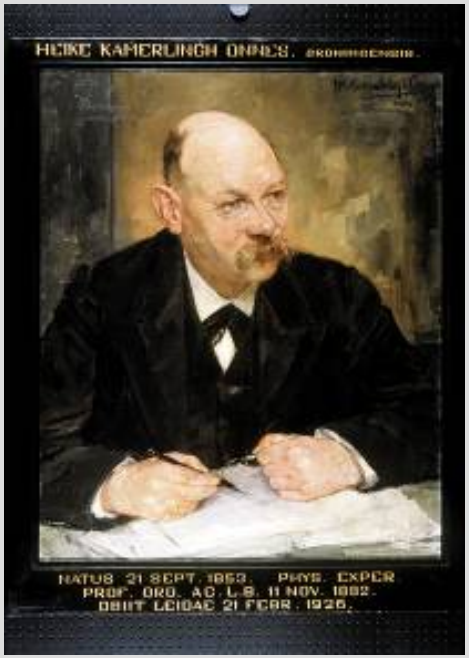
# Heike Kamerlingh Onnes and the Road to Superconductivity





**APS March Meeting 2011**
Dallas, March 21

**Dirk van Delft**
Museum Boerhaave
Leiden University



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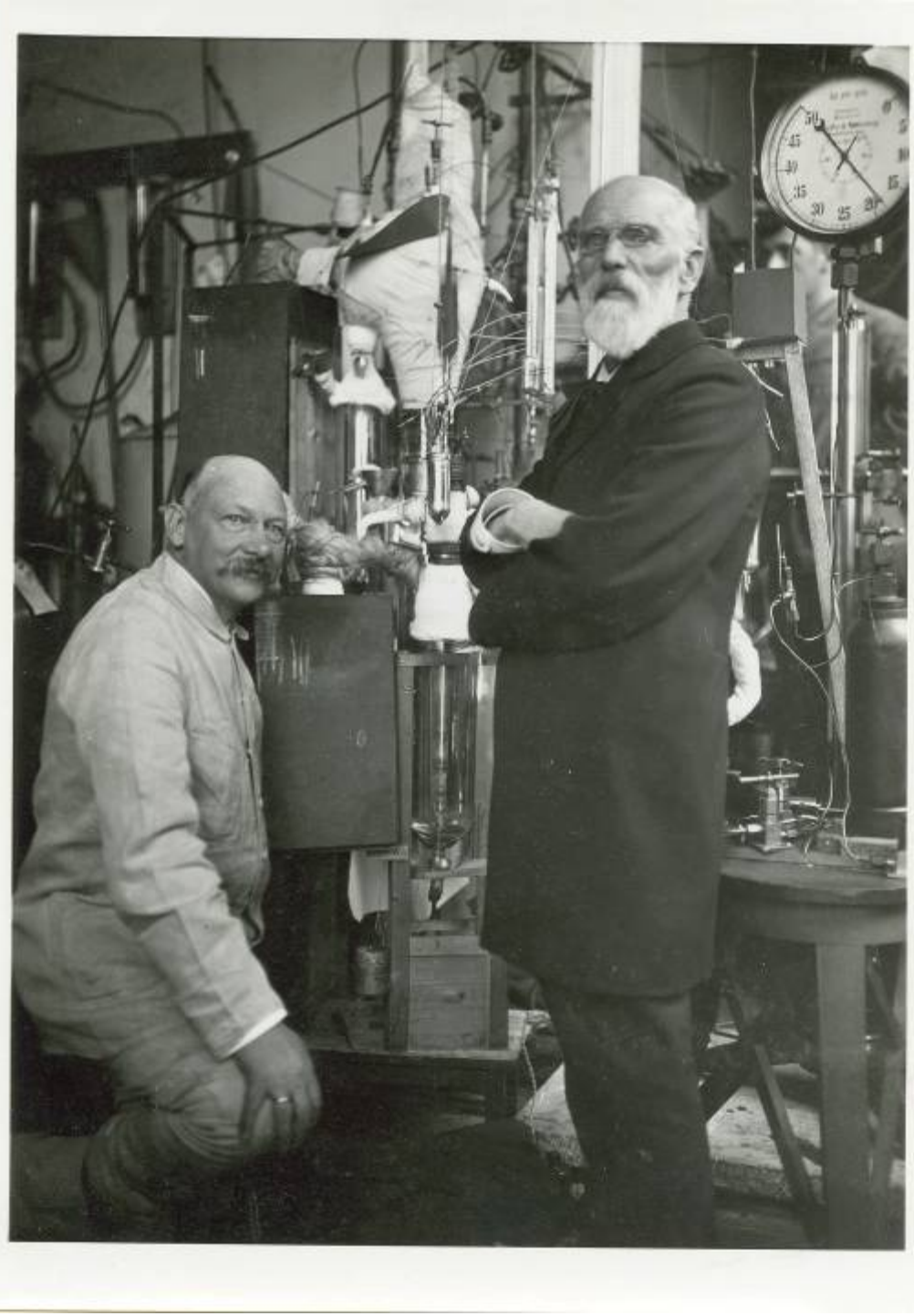

Leiden Scientific program:

molecular theories
J.D. van der Waals

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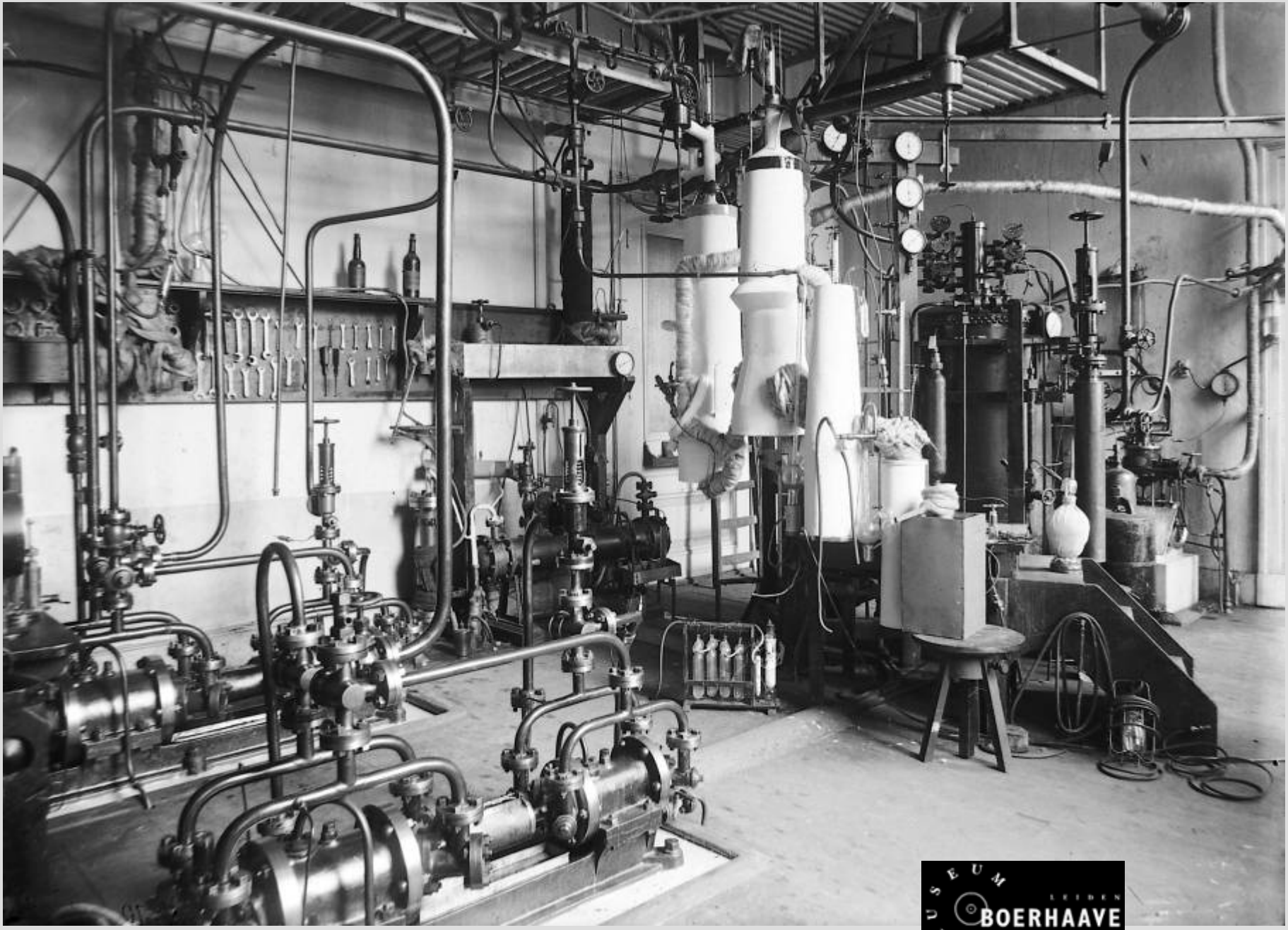
Leiden Cryogenic Laboratory, 1895

