

Cryogenic Engineering

Chapter 1.

INTRODUCTION TO CRYOGENIC SYSTEMS

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1.1 Introduction

CRYOGENIC=CRYO+GENE

Ice

Generation

CRYOGENICS

REFRIGERATION

-150 °C
(123K)

-40 °C
(233K)

25 °C

1.2 Liquid Nitrogen

- **Liquid nitrogen**



thebusinessofaction.com

1.2 Liquid Nitrogen

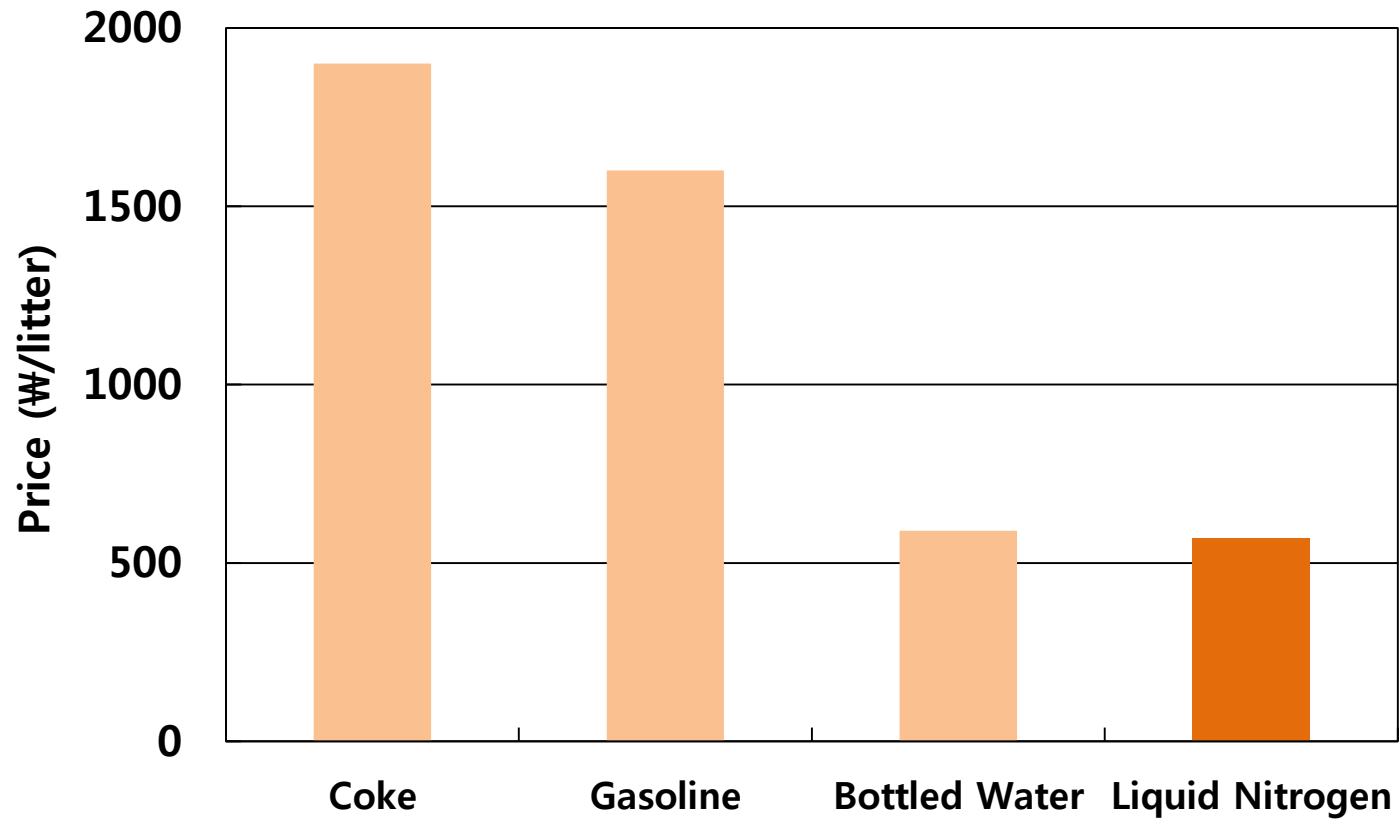
- How cold is it? (Video 03:30)

