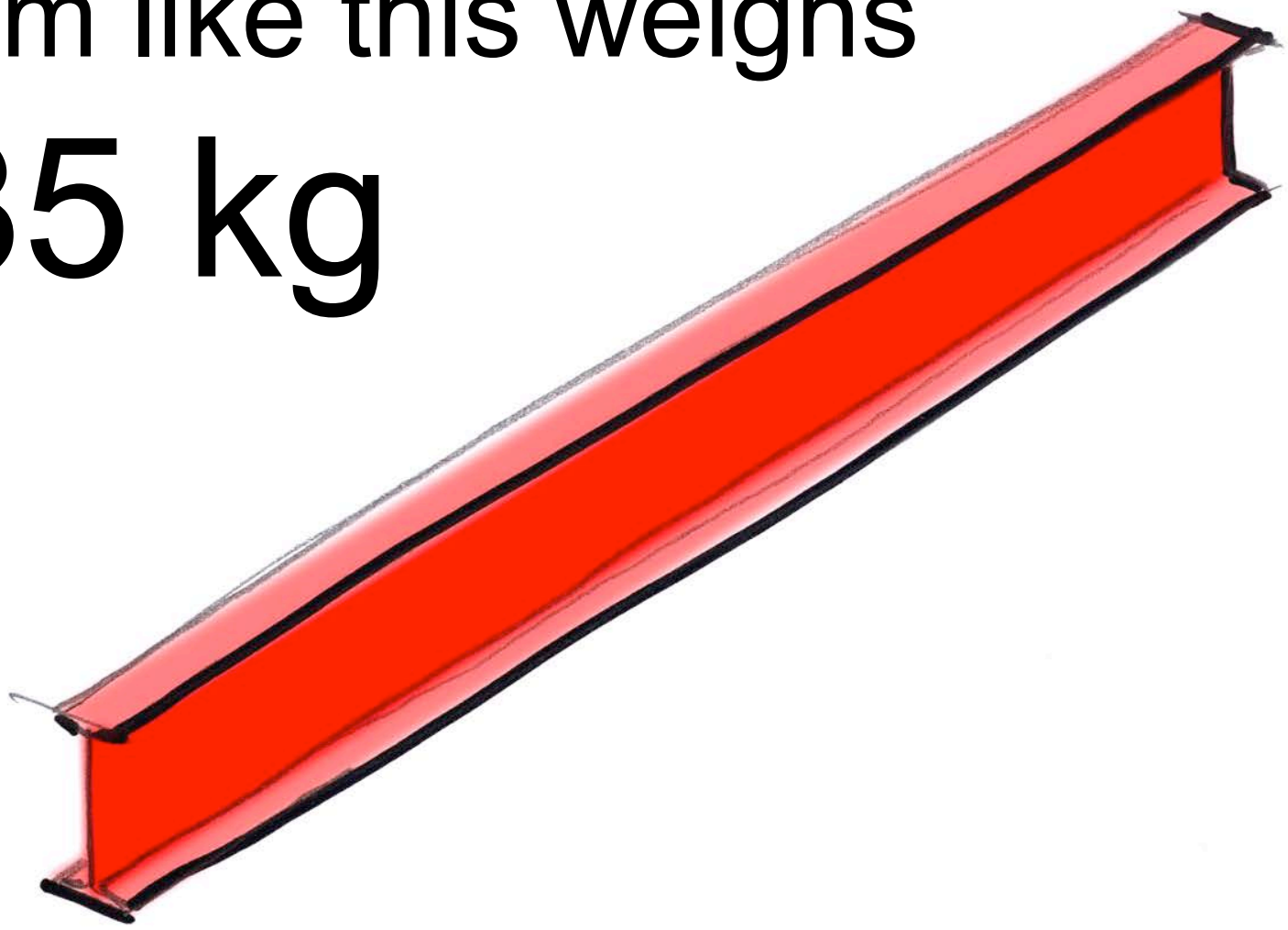
what can a humble designer do?

as an example, take one industry:

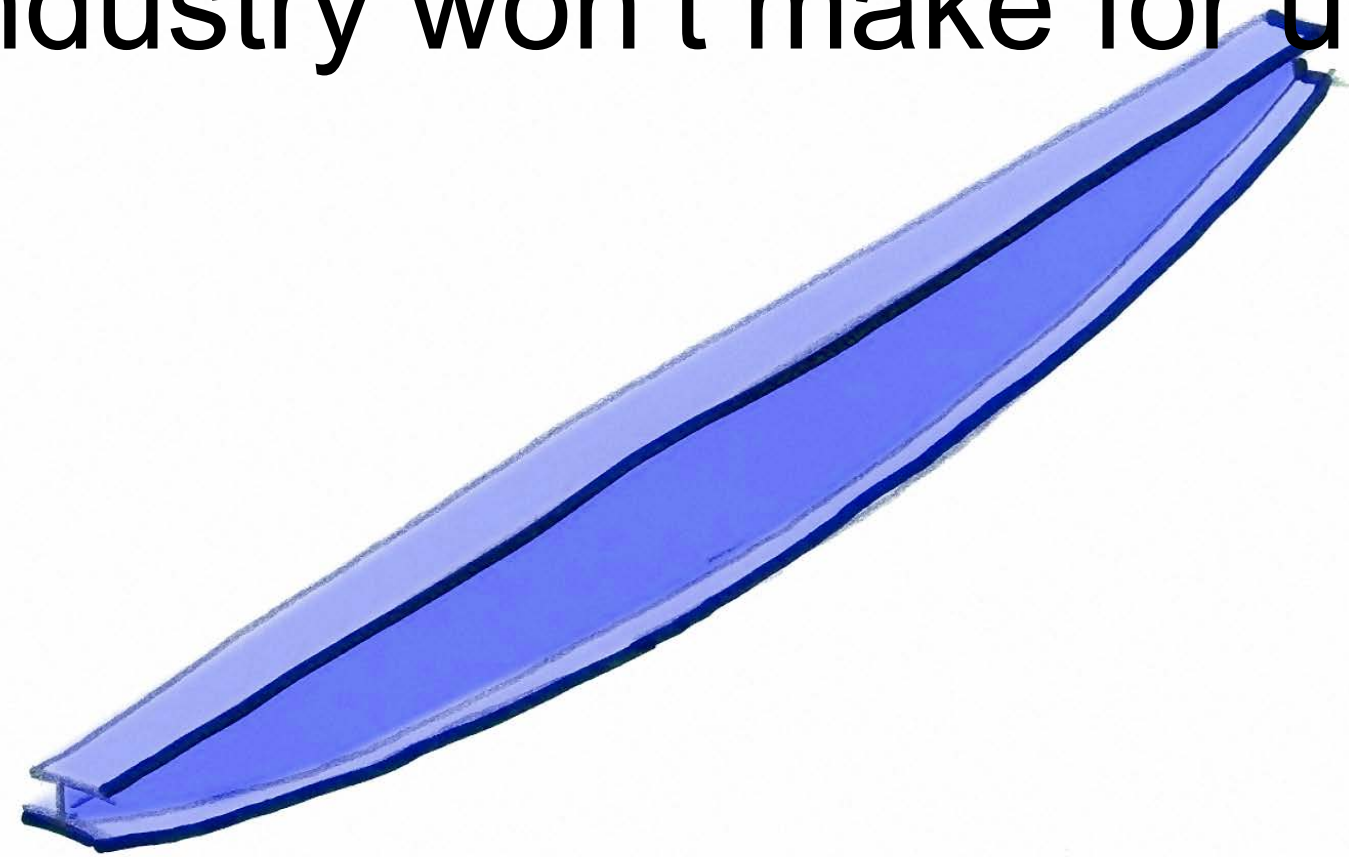
“Buildings”

