Unit Operations and Chemical Engineering Laboratory: *London*

Mark J. McCready, Salma Saddawi
January 14, 2016

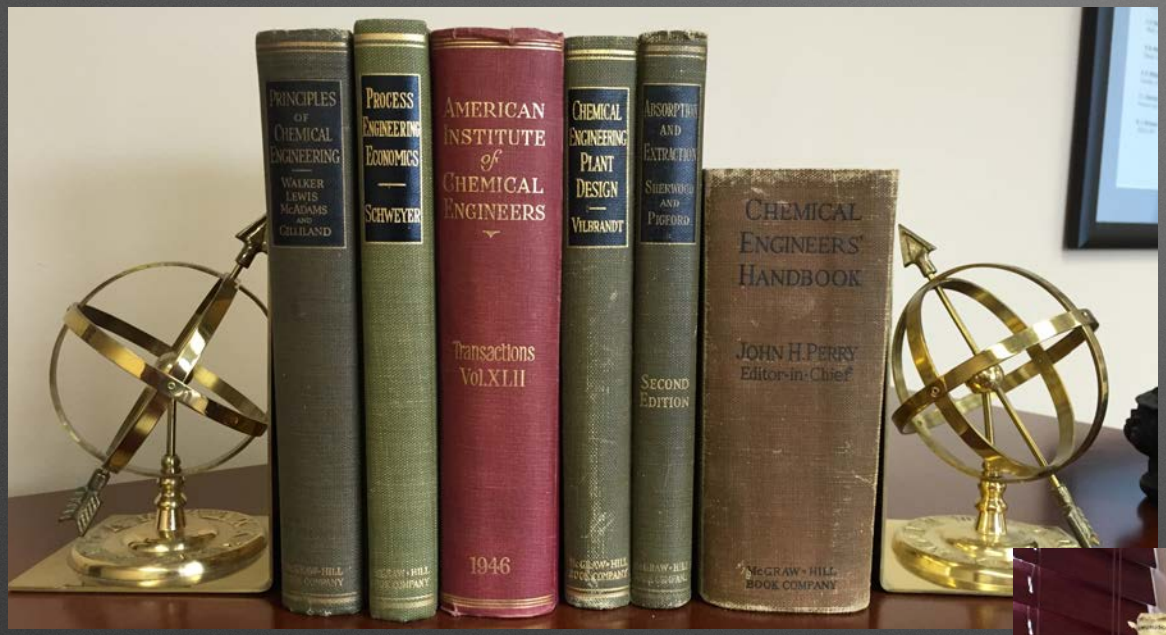
Plan for today

- Meet and Greet
- Course overview
- Some Logistics, here and there
- Description of CO_2 absorption using an aqueous amine

Academic honesty!

- You may not refer to, or even read from, any work done by students in previous years!
  - This includes spreadsheets used for various calculations.
- You are encouraged to share (verbal) information freely among yourselves except that your group should do all calculations with its own spreadsheet, Matlab files, etc.
  - It is OK to help another group create their own spreadsheet, etc. Or explain any principle or relate any statements (hopefully correctly) from the instructors or (if you wish), even relate what we asked at a “defense”.

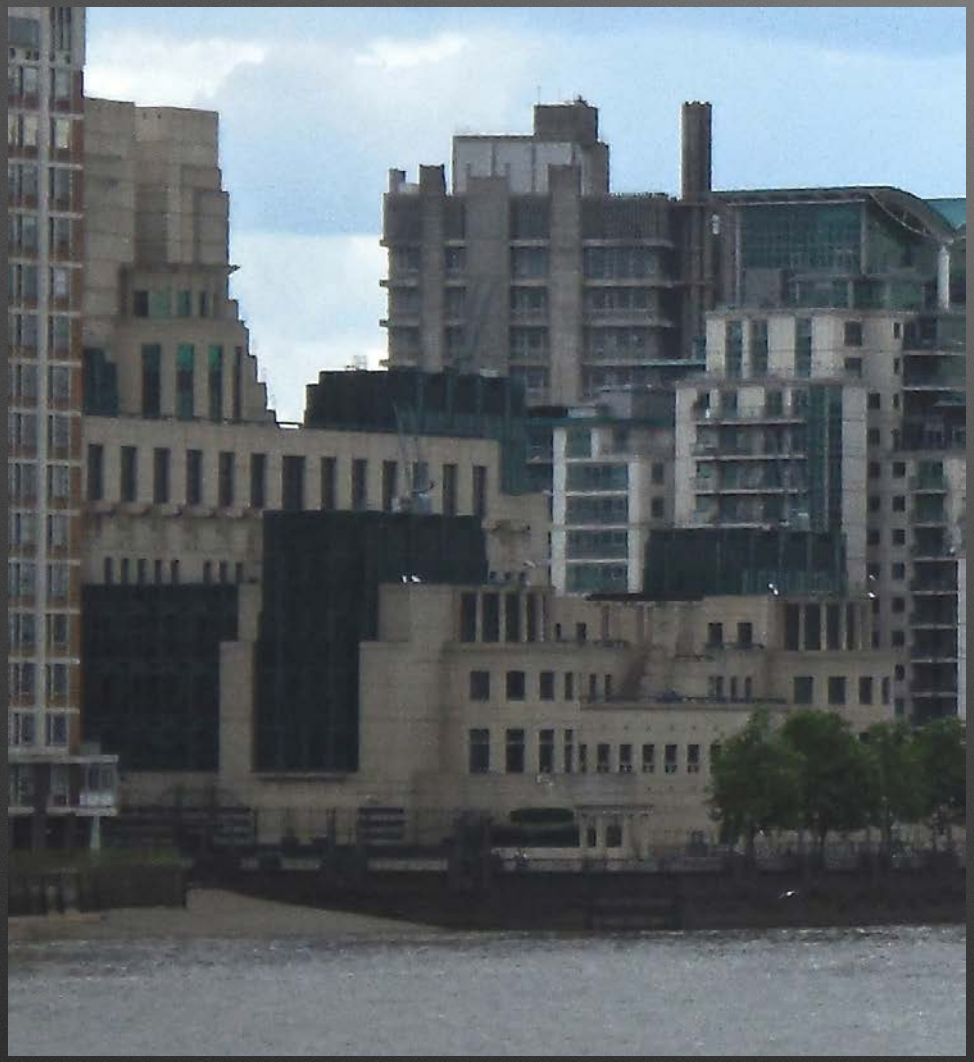
Chemical Engineering textbooks: Roll back the clock



Lots to See!