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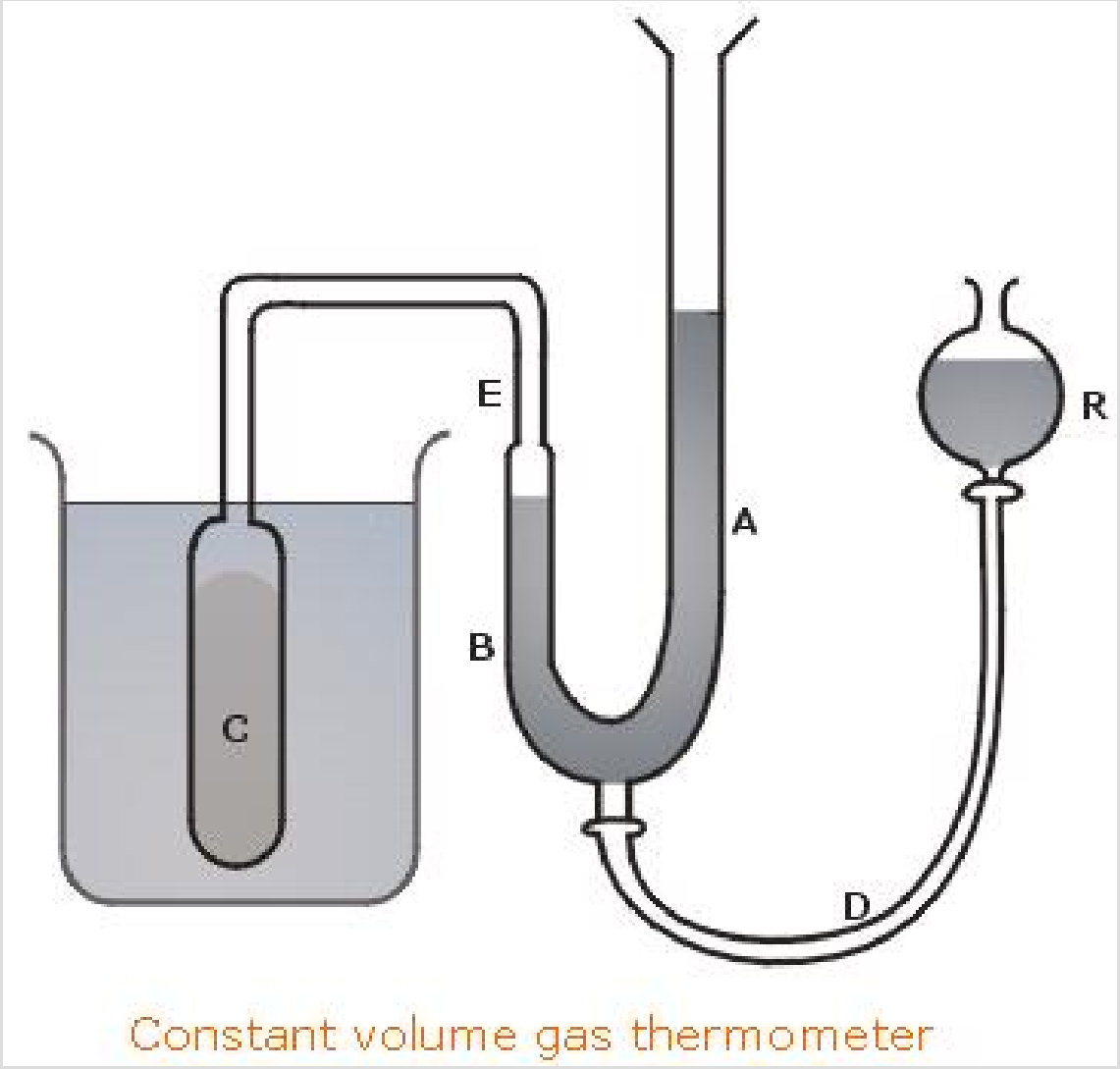
# Gas thermometer




Constant volume gas thermometer

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1860
William Siemens
Proposal platinum resistance thermometer

1885 – 1900
Hugh Callendar
Experimental work on platinum thermometer

1899
Proposal Callendar international temperature scale
Platinum thermometer
Quadratic interpolation formula
3 fixed points
Range: -100 °C - 650 °C

$$R_t = R_0 (1 + At + Bt^2)$$

Hugh Callendar
Cavendish Lab, Cambridge

William / Wilhelm Siemens

Jacob Clay

Calibration resistance thermometers:
Gold and Platinum wire
since 1902 used in Leiden

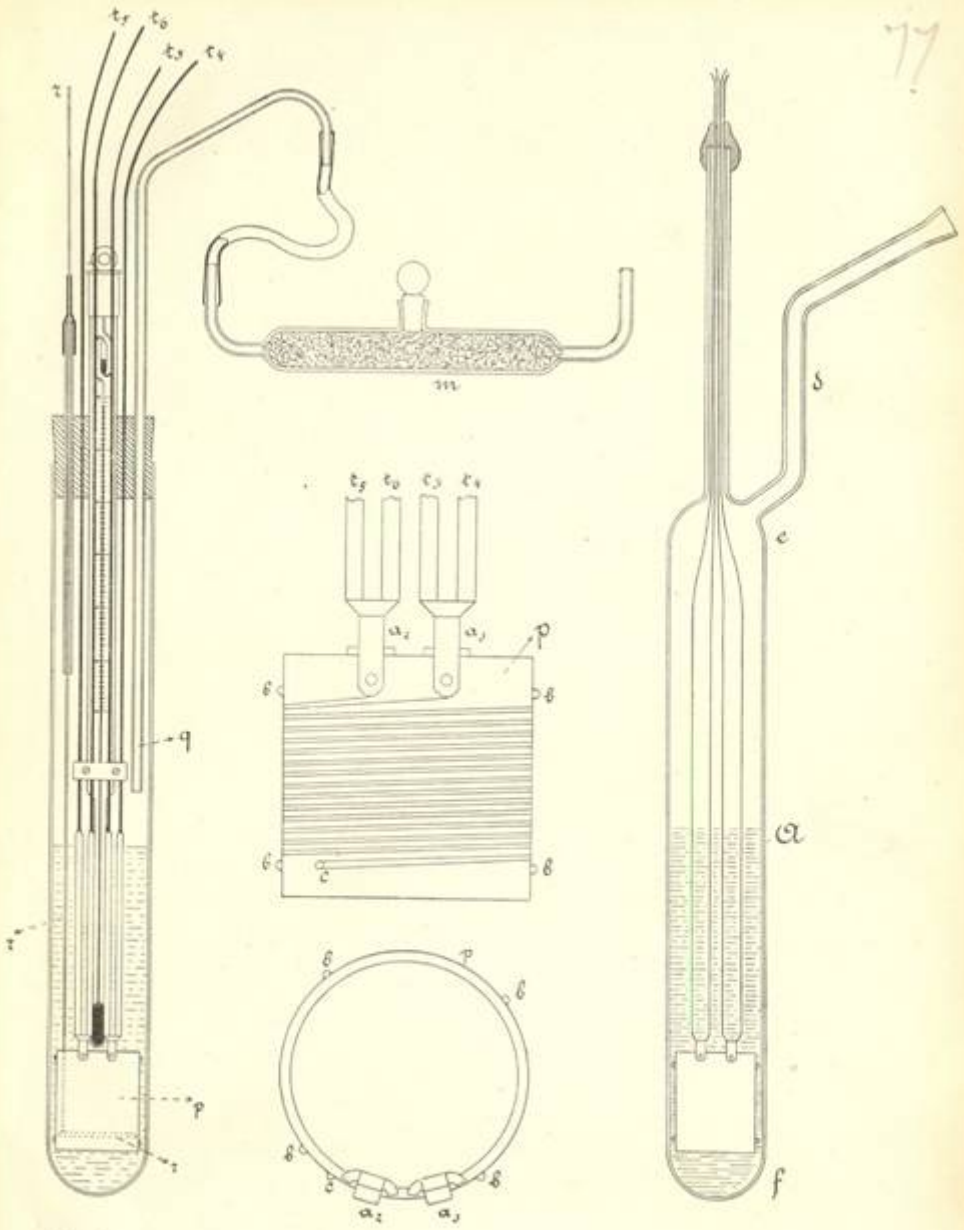
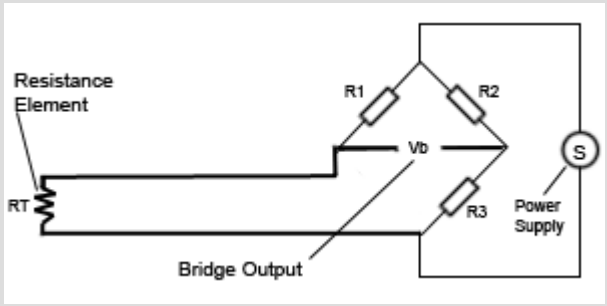


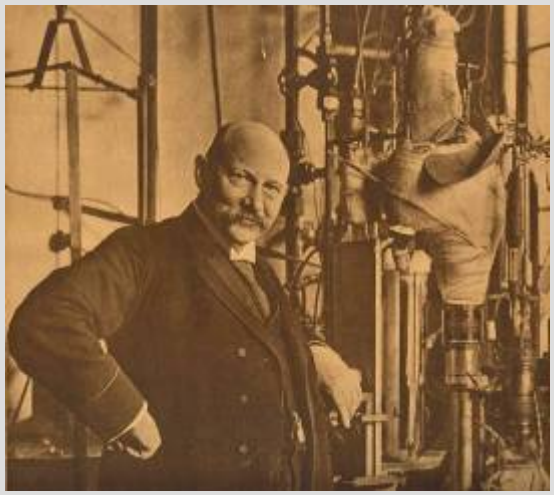
Fig. 4. Fig. 1. Fig. 3.

Communication No. 77.

B. MEILINK. „On the measurement of very low temperatures IV. Comparison of the platinum thermometer with the hydrogen thermometer."