where even a simple 9m office beam like this weighs

735 kg

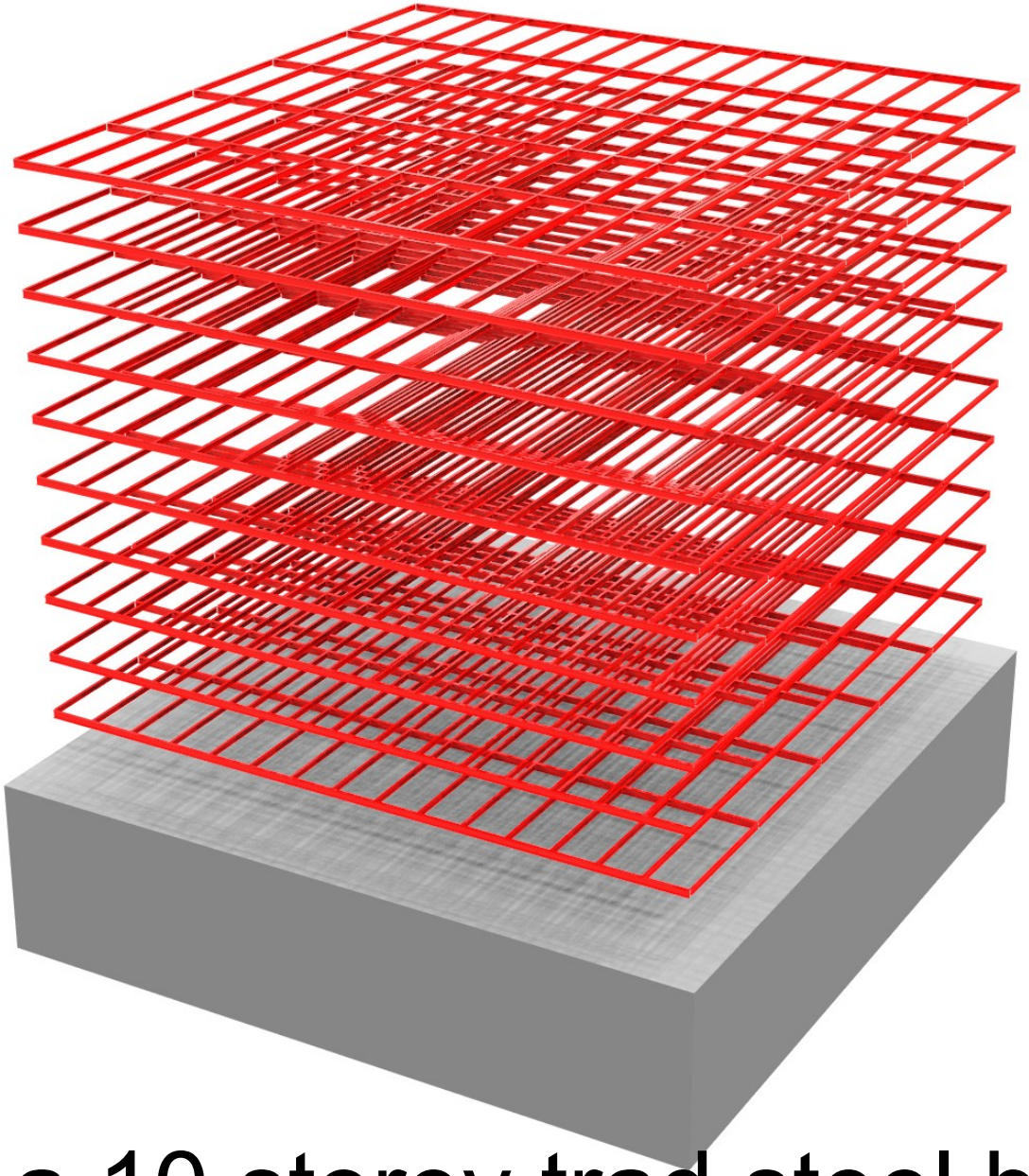


so here's a new one (which the industry won't make for us)

