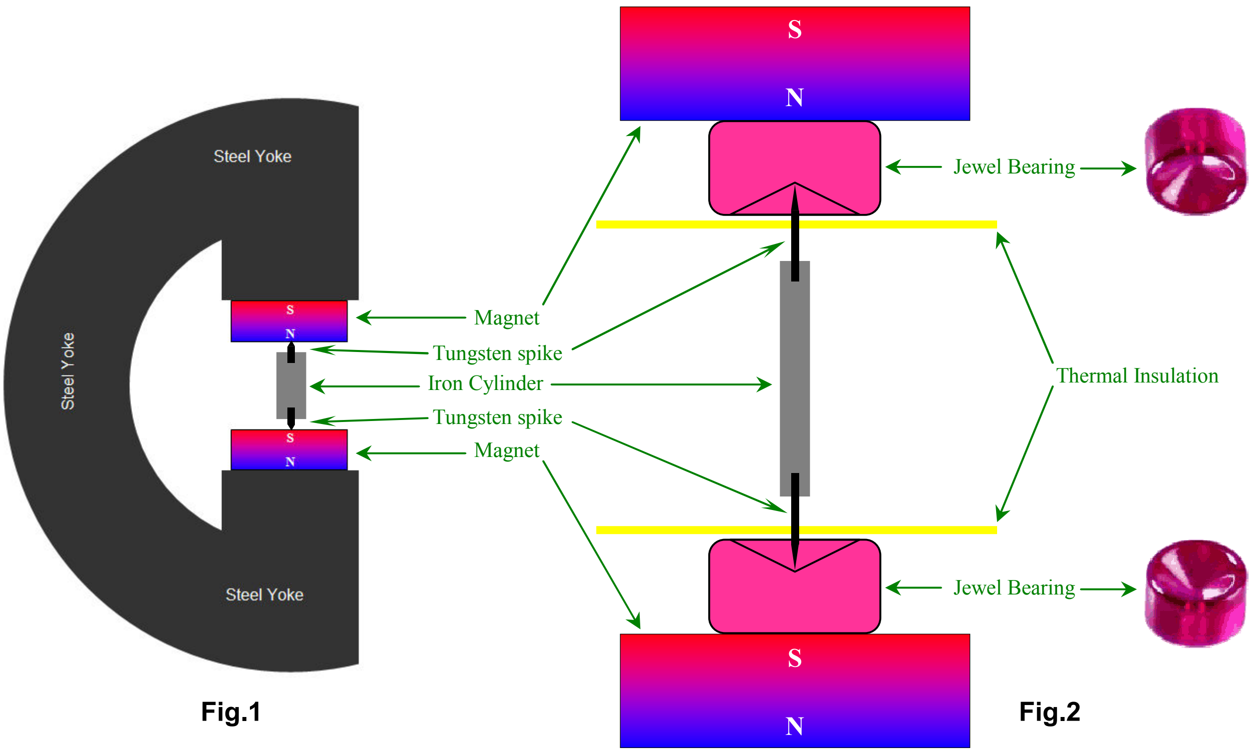

Fig.1 Fig.2

Two small tungsten spikes are press-fitted into a narrow iron cylinder/rod axially. The pointy ends of the spikes rest in a concave hard material (ideally small jewel bearings) – not shown in Fig.1.

The jewel bearings (shown in Fig.2) are glued to two NdFeB cylindrical permanent magnets and placed in an air gap of a steel yoke. The purpose of the yoke is to close the magnetic flux paths and increase the flux density in the air gap.

A sheet of thermal insulation (shown in Fig.2 in yellow color) is placed between the magnets and the iron cylinder in order to allow for the heating of the iron cylinder with a torch without heating the magnets. To minimize friction, the tungsten spikes should poke through this insulation but they cannot touch it.

The iron cylinder/rod is heated up to 900ºC and allowed to slowly cool while immersed in an axial magnetic flux of density 0.5T, generated by the permanent magnets held in the steel yoke. The tungsten spikes are not affected by this temperature.