Need a hammer? Take a banana :-)

ChemToddler - Banana hammer
<https://www.youtube.com/watch?v=gMWxCVMXAcQ>

1.2 Liquid Nitrogen

- Price comparison



한국물가협회 sbc.kprc.or.kr

1.2 Liquid Nitrogen

- **How to transfer it (Video 02:00)**



NorthwesternU - Filling and Maintenance of Liquid Nitrogen Tanks
www.youtube.com/watch?v=fGMgl-O4M5M&t=548s

1.3 LNG (Liquefied Natural Gas)

- S. Korea LNG import status (Video 00:40)

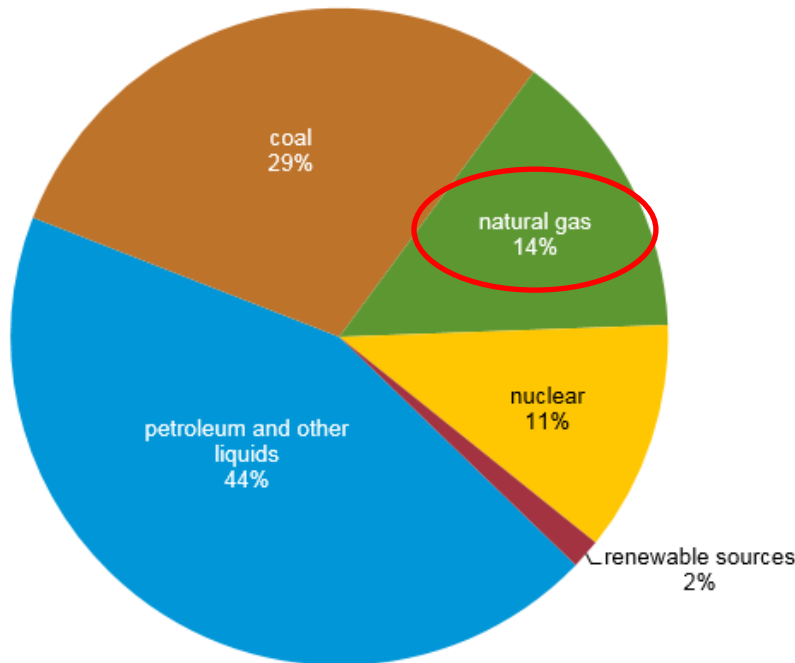


ARIRANG NEWS - S. Korea's LNG imports hit record high in 2018
<https://www.youtube.com/watch?v=JAtgKYSGAZs>