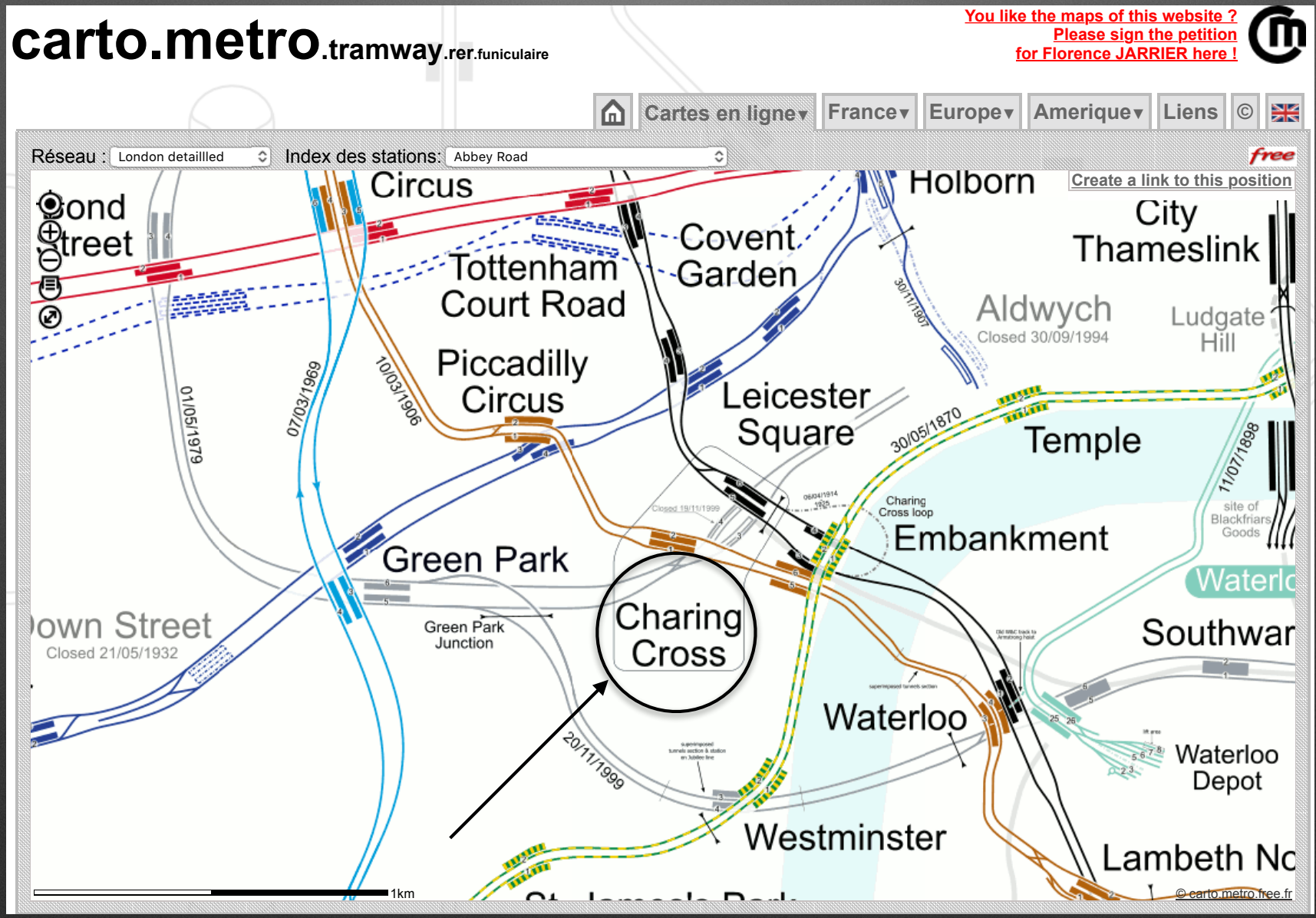
Cabinet War Rooms

James Bond



Video clip of Skyfall

Filming Location



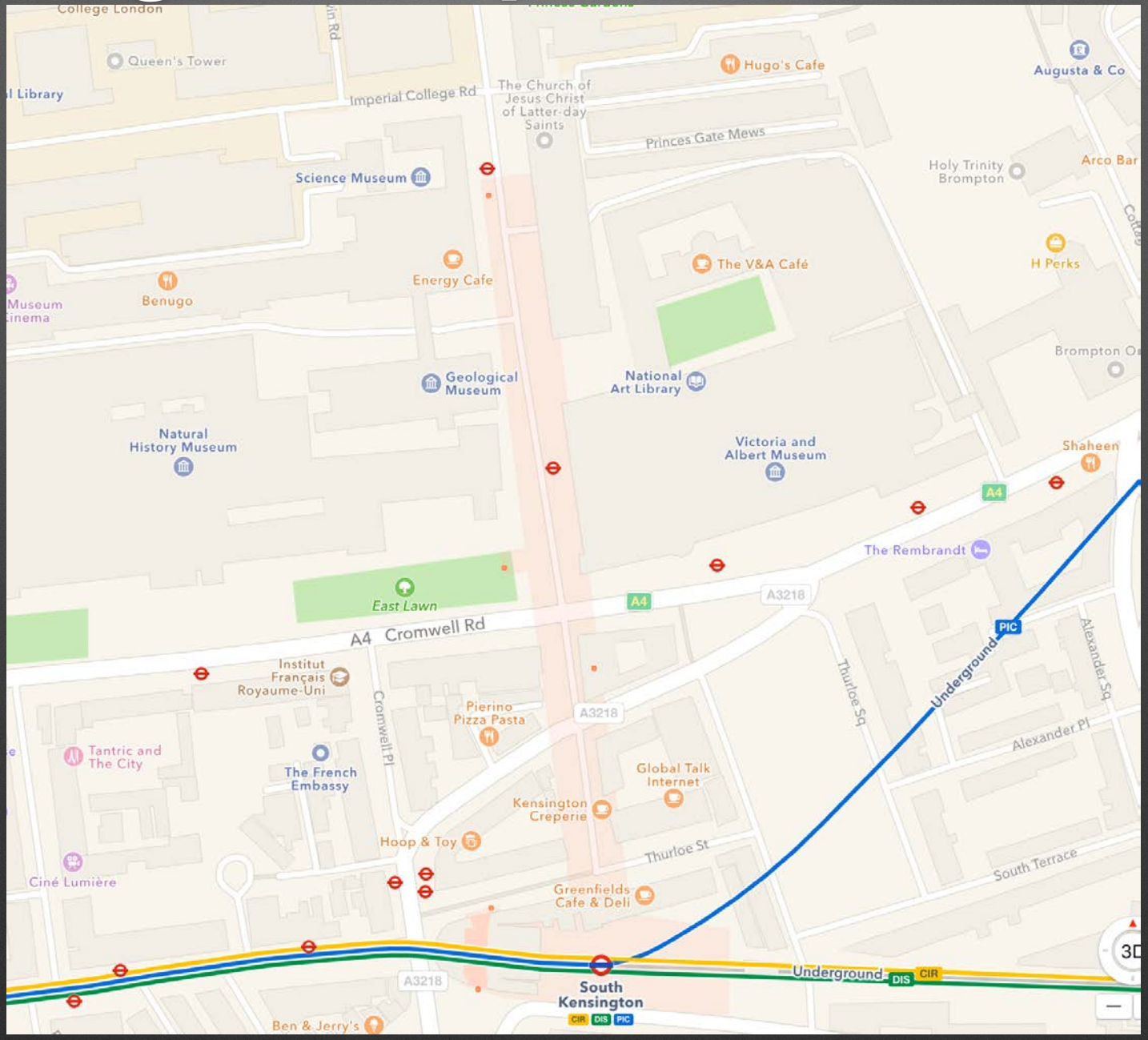
Stations and path correct…

Wrong trains!

When you want to go somewhere in London what do you say?

How long will it take to walk!

Underground paths save time!



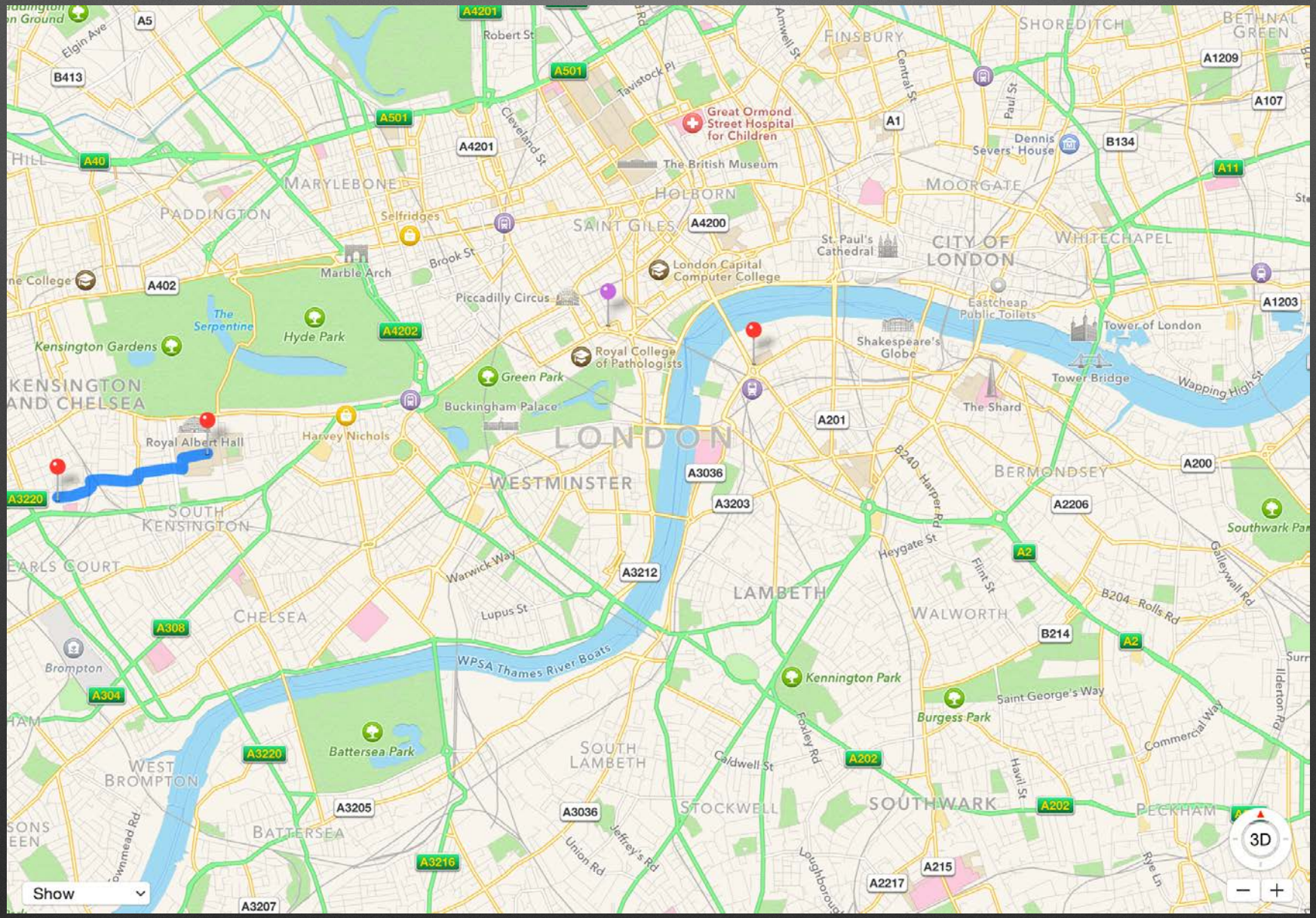
Professor McCready's Youtube URL:

