

# Magnetic Materials: Macro, Micro and Nano

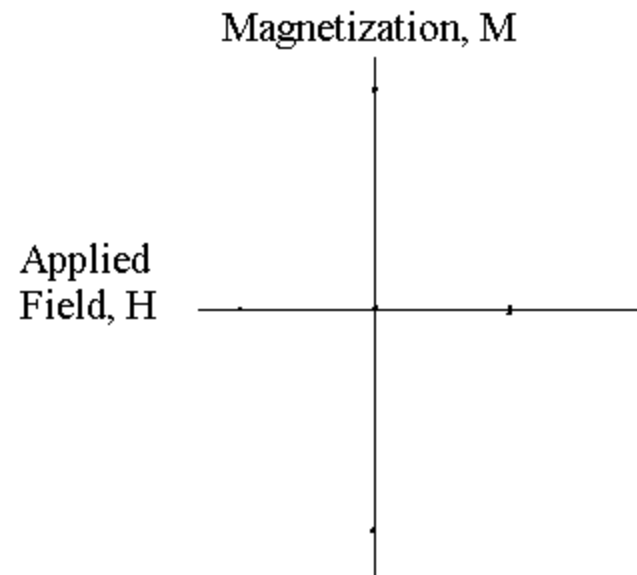
Stan Trout

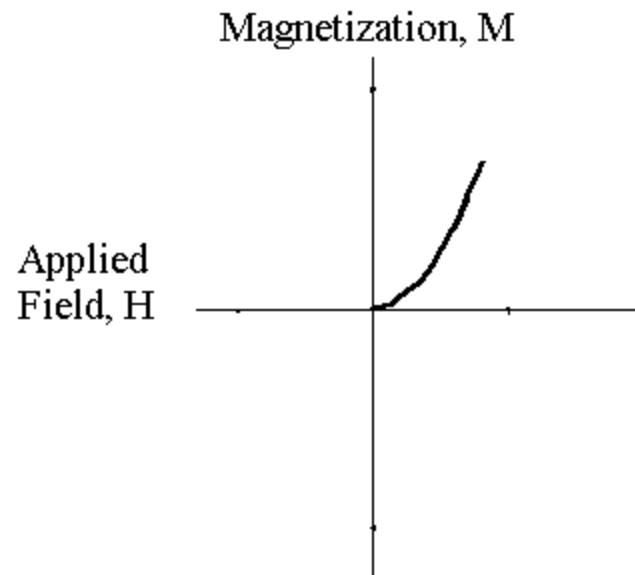
Spontaneous Materials

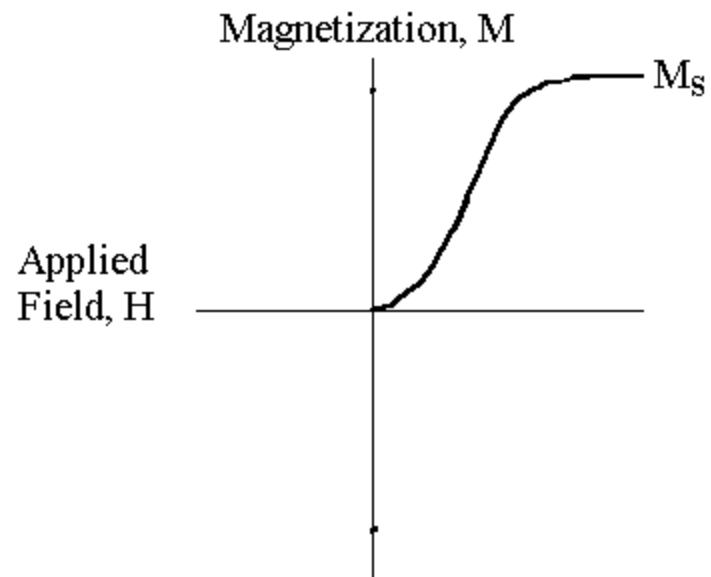
October 8, 2001