1.3 LNG (Liquefied Natural Gas)

→ Mainly from Qatar

Figure 2. South Korea total primary energy consumption by fuel type, 2017




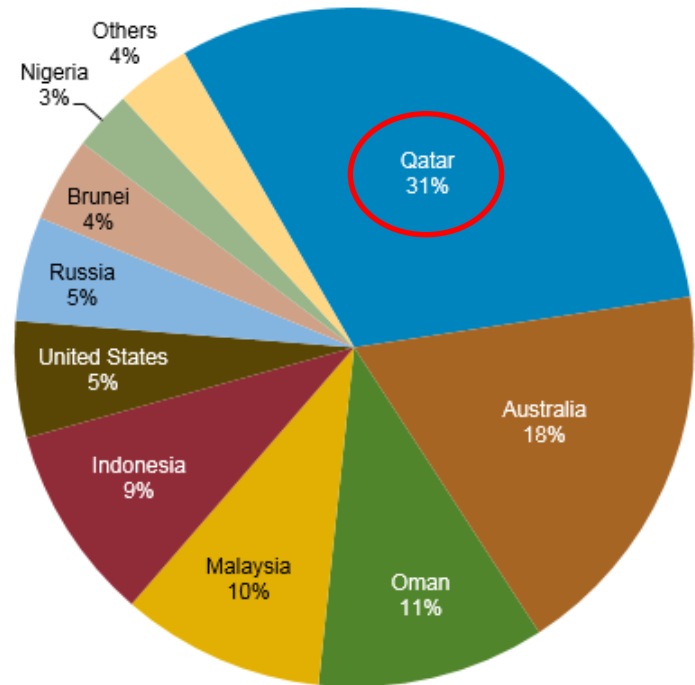
 Note: Petroleum and other liquids includes biofuels (ethanol and biodiesel)
Source: BP Statistical Review of World Energy 2018

Figure 8. South Korea LNG imports by source, 2017



 Source: IHS Energy
Note: Others include Algeria, Angola, Equatorial Guinea, Norway, Papua New Guinea, Peru, Trinidad and Tobago, and re-exports.

U.S. Energy Information Administration

1.3 LNG (Liquefied Natural Gas)

- LNG storage tank in Incheon



가스 신문 - LNG 공급 현장을 찾아서 - ㉮한국가스공사 인천생산기지 2006.04.19

1.3 LNG (Liquefied Natural Gas)

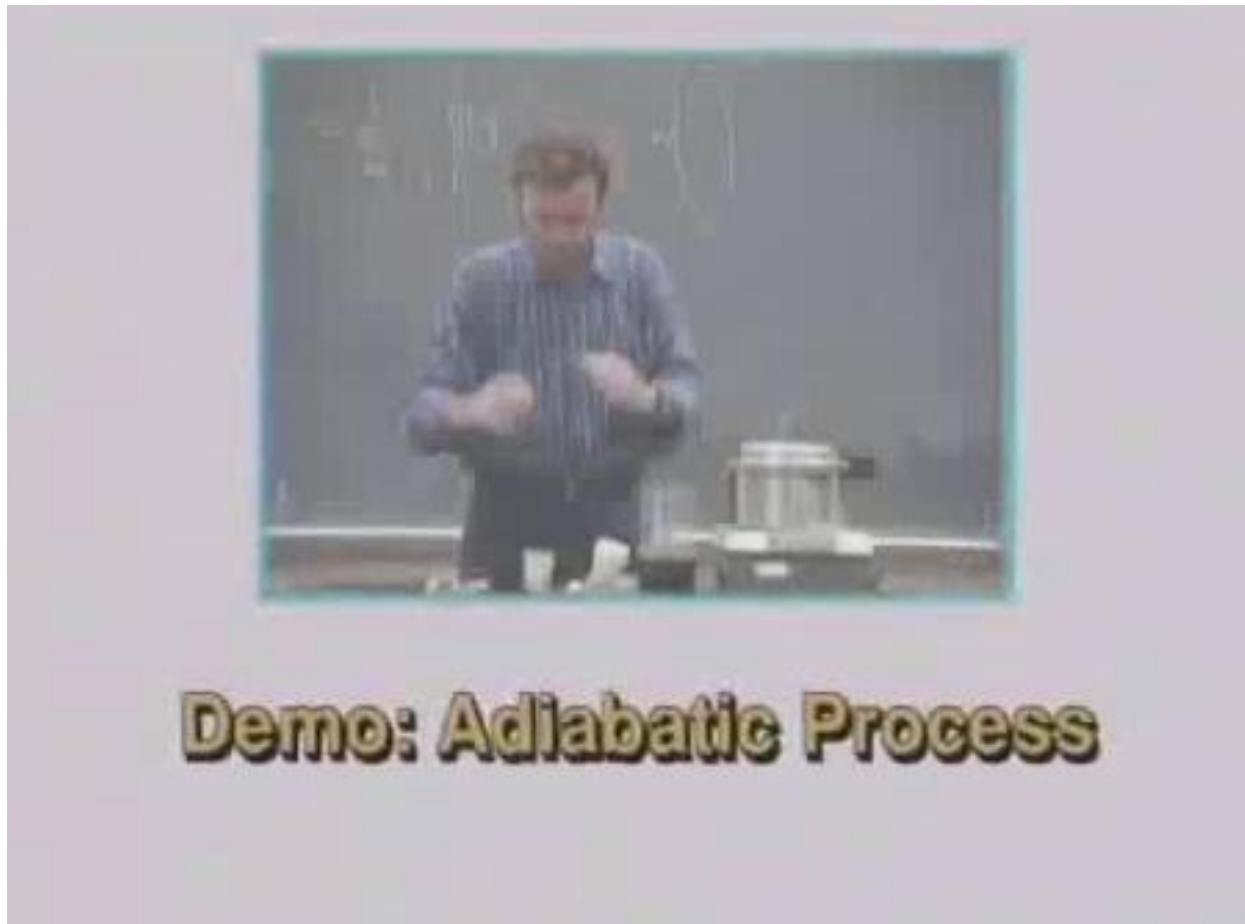
- Why is natural gas liquefied? (Video 03:30)