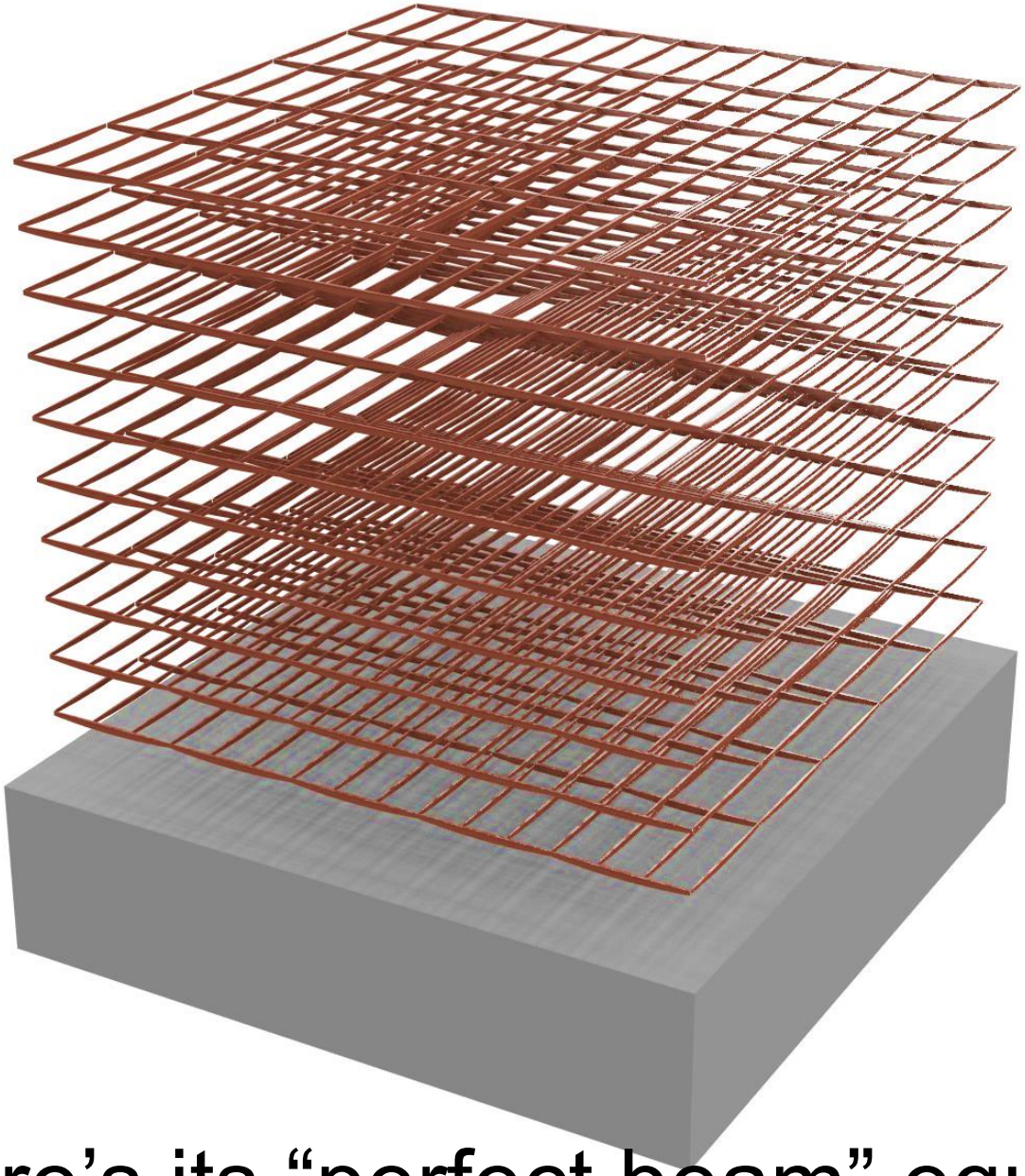


now only 513 kg

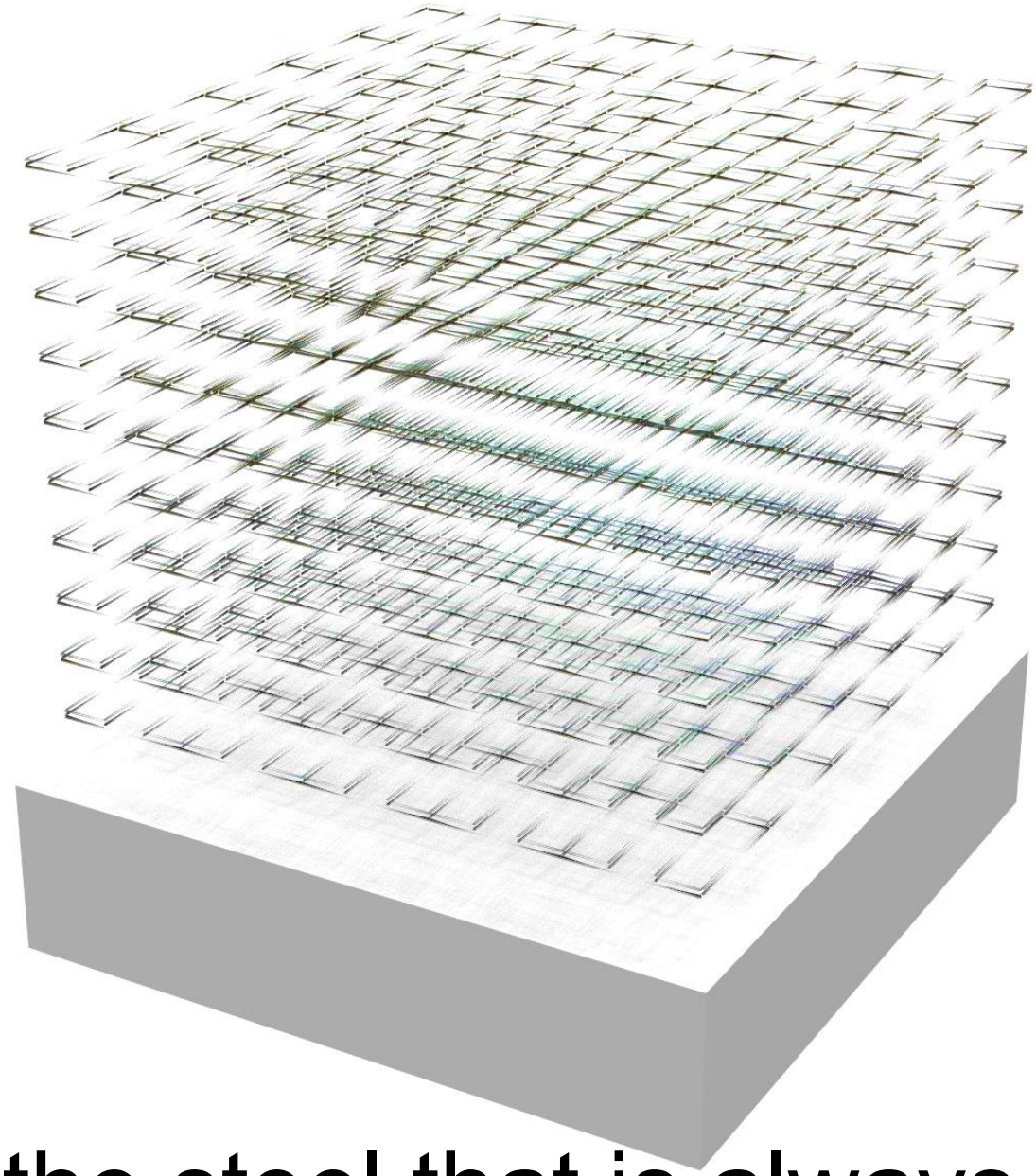
that's 30% lighter



Here’s a 10 storey trad steel building



And here’s its “perfect beam” equivalent



Here’s the steel that is always wasted

A ridiculous global waste of, say, 30 million tonnes of steel each year…

The carbon equivalent of not driving

120 billion miles….

…enough energy to boil
700 cups of tea
for everyone on the
planet…

No matter how wonderful the materials,
if designers and manufacturers won't work together
to make them economically viable…….

Inertia rules…….

And it has been scientifically proven that it’s always someone else’s responsibility…….

Sydney Olympics 2000

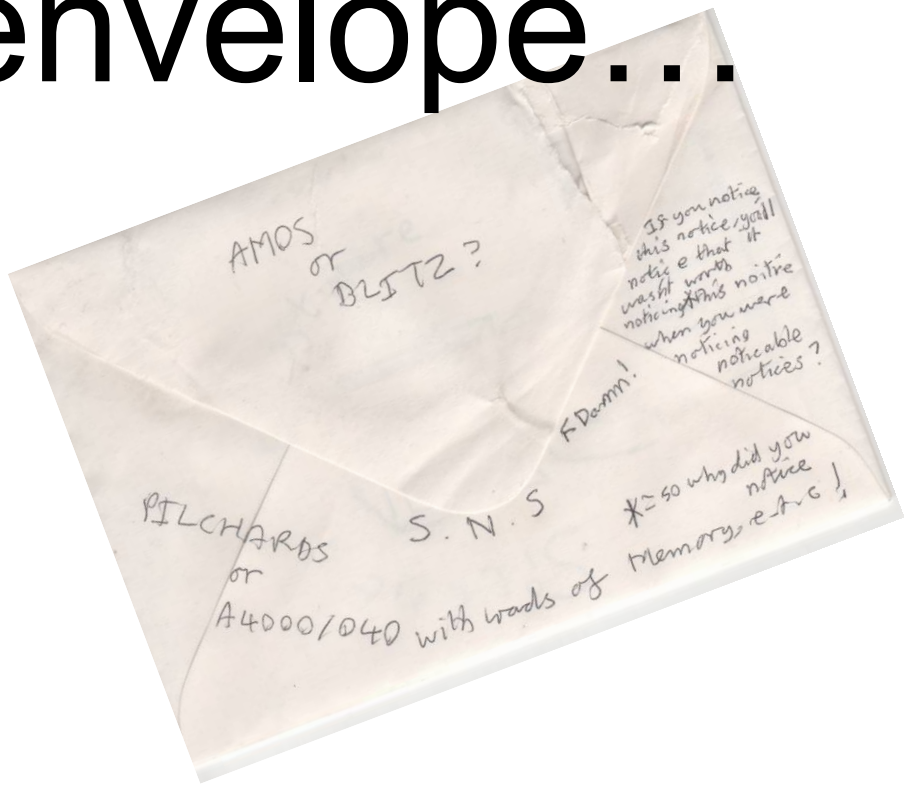
car miles in the steel structure : 79 million

8 years later: Beijing 2008

725
million car miles

Carbon stickers for buildings??

with only the back-of an envelope…



...we can save more and more

#1 RELAXING DEFLECTION LIMITS.

