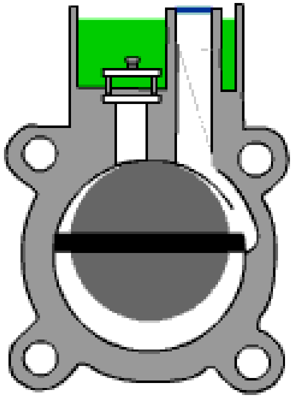
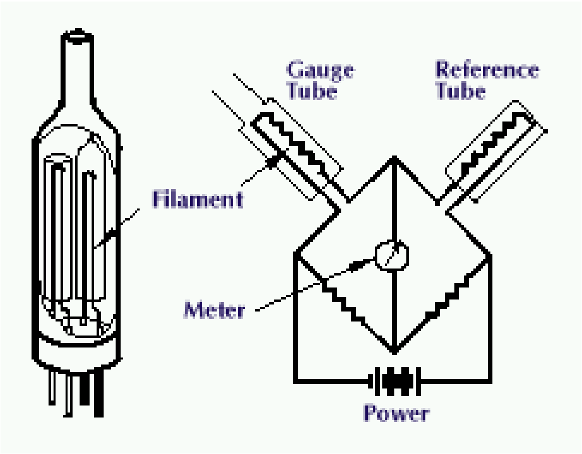
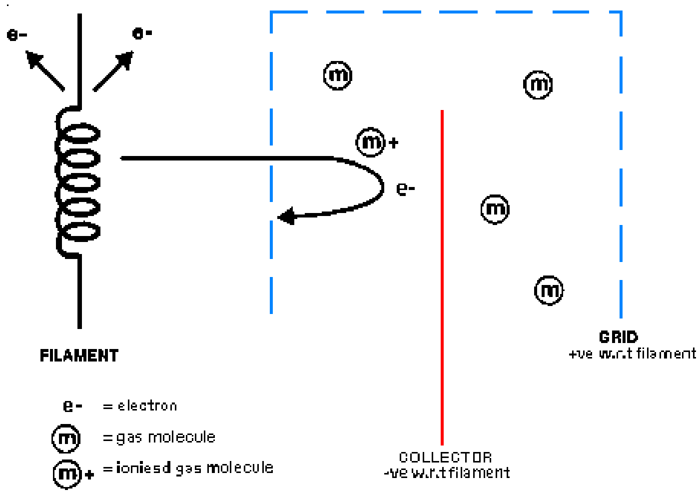
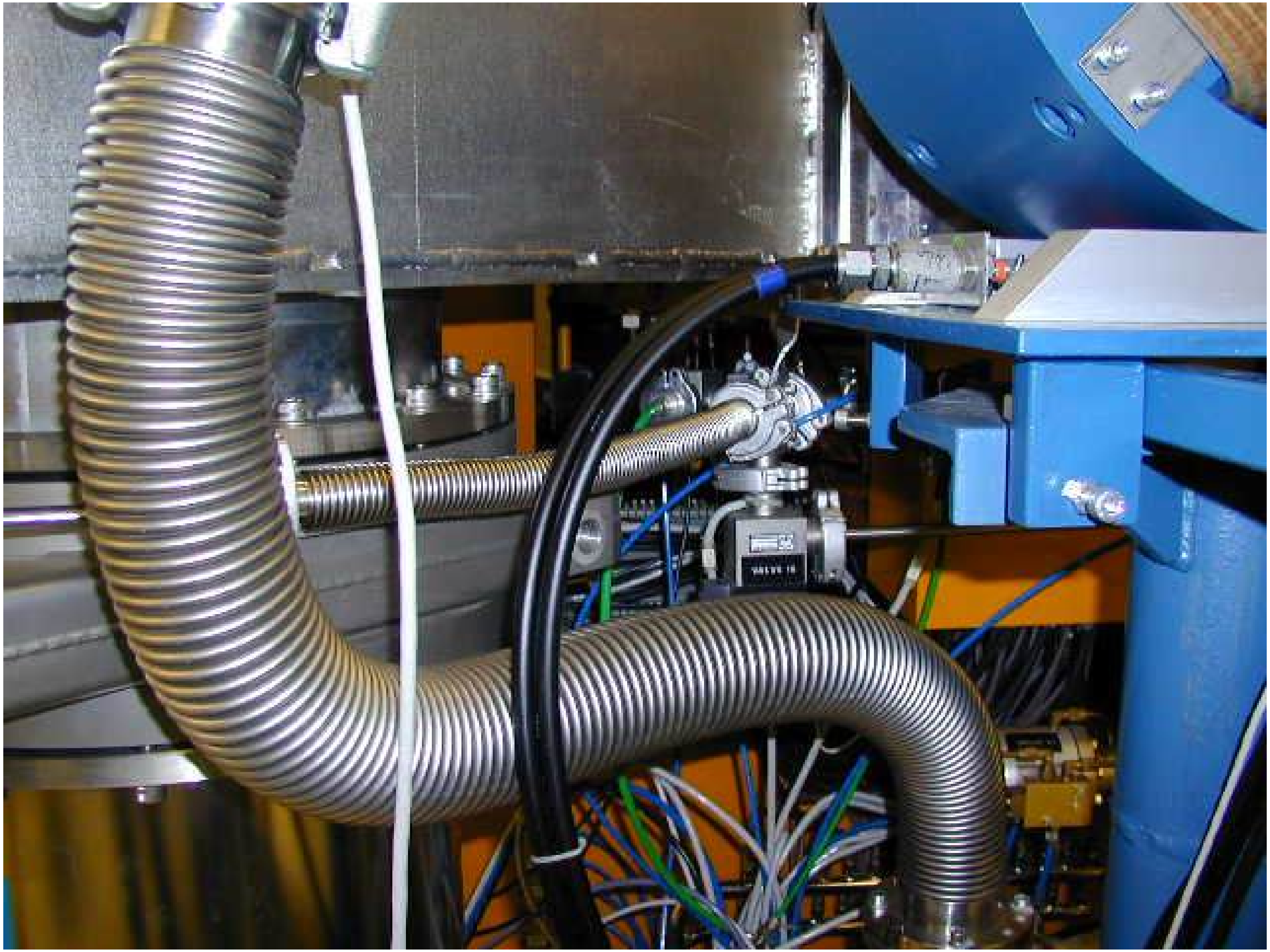
Vacuum equipment