**Open question**: What would happen to the resistance of a metal as its temperature approaches absolute zero?



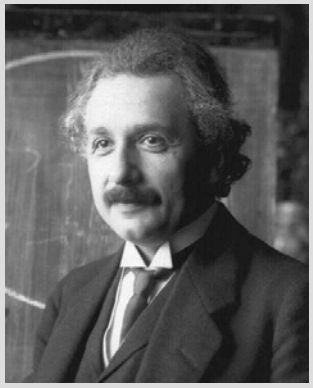
**Practical importance**: can metal wires still be used as thermometers at very low temperatures?

**Theoretical importance**: two rivalling theories

Lord Kelvin: the electrons ‘freeze’, no mobility, resistance goes to infinity

Paul Drude: electron gas in a metal; resistance gradually approches zero

So Kamerlingh Onnes, who tinkered with a theoretical Planck vibrators model himself, devised experiments to decide these matters



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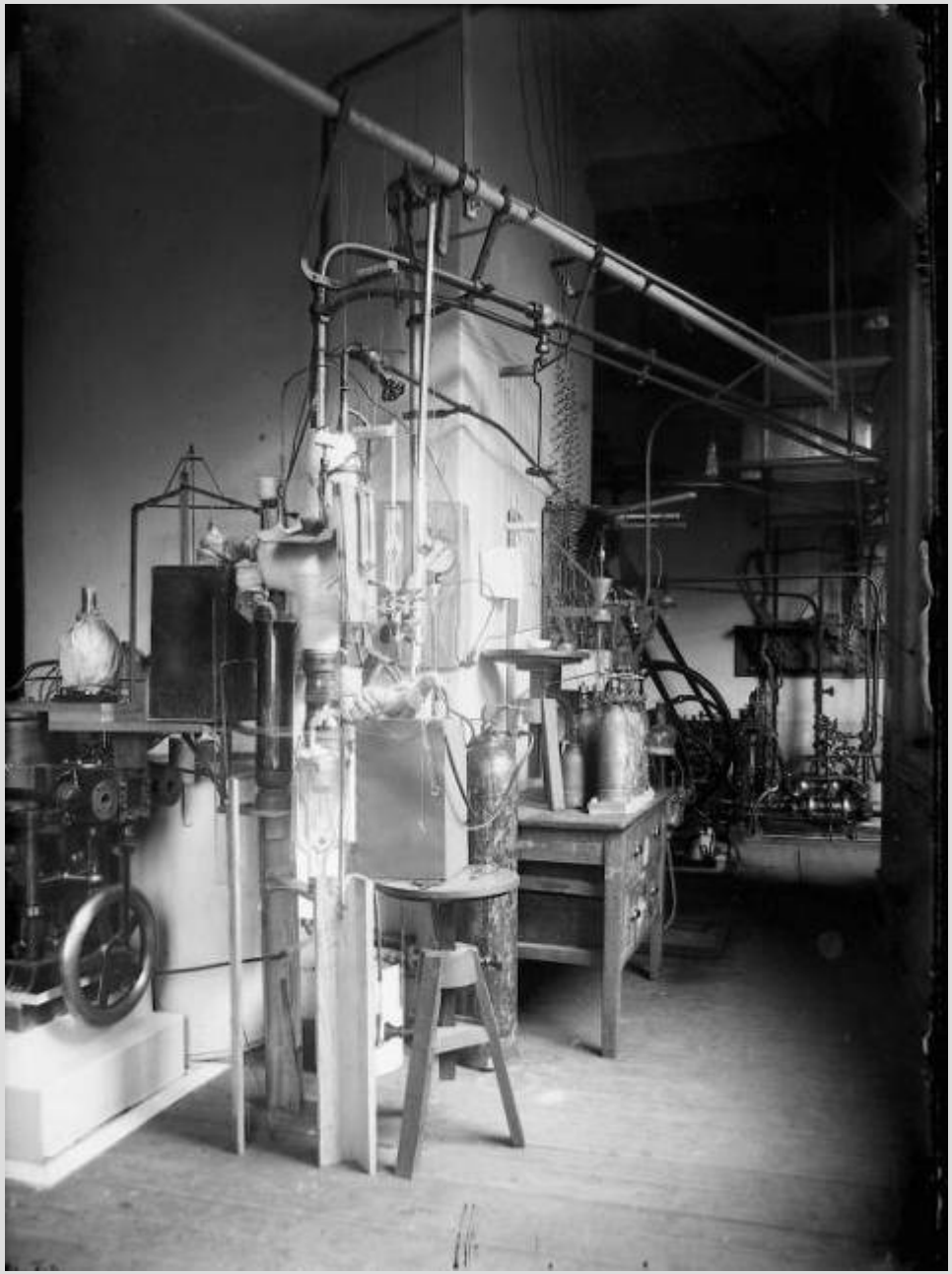
10 July 1908: Liquid Helium



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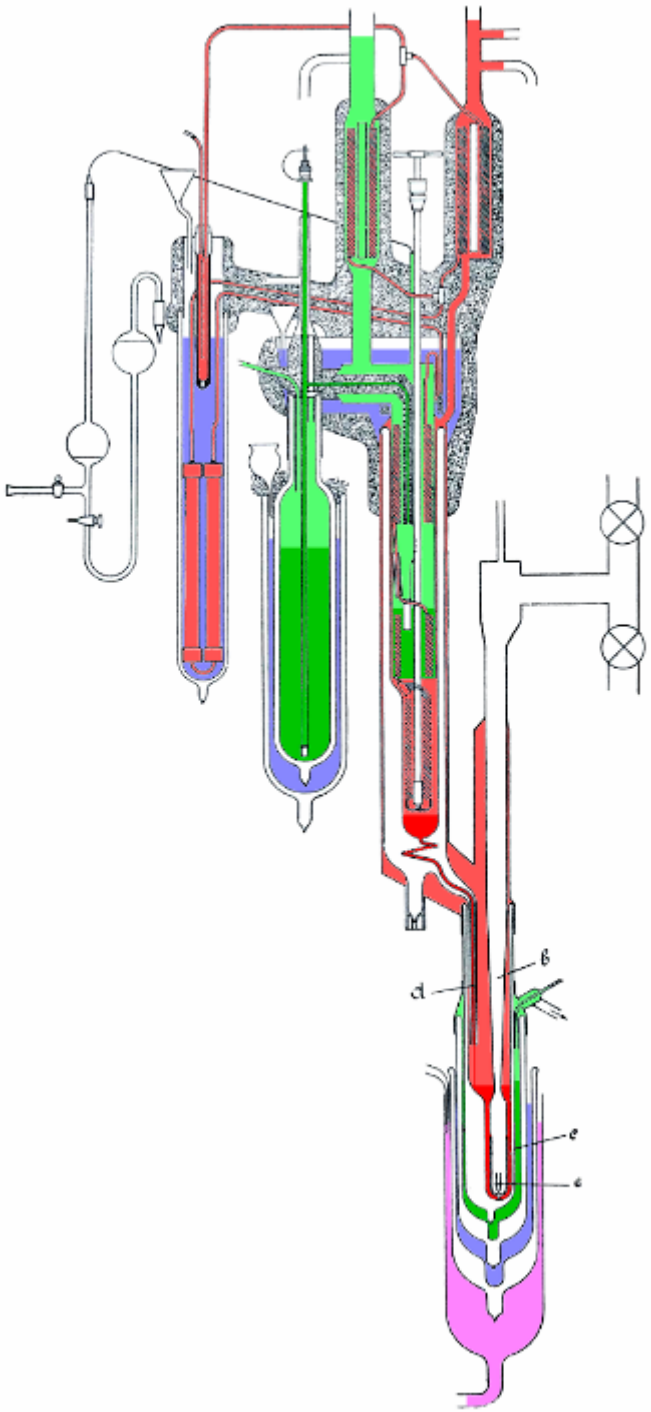


Transferring helium to a separate cryostat
12 March 1910

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Flim, Kesselring and some ‘blue-collar boys’

