

The Initial LIGO Suspension and Isolation

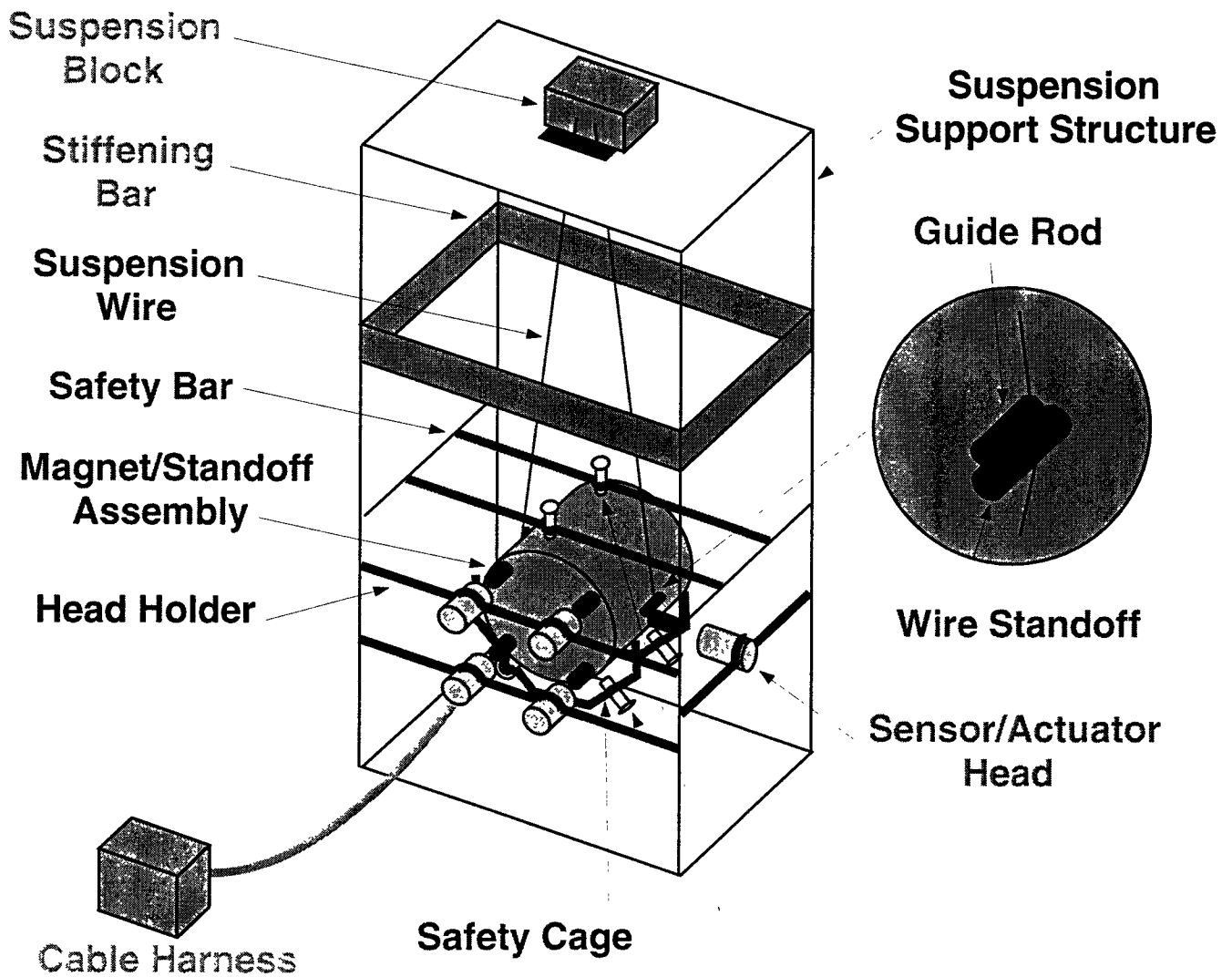
