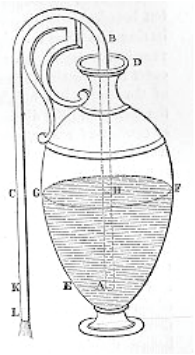
# 1500 – 1649



**Hero of Alexandria writes *Pneumatias* summarizing what is then known about siphons, pumps, etc.**
**c. 150 B.C.E.**
www.history.rochester.edu/steam/hero

**Translated to Italian by Giovanni Aleotti**
**1547**

**Galileo and Santorre Santorro (1561-1636)**
**Independently invent thermoscope for measuring temperature**
**c. 1612**

**Johannes van Helmont (1579-1644)**
**Defines *gas* (Flemish: chaos) to mean an air-like substance distinct from ordinary air**
**1620**

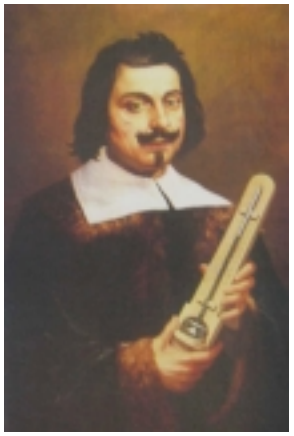
**Galileo Galilei (1564-1642)**
**Measures height limit of overhead water pump**
**1638**

**Otto von Guericke (1602-1686)**
**Produces a vacuum with his air pump**
**c. 1640**

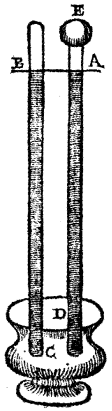
**Rene Descartes (1596-1650)**
**Suggests that a vacuum cannot exist.**
***Principa Philosophiae* 1644**

**Gasparo Berti (c. 1600-1643)**
**Produces vacuum (in water barometer)**
**c. 1640**

**Ferdinand II, Grand Duke of Tuscany**
**Liquid-in-glass thermometer**
**1641**



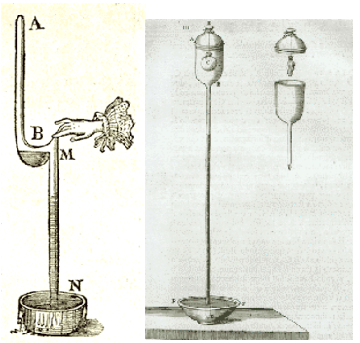
**Evangelista Torricelli (1608-1647)**




**Torricelli**
**Mercury barometer**
**1643**

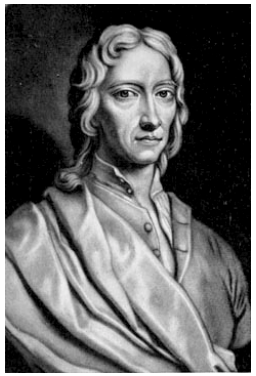
**Torricelli substitutes mercury for water in overhead pump**
**1644**

**Blaise Pascal (1623-1662)**
**Puy de Dôme Experiment.**
**Florin Perrier showed that the height of the column in a mercury barometer decreased with altitude, confirming the prediction of Pascal (his brother-in-law)**
**1648**

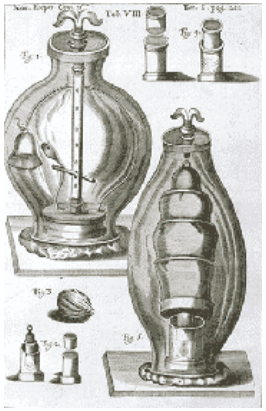



**Gilles Personne de Roberval (1602-1675)**
**Void within a void and expanding bladder experiments**
**1648**

# 1650 – 1699



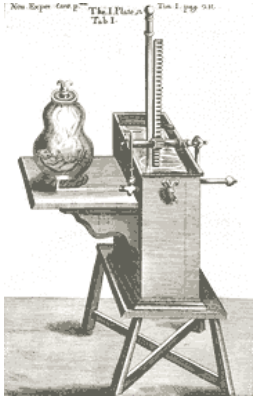
Robert Boyle
(1627-1691)
http://www.bbk.ac.uk/boyle/