Eagle LNG Achieves Major Milestone by Filing FERC Application for Jacksonville LNG Project
<https://www.youtube.com/watch?v=yzmJXmFsKmk>

1.4 Refrigeration System

- How we get cool temperature : Joule – Thomson Effect

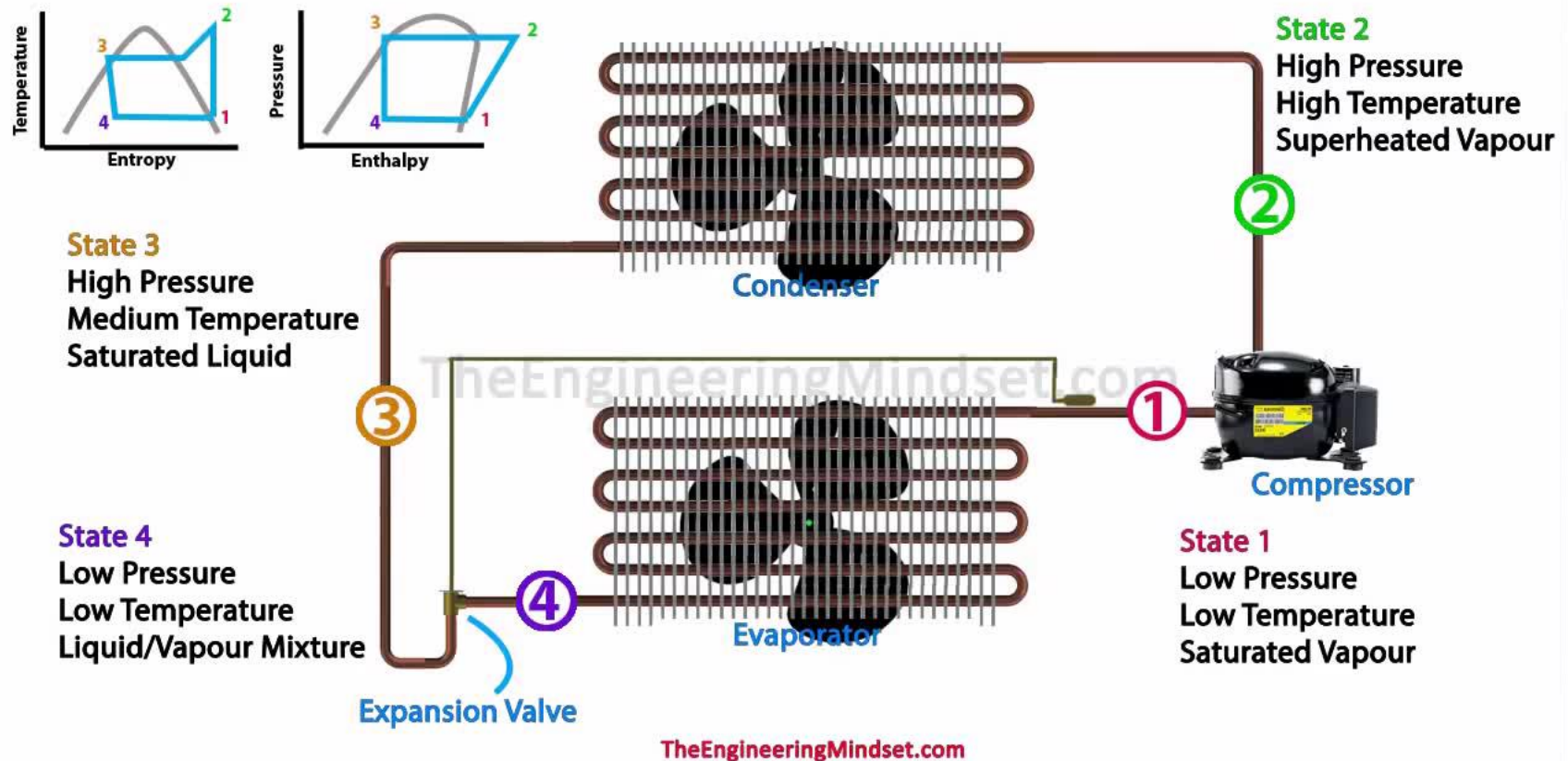


Expansion is a cooling process: Conceptual Physics with Paul Hewitt
https://www.youtube.com/channel/UCrJ5K-Br4RsBrDY_ZAC6iRw

1.4 Refrigeration System

- Refrigeration system basics (Video 04:30)

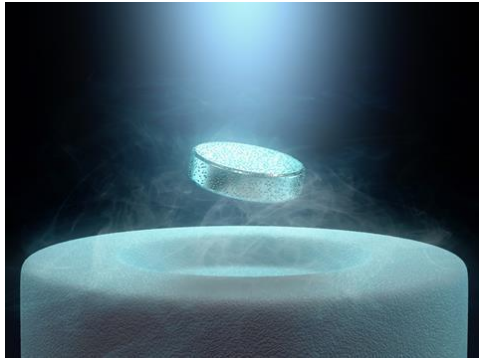
How Refrigerants Work



The Engineering Mindset - Refrigerants How they work in HVAC systems
<https://www.youtube.com/watch?v=IMqoKLi0Y4&t=459s>

1.5 Superconductivity

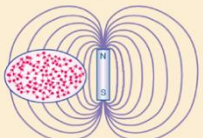
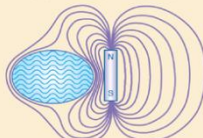
- General aspects of superconductor