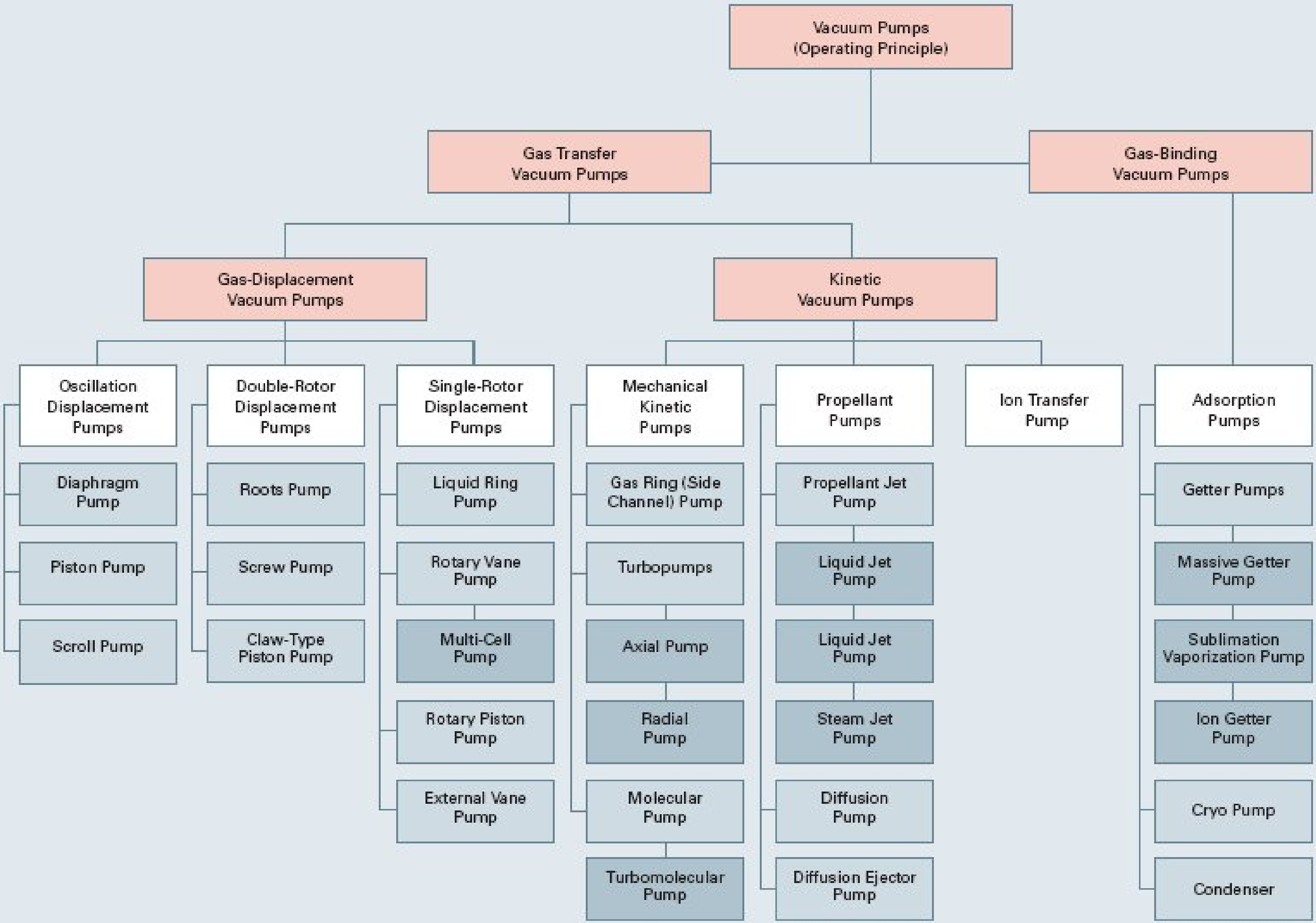

Gauge Tube
Reference Tube
Filament
Meter
Power


e-
e-
e-
FILAMENT
GRID
+ve w.r.t filament
e- = electron
m = gas molecule
m+ = ioniesd gas molecule
COLLECTOR
-ve w.r.t filament



Pumps

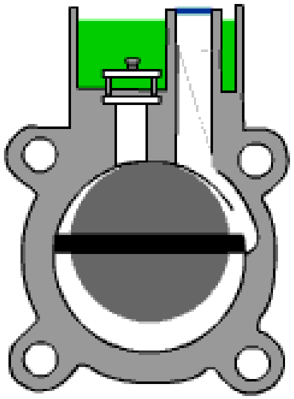
- Rotary vane pumps
- Rotary piston pumps
- Roots pumps
- Scroll pumps
- Turbo molecular pumps
- Diffusion pumps
- Getter pumps
  - Sublimation pumps
  - Non-evaporable getter pumps
- Ion pumps
  - Electrostatic pumps
  - Sputter-Ion pumps
- Cryogenic pumps



Courtesy of Pfeiffer

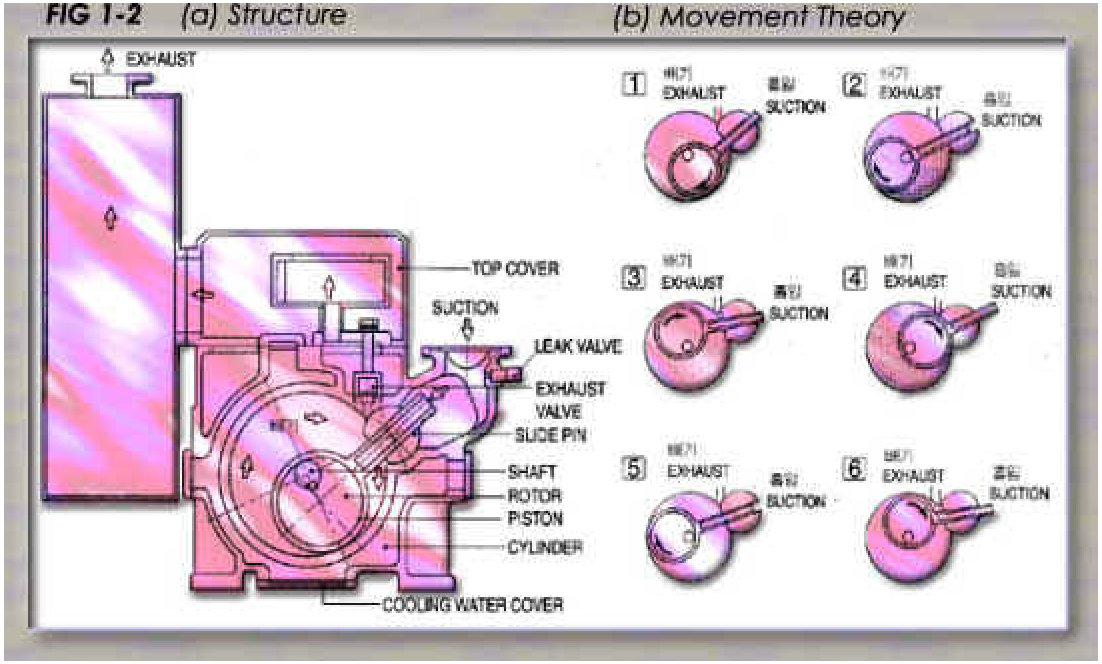
Rotary vane pumps

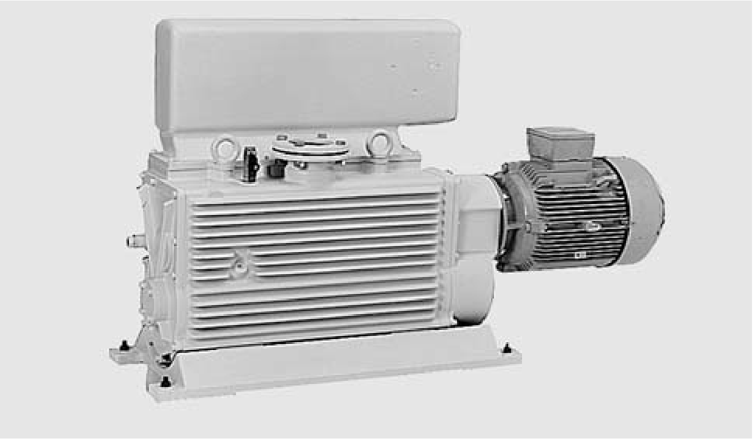
- Pressure range 1 to 10^5 Pa
- 10 to 200 m^3/h
  - Rough pumping
  - Backing for diffusion and turbo pumps