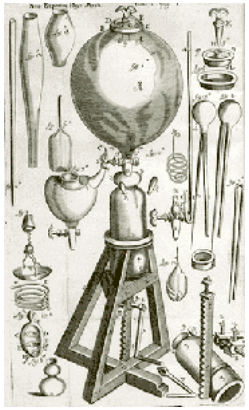


Boyle's bell within a vacuum
1660

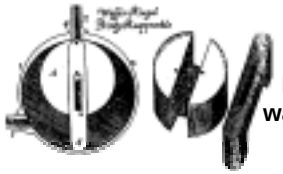
Otto von Guericke
Magdeburg hemisphere demonstration
1654

Richard Townley (1628-1607) and Henry Power (1623-1668)
Experimentally establish pressure-volume relation (Boyle's or Mariotte's Law)
1660





Boyle publishes *New Experiments Physio-Mechanical, touching on the Spring of Air and its Effects*
1660



Prince Rupert's water pump
1650

Von Guericke's air pump
1672

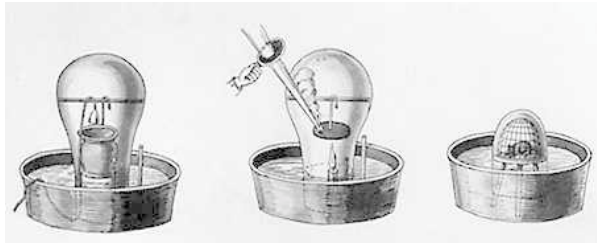


Otto von Guericke
(1602-1686 )
Treatise on vacuum experiments
1672

Franciscu Linus (1595-1675)
In response to Boyle's ideas, suggest the properties of a vacuum is due to invisible thread-like *funiculus* that strive to hold nearby objects together
1660

Boyle's Law for compression o f gases
1661

Jean Picard
(1620-1682)
Observes *barometric light*, a glow discharge induced by static electricity when a mercury barometer is shaken
1675



Mayow apparatus, c.1669

John Mayow (1641-1679)
Suggests that air may consist of two different gases
1674

Edmé Mariotte
(c.1620-1684)
Independently publishes relation between pressure and volume in *On the Nature of Air*
1676

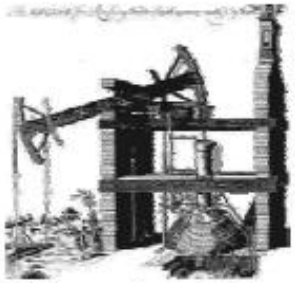
George Ernst Stahl
(1660-1734)
Proposes *phlogiston* as the agent of burning and rusting
1697

# 1700 – 1749

Hawksbee
air pump
1704

Francis Hauksbee the elder
(1666-1713)
Demonstrates that sound is not transmitted in a vacuum
1705

Daniel Bernoulli
(1700-1782)
First truly statistical treatment of kinetic theory of gases
1728-1733
Writes *Hydrodynamica* introducing concept of gas viscosity
1733-1738



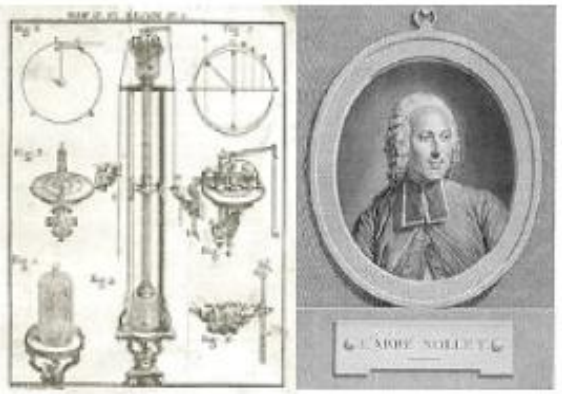
Thomas Newcomen
(1663-1729)
'Beam Engine' driven by partial vacuum produced by condensing steam
1712