- δ_{QP} UNLIMITED, $\delta_{IL} < \ell/360$

II ARM BEAM
$W_{req} = 1{,}210\,cm^3$
$I_{req} = 12{,}630\,mm^4$
→ UKB 457 X 152 X 60

I ARM BEAM
$W_{req} = 2{,}953\,cm^3$
$I_{req} = 30{,}193\,mm^4$
→ UKB 610 X 229 X 113

MATERIAL QUANTITIES: 2.64 T.

- δ_{QP} UNLIMITED, $\delta_{IL} < \ell/300$

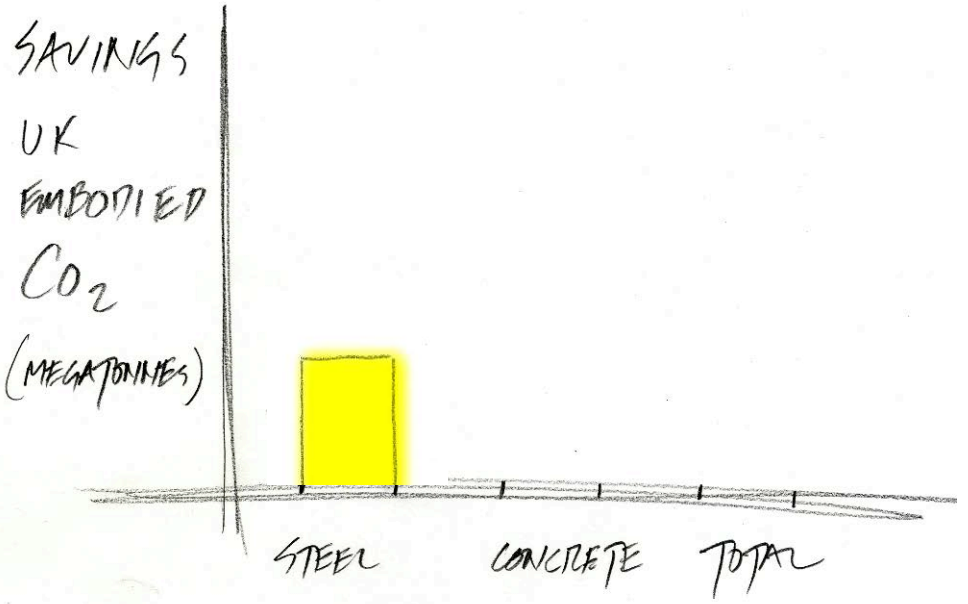
II ARM BEAM
$W_{req} = 1{,}210$
$I_{req} = 10{,}5$
→ UKB 457 X 152 X 60

I ARM BEAM
$W_{req} =$
$I_{req} =$
→ UKB 610 X 229 X 113

MATERIAL QUANTITIES: 2.64 T

- δ_{QP} UNLIMITED, $\delta_{IL} < \ell/200$

IDEM.



…each scribble saves more…

CALCULATIONS

JOB NO. | PAGE 4 | DATE

expedition

10 BILLION CAR MILES

#2 INFLUENCE OF LOAD SAFETY FACTORS

DIVIDE LOAD FACTORS BY 1.2 TO GET RID OF COMPONENT LINKED TO QUALITY OF WORKMANSHIP AND ANALYSIS.

$ULS = 1.125\,DL + 1.25\,IL$

II^{ARY} BEAMS	I^{ARY} BEAMS
$W_{req} = 916\ cm^3$	$W_{req} = 2{,}460\ cm^3$
$I_{req} = 7{,}017\ mm^4$	$I_{req} = 16{,}774\ mm^4$.
→ UKB 457 x 152 x 52	→ UKB 610 x 178 x 92

MATERIAL QUANTITIES 2.23 T

#3 INFLUENCE OF LIGHTER LIVE LOAD

USE VALUE FROM STANHOPE STUDY

$IL = 1.06\ kN/m^2$

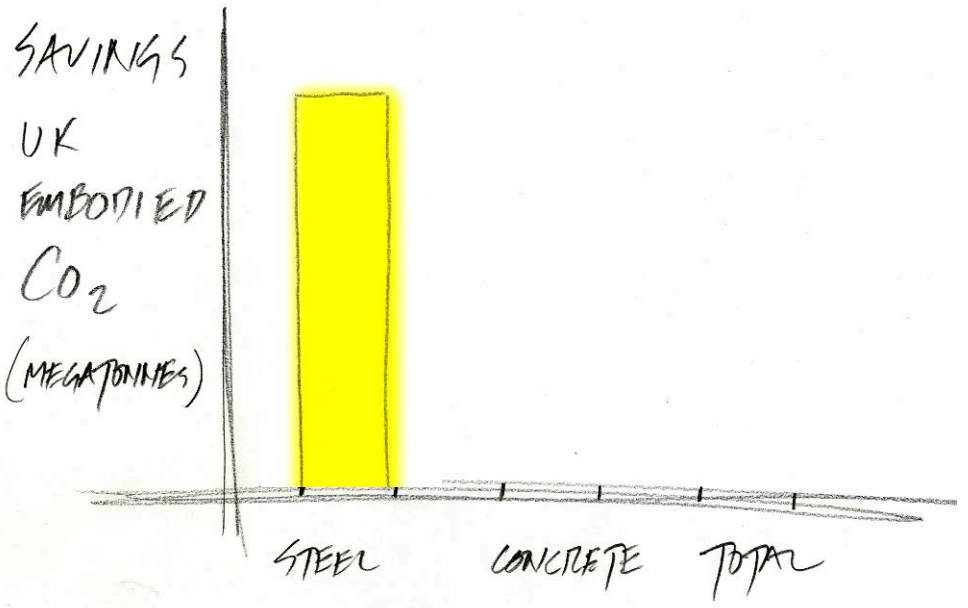
II^{ARY} BEAMS	I^{ARY} BEAMS
$W_{req} = 668\ cm^3$	$W_{req} = 1{,}792\ cm^3$
$I_{req} = 2{,}976\ mm^4$	$I_{req} = 7{,}113\ mm^4$
→ UKB 406 x 140 x 39	→ UKB 533 x 165 x 75

MATERIAL QUANTITIES: 1.74 T

#4 SCULPT

— 30%

MATERIAL QUANTITES: 1.22 T



... and more....

10 BILLION CAR MILES -

CALCULATIONS

JOB NO. ELEMENT CHD

JOB PAGE

BY DATE

expedition

#2 INFLUENCE OF LOAD SAFETY FACTORS

DIVIDE LOAD FACTORS BY 1.2 TO GET RID OF COMPONENT LINKED TO QUALITY OF WORKMANSHIP AND ANALYSIS.

