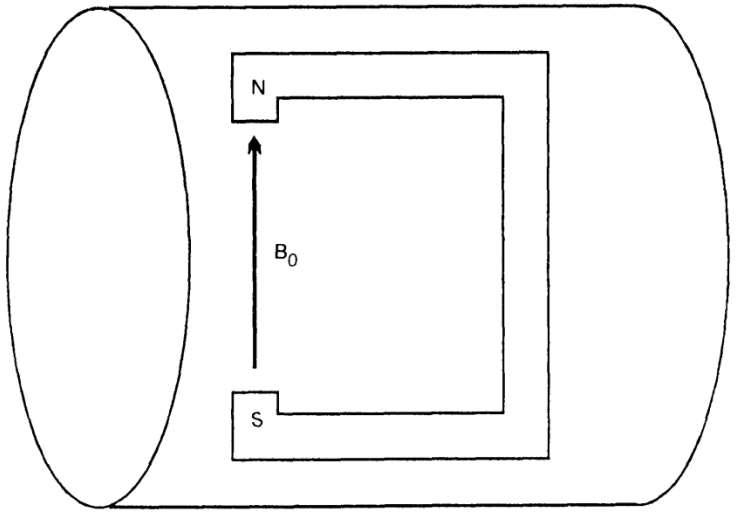
Lesson 13: MRI magnets

Types of magnets based on design

- Permanent
- Resistive
- Superconducting

Permanent magnet

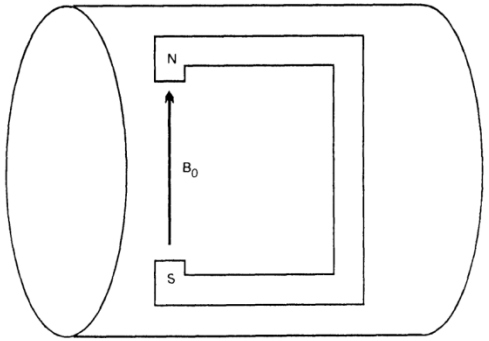
Permanent magnet



- A permanent magnet consists of a material, which has been magnetized such that it won't loose its magnetic field.
- Ferromagnetic substances (such as iron, cobalt and nickel)
- Most common material: an alloy of aluminum, nickel and cobalt known as Alnico

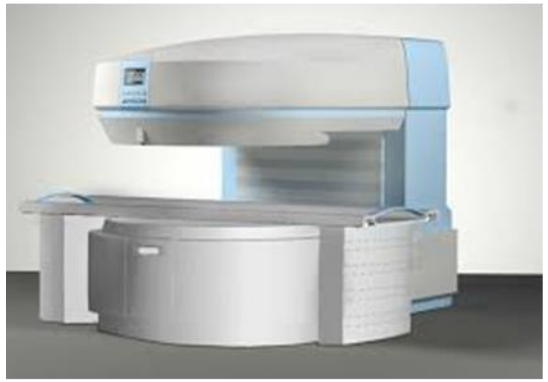
Permanent magnet advantages

- Low power consumption →
- Low cost
- Vertical magnetic field lines (flux lines) from S to N →
- Keeping the magnetic field virtually confined within the boundaries of the scan room.
- Small fringe fields



Permanent magnet advantages

- Mainly used in “Open MRI” scanners for:
- Claustrophobic patients
- Interventional procedures



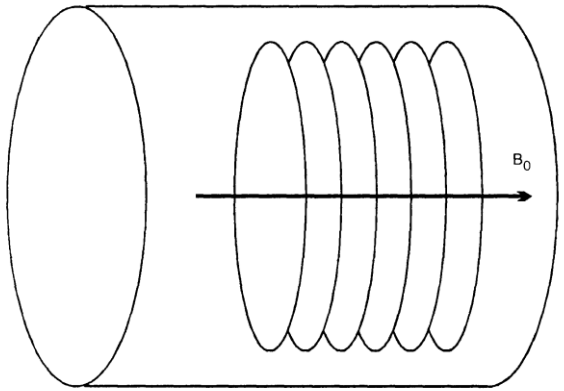
Permanent magnet disadvantages

- Very heavy pieces
- Field strength limited by weight of magnet
- Low field strength →
- Low SNR
- Usually long scan time
- Always stay on and cannot be turned off

Resistive magnets

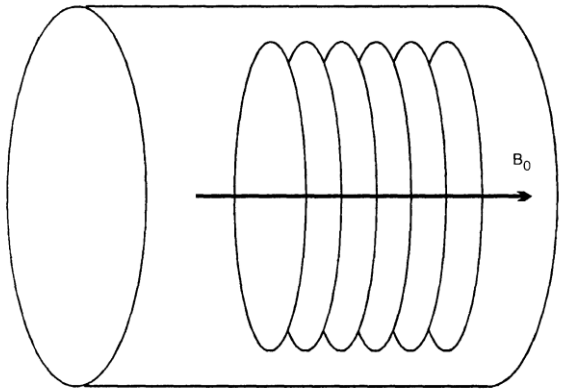
Resistive magnets

- Very large electromagnet
- Resistive magnets are based on the electromagnetic principle that electric current running through a coil produces a magnetic field.



Resistive magnets

- The magnetic field strength depends on ……
- the current which passes trough the coils of wire.
- Horizontal magnetic field lines from the head to the foot of the patient.



Resistive magnets advantages

- Can be switched on and off →
- Relatively safe
- Lighter than permanent magnets
- They usually have an open design, which reduces claustrophobia.

Resistive magnets disadvantages

- It needs large quantities of power →
  - ➢ Expensive
  - ➢ Limitation of max field strength
  - ➢ Low field strength →
    - Low SNR
    - Usually long scan time
- Large fringe fields
- They produce a lot of heat, which requires water-cooling.

Superconducting magnets

Superconducting magnet

Superconducting magnets

- Most commonly used magnets
- A form of electromagnets
- The magnetic field is generated by a current, which runs through a loop of wire.
- Some materials called superconductors exhibit zero resistance at near absolute zero temperature.
- Alloy of niobium and titanium

Superconducting magnets

- The wire is surrounded with a coolant, such as liquid helium, to reduce the electric resistance of the wire. At near absolute zero temperature electric wire looses its resistance. →
- Using very strong electric currents to generate a high magnetic field without generating significant heat (hence the name superconducting).

Superconducting magnets

- High field strengths:
- More than 1 T to 4 T for clinical imaging
- Up to 14 T for MRS and high Resolution studies

Superconducting magnets advantages

- High field strengths →
- High SNR
- Short scan time, fast scanning
- High magnetic field homogeneity
- Low power consumption

Superconducting magnets disadvantages

- To achieve the ultra low temperatures, cryogens (such as liquid nitrogen and/or liquid helium) are required, which are very expensive.
- Permanently on unless “quenched” when helium allowed to boil off
- Large fringe field due to horizontal flux line

References

- Westbrook C, MRI at a Glance, Blackwell Science, Second edition
- Westbrook C, Kaut Roth C, Talbot J, MRI in practice, Wiley