Daniel Gabriel Fahrenheit
(1686-1736) Germany
Invents mercury thermometer standardized with ice and boiling water
1714

Jacob Hermann
(1678-1733)
Postulates that pressure is proportional to density and to the square of the average velocity of the particles in motion
1716

Anders Celsius
(1701-1744)
Suggests a new temperature scale
1742

Carl von Linné (1707-1778)
Revises Celsius scale
1745



Jean-Antoine Nollett (1700-1770)
Describes falling bodies in a vacuum experiment
1743

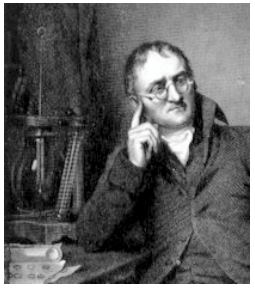
***Experiment on a Bird in the Air Pump***
**Joseph Wright of Derby (1734-1797)**
National Gallery, London

# 1750 – 1809

John Smeaton
(1724 -1792 )
Improved air pump and
"Pear" vacuum gauge
1/1000 atm
1751

Jacques A. C. Charles
First manned hydrogen-filled
balloon flight
December 1783

Jacques-Alexander César Charles
(1746-1823)
Establishes that for a given
temperature change, different gases
expand the same amount
Charles' Law
1787



John Dalton
(1766-1844)
Dalton's Law of Partial Pressures
Each gas in a gaseous mixture
exerts the same pressure that it
would if it were alone in the same
container at the same temperature
1801

William Watson
(1715-1787)
Studies static electrical
discharges in
Torricellian vacuum
1752

Edward Nairne
(1726-1806)
Studies electrical
discharges in vacuo
1777

Henry Cavendish
(1731-1810)
Discovers Hydrogen
1766

Phlogiston
theory
abandoned
1791

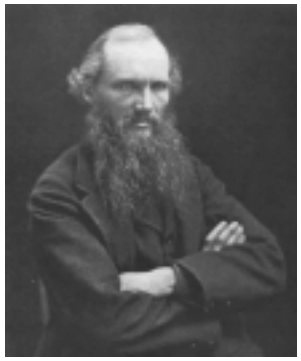
Joseph Louis Guy-Lussac
(1778-1850)
Gay-Lussac's Law
At a given pressure, the change in
volume is proportional to the change
in temperature
1802

# 1810 – 1851

**Amedeo Avogadro**
**(1776-1856)**
**Avogadro's Law**
**All gases have the same number of molecules in a given volume at a specific temperature and pressure**
**1811**

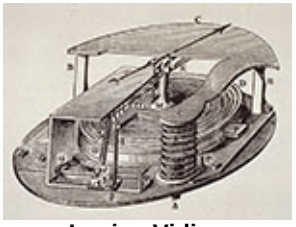
**Humphrey Davy**
**(1778-1829)**
**Studies electrical discharges in vacuo**
**1821**

**Michael Faraday**
**(1791-1867)**
**Reports on studies of gas discharges**
**1838**



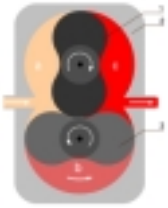
**William Thomson**
**(Lord Kelvin)**
**(1824-1907)**
**Suggests absolute temperature scale**
**1848**