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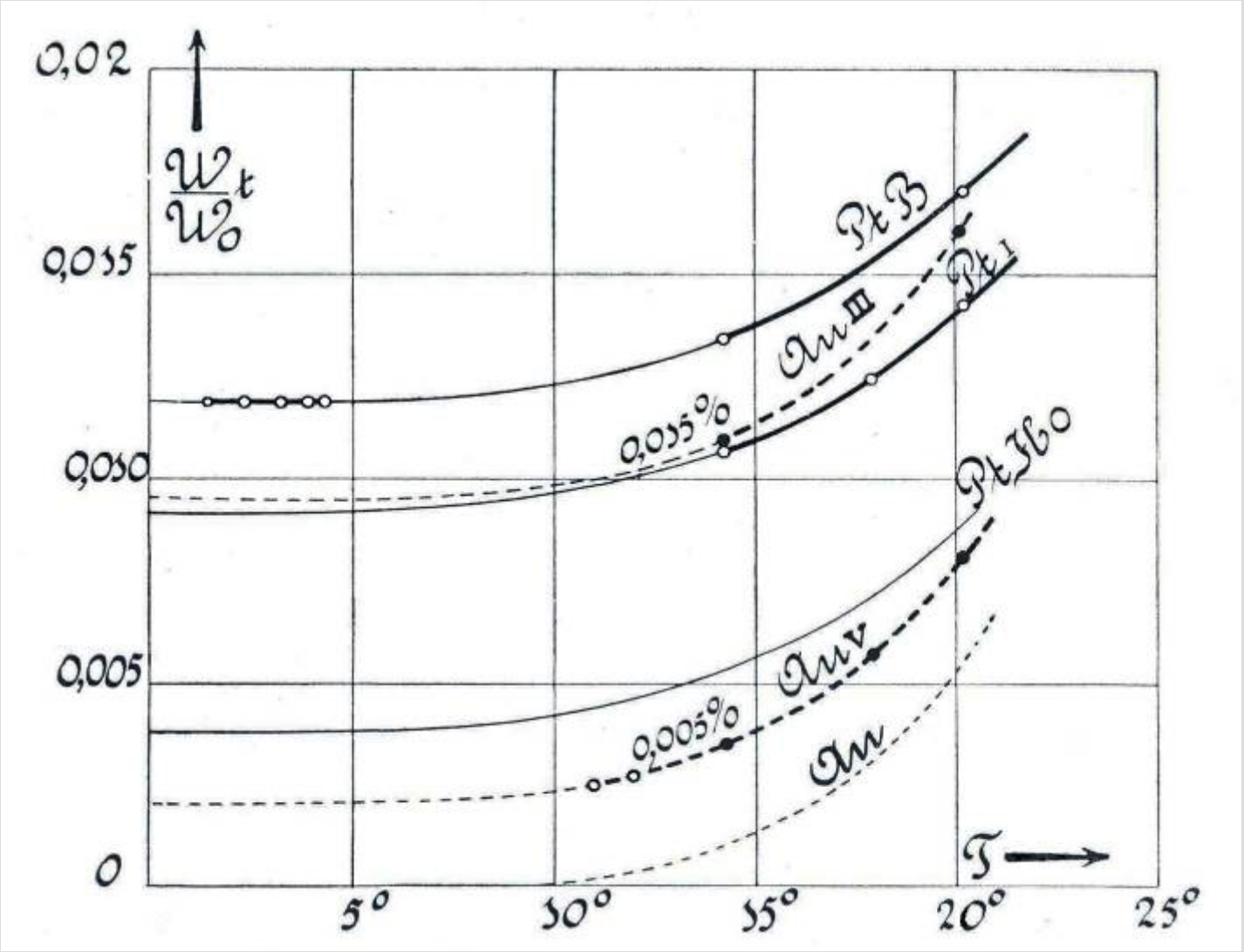
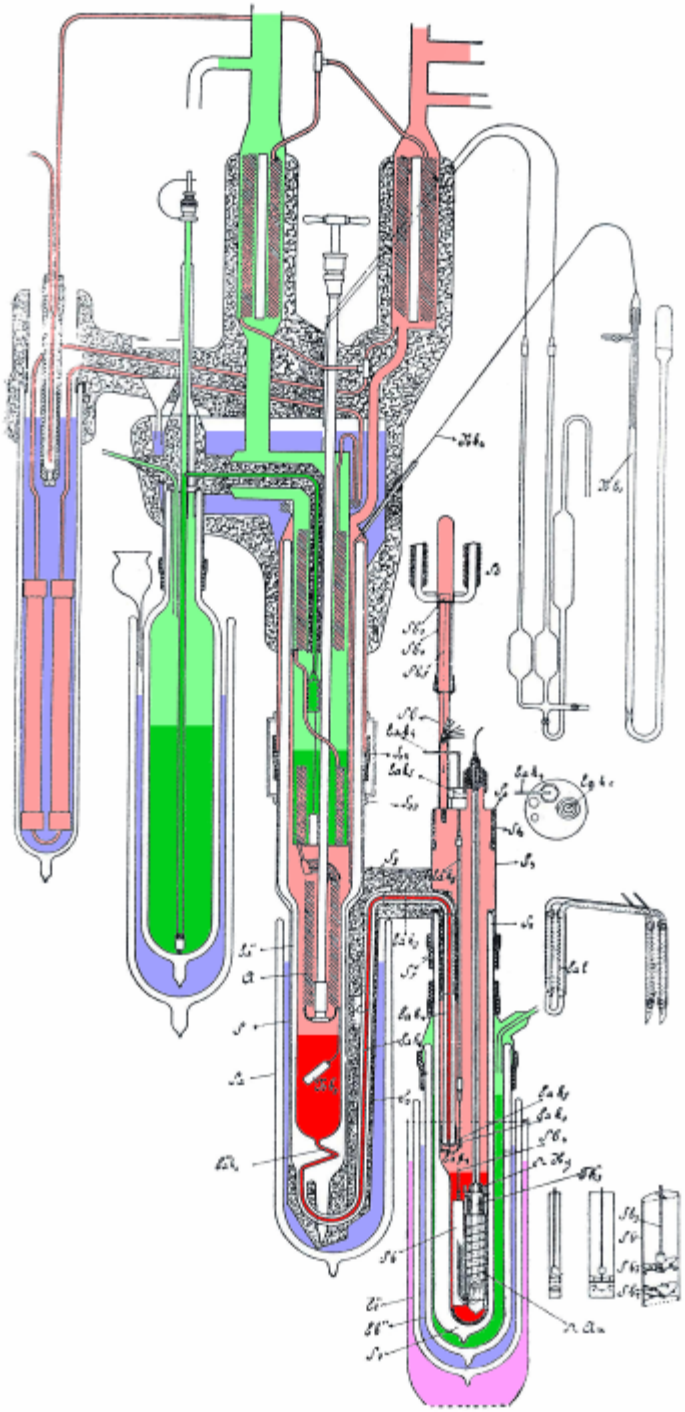
(R,T) graphs Platinum and Gold wires; December 1910





Helium liquefier and cryostat, April 1911

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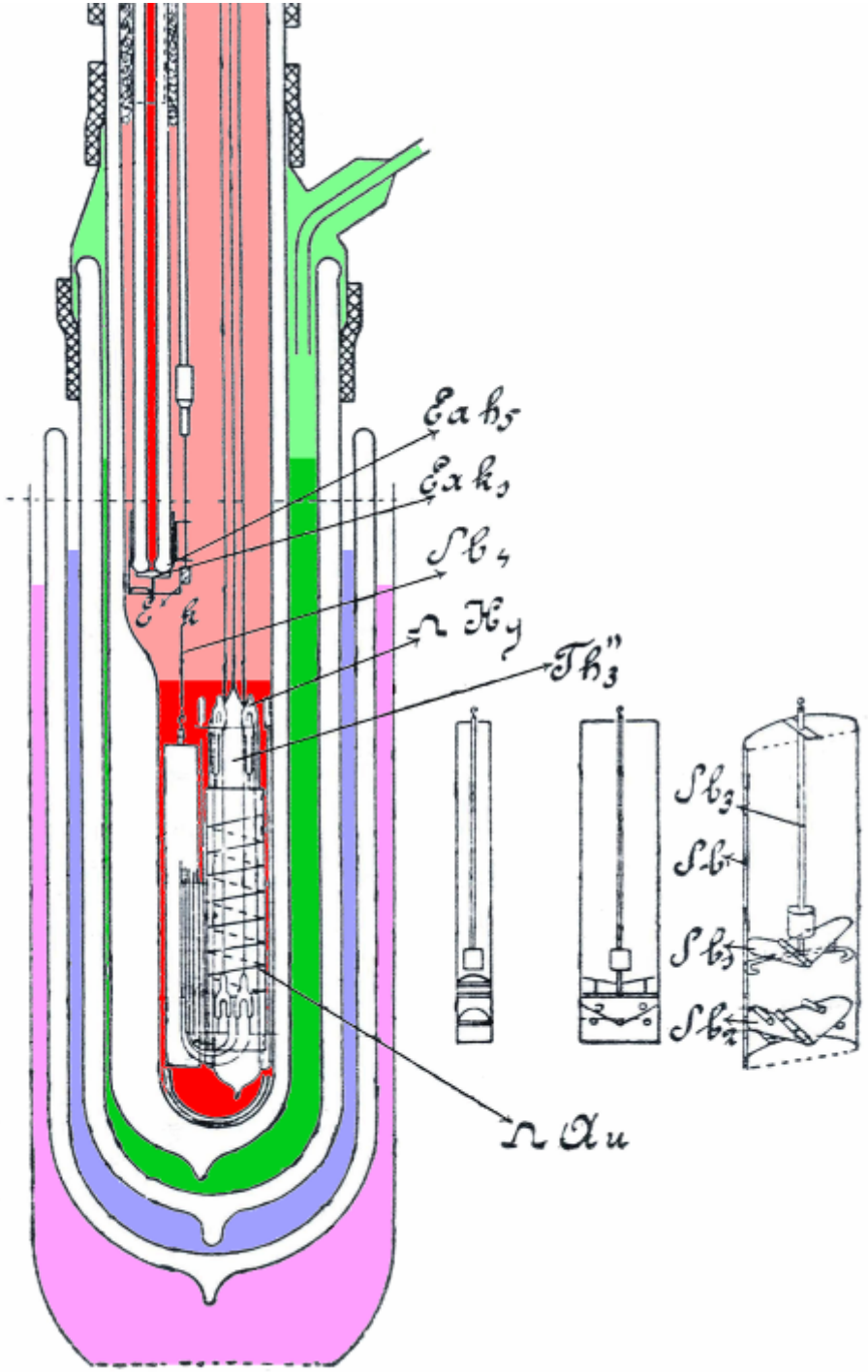