- https://www.youtube.com/channel/UC5RN8K4zUMnPk7xJ7exPogQ

Tourism

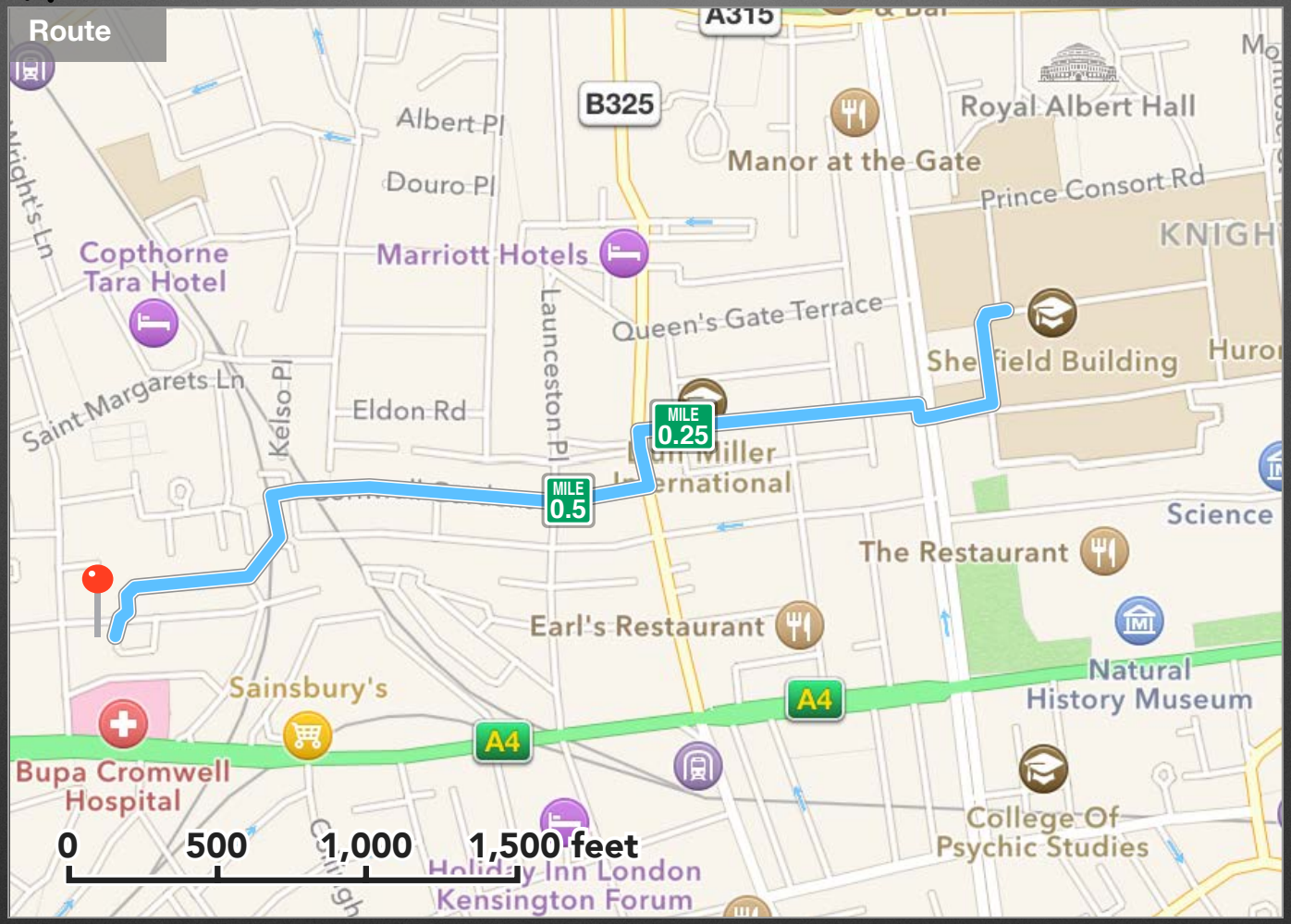
- Hopefully your schedule will be firmed up soon by ~March
- I suggest that you make a “tourism” plan
- *The History Channel* and *YouTube* have many programs about London, England, United Kingdom (or your could read books). Background knowledge will add to your enjoyment and make this experience more “international”
  - “The Imitation Game” movie could be of interest
  - I read a book on the *Battle of Britain* while I was there: There is an RAF museum and some of the airfields are still existent

Notre Dame “London”



Where you are going!

Lee Abbey International Students' Club 0.9 miles, 19 min



Nice Neighborhood

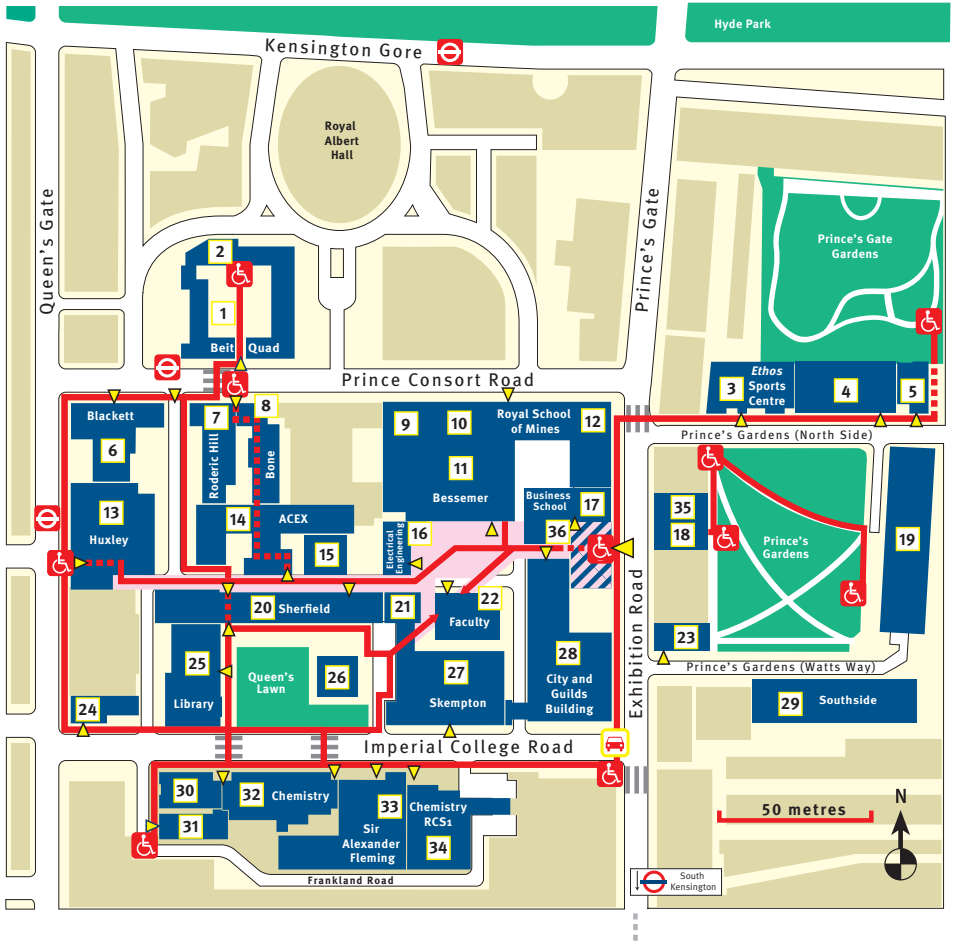
Nice neighborhood

Right by Imperial College

Imperial College

Imperial College London

South Kensington Campus



Of course the President of Imperial College is a Chemical Engineer!