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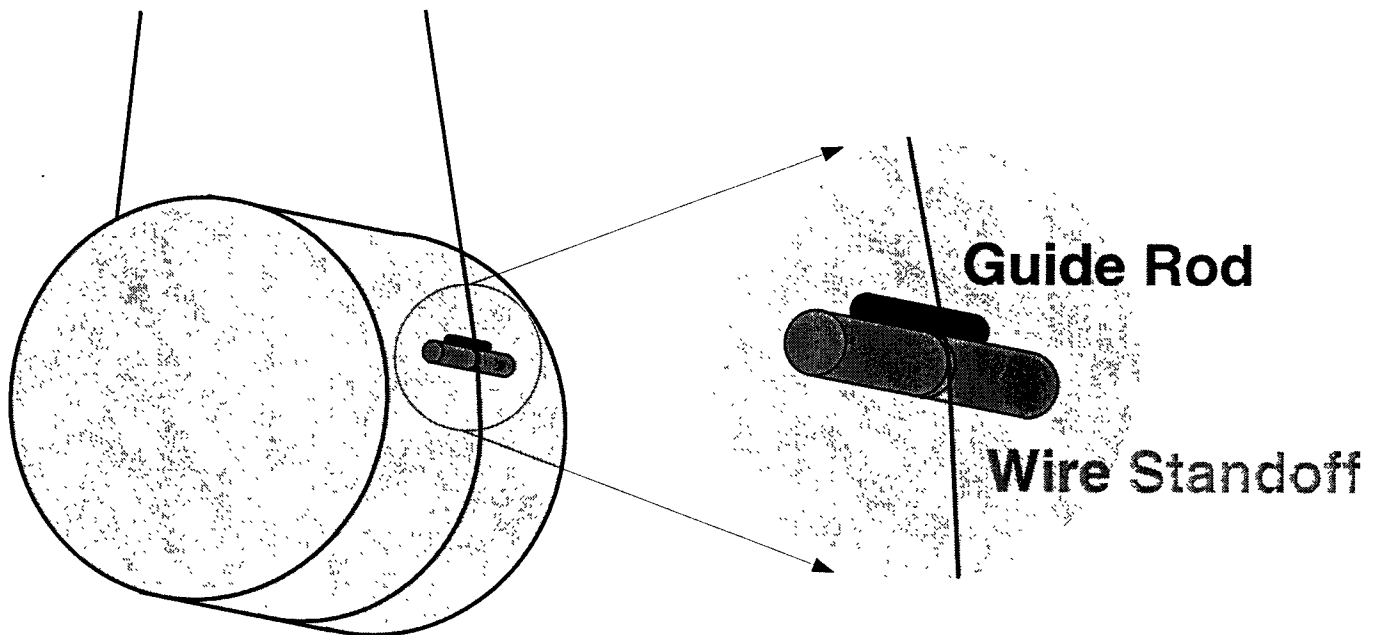