Helium cryostat

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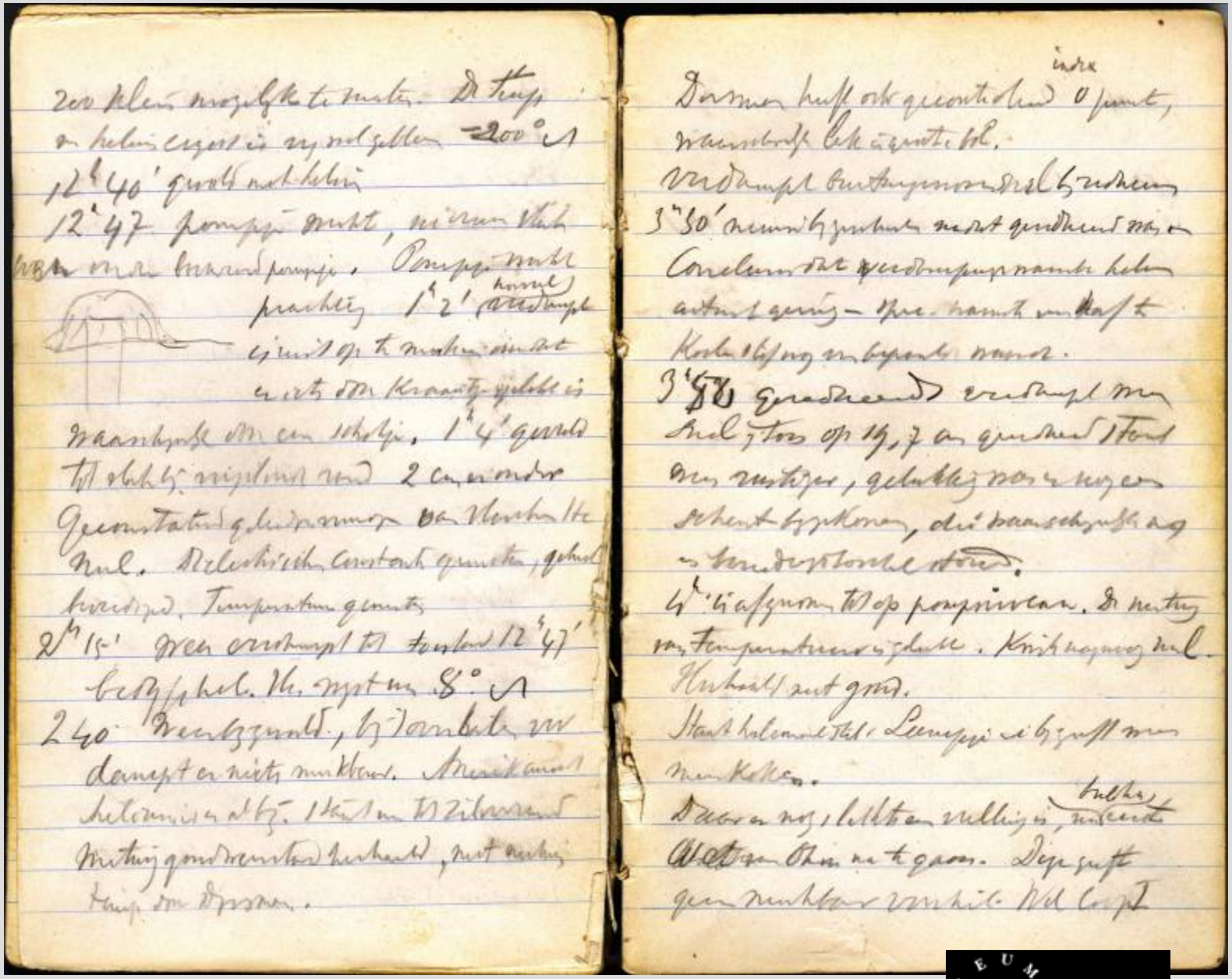
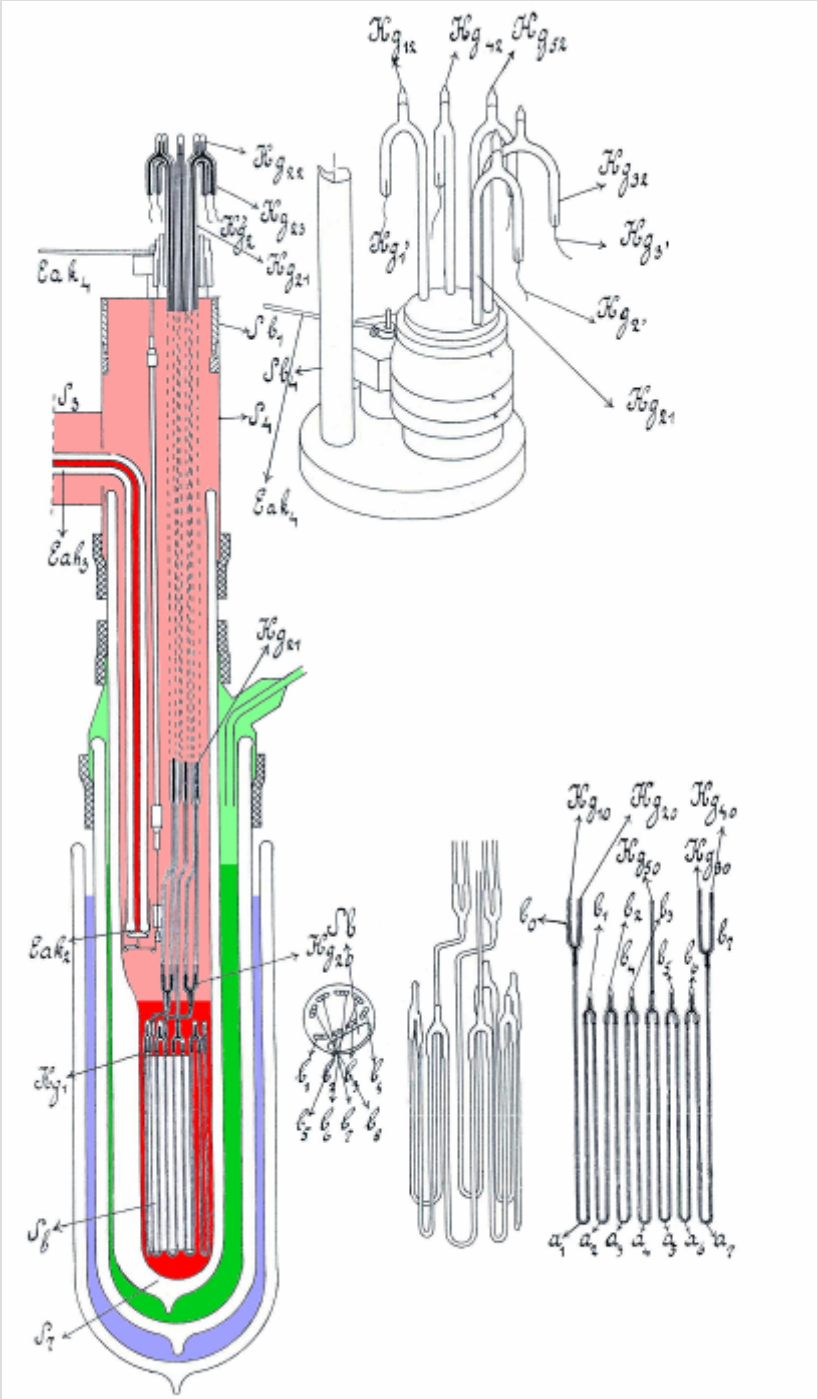
# Notebook #56





‘Mercury practically zero’
8 April 1911

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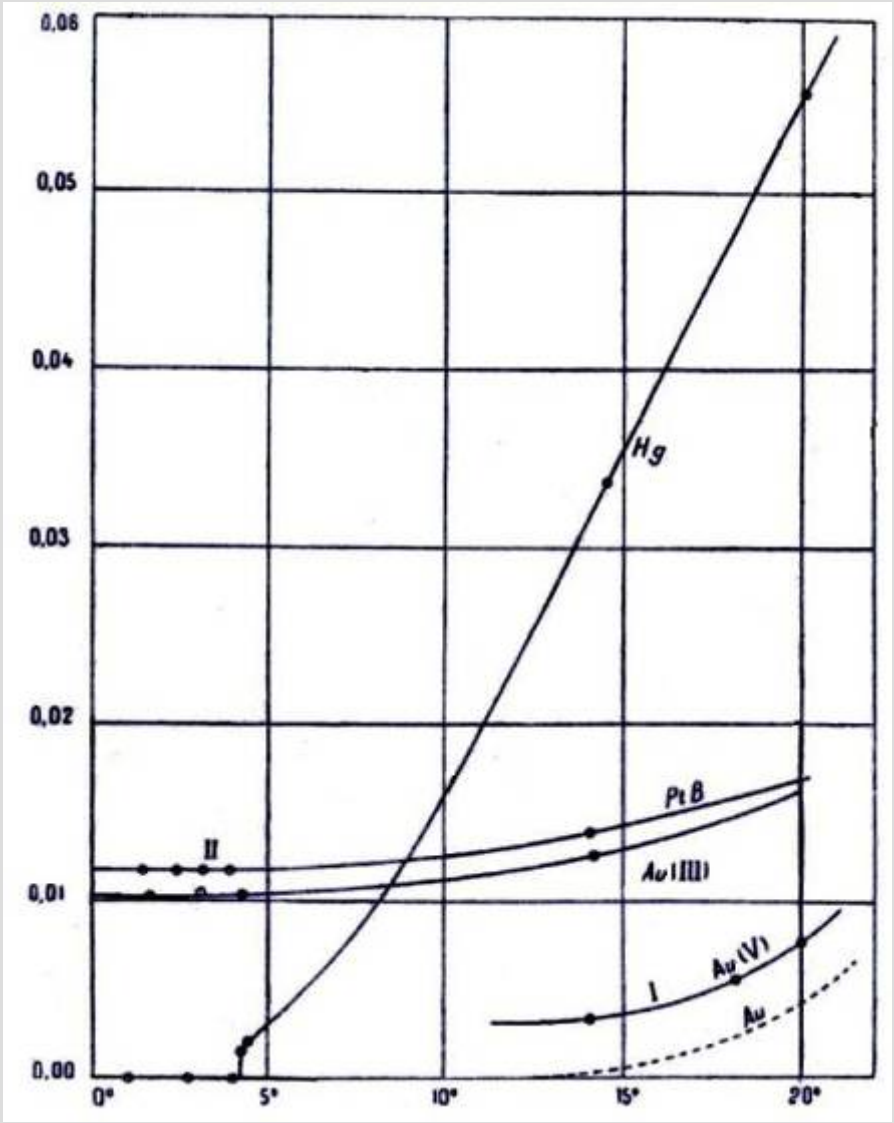
R,T graphs Hg, Pt, Au