Imperial College London

HOME

PROFESSOR ALICE P. GAST

Central Faculty, Office of the President

President

SUMMARY

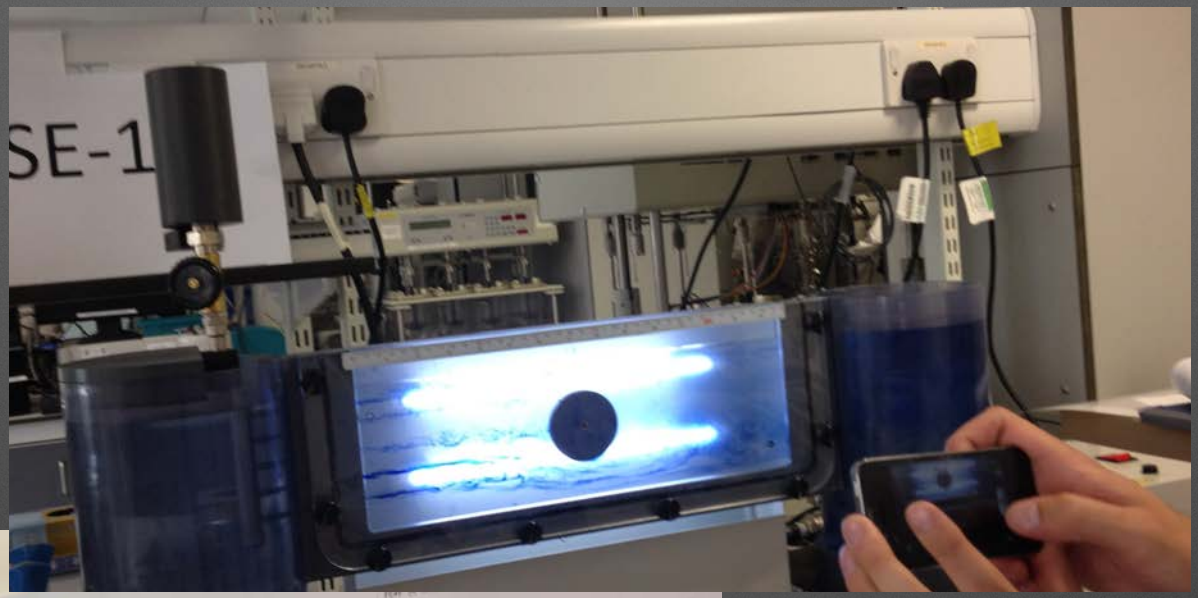
Professor Alice P. Gast, an internationally renowned academic leader, scholar, and researcher, became President of Imperial College London on 1 September 2014.

Prior to her appointment at Imperial, Professor Gast was the 13th President of Lehigh University, Pennsylvania, USA, from August 2006 to August 2014. Other leadership roles include serving as the Vice-President for Research and Associate Provost and Robert T. Haslam Chair in Chemical Engineering at the Massachusetts Institute of Technology from 2001 - 2006.

CONTACT

Email

Fluid Flow experiments



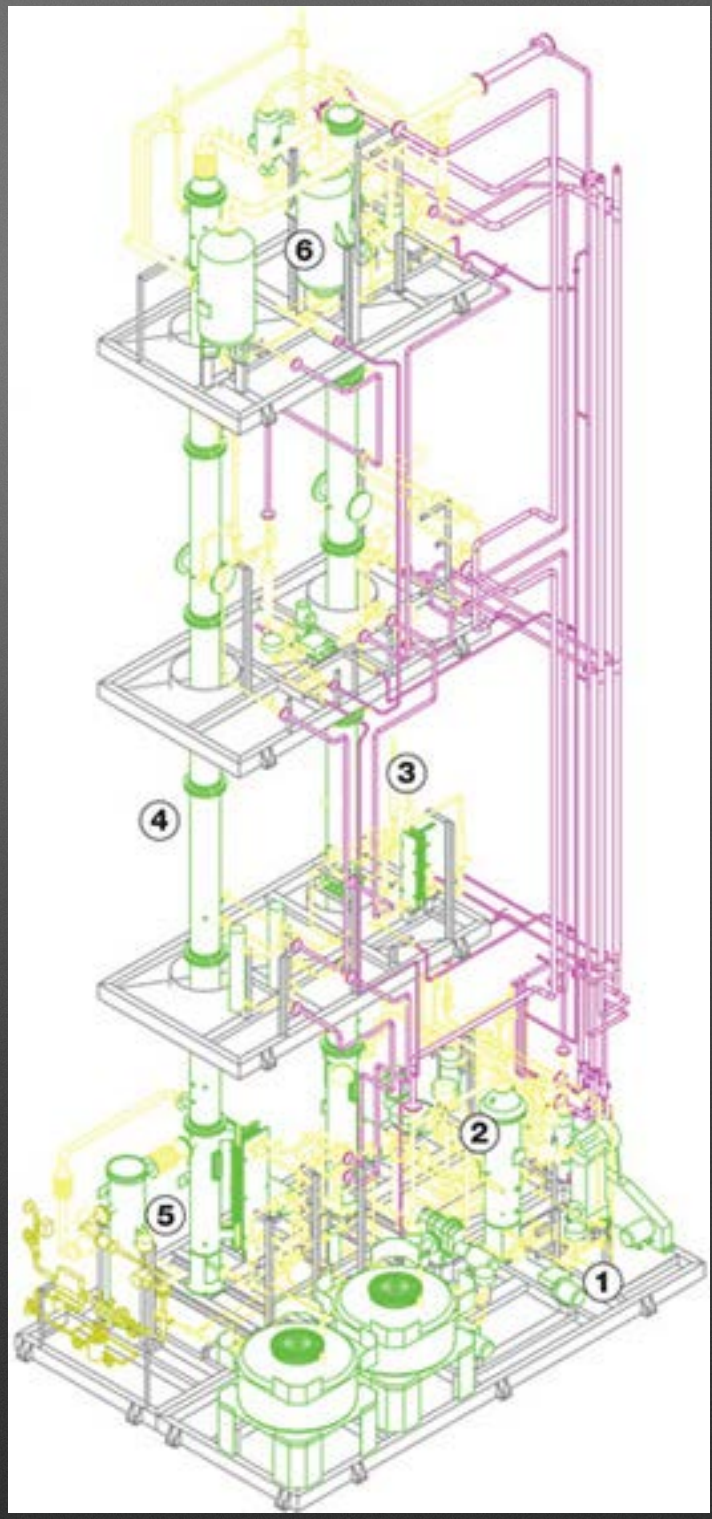
ND ChEgs making “steam”