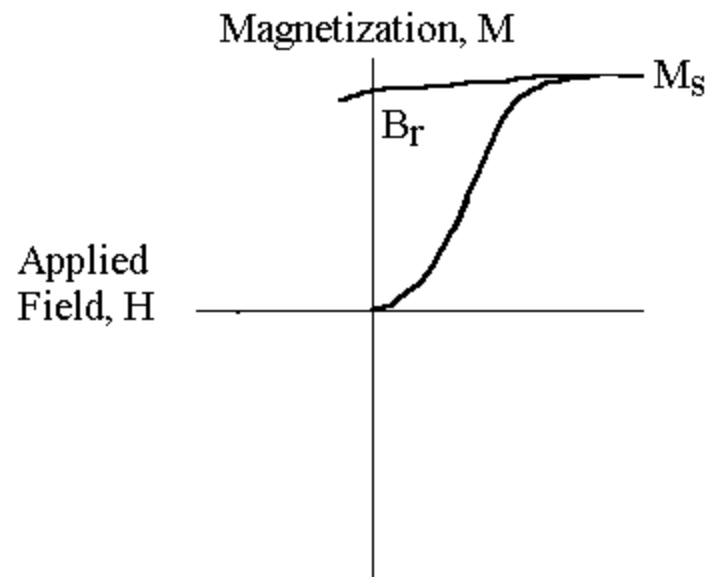
# Magnetic Hysteresis

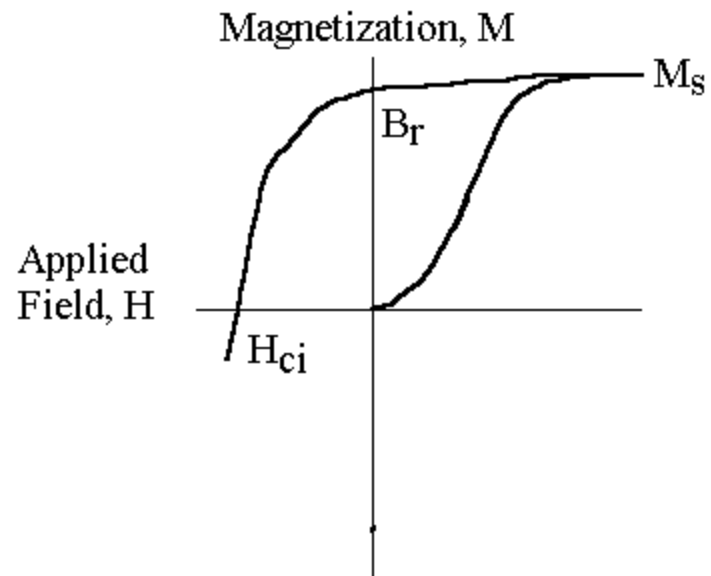
- A delayed response to a stimulus
- In this case, the stimulus is an applied magnetic field and the response is the magnetization or flux density