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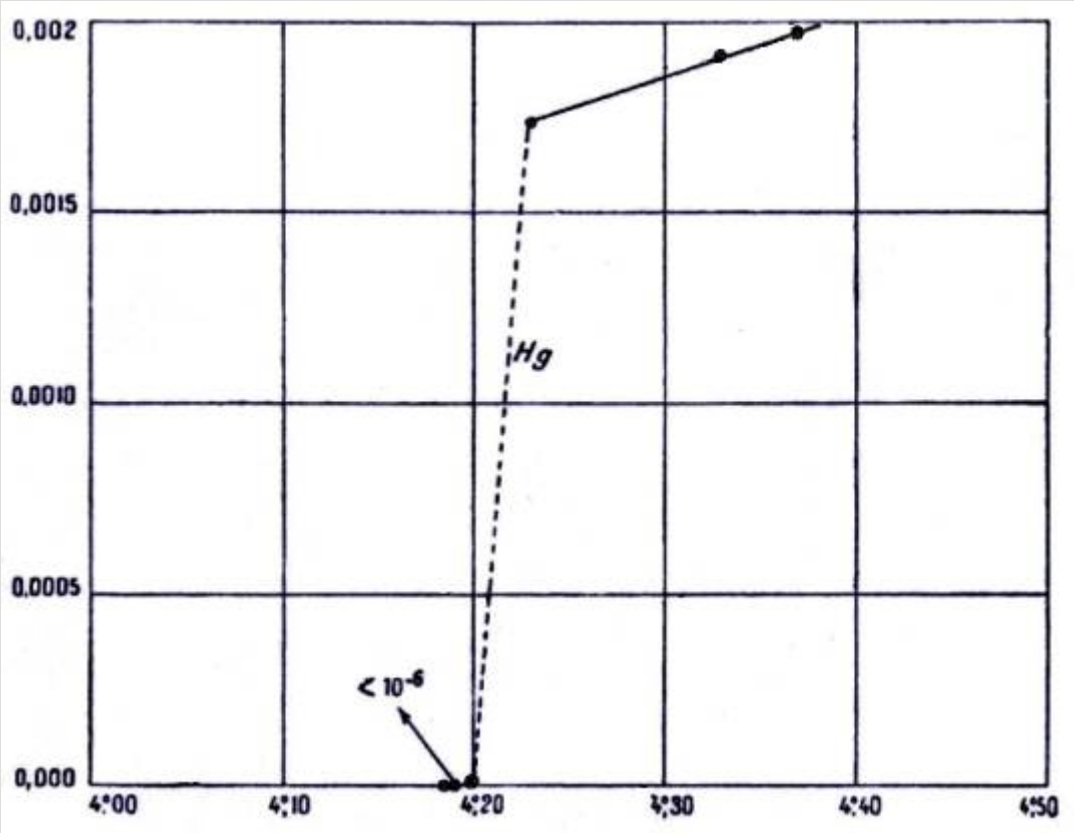


October 1911

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# First Solvay Conference, October/November 1911

**Who discovered superconductivity on 8 April 1911?**

Heike Kamerlingh Onnes: director, took the initiative to the mercury measurements

Gerrit Jan Flim: chief technician of the cryogenic laboratory, responsible (together with Kamerlingh Onnes) for the cryogenic apparatus

Cornelis Dorsman, assistent, handled the gas thermometer (temperature measurement)

Gilles Holst, assistent, measured the resistance of the mercury using a Weastone bridge and a mirror galvanometer in Room I. He noticed a sudden swing of the galvanometer. Short circuit? No!

Oskar Kesselring, master glassblower, built the capilairies filled with mercury.

Single author superconductivity publications: H. Kamerlingh Onnes
Acknowledgement of ‘most valuable help’ by Holst, Dorsman, Flim and Kesselring

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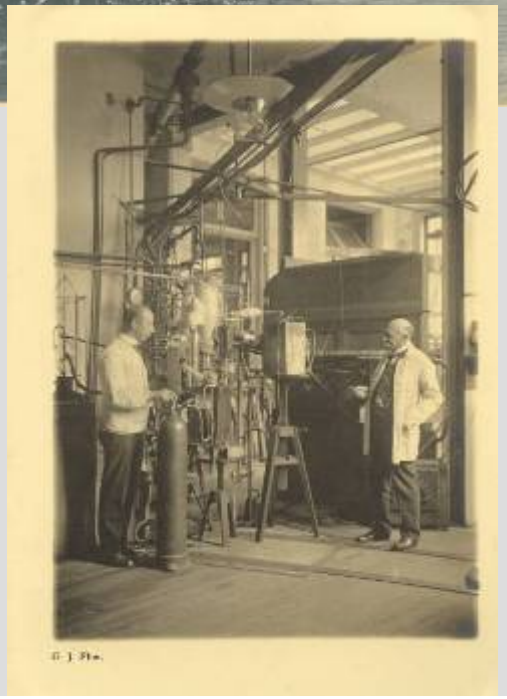

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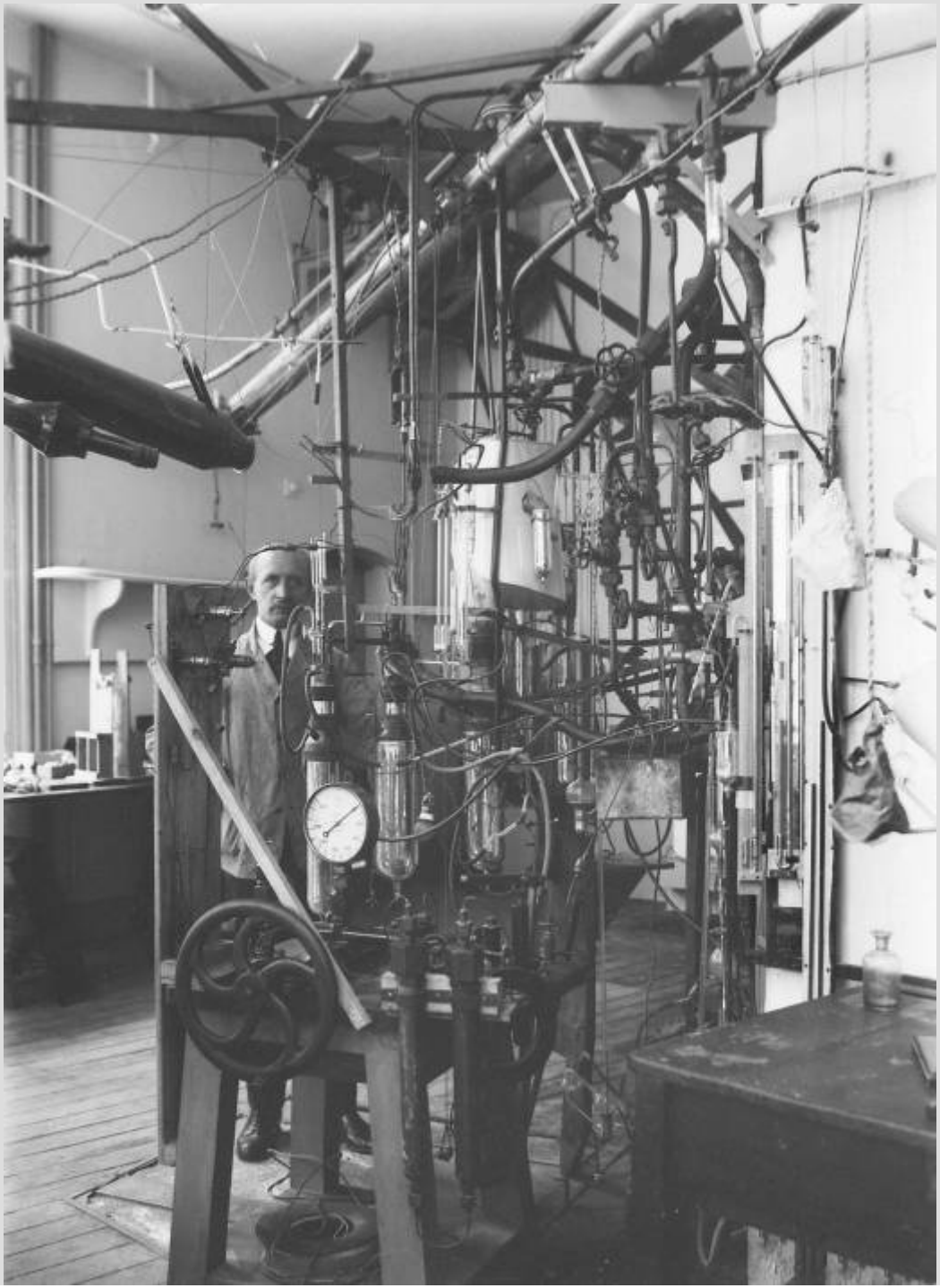

First example of Big Science

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First superconducting lead coil, 1912
Threshold value (4.25 K) only 600 Gauss