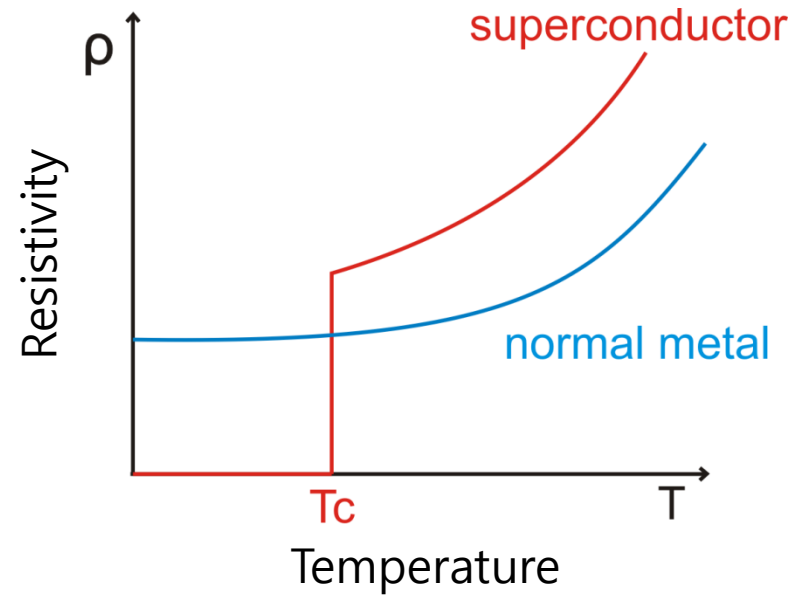
Superconductivity

Meissner Effect

An Example of Invincibility in the Quantum Physics of Superconductivity

ORDINARY CONDUCTOR	SUPERCONDUCTOR
	
In an ordinary electrical conductor, incoherent, disordered electrons allow penetration by an external magnetic field.	In a superconductor, coherent collective functioning of the electrons spontaneously excludes an external magnetic field, and maintains its impenetrable status.

