Cryogenics

Spring 2011

Phy 4550 (section 1329)

Phy 6555C (sections 1339 and 8890)

Tuesday/Thursday (5:10 pm to 6:25 pm) Rm 1002 NPB

Right after Physics Colloquium

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352-392-9244 2253 NPB

http://www.phys.ufl.edu/~hitt/

HITT RF Remote Login Procedure:

The radio channel number for this room is "09" (zero, nine).

It is STRONGLY recommended to login your remote for every class just to be sure it is on the correct radio channel and working before class.

1. PRESS AND HOLD THE DOWN ARROW KEY until the GREEN light on the remote turns RED.
2. PRESS THE "0" KEY and you will see the RED light flash GREEN.
3. PRESS THE "9" KEY and you will see the RED light flash GREEN.
4. PRESS AND RELEASE THE DOWN ARROW KEY again and you will see the red light search for the receiver, if it BLINKS GREEN MULTIPLE TIMES you are logged in.

Welcome to the Wonderful World of Cryogenics

HITT student response system practice--

I plan to use this course:

A. To make lots of money

B. To become knowledgeable about the ubiquitous use of cryogenics in the world

C. To become a professional in cryogenics

D. To make liquid nitrogen ice cream

E. All of the above

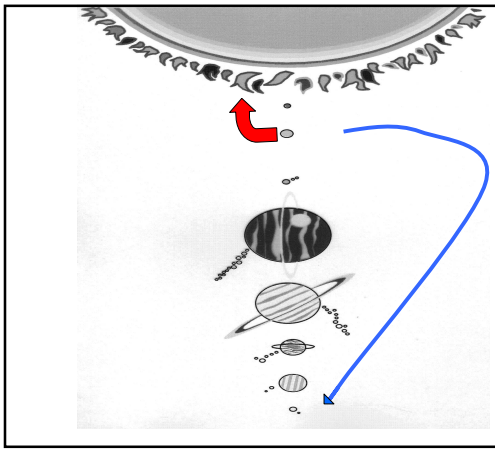
Milestones in Civilization

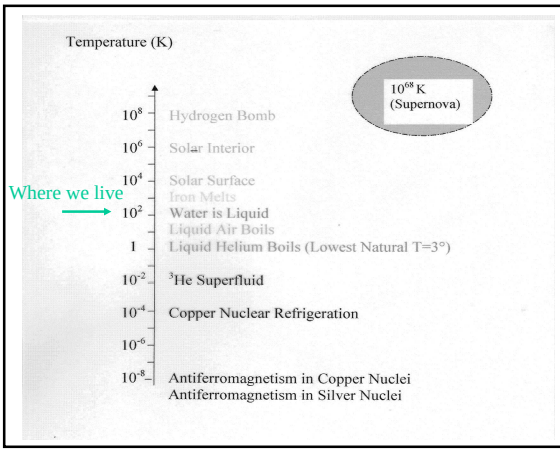
Antoine Laurent Lavoisier

Antoine Laurent Lavoisier, 1743–1794, a portrait by David (Photo Roger-Viollet)

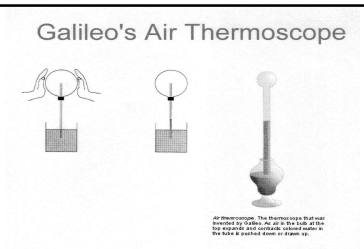
1743–1794

Father of Low Temperature Physics





Galileo's Air Thermoscope



Push the tube into the stopper so that the tube extends about half way into the flask. The flask is then inverted into a beaker of colored water and heated by rubbing your hands together and then holding the flask. As the flask returns to room temperature, the liquid will rise in the tube.

What are the problems with this design?

Ice comes from….

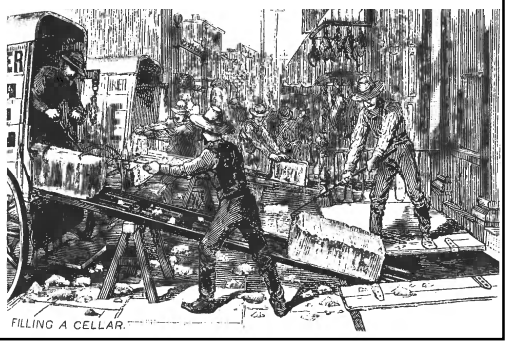
From the Simpsons' featuring the cultivation of ice from the North Pole. When the ice deliveryman arrives at the Quik - E – Mart with his cargo, he says to Apu, "you've got to start charging more than a dollar a bag. We lost four more men on this expedition!" to which Apu replies, "If you can think of a better way to get ice I'd like to hear it."

"If the ice crop was poor, the price rose to the exorbitant rate of $1.25 a pound." In today's dollar this price corresponds to over $150 for a typical 3lb bag of ice (3).