Mechanical System of LIGO Suspension



Balancing Test Mass with Single Loop Wire

- Test Mass: balanced within 0.3 mrad.
- Q : OK with attachments



Screening of Wire Material

Wire ^a	Clamp ^b	Tension (N)	Measured Q	Yield Tension (N)	Extrapolated Q for LIGO Suspension ^c
Steel Music Wire	H, S	10 - 34	17,000 - 40,000	90	200,000
Invar	H, S	3.5 - 11	28,000 - 91,000	21	140,000
Tungsten	H, S, T	13 - 32	10,000 - 40,000	100	130,000
Niobium	S	3.6	25,000 - 31,000	10	65,000
Molybdenum	S	6 - 14	14,000 - 14,500	30	59,000
	A	1	900 - 1,600	N/A	N/A
Tantalum	S	1.3	15,000	8	46,000
Titanium	H, T	4 - 10	20,000 - 43,000	8	22,000
Beryllium Copper	S	4 - 5	1,000 - 11,000	12	20,000
Aluminum	Too weak to test			3	N/A

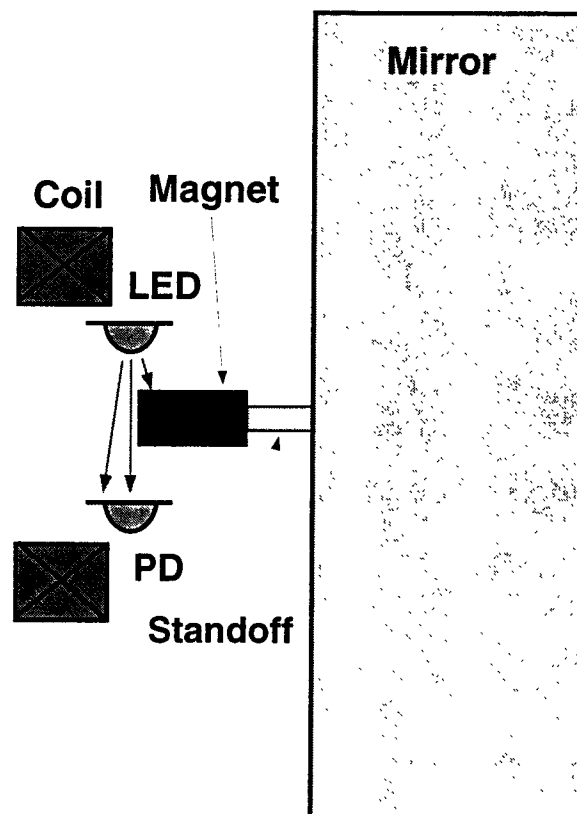
a. $l = 10$ cm, $\phi = 0.25$ mm except steel music wire ($\phi = 0.30$ mm)

b. H: Hardened steel, S: Stainless steel, T: Titanium, A: Aluminum

c. Diameter of wire is chosen to give half yield tension for the LIGO test mass (10.7 kg).

Sensor and Actuator

- Resonant frequency of the magnet/standoff assembly: ~8 kHz
- Q : OK with attachments



Requirements (Large Optics Suspension)

<i>Item</i>		<i>Requirements</i>
Actuator Range	Displacement	$> 40 \mu\text{m}_{\text{pp}} (f < 0.15 \text{ Hz})$
	Orientation	$> 2 \text{ mrad}_{\text{pp}} (f < 0.15 \text{ Hz})$
Actuator Noise		$> 5 \times 10^{-20} \times \left(\frac{40\text{Hz}}{f}\right) \text{m} / \sqrt{\text{Hz}}$
Mechanical Loss	Internal Mode	$< 4 \times 10^{-7}$
	Pendulum	$< 7 \times 10^{-6}$
	Eddy Current	$< 6 \times 10^{-9}$ at 0.74 Hz
Resonance of Support Structure	Frequency	160 Hz
	Q	< 300

Seismic Isolation

Contract with HYTEC

- 4-stage stack (for the test mass chamber)
3-stage stack (for the mode cleaner chamber)
- 4 legs
- Hollow Downtube welded to honeycomb optical table (for the test mass chamber)
Honeycomb optical table (for the mode cleaner chamber)
- Coiled constrained layer damping spring
($f_0 \sim 3$ Hz, Q : 25 - 50)
- Motor-driven off-line coarse actuator
(2 mm_{pp})
- PZT-driven fine actuator
(100 μ m_{pp} for $f < 0.15$ Hz)

Schedule

- Suspension

- ›› Preliminary design: done
- ›› Prototype test: under way
- ›› Final design of mechanical system: Spring 97
- ›› Final design of control system: Autumn 97
- ›› Installation: Autumn 98

- Seismic Isolation

- ›› Design requirement review: done
- ›› Preliminary design: Feb. 97
- ›› Fabrication of the first article: Winter 97
- ›› Installation: Spring 98