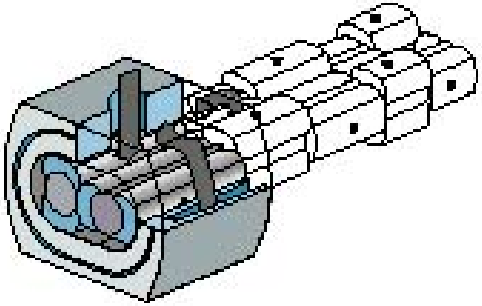
Rotary piston pumps

- Roughing pumps
- In combination with Roots
- 30 to 1500 m^3/h
- Rugged and simple

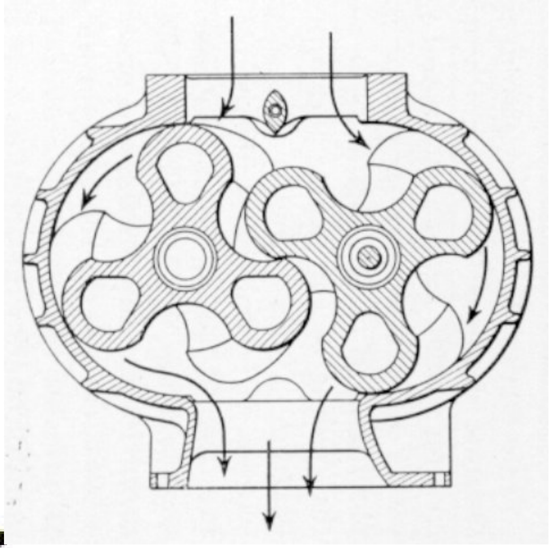




Roots pumps



- Positive displacement blower
- 3000 to 3500 rpm
- Two lobed rotors on parallel shafts
- Pumping speed: n x 100 m^3/h