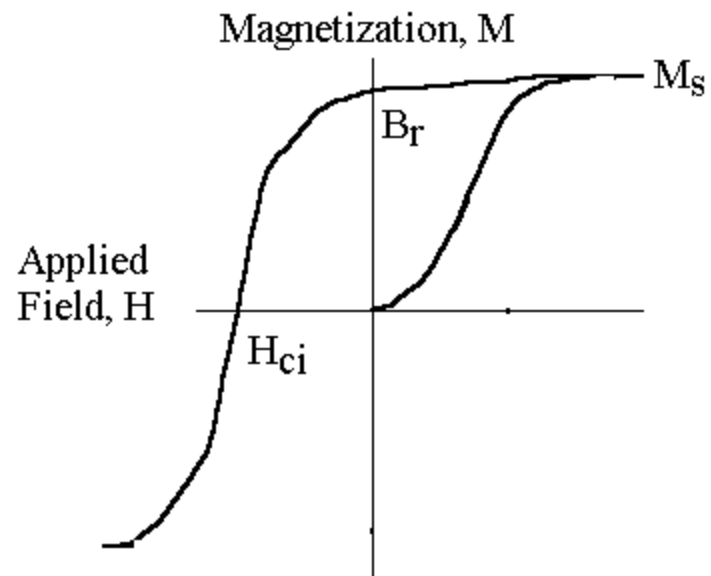




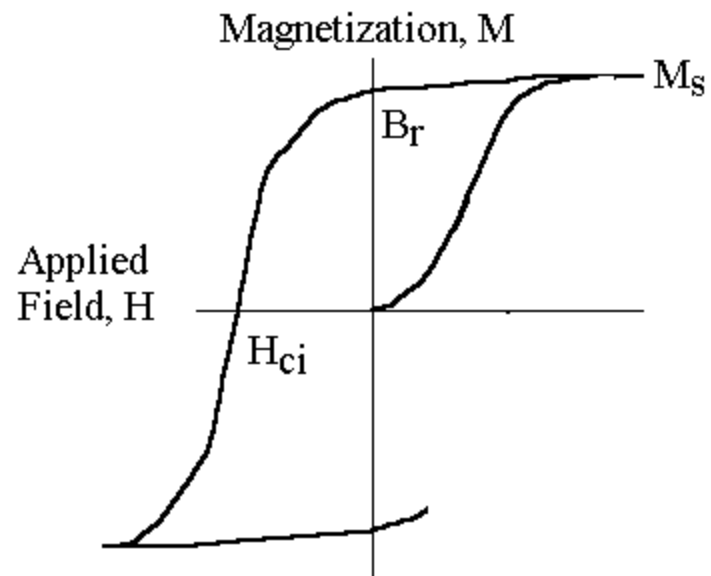


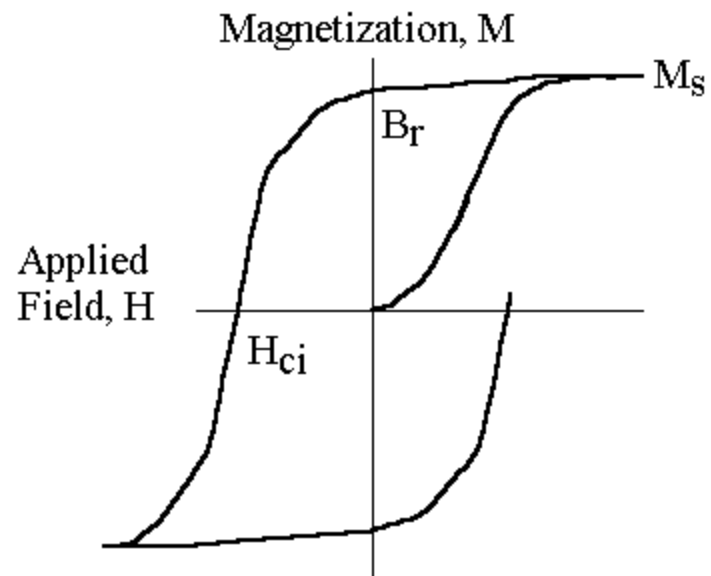


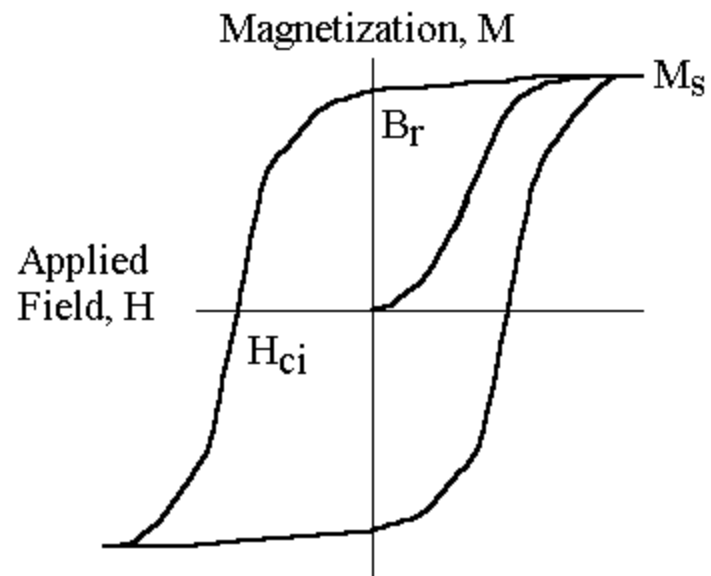




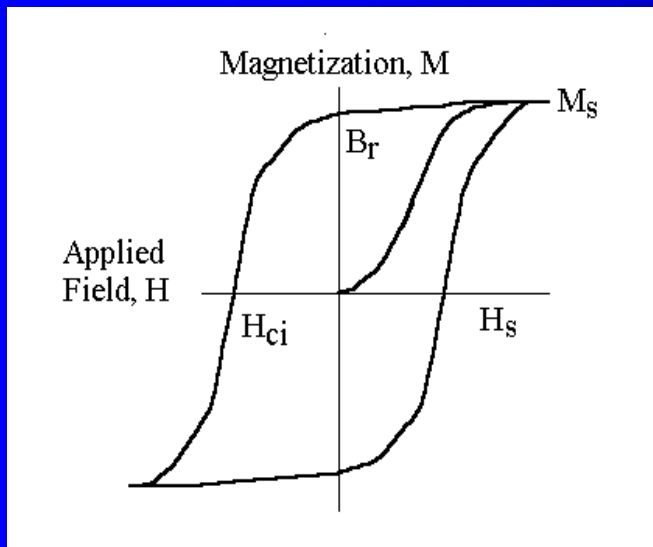