Refrigeration cycle experiment

Figure 3. Apparatus

Pilot Plant facility

Schematic of Imperial Pilot Plant

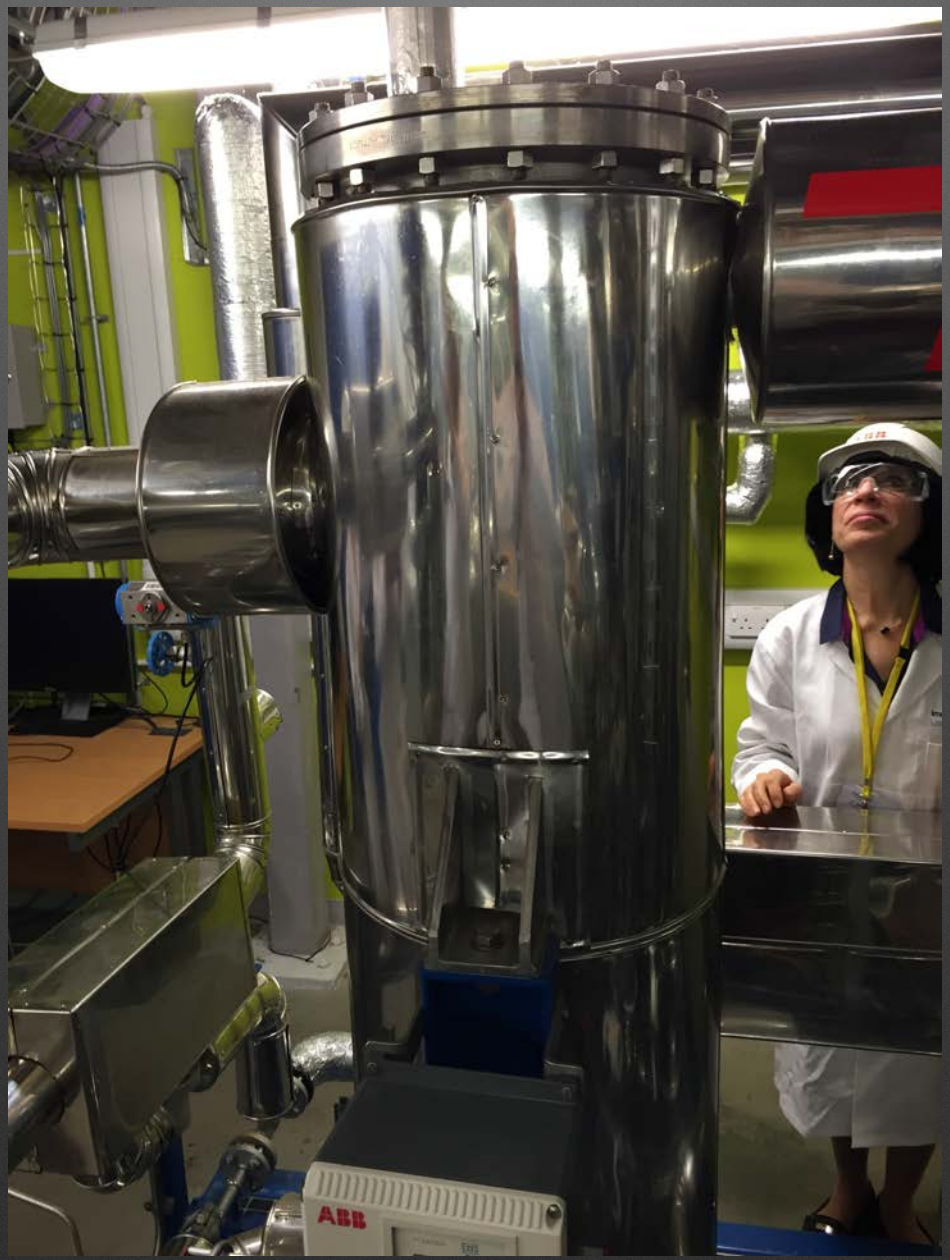


Pilot Plant

The two columns

Elise instructs the group!

Professor Saddawi inspects the reboiler!



Control Room

Lots of sensors for “control”

Process diagram

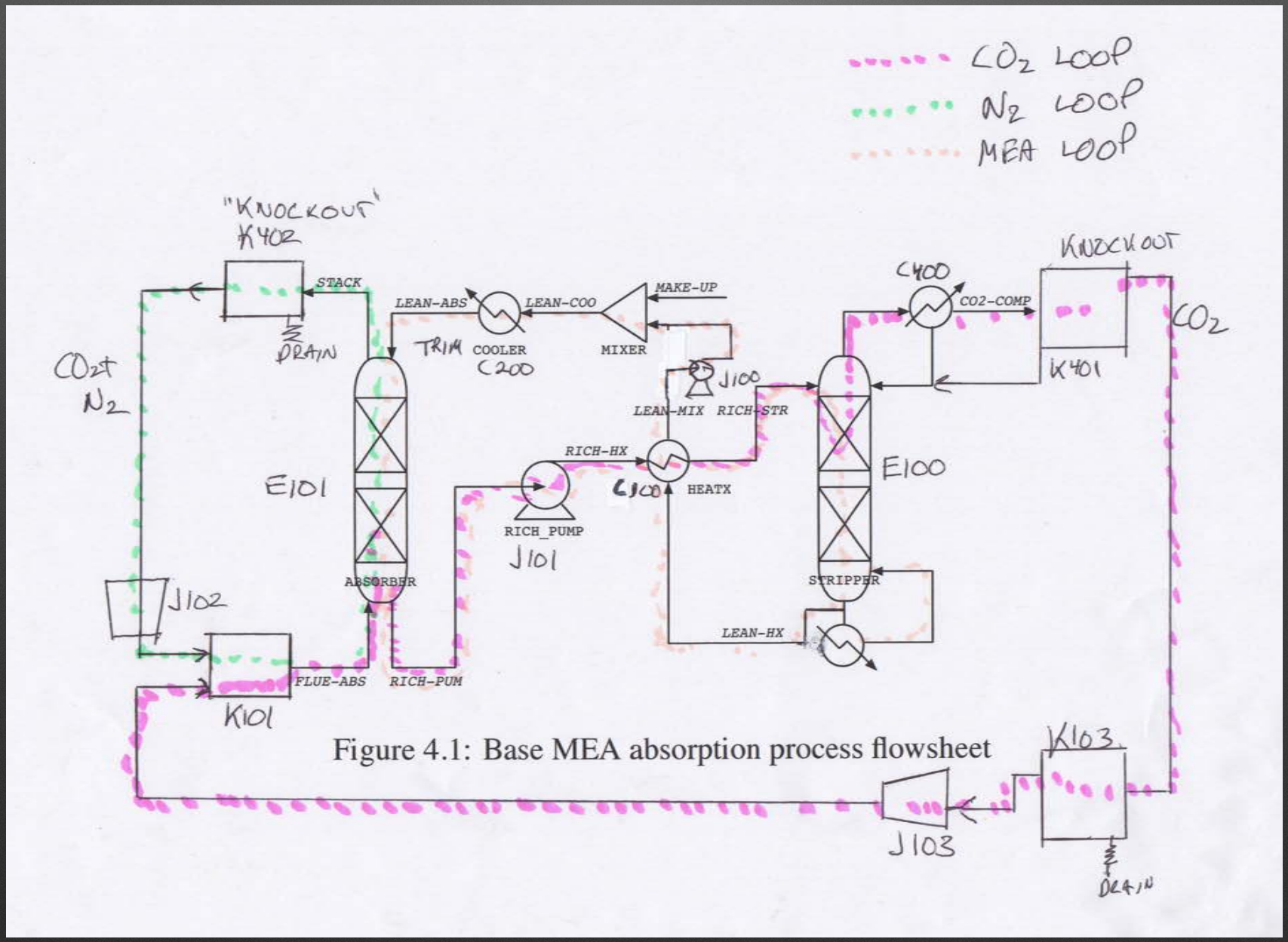
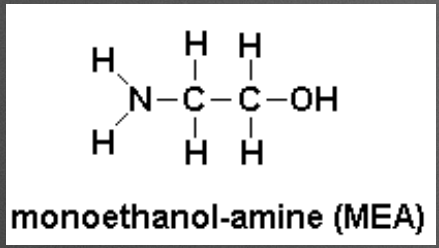


Figure 4.1: Base MEA absorption process flowsheet

Solvent

- Monoethanolamine (15% in water)



monoethanol-amine (MEA)

$$2\,H_2O \rightleftharpoons OH^- + H_3O^+ \quad (4.1)$$
$$CO_2 + 2\,H_2O \rightleftharpoons HCO_3^- + H_3O^+ \quad (4.2)$$
$$HCO_3^- + H_2O \rightleftharpoons CO_3^{2-} + H_3O^+ \quad (4.3)$$
$$RNH_3^+ + H_2O \rightleftharpoons RNH_2 + H_3O^+ \quad (4.4)$$
$$RNHCOO^- + H_2O \rightleftharpoons RNH_2 + HCO_3^- \quad (4.5)$$