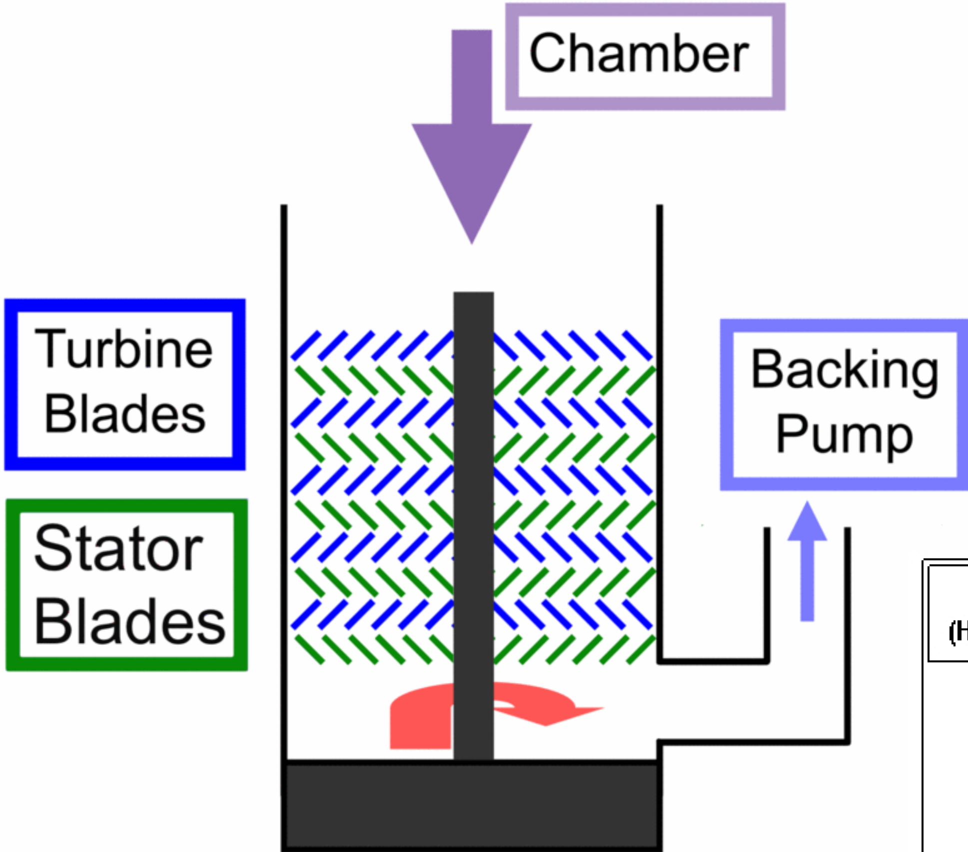


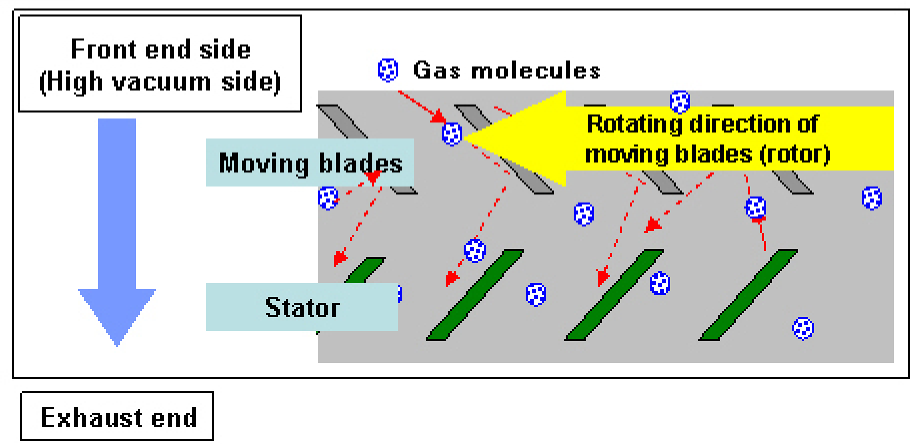
Scroll pump

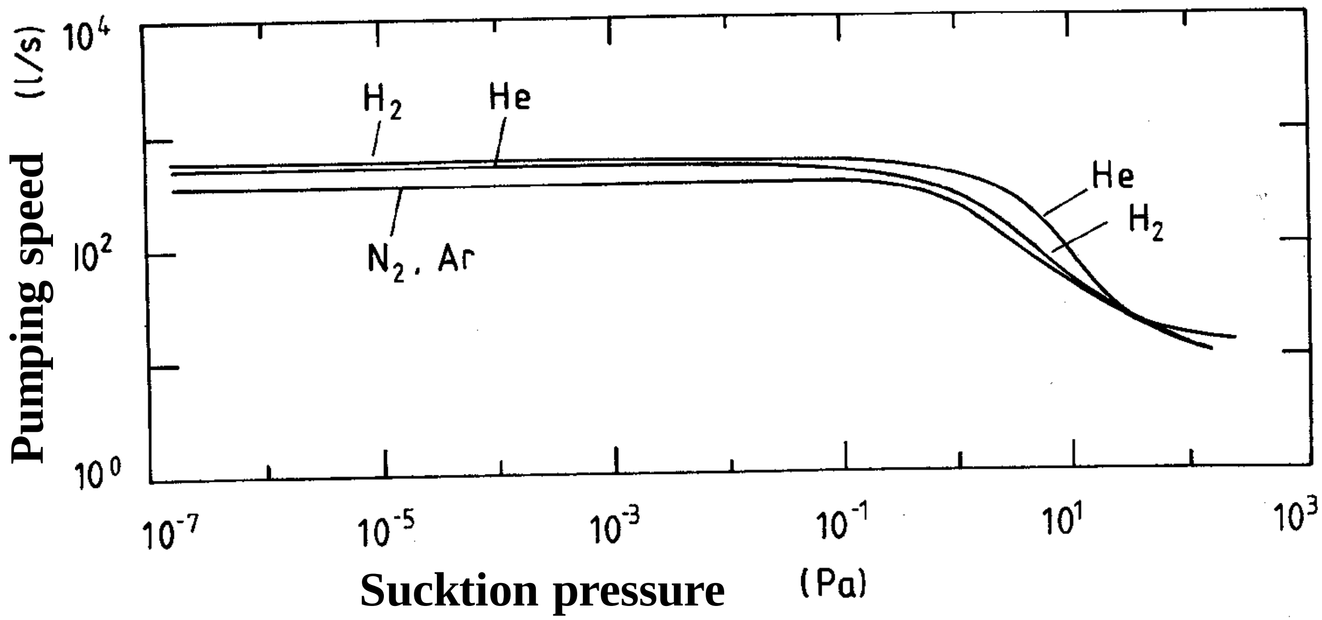
- Oil free (dry)
- Tens of m^3/h
- Down to 10^{-2} mbar

Turbo pumps

- High speed turbine
- Down to 10^{-8} Pa
- Vane speed higher than molecular speed
  - 100 – 500 m/s
  - Momentum transfer


Chamber
Turbine Blades
Stator Blades
Backing Pump

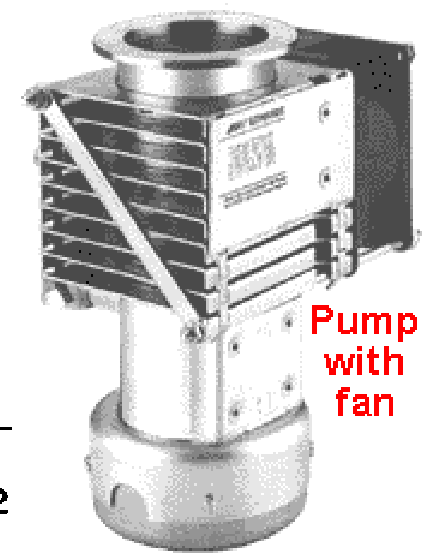

Front end side
(High vacuum side)
Gas molecules
Rotating direction of moving blades (rotor)
Moving blades
Stator
Exhaust end

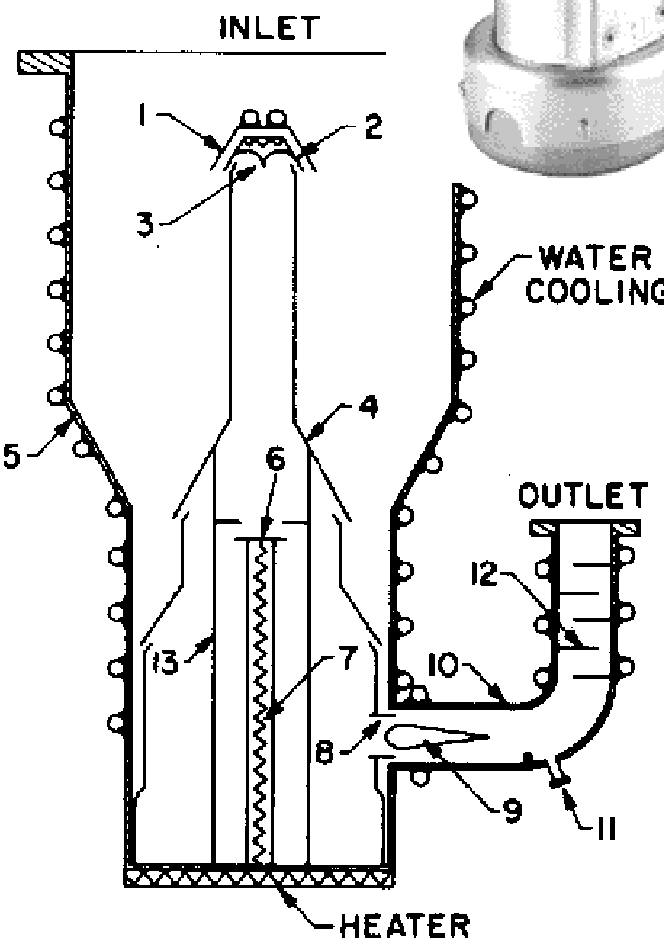


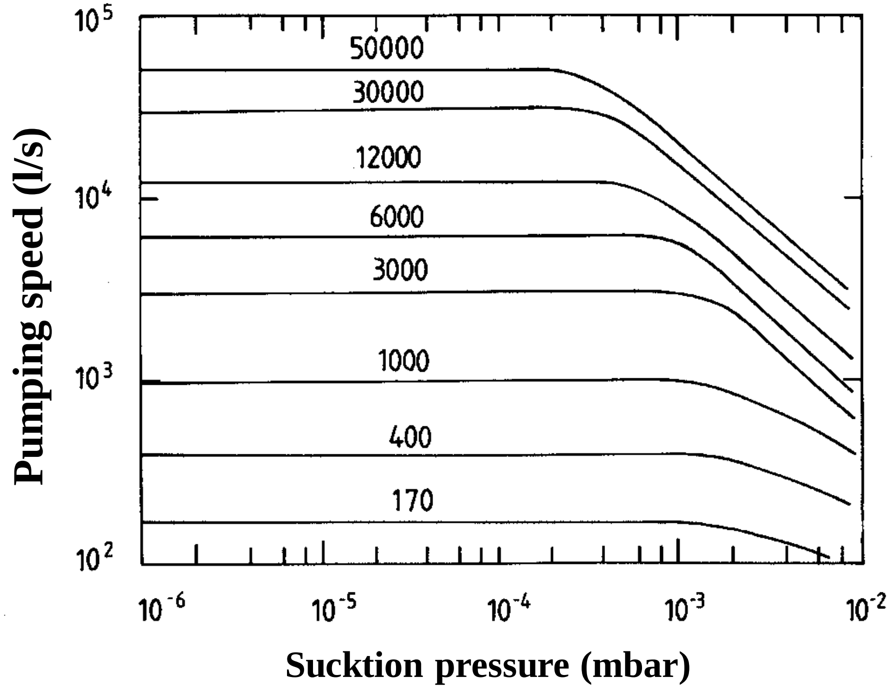
Pumping speed of a turbopump for different gases as a function of inlet pressure

Diffusion pumps

- Vapor jet
  - Momentum transfer on oil collision with the vapor stream
- Ultimate pressure 10^{-10} Pa







Pumping curves for a diffusion pump as a function of inlet pressure. Pumping speed for dry air has been marked for the curves