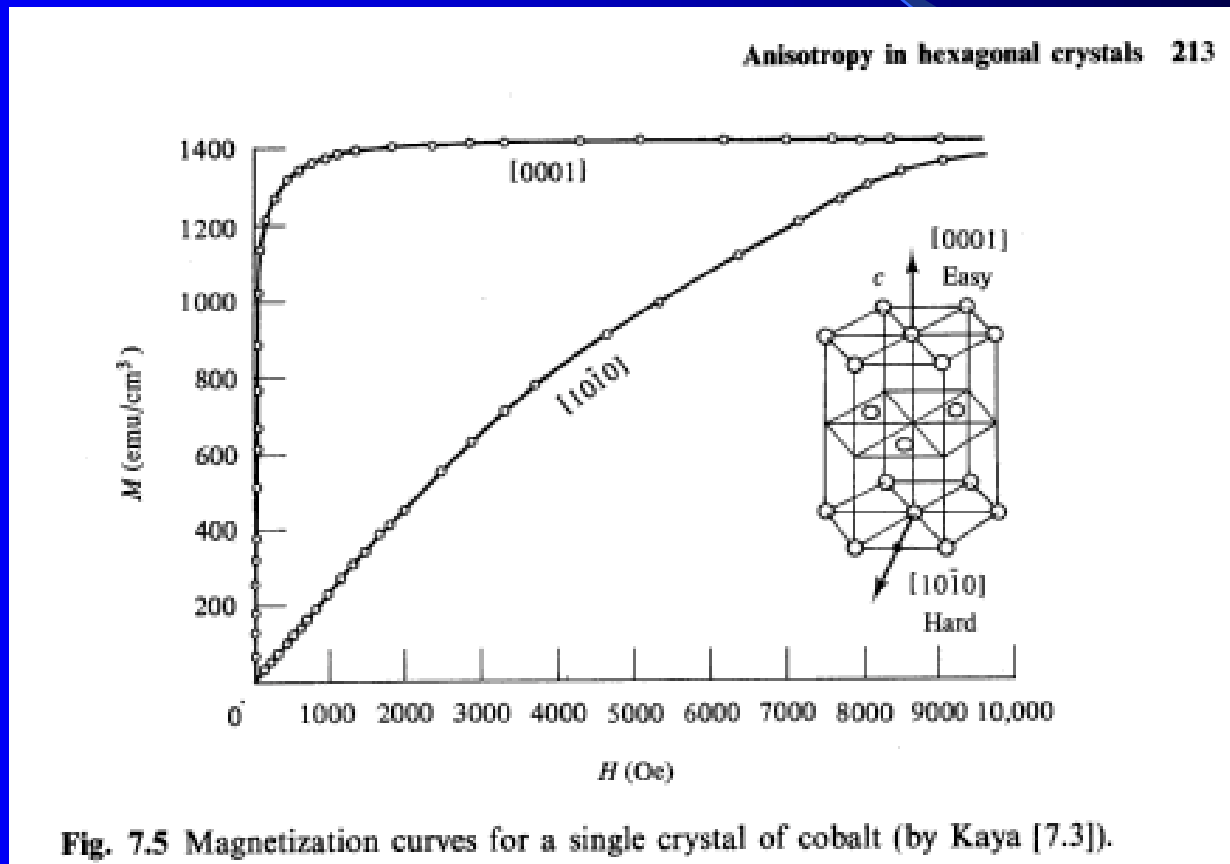
# Magnetic Hysteresis



# Magnetic Anisotropy

- Properties that vary with the direction of measurement
  - Crystalline
  - Shape
  - Stress