ULS = 1.125 DL + 1.25 IL

II ARM BEAMS

$W_{req} = 916\ cm^3$

$I_{req} = 7017\ mm^4$

→ UKB 457 x 152 x 52

I ARM BEAMS

$W_{req} = 2460\ cm^3$

$I_{req} = 16,774\ mm^4$.

→ UKB 610 x 178 x 92

MATERIAL QUANTITIES 2.23 T

#3 INFLUENCE OF LIGHTER LIVE LOAD

USE VALUE FROM STANDARD STUDY

$IL = 1.06\ kN/m^2$

II ARM BEAMS

$W_{req} = 668\ cm^3$

$I_{req} = 2976\ mm^4$

→ UKB 406 x 140 x 39

I ARM BEAMS

$W_{req} = 1792\ cm^3$

$I_{req} = 7,113\ mm^4$

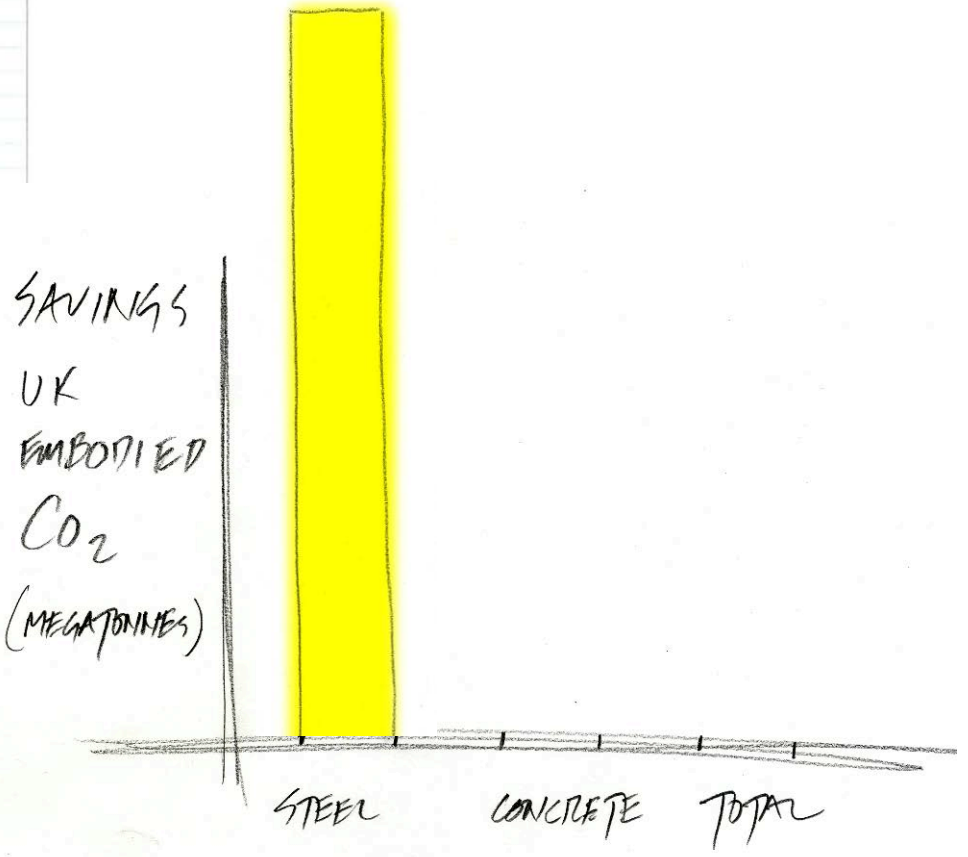
→ UKB 533 x 165 x 75

MATERIAL QUANTITIES: 1.74 T

#4 SCALES

− 30%

MATERIAL QUANTITIES: 1.22 T



... and more....

CALCULATIONS

JOB NO.

JOB

BY

expedition

10 BILLION
AR MILES -

#2 INFLUENCE OF LOAD SAFETY FACTORS

DIVIDE LOAD FACTORS BY 1.2 TO GET RID OF COMPONENT LINKED TO QUALITY OF WORKMANSHIP AND ANALYSIS.

$ULS = 1.125\,DL + 1.25\,IL$

II^ARY BEAMS	I^ARY BEAMS
$W_{req} = 916\ cm^3$	$W_{req} = 2{,}460\ cm^3$
$I_{req} = 7{,}017\ mm^4$	$I_{req} = 16{,}774\ mm^4$.
→ UKB 457 x 152 x 52	→ UKB 610 x 178 x 92

MATERIAL QUANTITIES 2.23 T

#3 INFLUENCE OF LIGHTER LIVE LOAD

USE VALUE FROM STANHOPE STUDY

$IL = 1.06\ kN/m^2$

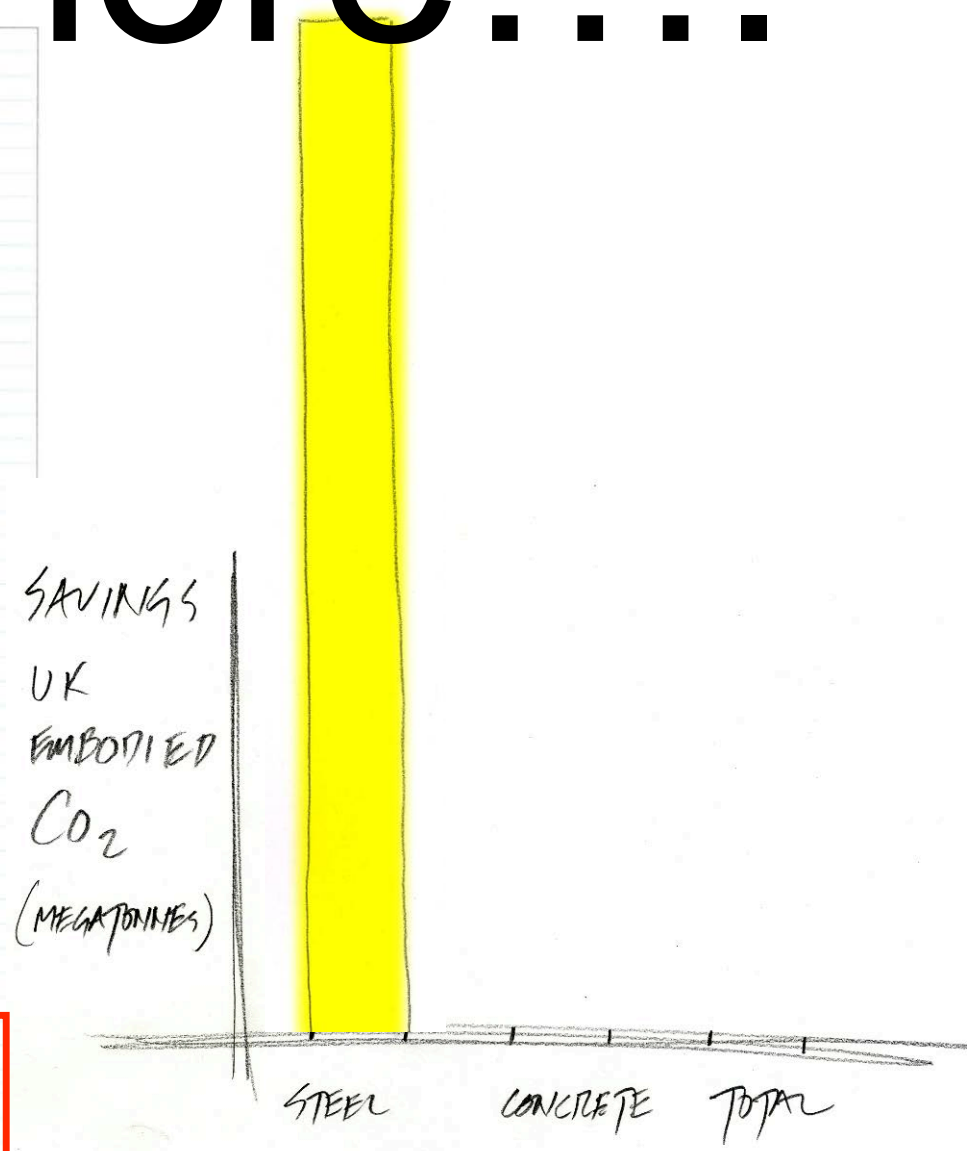
II^ARY BEAMS	I^ARY BEAMS
$W_{req} = 668\ cm^3$	$W_{req} = 1{,}792\ cm^3$
$I_{req} = 2{,}976\ mm^4$	$I_{req} = 7{,}113\ mm^4$
→ UKB 406 x 140 x 39	→ UKB 533 x 165 x 75