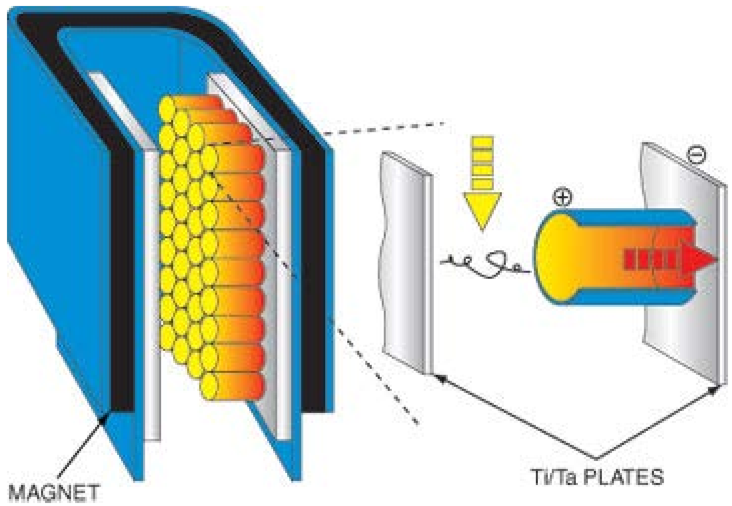
Getter pumps

- Gas molecules collide and react with the surface
- Sublimation pump is a surface getter pump for active gases
  - Titanium: inexpensive, effective, easily sublimed
- Non-evaporable getter
  - Pump by surface adsorption followed by bulk diffusion
  - High temperatures

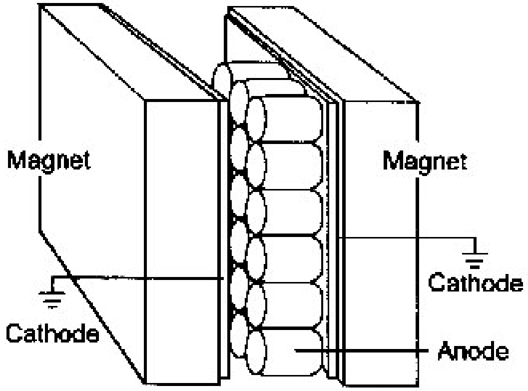
The first titanium sublimation getter pump has been assembled and is being tested in the PBFA-II Integrated Test Facility

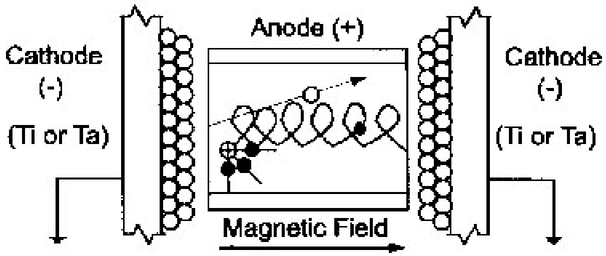
Ion pumps

- Ions are pumped easily because they are more reactive with surfaces than neutral molecules
  - Bombarding electrons



- The pump is started by applying high voltage between the tube shaped anode and the cathode of the ion pump.
- Electrons are accelerated toward the positive anode and are forced to follow a spiral path in the tube shaped anode because of the magnetic field.
    - This has the effect of sweeping out more space and increasing the probability that an electron will collide with a gas molecule.
- The positive ions that are formed in the collisions strike the chemically active titanium cathode "getter" plate.
- The ions combine with the cathode material and eject more cathode material which ends up on the surface of the anode.
    - This constantly replenishes the film of chemically active cathode material on the anodes which combines with active gas molecules and effectively pumps them from the system. This process of removing **chemically active gasses** such as Nitrogen, Oxygen, and Hydrogen is called "gettering".





Inert gasses are handled a little differently. They are buried in the pump surfaces. This happens when they are ionized and hurled into the cathode. They penetrate a few layers and bury themselves in the cathode lattice structure. They can be re-emitted when other ions strike the surface so they tend to collect where there is little of this "sputtering" going on.

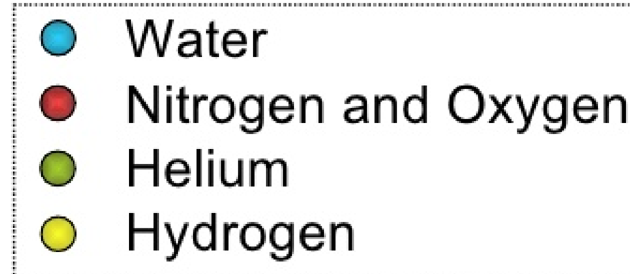
Cryogenic pumps

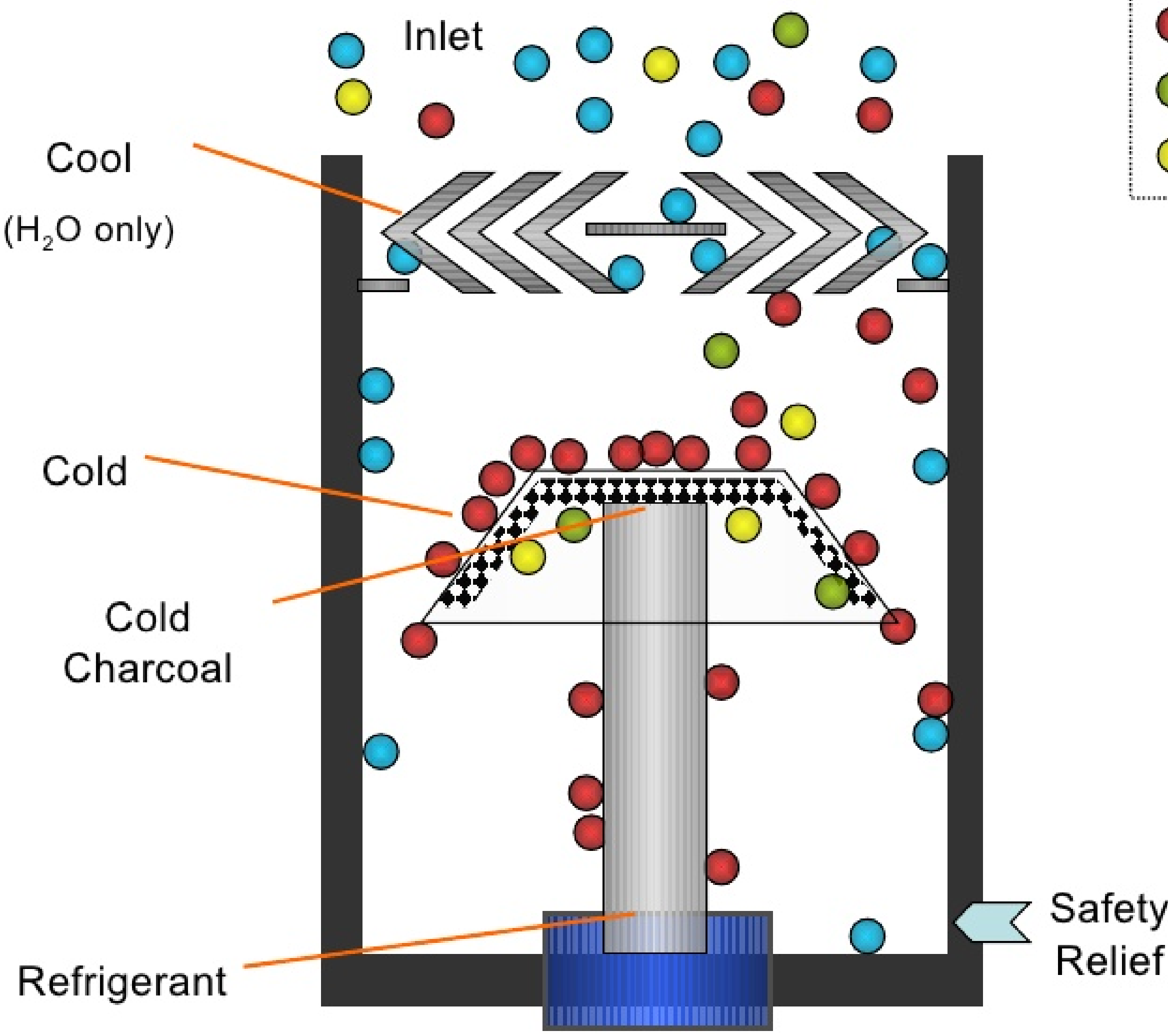
- Entrainment of molecules on a cooled surface by weak van der Waals or dispersion forces
- In principle, any gas can be pumped, provided that the temperature is low enough
- Cryocondensation, cryo sorption and cryotrapping
- Down to 10^{-9} mbar