# Magnetocrystalline Anisotropy





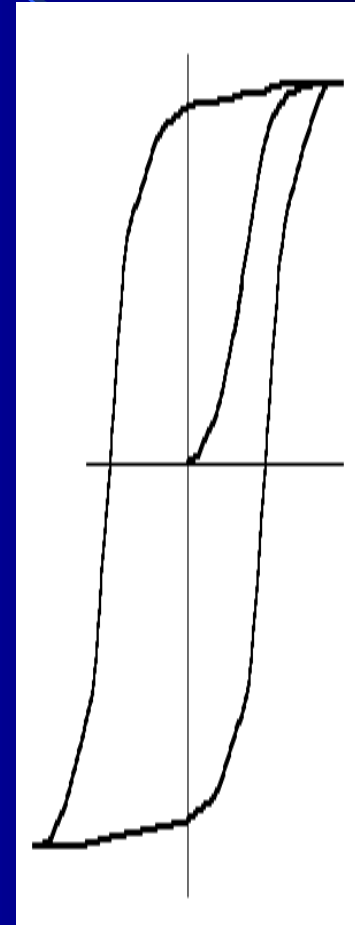
# Four types of Materials

- Soft Magnetic
- Hard Magnetic (Permanent Magnets)
- Recording
- High Flux



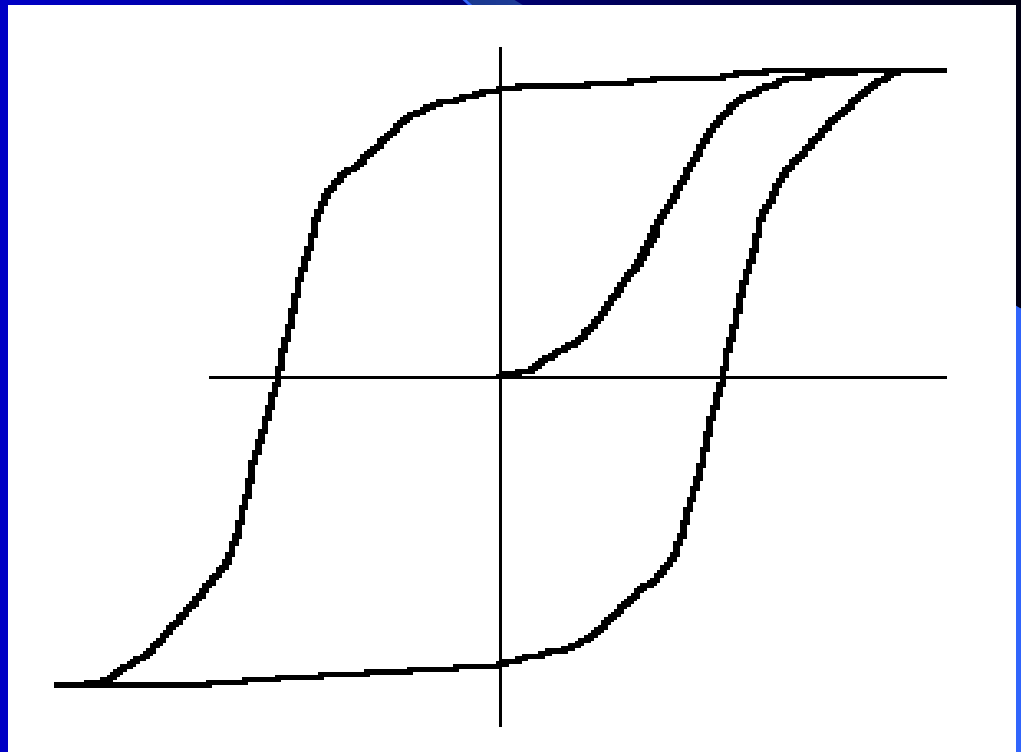
# Soft Materials

- Low  $H_{ci}$
- High Saturation
- Permeability
- Anisotropy, maybe
- Applications
  - Transformers
  - Inductors
- Materials
  - Fe, Si-Fe, Ni-Fe, Fe-B