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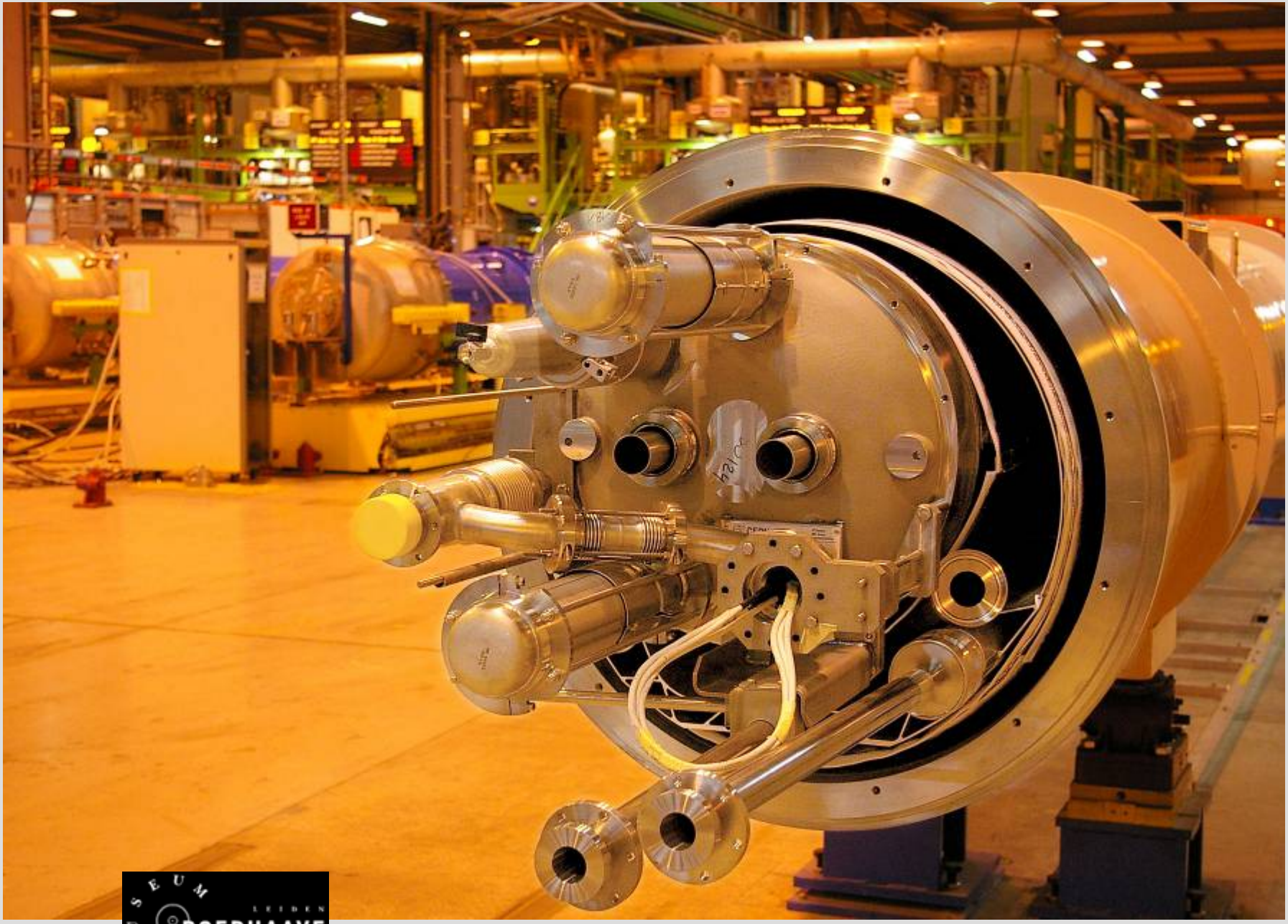
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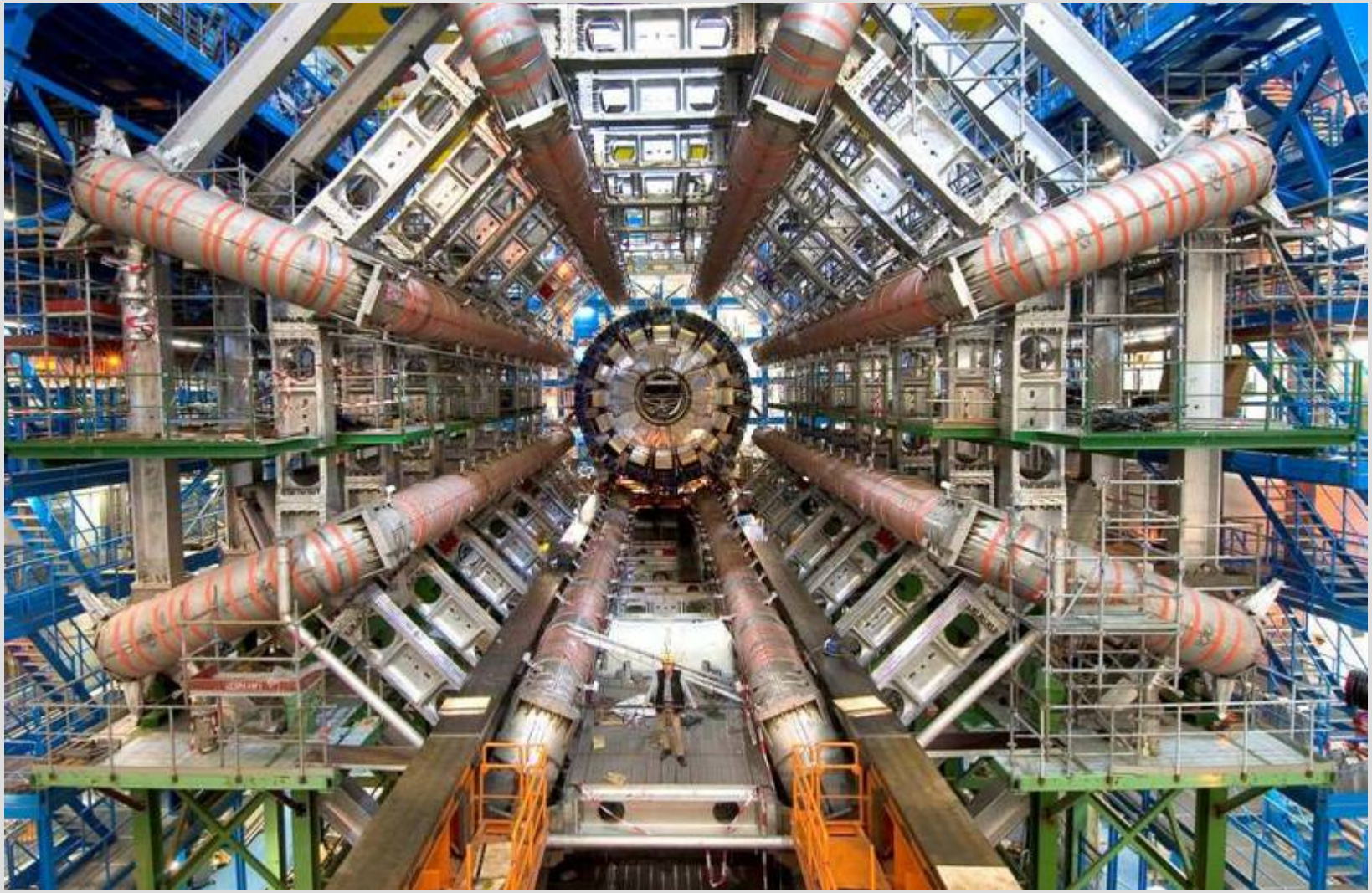
# ATLAS-detector Large Hadron Collider