CTI-CRYOGENICS

How do we get the gas out of the space?

Cryo-pump design and performance

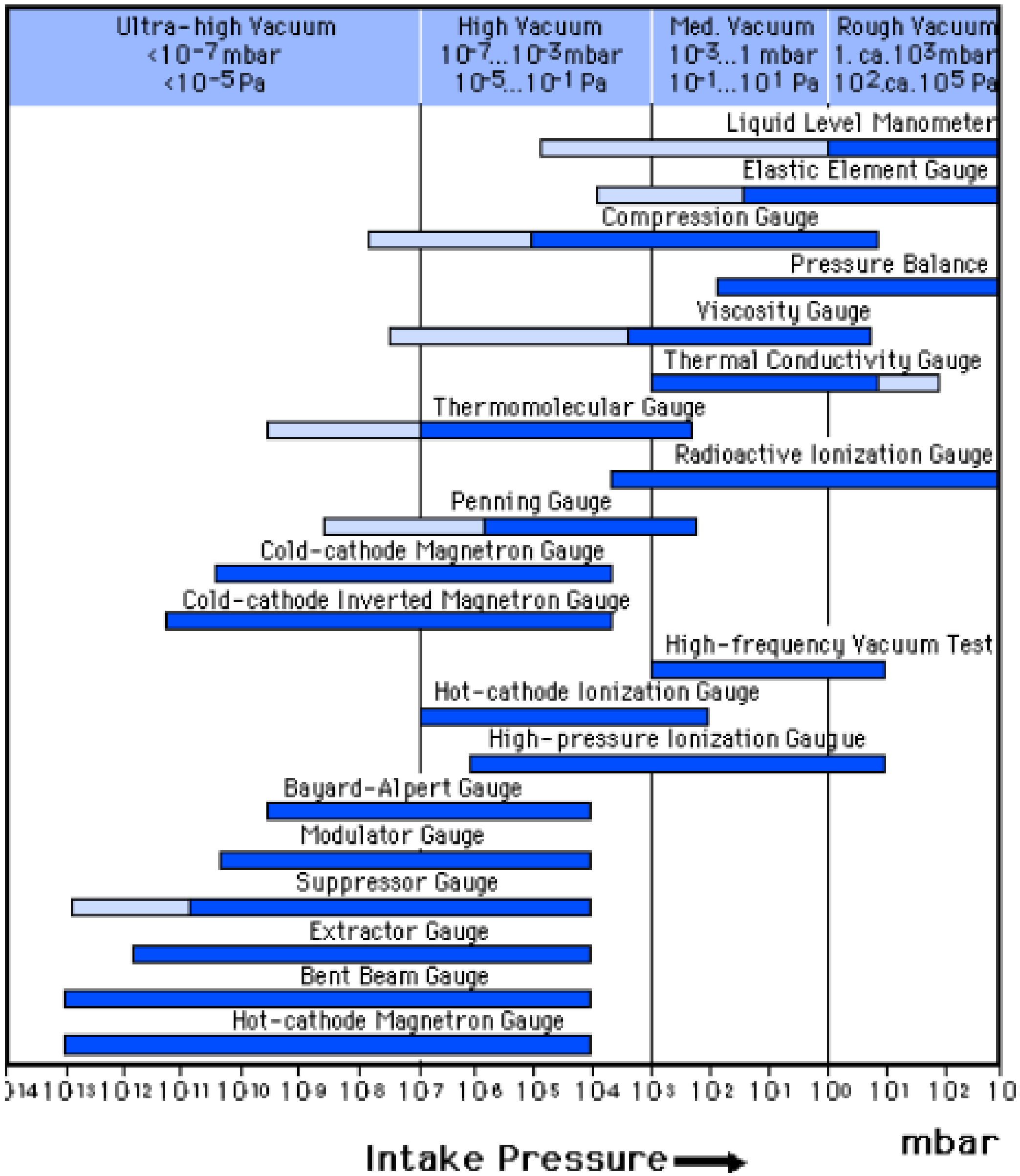


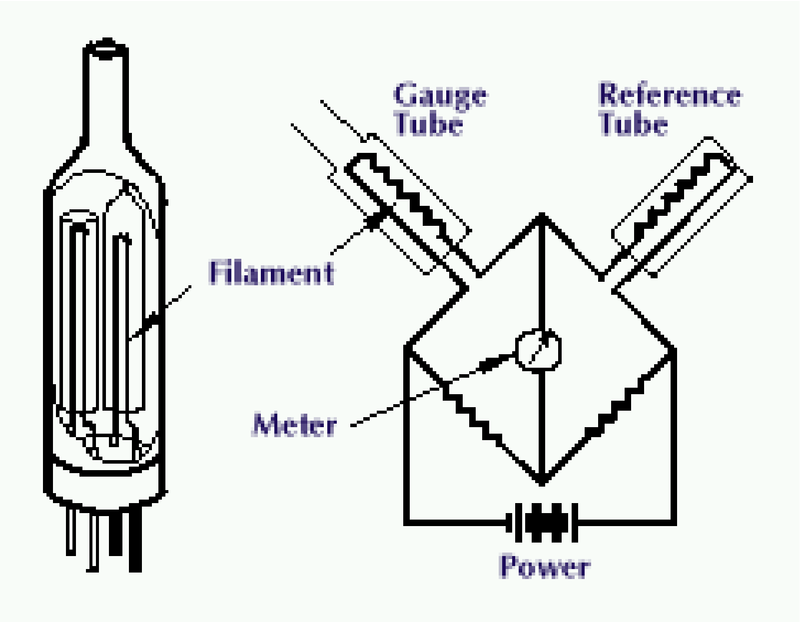


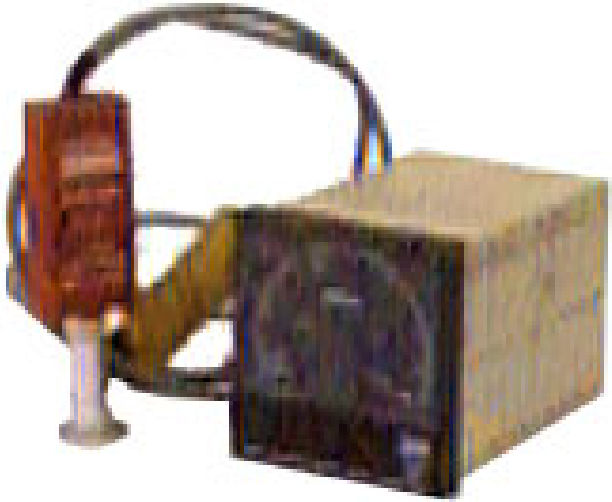
Cryopumps usually consist of two internal stages