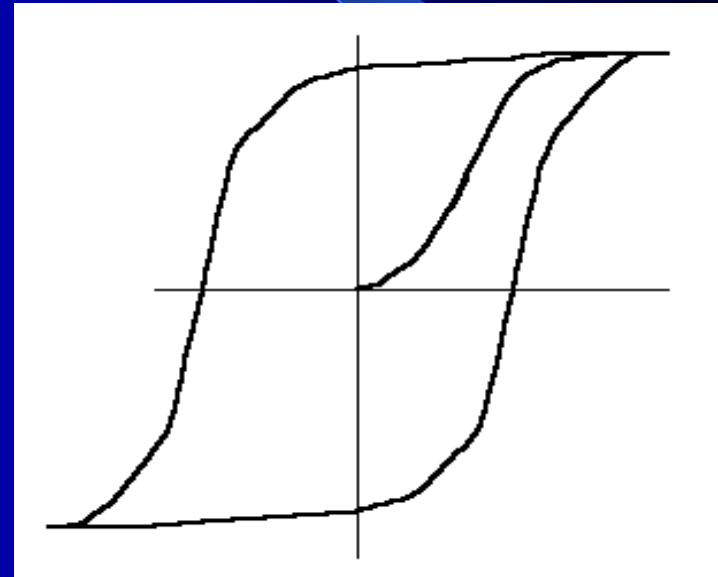
# Permanent Magnets

- High  $H_{ci}$
- High Anisotropy
- High  $B_r$
- Applications
  - Motors, sensors,
  - Actuators
- Materials
  - Alnico, Ferrite
  - SmCo, NdFeB



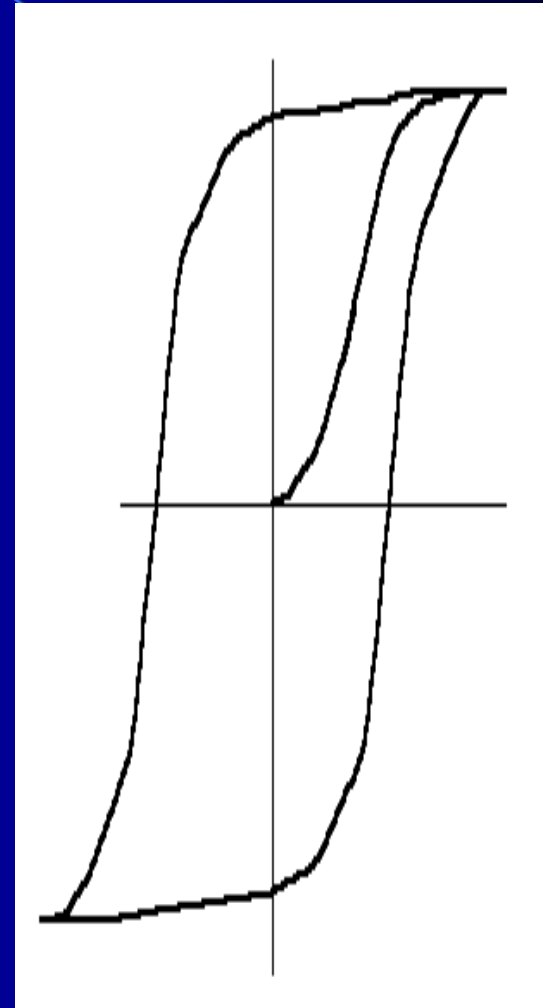
# Recording Media

- Moderate  $H_{ci}$
- Moderate  $B_r$
- Applications
  - Tapes, Films
- Materials
  - $Fe_2O_3$ ,  $CrO_2$ , Fe