As the iron cylinder/rod cools naturally and passes through the Curie temperature (T_C), its internal magnetic moments and microscopic angular momenta align in one direction creating a measurable macroscopic/mechanical angular acceleration α.

To maximize angular acceleration during the ferromagnetic phase transition, the cylinder's geometry needs to be optimized by considering the competing effects of moment of inertia and magnetic moment change.

Analysis of Optimal Proportions:

The angular acceleration α is given by: $\alpha = \tau/I = \Delta M \times B / I$

Where:
- ΔM = change in magnetic moment during phase transition
- B = external magnetic field (0.5 T)
- I = moment of inertia = $\frac{1}{2}mR^2$ (for solid cylinder)

Key Optimization Considerations:

1. **Length-to-diameter ratio**: A long, thin cylinder/rod is optimal because:
   - Magnetic moment scales with volume ($\propto L\times R^2$)
   - Moment of inertia scales as $\propto R^2$
   - Therefore $\alpha \propto L/R^2$ - favoring high L/R ratios

2. **Absolute size**: Smaller radius maximizes α since $I \propto R^4$ while magnetic moment $\propto R^2$

Example cylinder/rod proportions:
- Diameter: 5 mm → Radius: 2.5 mm = 2.5×10^{-3} m
- Length: 50 mm = 0.05 m
- External magnetic field: 0.5 T
- Iron properties: ρ = 7,870 kg/m³, Ms = 1.7×10^6 A/m
- Gyromagnetic ratio: $\gamma \approx 1.76 \times 10^{11}$ C/kg

Step-by-step Calculation:

- **Volume:** $V = \pi r^2 L = \pi \times (2.5\times10^{-3})^2 \times 0.05 = \pi \times 6.25\times10^{-6} \times 0.05 = 9.82 \times 10^{-7}$ m³
- **Mass:** $m = \rho V = 7{,}870 \times 9.82\times10^{-7} = 7.73 \times 10^{-3}$ kg
- **Moment of inertia (solid cylinder about its axis):** $I = \frac{1}{2}mr^2 = \frac{1}{2} \times 7.73\times10^{-3} \times (2.5\times10^{-3})^2 = 2.42 \times 10^{-8}$ kg·m²
- **Magnetic moment change during Curie transition:** $\Delta M = Ms \times V = 1.7\times10^6 \times 9.82\times10^{-7} = 1.67$ A·m²
- **Magnetic angular momentum:** $L\_mag = \mu/\gamma = 1.67/(1.76\times10^{11}) = 9.49 \times 10^{-12}$ kg·m²/s
- **Mechanical angular momentum (conservation):** $L\_mech = -L\_mag = -9.49 \times 10^{-12}$ kg·m²/s
- **Final angular velocity:** $\omega = |L\_mech|/I = (9.49\times10^{-12})/(2.42\times10^{-8})$ = $\mathbf{3.92 \times 10^{-4}}$ **rad/s**

This is a calculated acceleration, but the actual observable effect would be much smaller due to:

- Gradual rather than instantaneous magnetization change
- Incomplete magnetization
- Thermal effects: fluctuations, convection, damping
- Non-ideal alignment efficiency (~10-30%)

NOTE: Gadolinium cylinder/rod would be less problematic for this experiment because its Curie temperature is only 20ºC, so thermal insulation of the magnets is not necessary and thermal effects are minimal, also:

- Density: 7901 kg/m^3 (similar to iron)
- Gyromagnetic ratio: 1.76×10^{11} C/kg (similar to iron)
- Saturation magnetization: $\sim 2.5 \times 10^{6}$ A/m (~47% higher than iron)

Expected improvement with Gadolinium cylinder (5mm × 50mm):
Magnetic moment: $1.67 \times 1.47 = 2.45\ A \cdot m^2$
Final angular velocity: $(2.45/1.76\times10^{11})/(2.42\times10^{-8}) = 5.76 \times 10^{-4}$ rad/s