MATERIAL QUANTITIES: 1.74 T

#4 SCULPT

— 30%

MATERIAL QUANTITES: 1.22 T



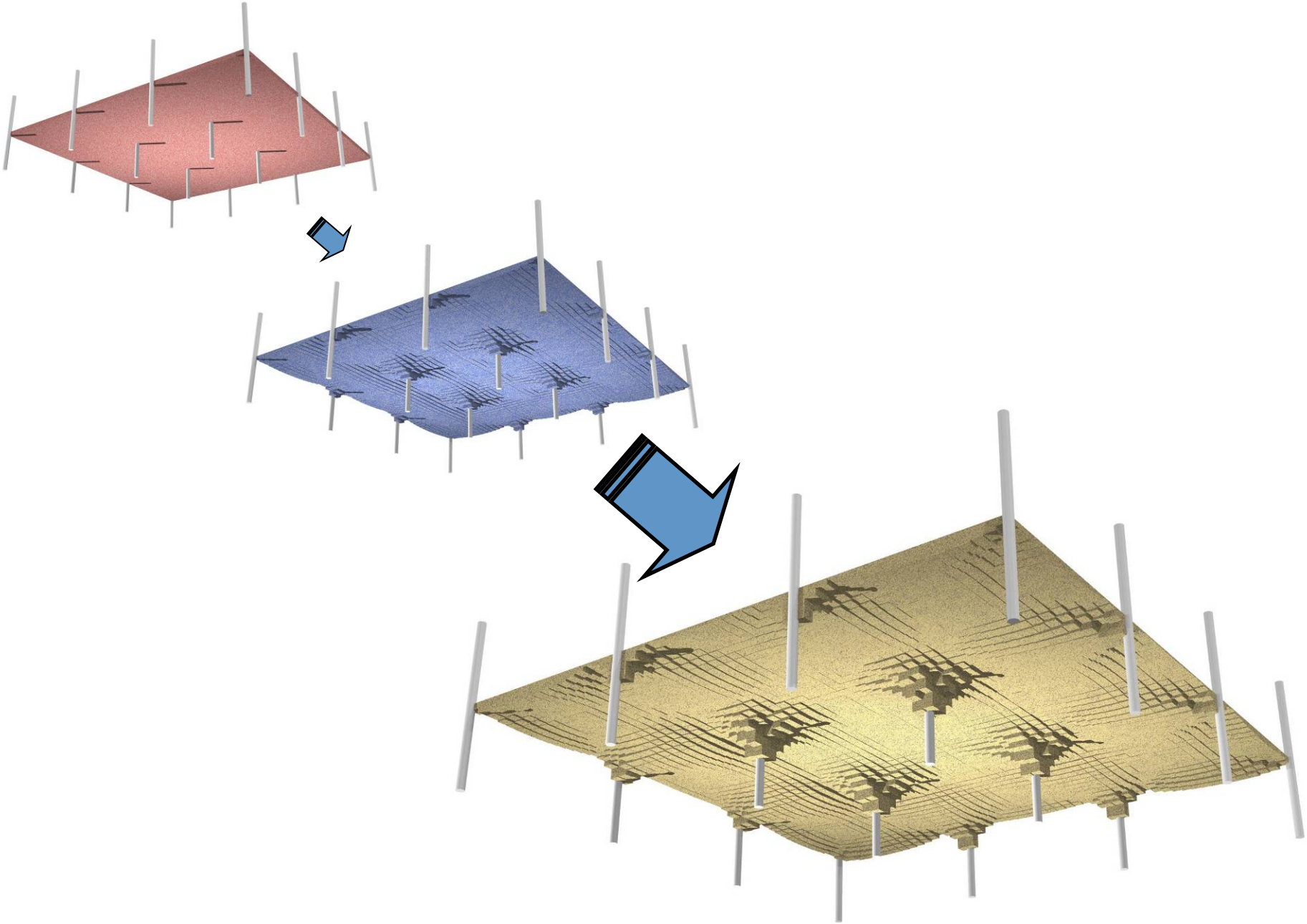
those four little design steps
save

10 billion car miles

in a single year

just in the UK

how about
bog-standard concrete
floors
(shaped by genetic
algorithms) ?