Meissner Effect



Critical temperature of a superconductor

Deirdre Black - 100 years of superconductivity, The Mole

P. Grima-Gallardo et. al. - Superconductivity observation in $(\text{CuInTe}_2)_{1-x}(\text{NbTe})_x$ Alloys with $x=0.5$, Adv. Mat. Sci. & Technol. 2013

Dwi Prananto – Superconductivity, Simpliphy

1.5 Superconductivity

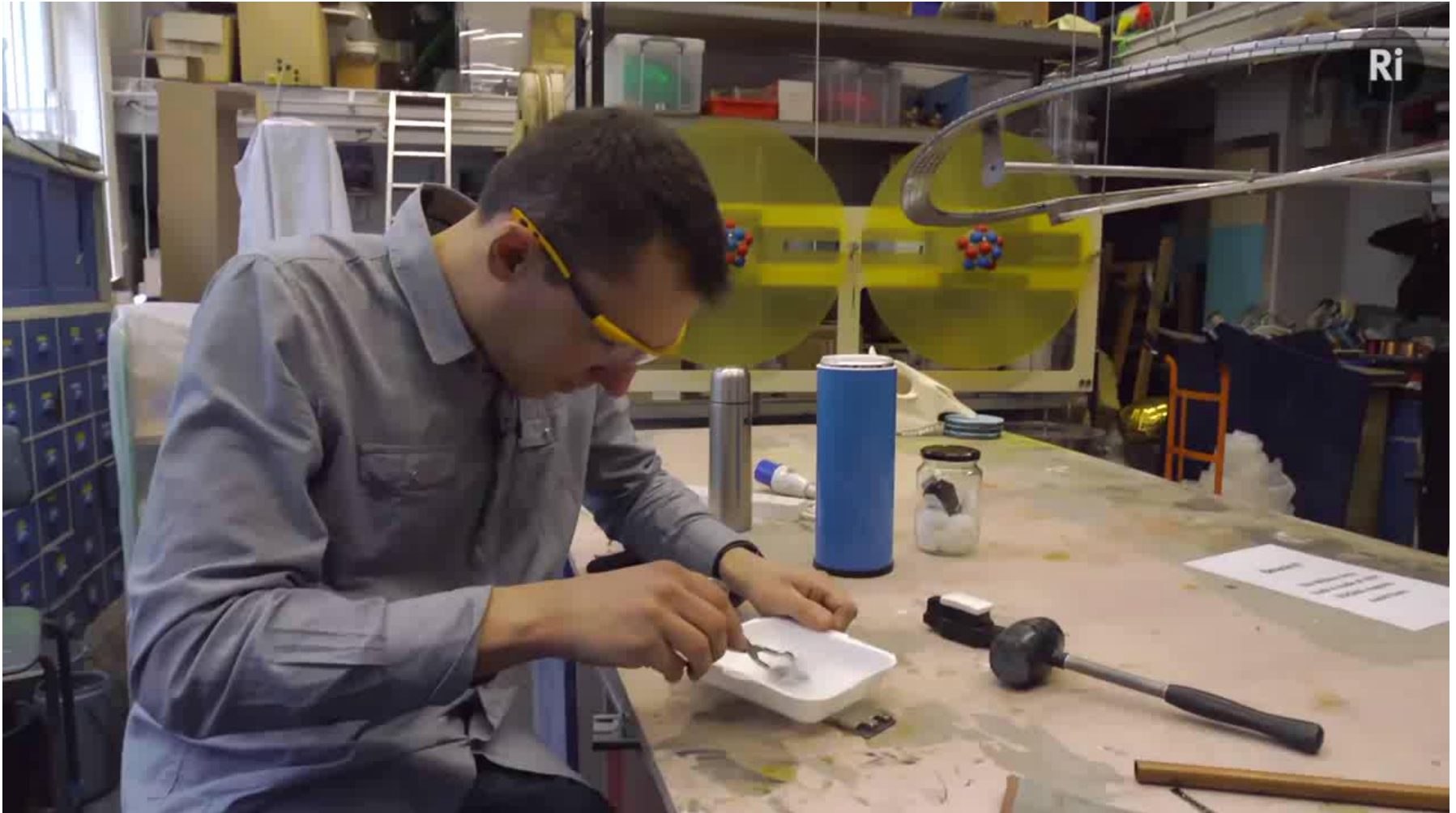
- Magnet levitation train in Incheon (Video 05:00)