- Reactions with CO2 and water

Key aspects of such a process

- Why do: To get “pure” CO2
- Reversible, cyclical process:
  - CO2 (selectively) dissolves in (lean) MEA solution in the absorber)
    - reversible chemical reaction greatly increases solvent capacity and selectivity
  - MEA solution is pumped to the “stripper” where heat (from steam) is used to change reduce the CO2 solubility (and reverse the reaction) so that CO2 (now) without N2 come off.
- Usually need to hit a “spec” on CO2 emitted.
- Need efficient contacting of gas and liquid
- CO2 capacity per mass of solvent significantly influences the cost
- Energy to regenerate influences cost

Packed tower for gas absorption

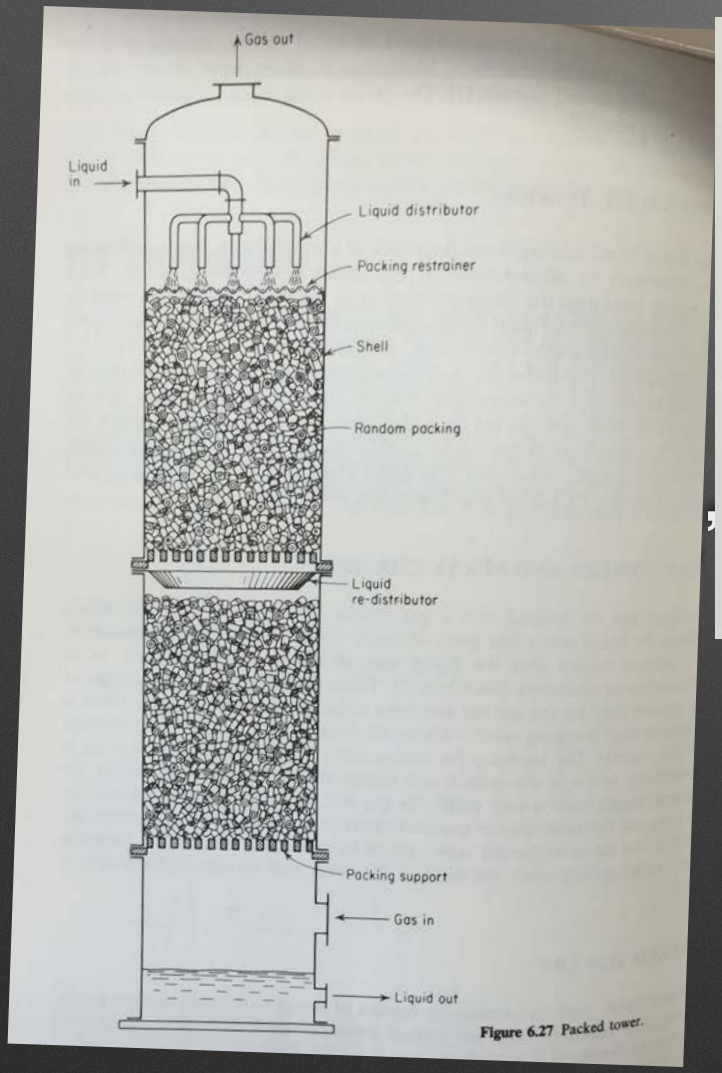


Figure 6.27 Packed tower.

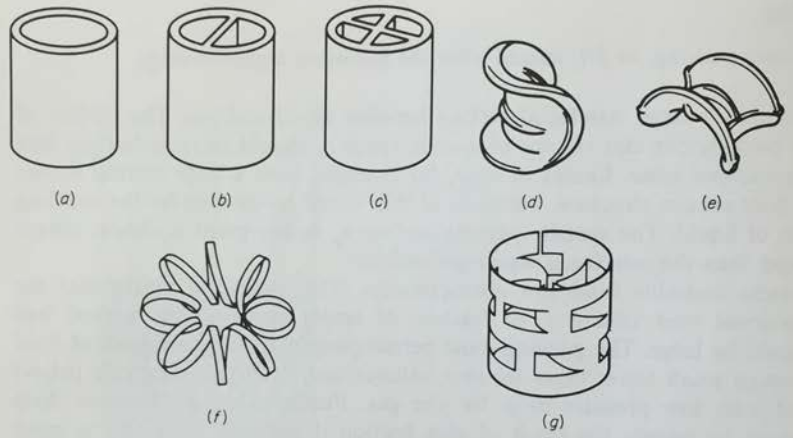


Figure 6.28 Some random tower packings: (*a*) Raschig rings, (*b*) Lessing ring, (*c*) partition ring, (*d*) Berl saddle *(courtesy of Maurice A. Knight)*, (*e*) Intalox saddle *(Chemical Processing Products Division, Norton Co.)*, (*f*) Tellerette *(Ceilcote Company, Inc.)*, and (*g*) pall ring *(Chemical Processing Products Division, Norton Co.)*.

j12kj

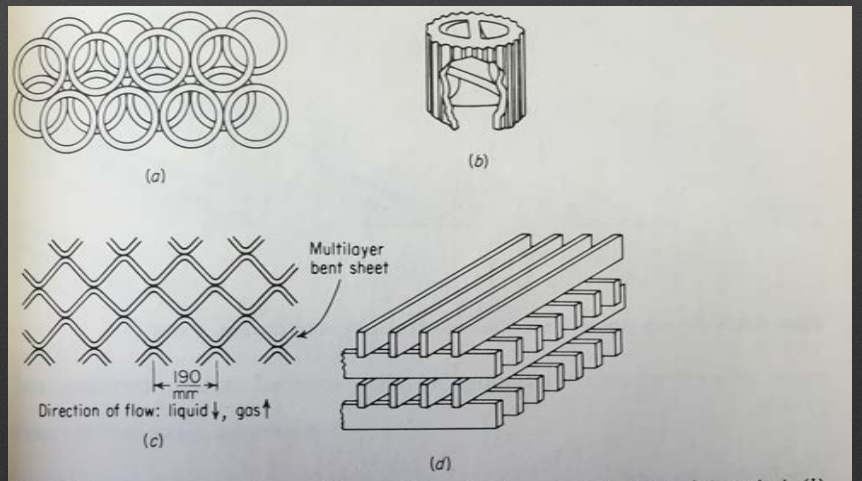
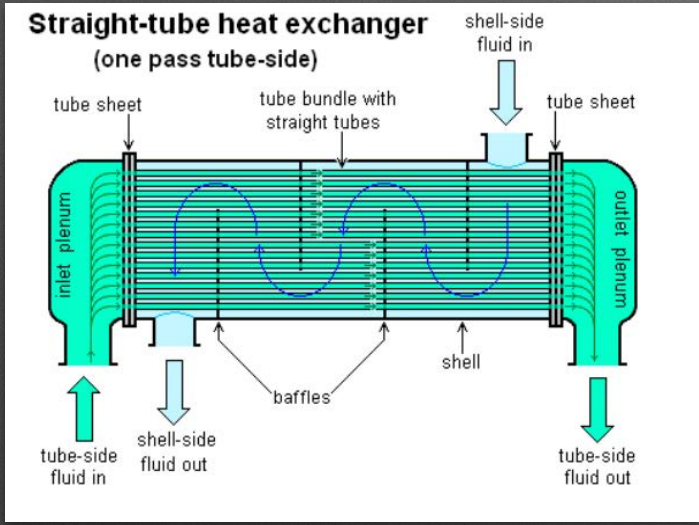
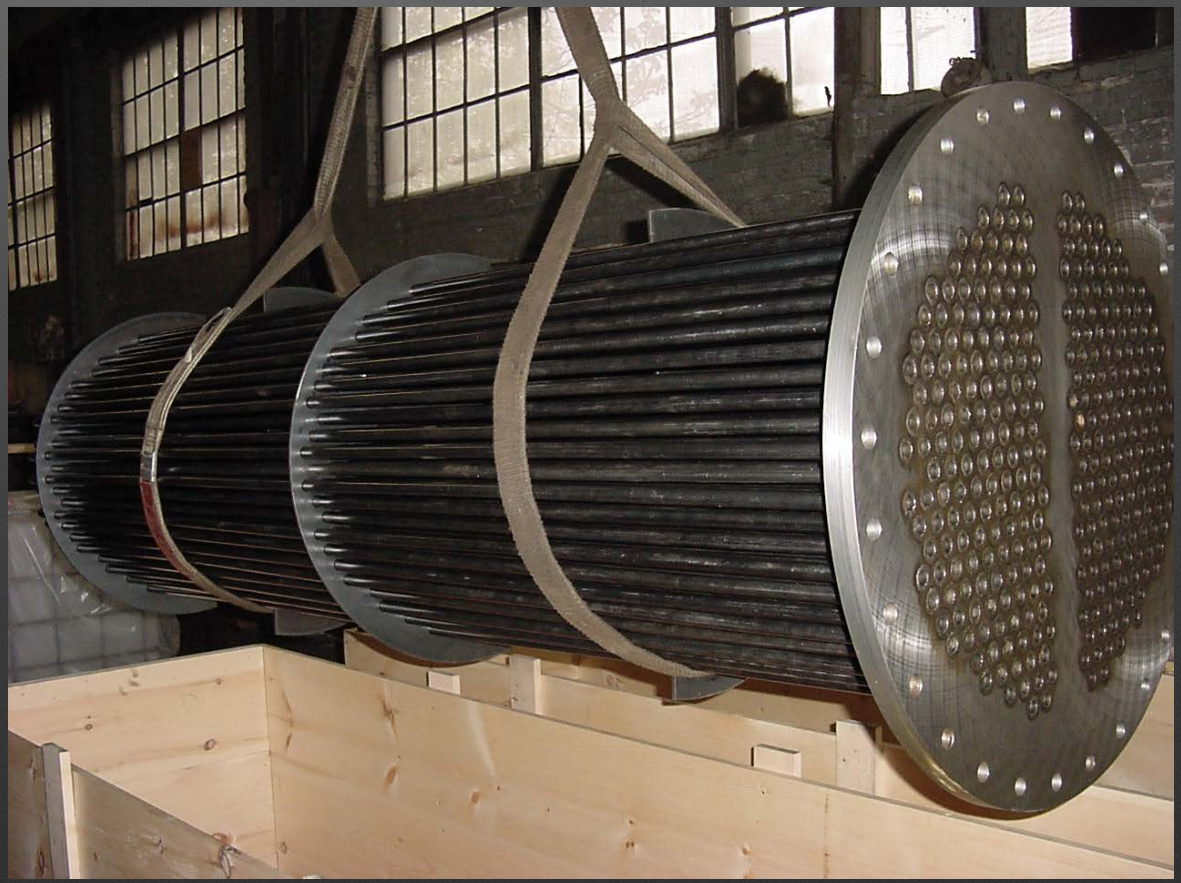