- The inlet array
  - 65 -100 K.
  - pumps or captures water vapor
- The second stage consists of a series of metal pumping surfaces
  - 10 - 20 K
  - pumps gases such as nitrogen and argon
- The metal pumping surfaces are partially covered with charcoal granules
  - Gases such as hydrogen and helium, which cannot be frozen at typical second-stage temperatures, are adsorbed by the charcoal granules and thereby removed from the vacuum chamber

Working Pressure Ranges of Vacuum Gauges

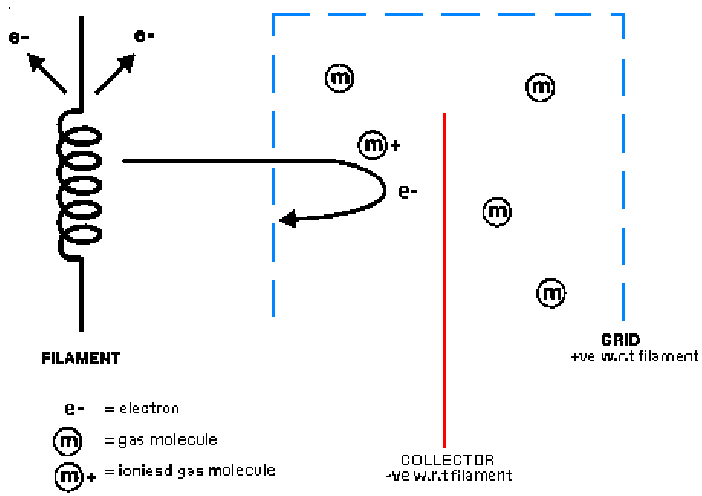






Pirani

- Thermal conductivity gauge
- Heated wire forms one arm of a Wheatsone bridge
- Down to 10^{-3} Pa with a compensating tube



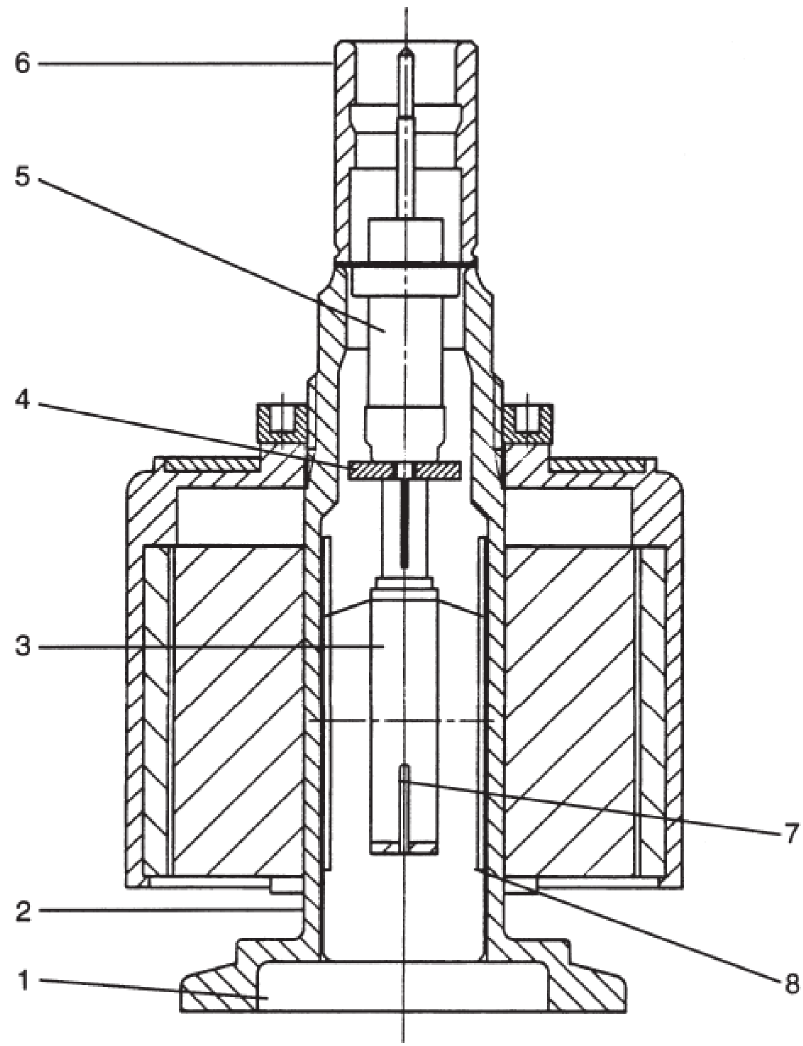
Penning

- Cold cathode tube
- Magnetic field guides electrons: more effective ionization of residual gas
- Down to 10^{-8} Pa
- Pressure by measuring current

$$i_+ = kP^n$$

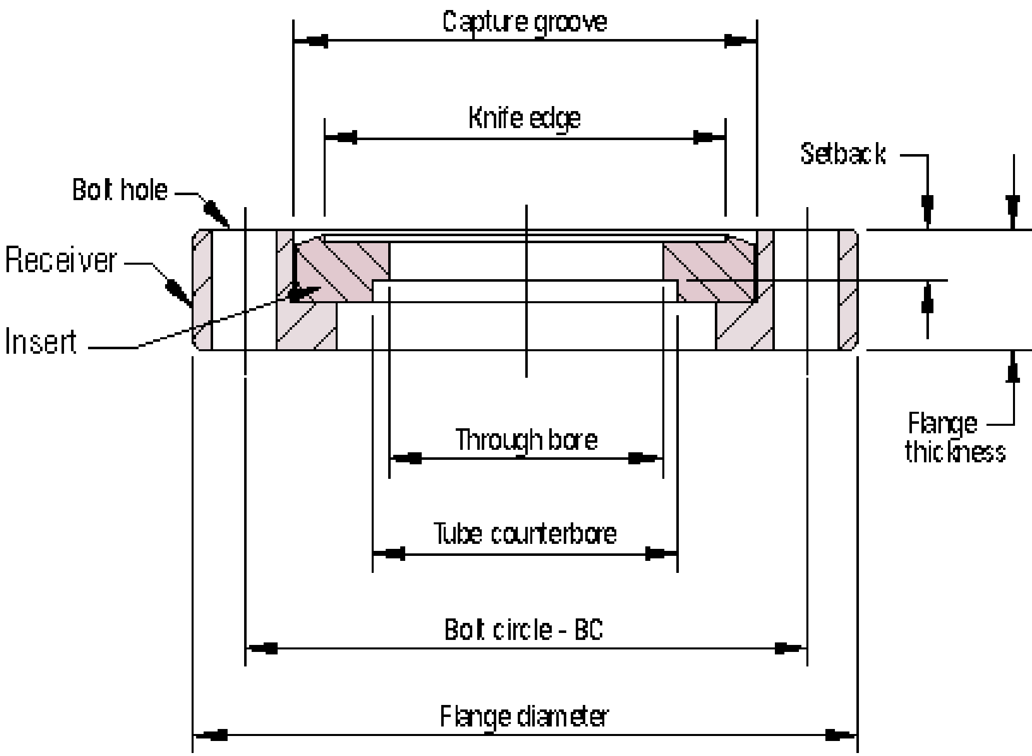
Gauge constant (k)