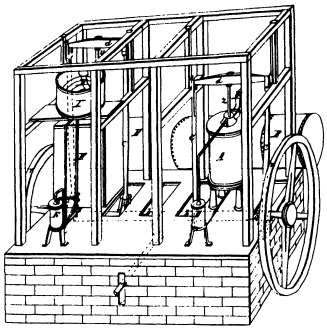
Then

Now

Natural Ice

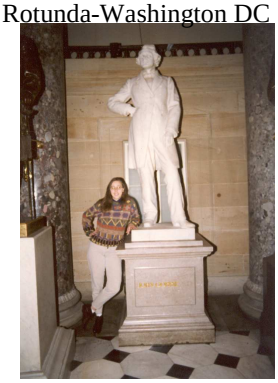


Artificial Ice Machine

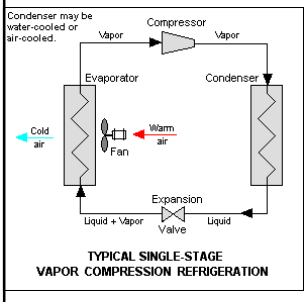


Invented by John Gorrie-1850

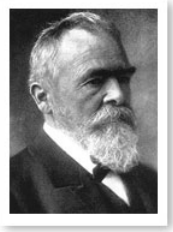
Rotunda-Washington DC



Cold Beer



1873



Carl von Linde

dimethyl ether refrigerant--made Spatenbrau beer

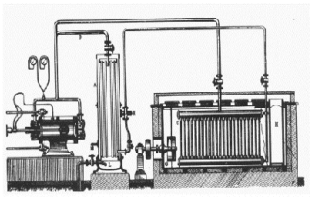
LOX-1877

French

Louis Paul Cailletet

Raoul Pictet

French



Cailletet & Pictet's oxygen liquefaction

Space Shuttle Main Engine

Polish

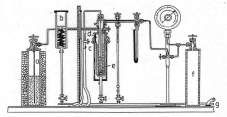


Fig. 3.3. Schematic apparatus by Wróblewski and Olszewski (after ref. 4): a, bottle with liquid ethylene; b, container with Thilorier mixture; c, hydrogen (gas) thermometer; d, glass container with liquid ethylene; e, thick-walled glass capillary where oxygen is condensed; f, steel cylinder with gaseous oxygen (≈60 atm).

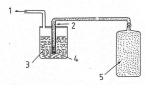
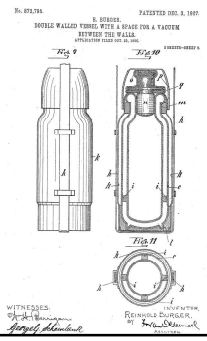


Fig. 3.4. Principle of operation of apparatus by Wróblewski and Olszewski (after ref. 4): 1, conduit to pump; 2, glass tube with reinforced walls; 3, ethylene boiling under reduced pressure (−130 °C); 4, condensed oxygen; 5, steel high-pressure gaseous-oxygen cylinder.

Polish

Dewar Flask

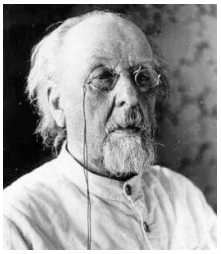
Jules Violle in 1882



Dewar's improvement in 1892?

Vacuum insulation and silvering

Father of Rocketry



Konstantin Tsiolkovsky 1903

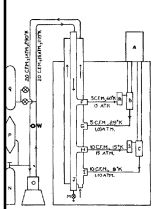
Identified LH_2 and LO_X as the respective fuel and oxidizer of choice, and also suggested use of multi-stage rockets

Liquefaction of helium - 1908

Kamerlingh Onne in Leiden

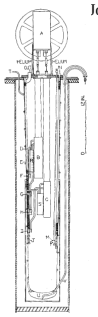
Joule-Thomson Effect

Samuel C. Collins - 1947

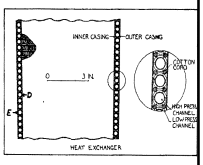


Gas Flow

Cryostat



cross-section



Heat exchanger

Blood Storage and Handling

In 1915, Dr. Richard Weil discovered that refrigeration in conjunction with citration (to prevent blood clotting) allowed for the storage of blood for several days. Until then, blood transfusions needed to be made directly from donor to recipient. Refrigerated "Percipitation" of blood also developed.

Cryogenics and Rocketry

Robert H. Goddard - 1926-41 feet

V2 Rocket Herman Oberth

Werner von Braun

Freon Refrigerants

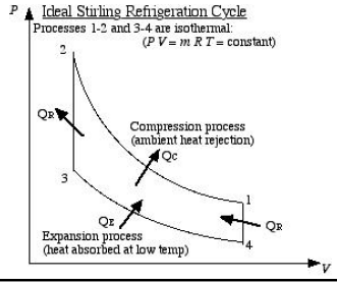
halogenated hydrocarbon

Formerly used toxic refrigerants included ammonia, butane, methyl chloride (or bromide), and sulfur dioxide

Charles Kettering and Thomas Midgle invented the non-toxic freons in about 1935

Cryo-coolers

Based on Sterling engine, first introduced to cryogenics at 1956 Cryogenic Engineering Conference by J.W.L.Kohler



Satellites-1957 and on…

Cryonics

1940: Basil Luyet published "Life and Death at Low Temperatures"

In 1964 Robert Ettinger published *The Prospect of Immortality* promoting the concept of cryonics to a wide audience. Ettinger subsequently founded Alcor Society for Solid State Hypothermia.