Figure 6.29 Regular, or stacked, packings: (*a*) Raschig rings, stacked staggered (top view), (*b*) double spiral ring *(Chemical Processing Products Division, Norton Co.)*, (*c*) section through expanded-metal-lath packing, (*d*) wood grids.

Imperial Absorber

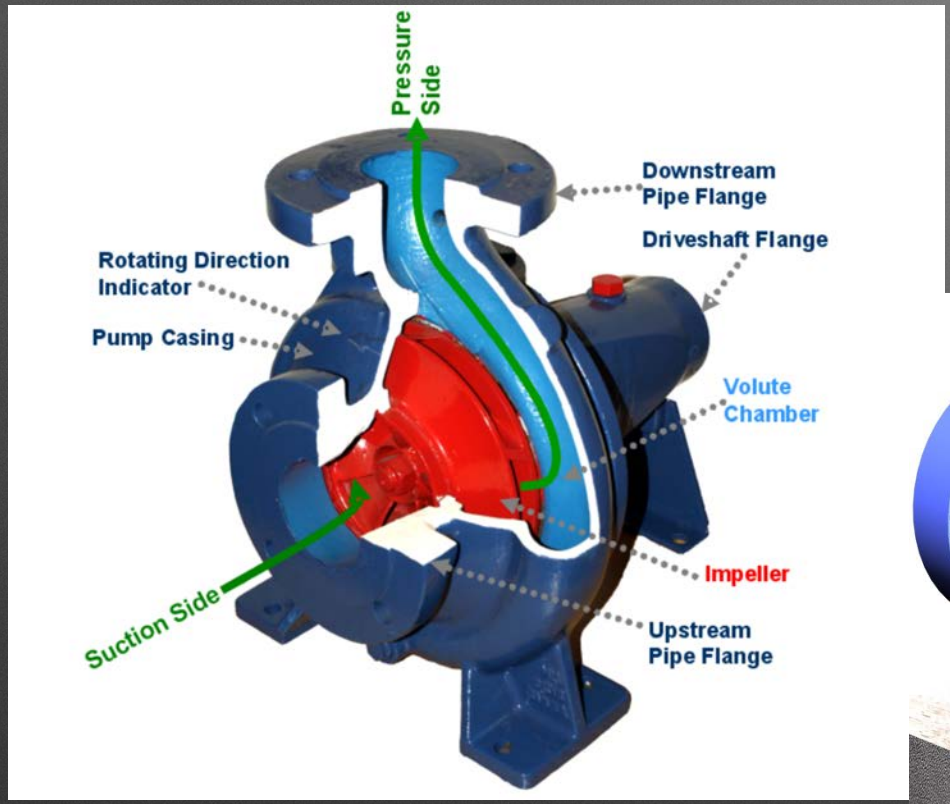
Heat exchangers

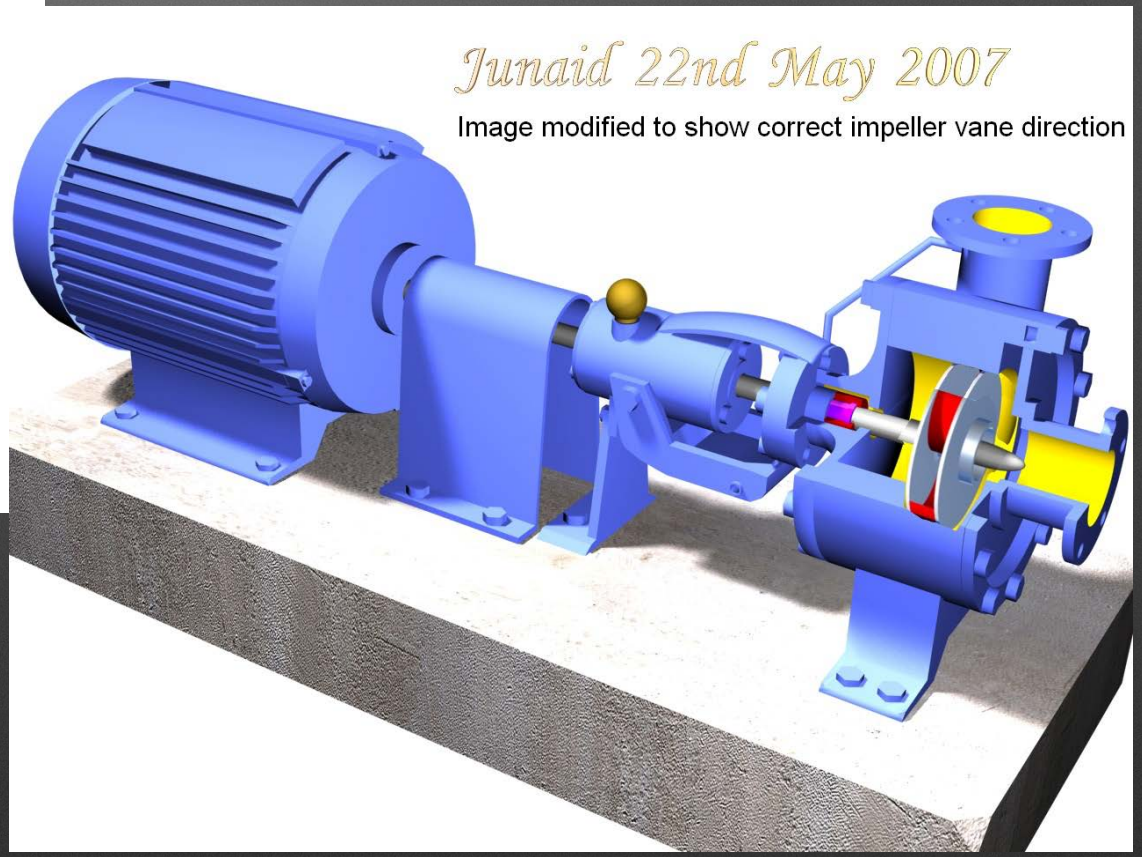




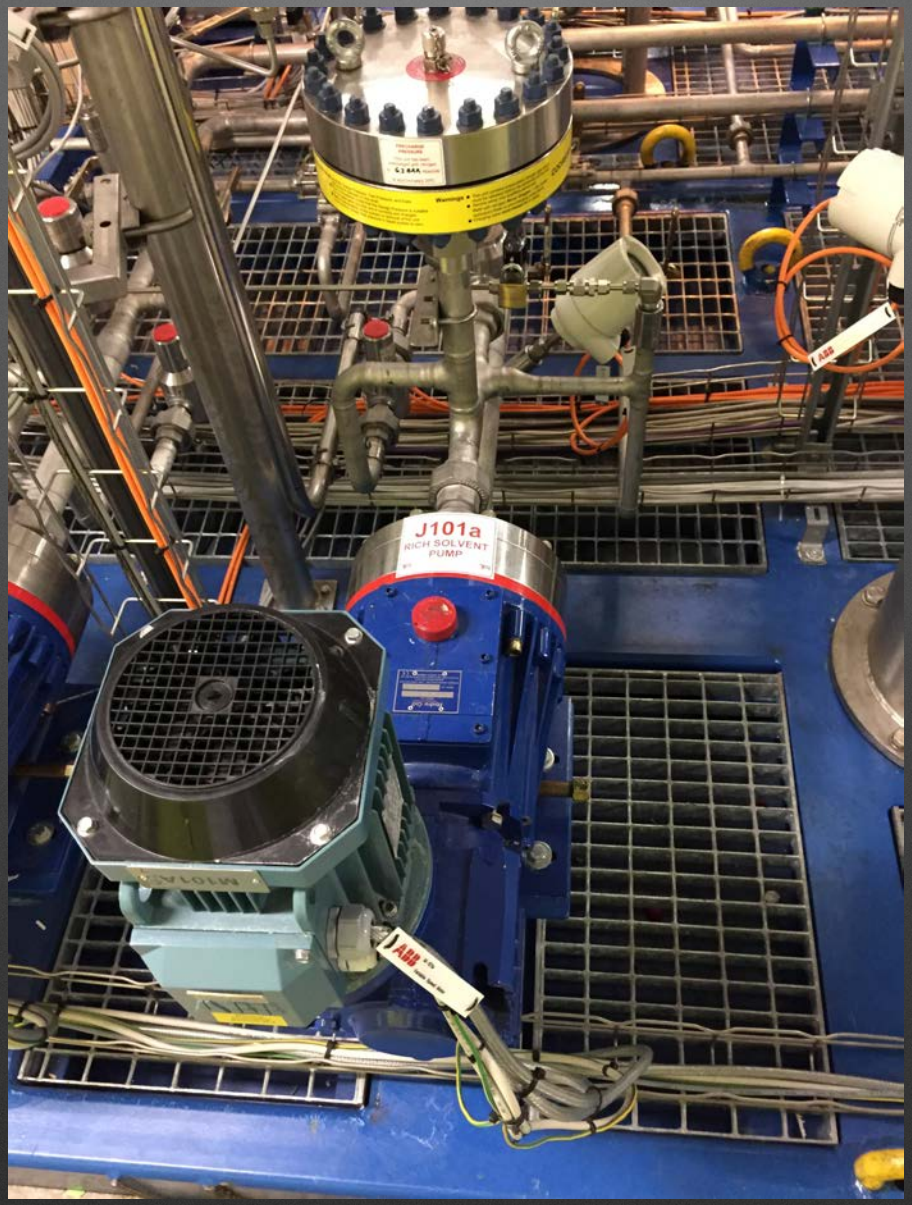