that’s another

10 billion miles

designed out

Etc etc etc

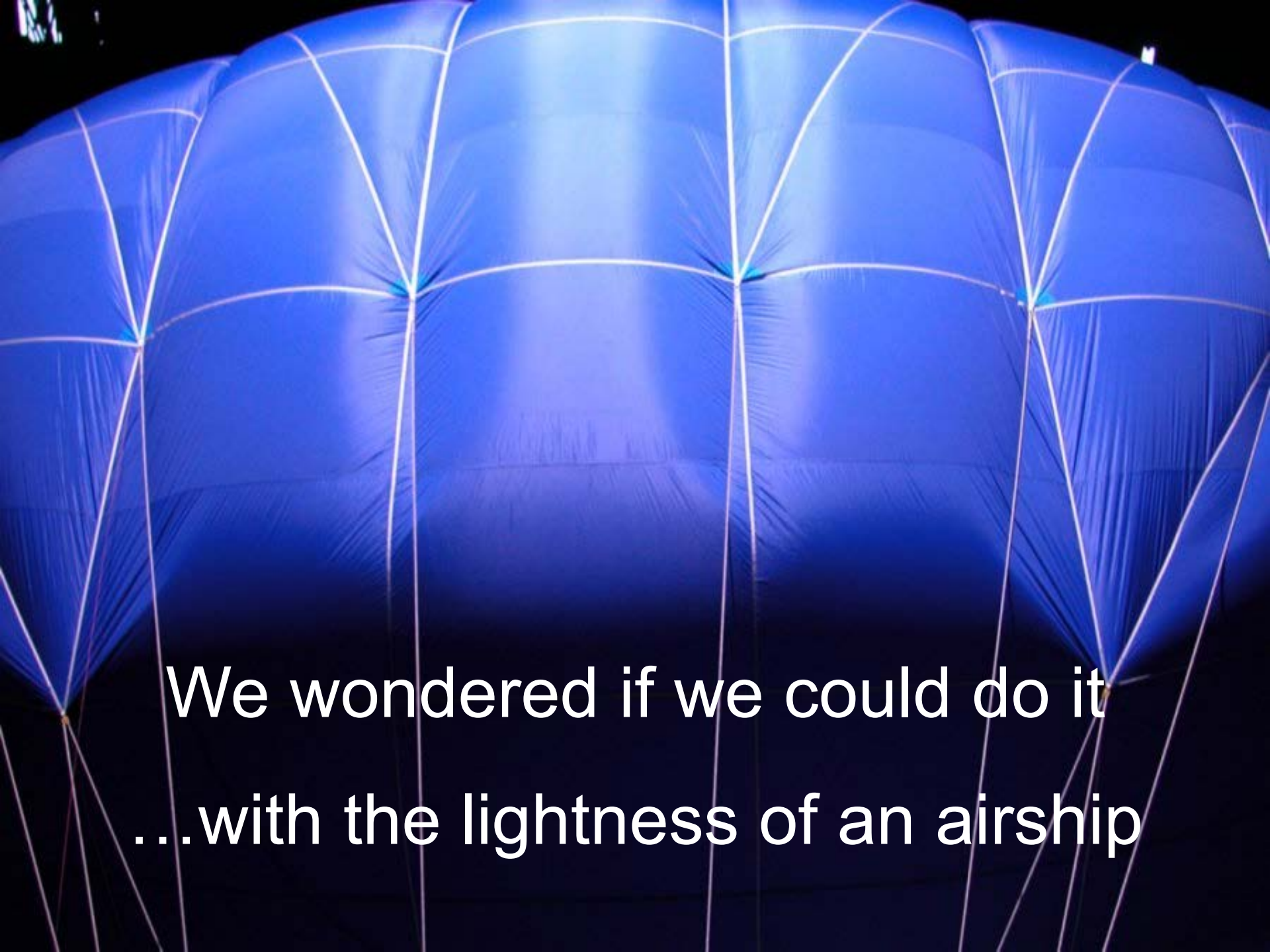
the
Stradi-velodrome

BROOKE BOND
PICTURE CARDS

Butterflies of the World

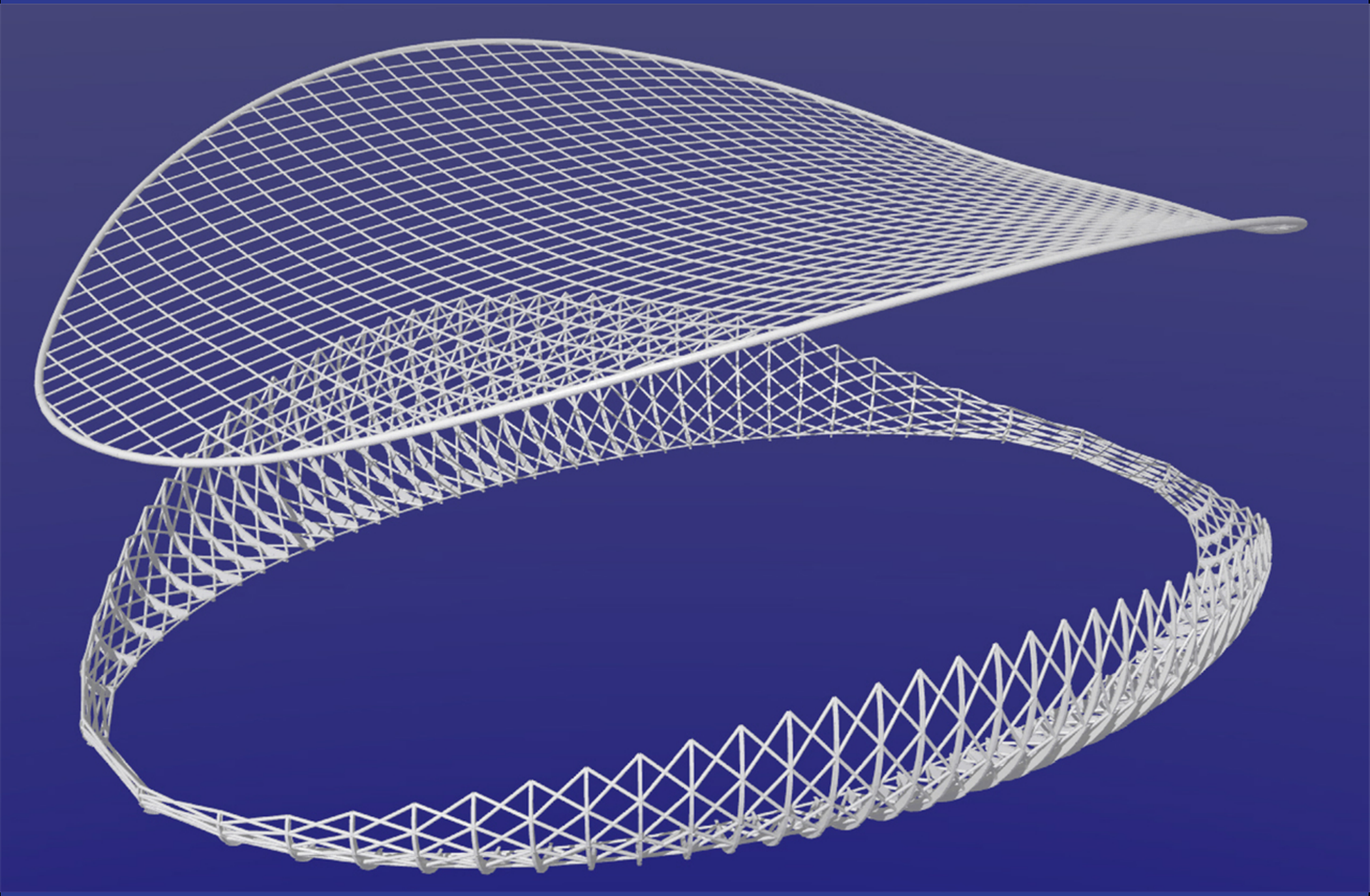
ILLUSTRATED AND DESCRIBED BY RICHARD WARD