**Heinrich Daniel Ruhmkorff,**
**(1803-1877)**
**Induction coil used in Geissler and Crookes tube experiments**
**1851**

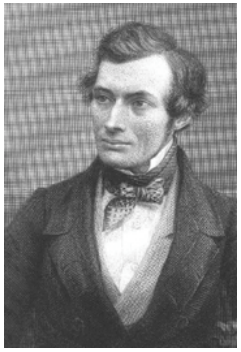


**Lucien Vidie**
**(1805-1866)**
**Aneroid barometer**
**1843**

**Isaiah Davies**
**Rotary-lobe pump**
**(Roots pump)**
**1848**



**Vacuum still for concentrating sugar solutions**
**Edward Howard**
**1812**



**Thomas Graham**
**(1805-1869)**
**Laws of diffusion and effusion of gases**
**c. 1829**

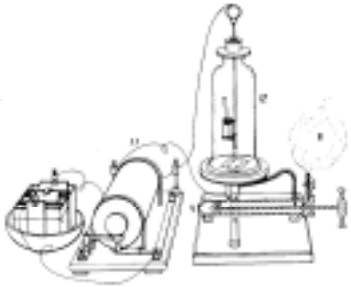
**Pneumatic passenger train operated in Ireland**
**1840s**

**John James Waterston**
**(1811-1883)**
**Introduces concept of Mean Free Path**
**1843**

**Eugène Bourdon**
**(1808-1884)**
**Bourdon-tube pressure gauge**
**1849**

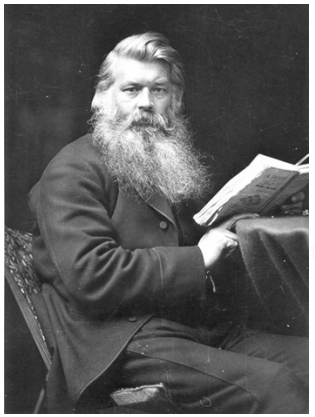
# 1852 – 1860

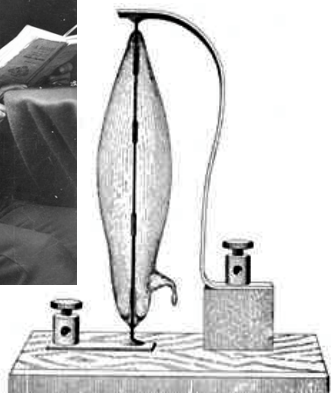
William Robert Grove
(1811-1896)
First description of sputtering phenomenon
1852



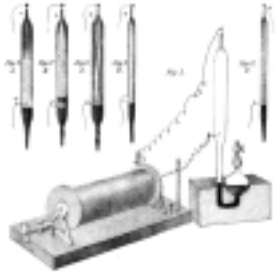
Grove's experimental apparatus

Rudolf Clausius
(1822-1888)
Introduces concept of Mean Free Path of a diffusing particle
1858





Joseph Wilson Swan (1828-1914)
Patents carbon incandescent lamp that operates in partial vacuum
1860



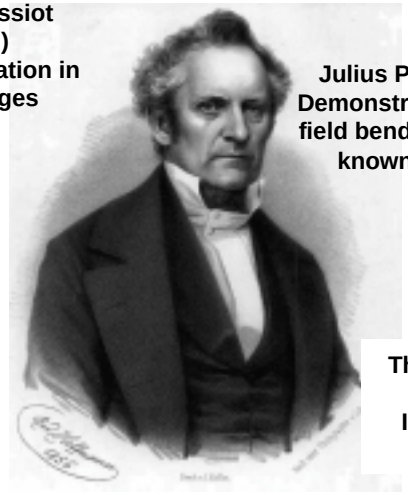
Karl Kronig
(1822-1879)
Suggests that gas molecules
in equilibrium travel in straight linesunless they collide with something
1856

John Peter Gassiot
(1797-1877)
Studies stratification in glow discharges
1858

Josiah Latimer Clark
Vacuum Pneumatic Tube Message System
New York City
1854

Johann Heinrich Wilhelm Geissler
(1814-1879)
Develops Geissler mercury vacuum pump, constructs the first practical vacuum discharge tubes (Geissler tubes), invents platinum-to-glass hermetic seal
1855

Michael Faraday
Reports on thermal vaporization of metals in a vacuum
1857



Julius Plücker (1801-1868)
Demonstrates that a magnetic field bends what later became known as cathode rays
1858

The brothers Philander and Francis Roots
Invent Roots water pump
1859