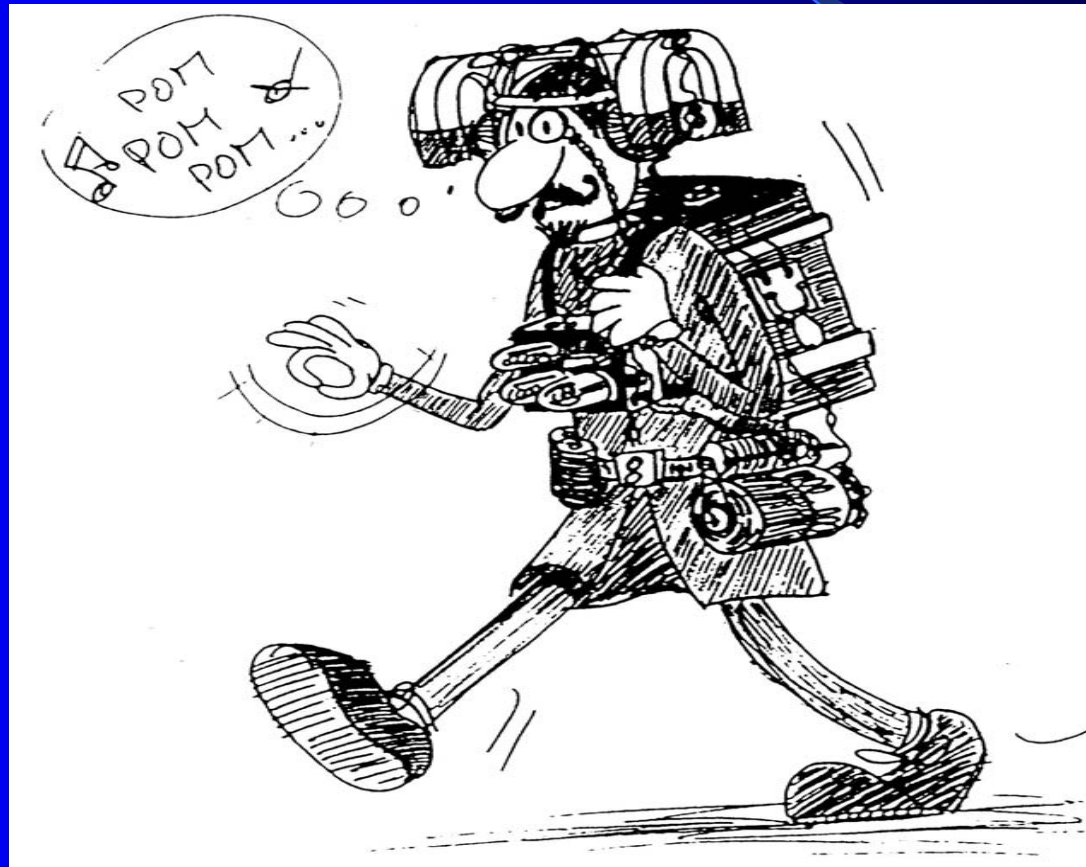


# High Flux

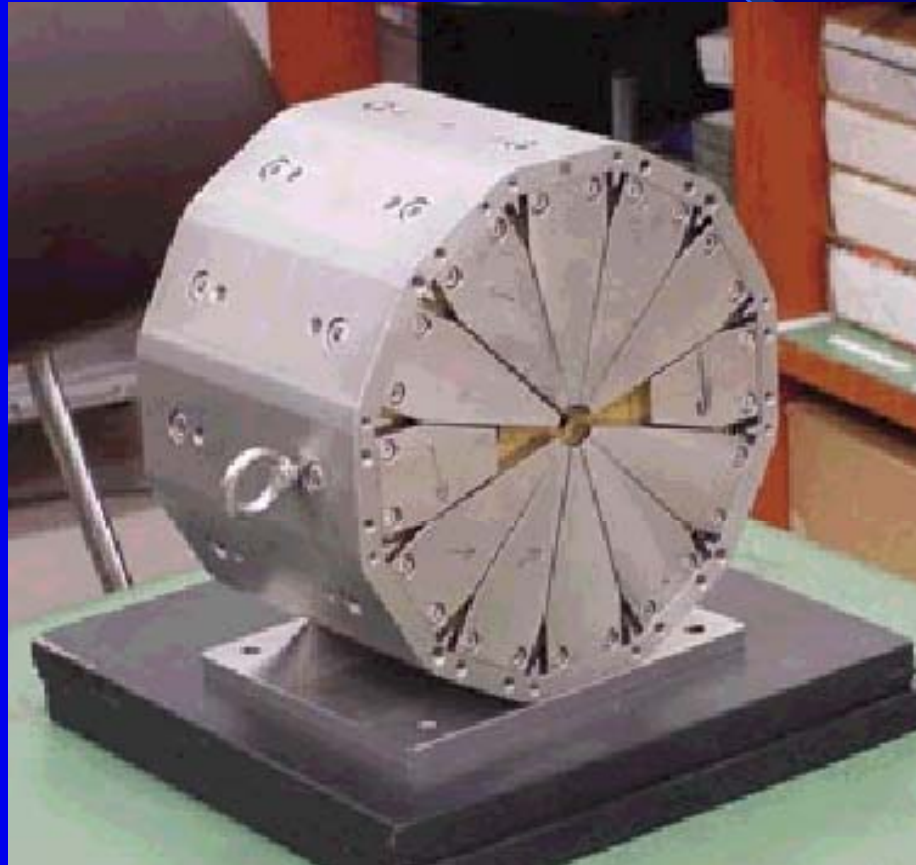
- High  $M_s$
- Applications
  - Return path
  - Pole piece
- Materials
  - Fe, low carbon steel
  - Fe-Co
  - Ho