ARIRANG NEWS - Korea to operate homegrown maglev train in July
<https://www.youtube.com/watch?v=M4Z7xqoFM6Y>

1.5 Superconductivity

- **Superconductor (Video 05:00)**



The Royal Institution - Levitating Superconductor on a Möbius strip
<https://www.youtube.com/watch?v=zPqEEZa2Gis>

1.6 Magnetic cooling

- **BASF magnetocaloric refrigerator at room temperature**



BASF - Premiere of cutting-edge magnetocaloric cooling appliance
<https://www.youtube.com/watch?v=Py9IaztpKzs>

1.7 Superfluid

- **Superfluid (Video 01:30)**



BBC - Ben Miller experiments with superfluid helium - Horizon: What is One Degree? - BBC Two
<https://www.youtube.com/watch?v=9FudzqfpLLs>

1.8 Other Cryogenic Related

- **Rocket propulsion**



Liquid hydrogen as a rocket fuel

NASA - Setting the Pace
NASA - Fueling of MAVEN's Atlas V Rocket Underway
Design News - Composite Rocket Fuel Tank Will Explore Deep Space



Liquid oxygen as an oxidizer in Atlas V Rocket

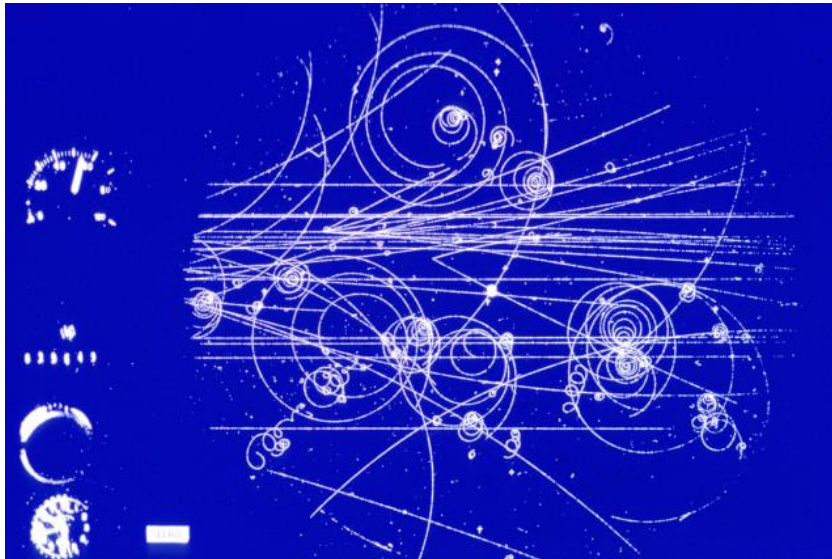


Carbon composite cryogenic fuel tank

1.8 Other Cryogenic Related

- **Studies in high-energy physics**

- The hydrogen bubble chamber uses liquid hydrogen in large particle accelerators.
- The hydrogen bubble chamber is used to detect high-energy particle