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MRI scanner

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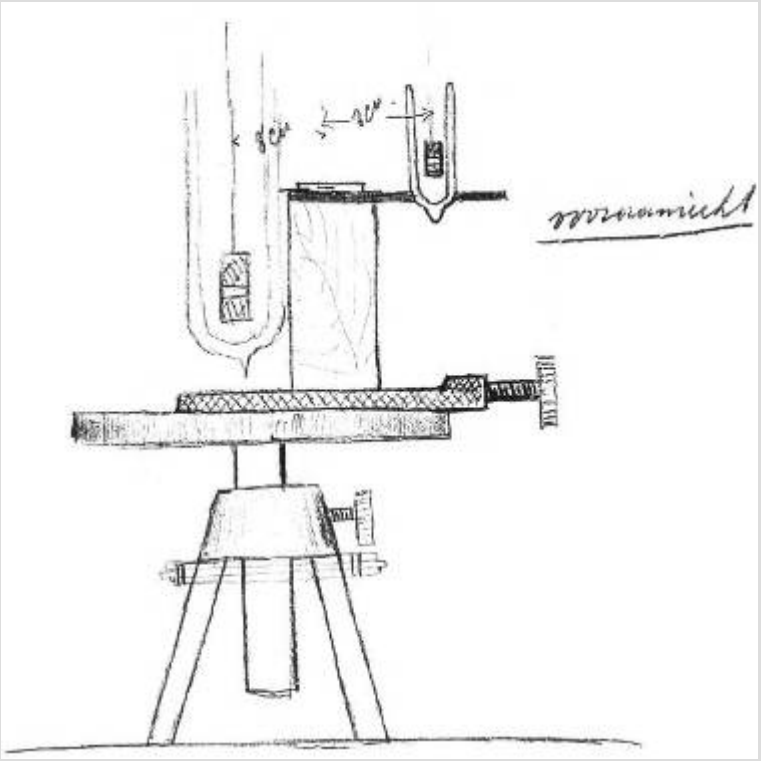
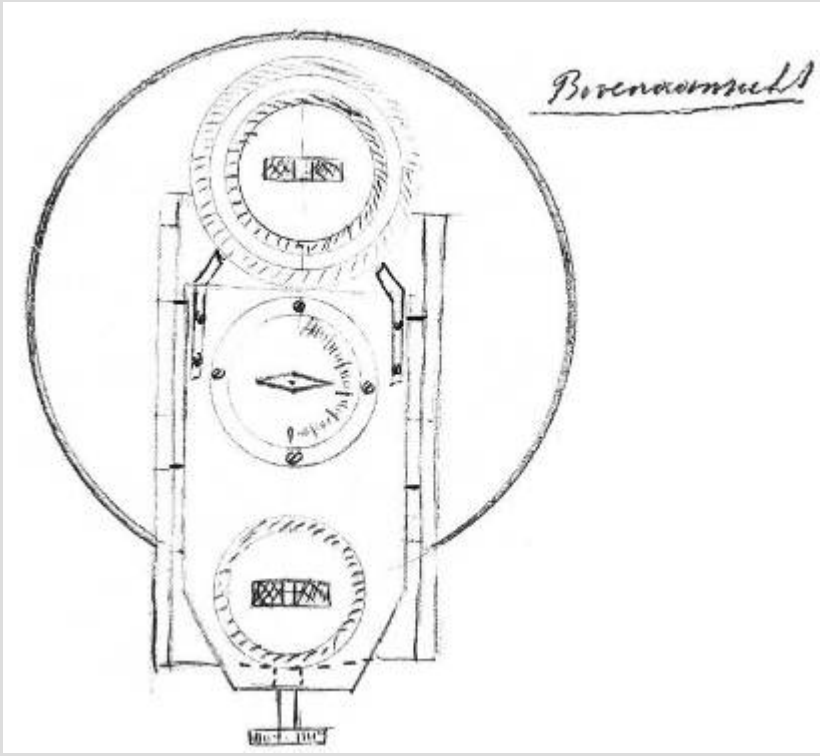
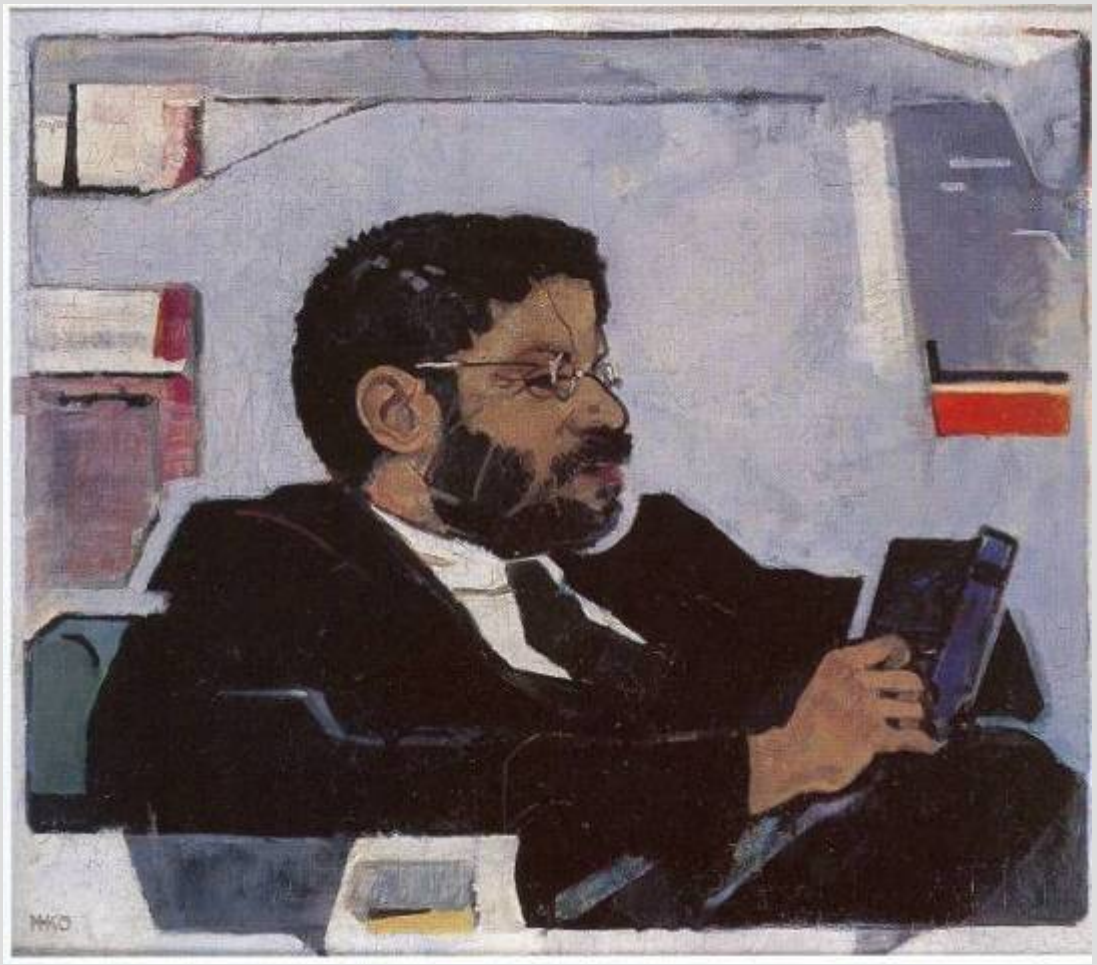
Persistent current experiment, 1914





Drawings by Flim



Paul Ehrenfest

‘I attended a fascinating experiment at the laboratory. Unsettling, to see the effect of this “permanent” current on a magnetic needle. It is almost tangible, the way the ring of electrons goes round and round and round in the wire – slowly and virtually without friction.’

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Demonstration persistant current in Royal Institution (London), 1932


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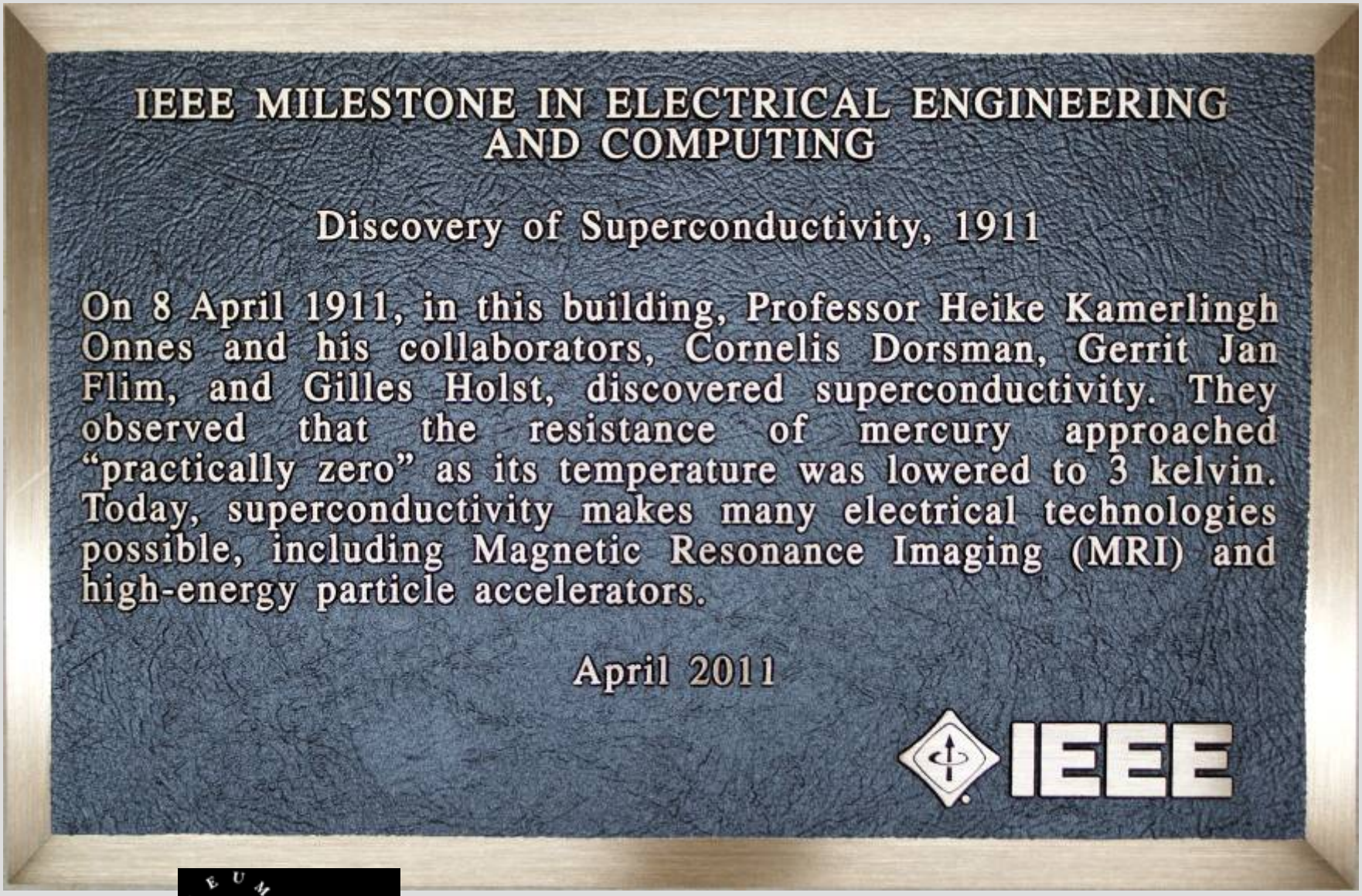
Museum Boerhaave, Leiden

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