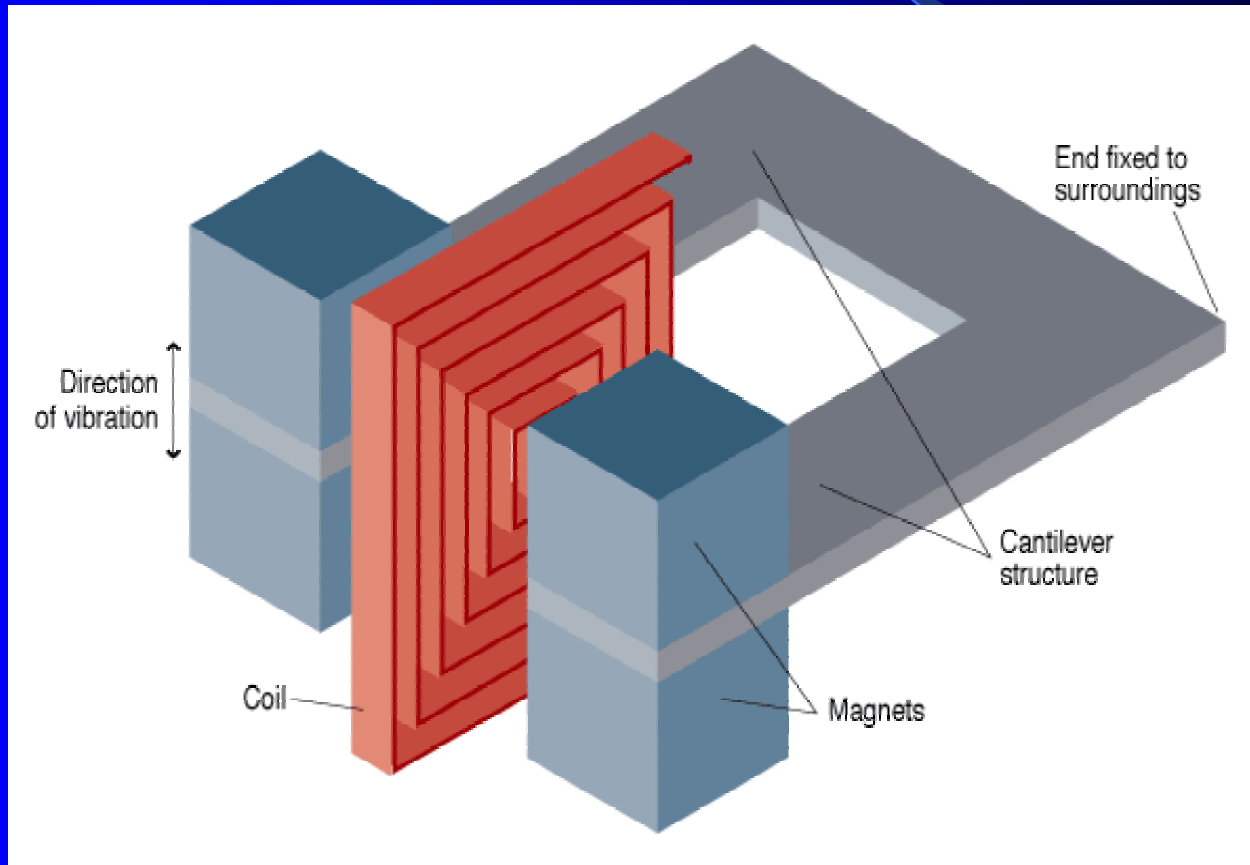
# The Walkman circa 1930



# Scalable Magnetic Field



# MEMS Device



# Conclusions

- In the past, we were asked to find new materials to fill a specific need or asked to explain the behavior of existing materials.
- In the future, we will be asked to find new materials to fill a specific need or asked to explain the behavior of existing materials.
- While the materials of interest change, the fundamental paradigm of Materials Science does not.