Imperial Heat Exchangers

Pumps


Pressure Side
Downstream Pipe Flange
Driveshaft Flange
Rotating Direction Indicator
Pump Casing
Volute Chamber
Impeller
Suction Side
Upstream Pipe Flange

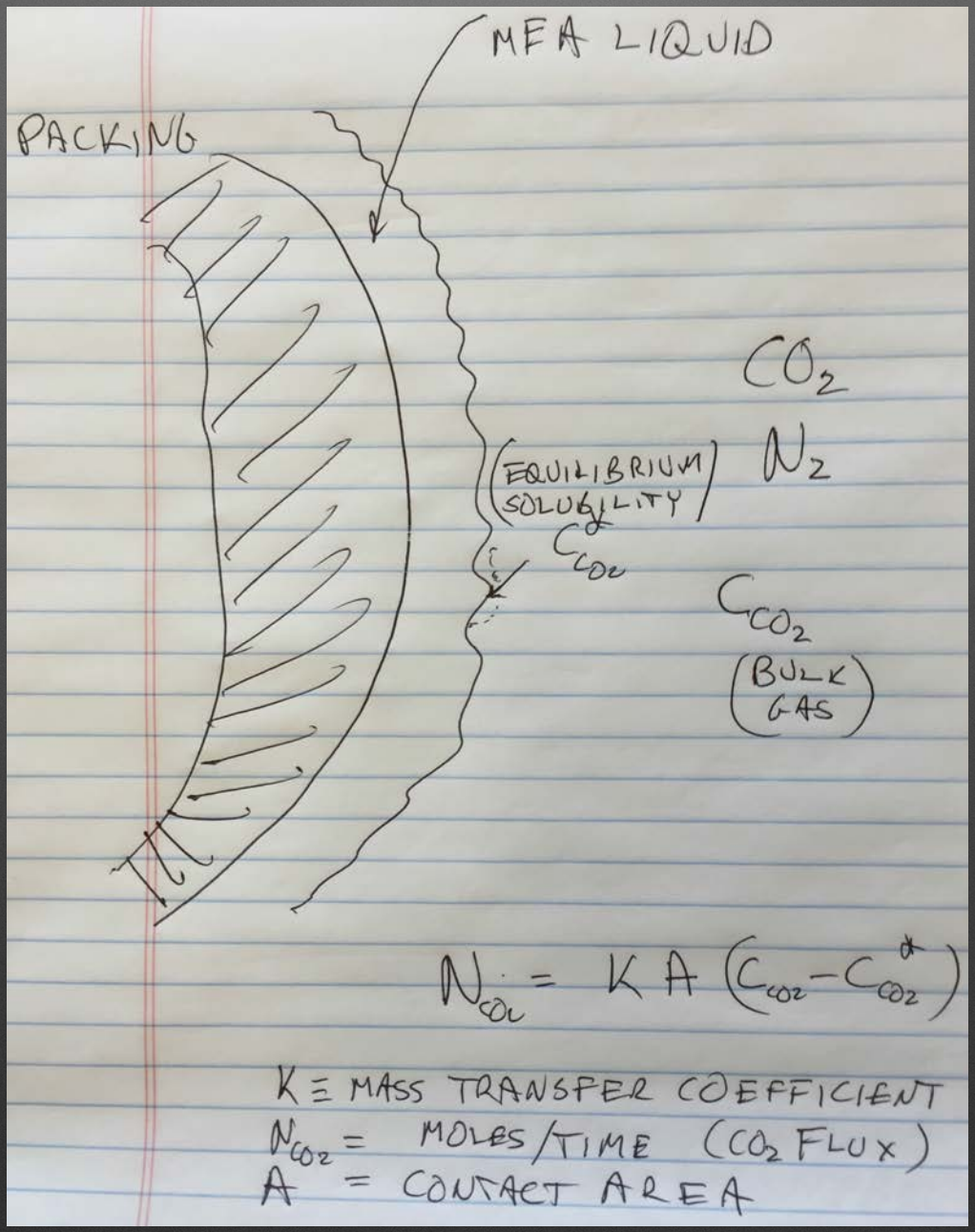

Junaid 22nd May 2007
Image modified to show correct impeller vane direction

Pump for MEA



Gas Compressor/Blower

Gas absorption



Basic Thermodynamics