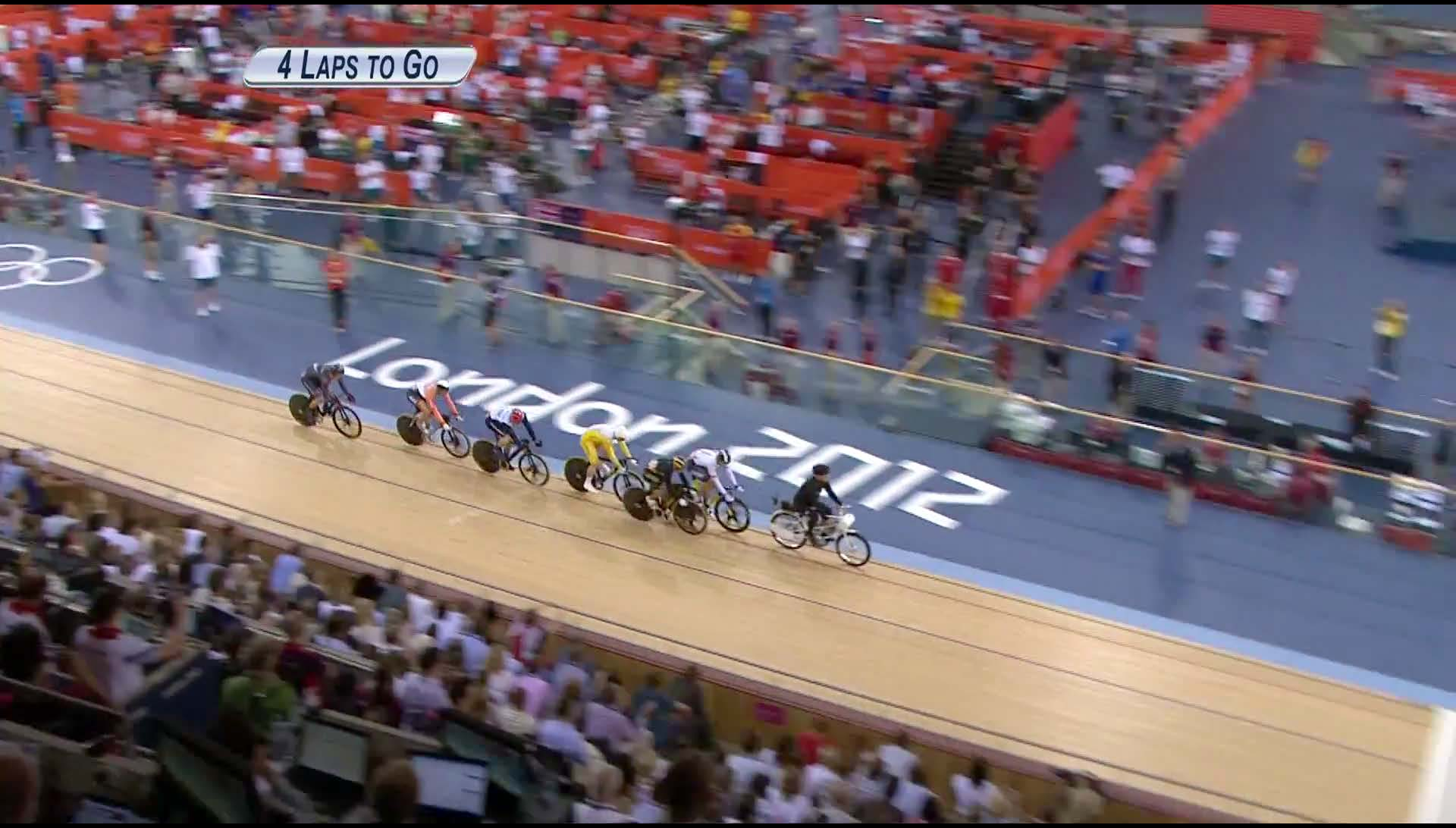
PRICE SIXPENCE


We wondered if we could do it
…with the lightness of an airship

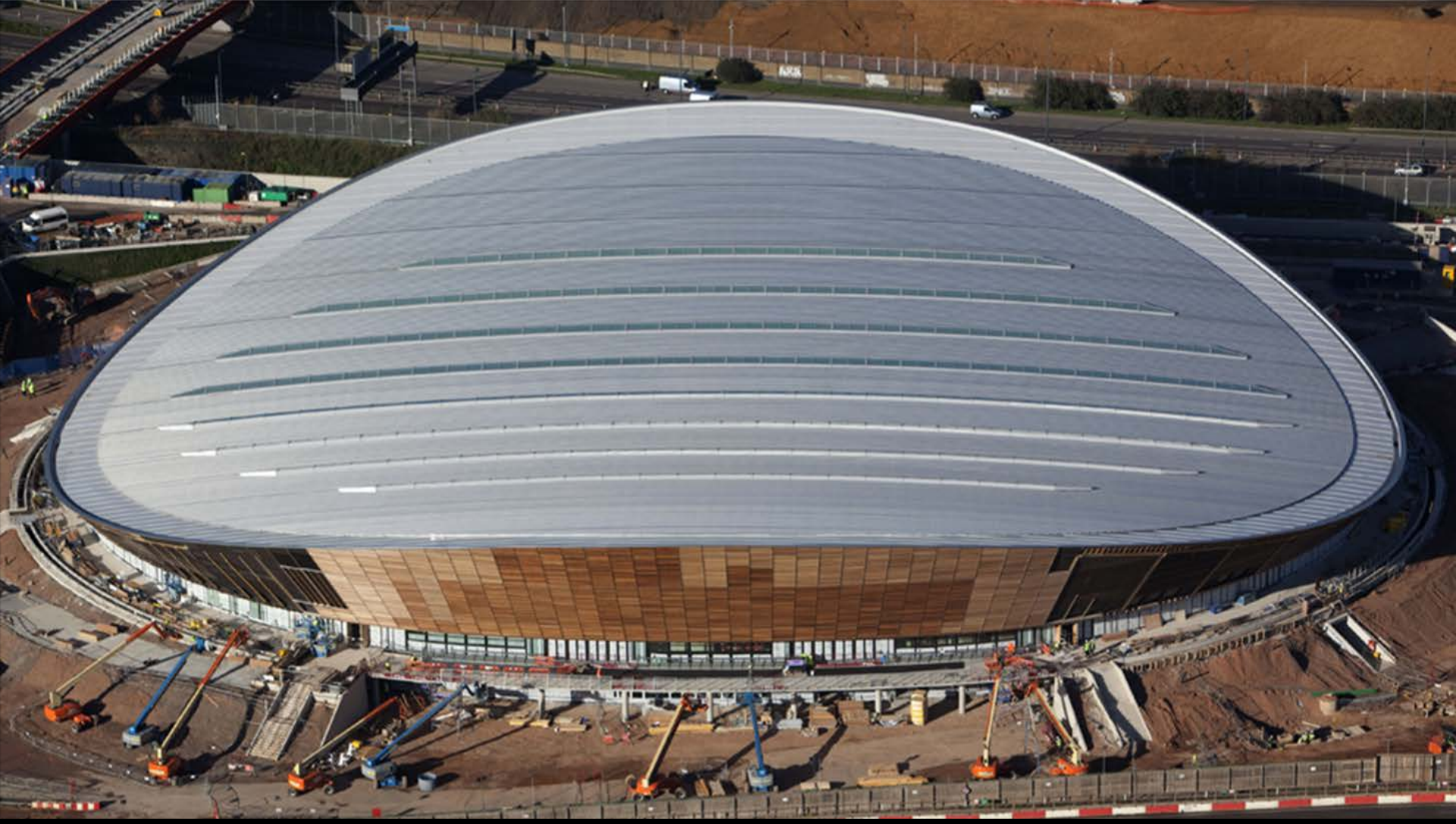
….airship plus the technology of spiders

….and the craftiness of the Welsh




4 LAPS TO GO
London 2012

car miles:
43 million



car miles:

7 million

What is there to learn from Stradivarius?

(and from Cathedrals….)

What is there to learn from Stradivarius?

Understand your materials

What is there to learn from Stradivarius?

Respect the laws of nature

What is there to learn from Stradivarius?

Master your tools

What is there to learn from Stradivarius?

Design from the inside out

What is there to learn from Stradivarius?

Design by performance not regulation

What is there to learn from Stradivarius?

Be a good apprentice

What is there to learn from Stradivarius?

Devote 10,000 hours if you want to develop mastery