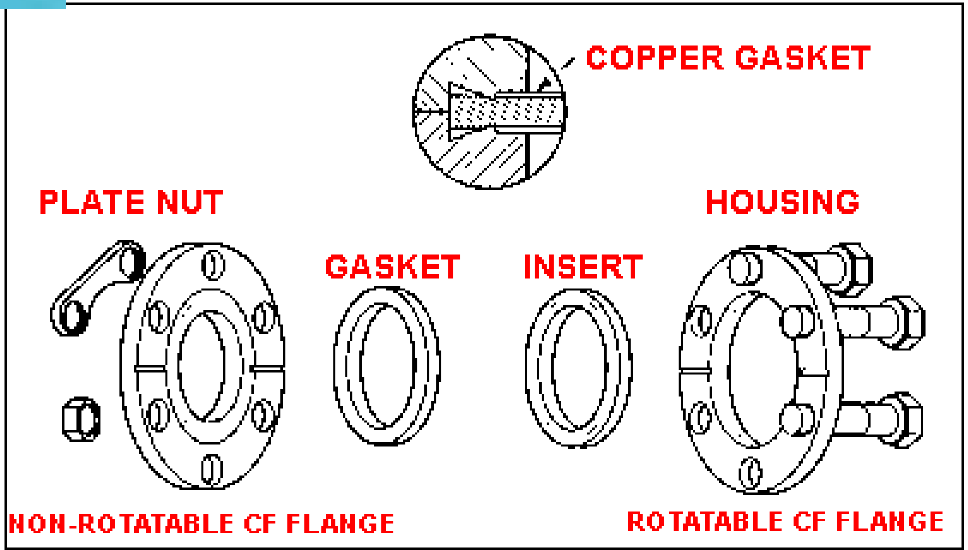
1.1 – 1.4 (n)



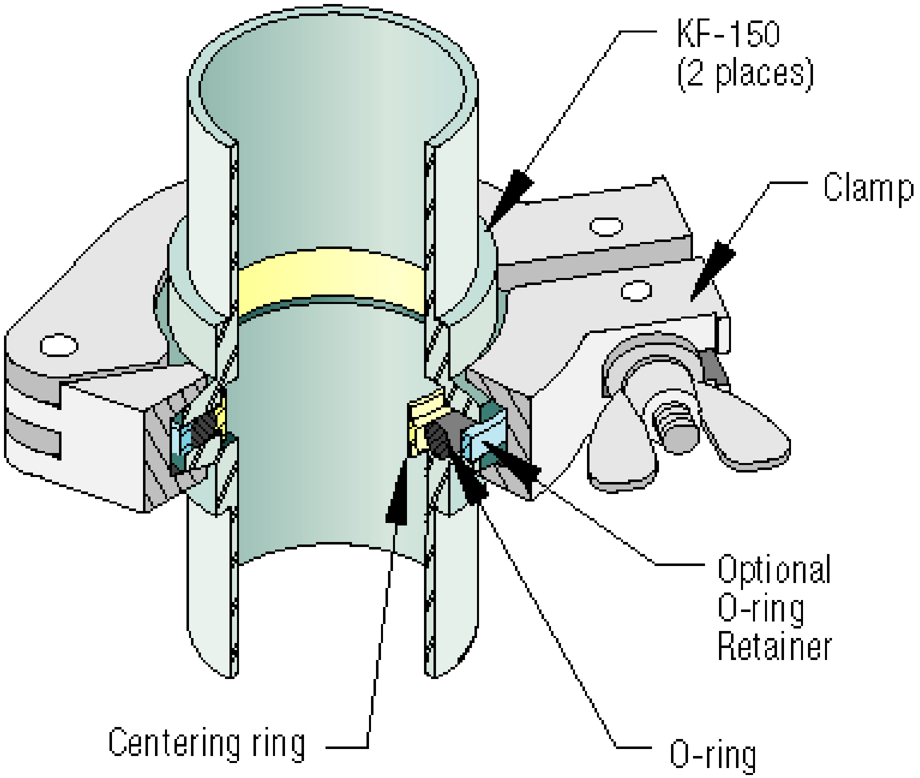
1 Small flange DN 25 KF; DN 40 KF
2 Housing
3 Ring anode with ignition pin
4 Ceramic washer
5 Current leadthrough
6 Connecting bush
7 Anode pin
8 Cathode plate

CF

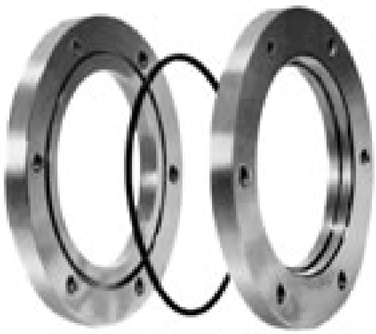

Capture groove
Knife edge
Setback
Bolt hole
Receiver
Insert
Through bore
Tube counterbore
Bolt circle - BC
Flange diameter
Flange thickness


COPPER GASKET
PLATE NUT
HOUSING
GASKET
INSERT
NON-ROTATABLE CF FLANGE
ROTATABLE CF FLANGE

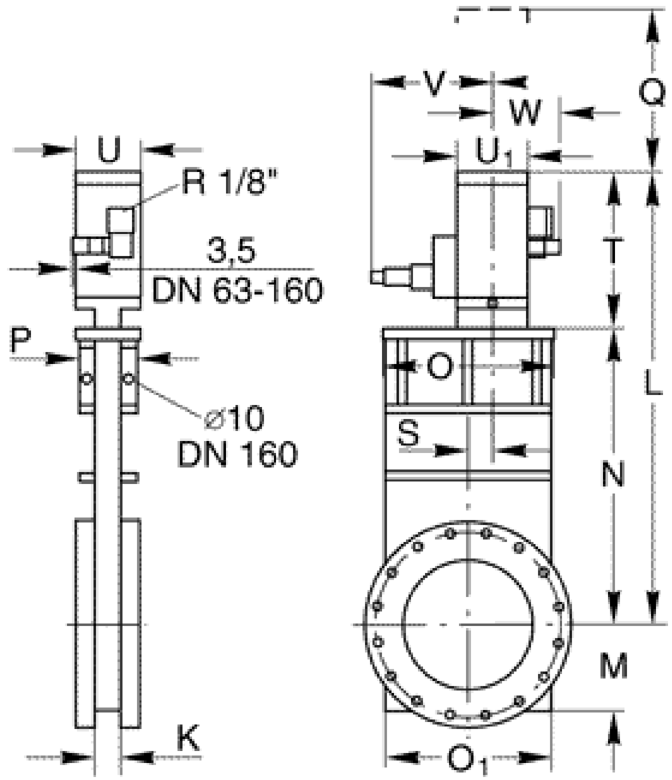
KF


KF-150
(2 places)
Clamp
Optional
O-ring
Retainer
Centering ring
O-ring

ISO-K



ISO-F



Valves