Ångstrom™ Passive Cryogenic Actuators for NGST Primary Mirror Phasing and NASA's Origins Mission

Alson E. Hatheway

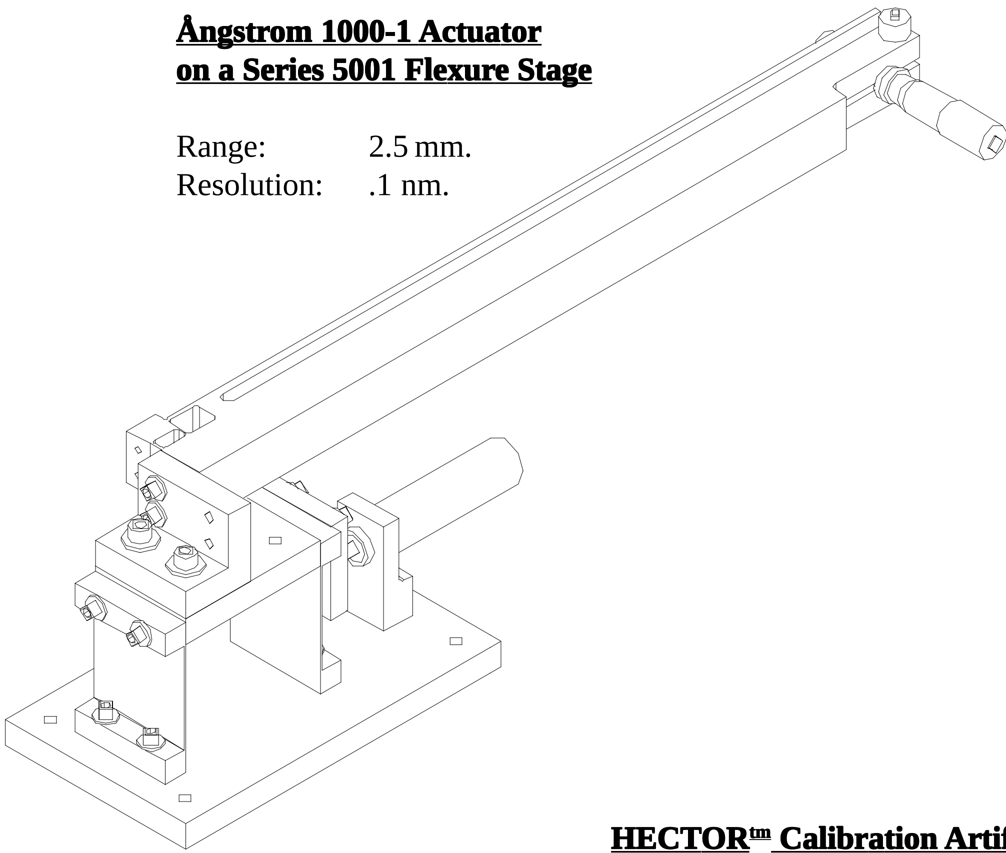
Alson E. Hatheway Inc.
Suite 400
595 East Colorado Boulevard
Pasadena, CA 91101
v: (626) 795-0514
f: (626) 795-0781
e: aeh@aehinc.com

AEH.

Ångstrom™ Actuators

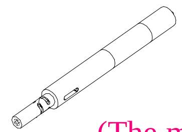
Ångstrom 1000-1 Actuator
on a Series 5001 Flexure Stage

Range: 2.5 mm.
Resolution: .1 nm.

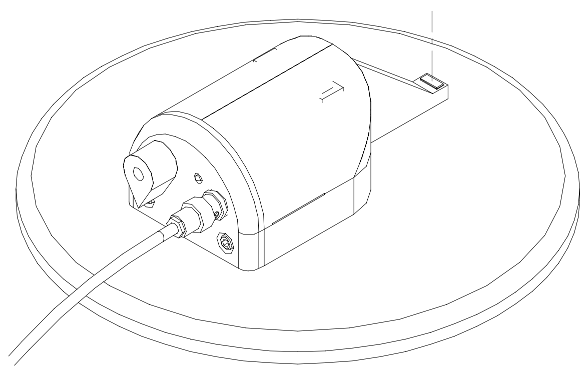


Ångstrom Thimble™ Actuator

Range: 100 µm.
Resolution: .1 nm.



(The model for NGST, Type 2)



HECTOR™ Calibration Artifact

Fixed Step Heights: 100, 10, 1, .1 nm.
User-set Step Heights: 1.0 µm., max

AEH.