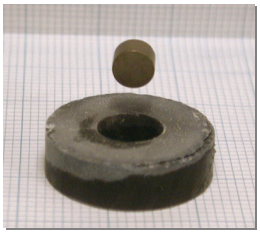
This is a manikin

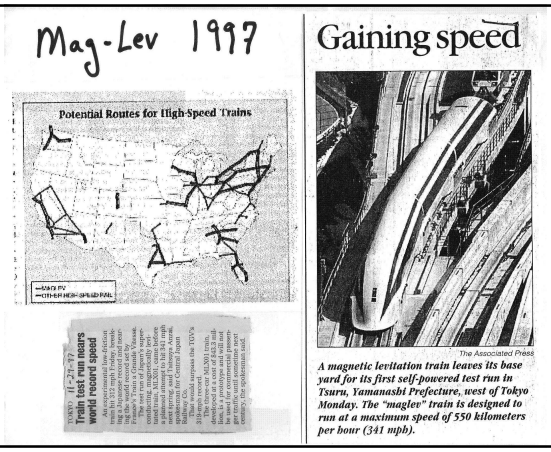
Cryogenics in Creating New Life

Cryo-preserve sperm, oocytes, and embryos

Maglev using Cryogenics

Meisner Effect





What cryogen was used in the manufacture of beer?

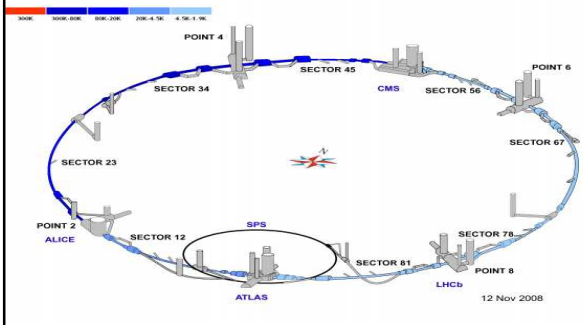
A. Helium
B. Nitrogen
C. Oxygen
D. Neon
★ E. Dimethyl Ether

What was the nationality of the first workers to liquefy Oxygen?

A. USA
B. British
C. French
★ D. Polish
E. Russian

Cryo-Disasters: Life at CERN

Large Hadron Collider



4-6 tons of liquid helium escaped

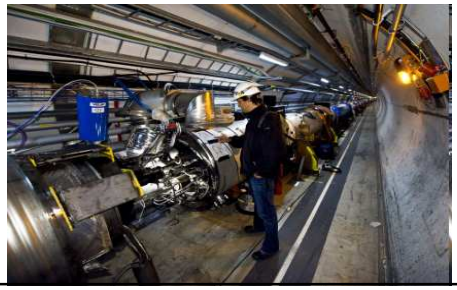
Two of the most severely broken interconnects, which are between the magnets in LHC sectors 3 and 4. The superconducting magnets, used to direct and focus the proton beams in the experiment, are cooled by liquid helium. An electrical fault caused the liquid helium to leak, resulting in a need for repairs that has put the experiment out of action until at least summer 2009.

Magnets weighing 10's of tons moved

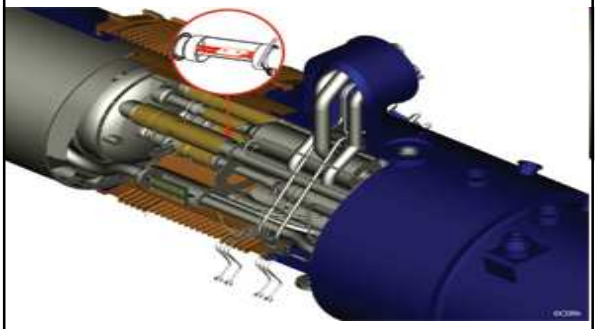
Damage to the support of one of the quadrupole magnets in sectors 3 to 4. The LHC uses quadrupole magnets to focus opposing proton beams, and dipole magnets to keep the beams on their respective paths.

Site of the electrical fault that caused the helium leak. A resistive zone developed in one of the electrical connections, creating an electrical arc that punctured one of the helium enclosures around a magnet, according to an analysis by CERN. The warming helium expanded in the vacuum enclosure of the central subsector of the pipe, damaging the vacuum

barriers separating the central subsector from the neighboring subsectors.



The Fault?



Investigations have shown that a faulty electrical connection between two magnets (shown in red) was the cause of the incident in sector 3-4 of the LHC on 19 September.

Can you bring a computer, i-phone, or droid (phone, not robot) to class?

A. yes
B. no
C. That's asking too much