The decay of a lambda particle in the 32 cm hydrogen bubble chamber

CERN
age FOTOSTOCK

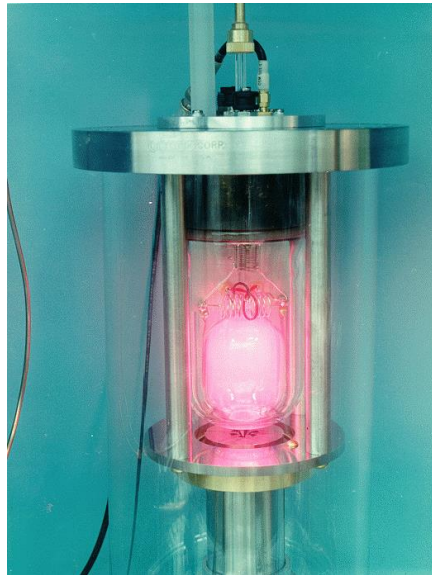


Bubble chamber and a copper RF accelerating device

1.8 Other Cryogenic Related

- **Electronics**

- Electronic device like masers (sensitive microwave amplifiers), SQUIDs (superconducting quantum interference devices) are cooled to liquid nitrogen or liquid helium so that thermal vibrations of the atoms do not interfere with device operation.



Maser

NASA/JPL-Caltech

1.8 Other Cryogenic Related

- **Space simulation and high-vacuum technology**

- To produce a vacuum, one of the more effective methods involves low temperature : **Cryopumping**
- Cryopump traps gases and vapors by condensing them on a cold surface.



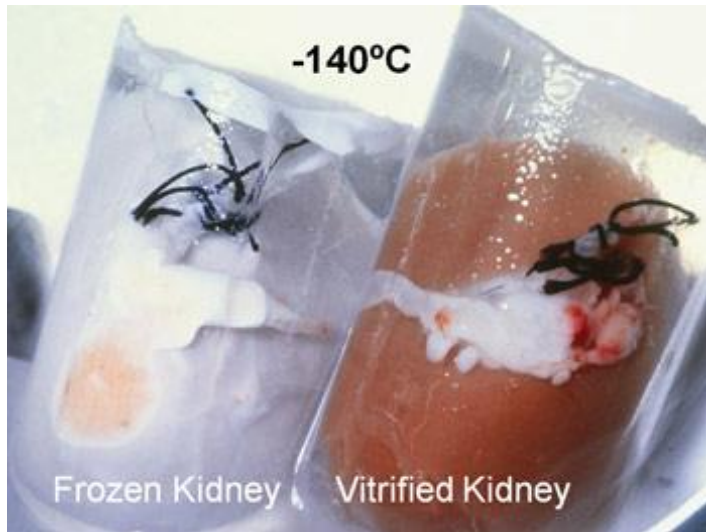
Cryopump

ULVAC CRYOGENICS KOREA INC.

1.8 Other Cryogenic Related

- **Biological and medical application**

- To preserve biological material, the use of cryogenics, **cryobiology** has aroused much interest.
- Cryogenic surgery has been used for many disease.



Frozen kidney



Cryobiology

OSIRISCRYONICS - SUCCESS IN CRYONICS
CRYOBIOLOGY - TEENBIOTECHCRYOBIOLOGY.YOLASITE.COM/