The Ångstrom[tm] Tunable Etalon

Wave Length: 500 nm.
Spectral Resolution: .00640 å
Free Spectral Range: .125 nm.
Tunability: 4 interference orders

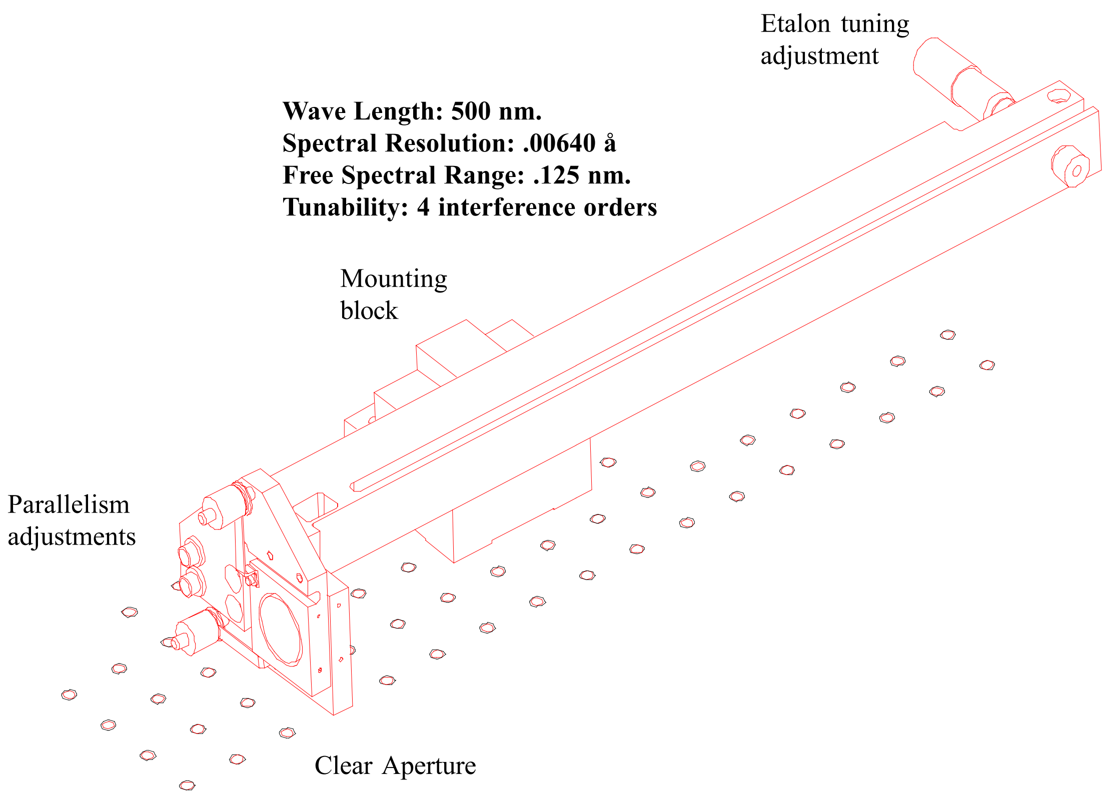
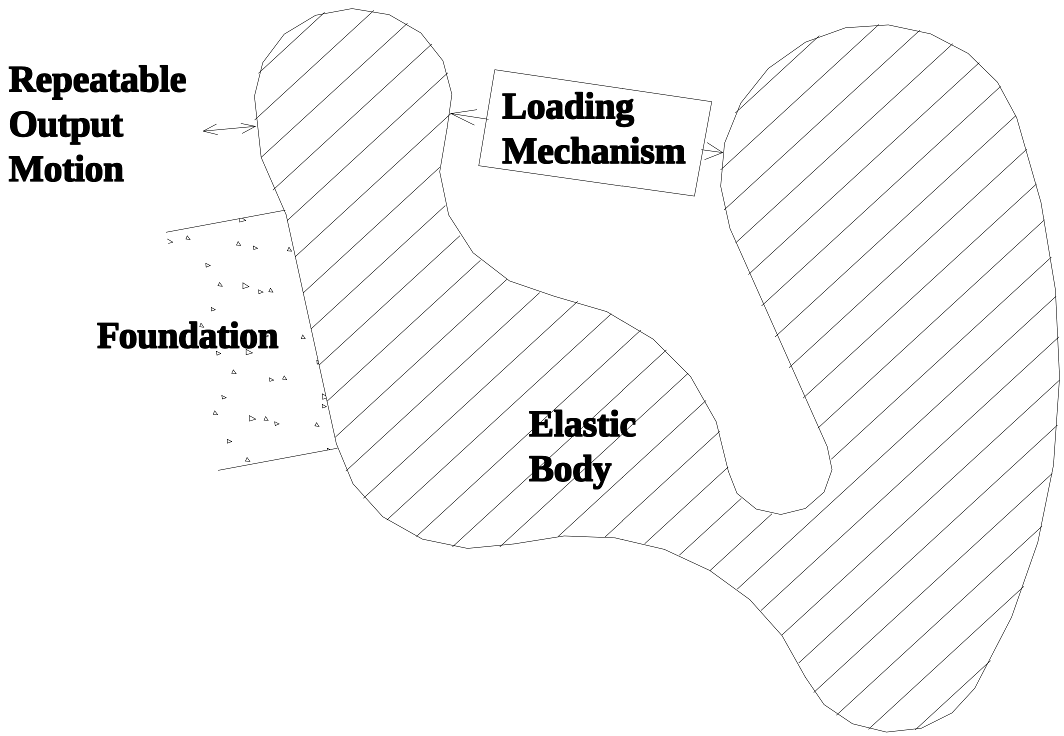


Figure 6. The tunable etalon mounted on a Model 1000-1 actuator for use in an experiment.

AEH.

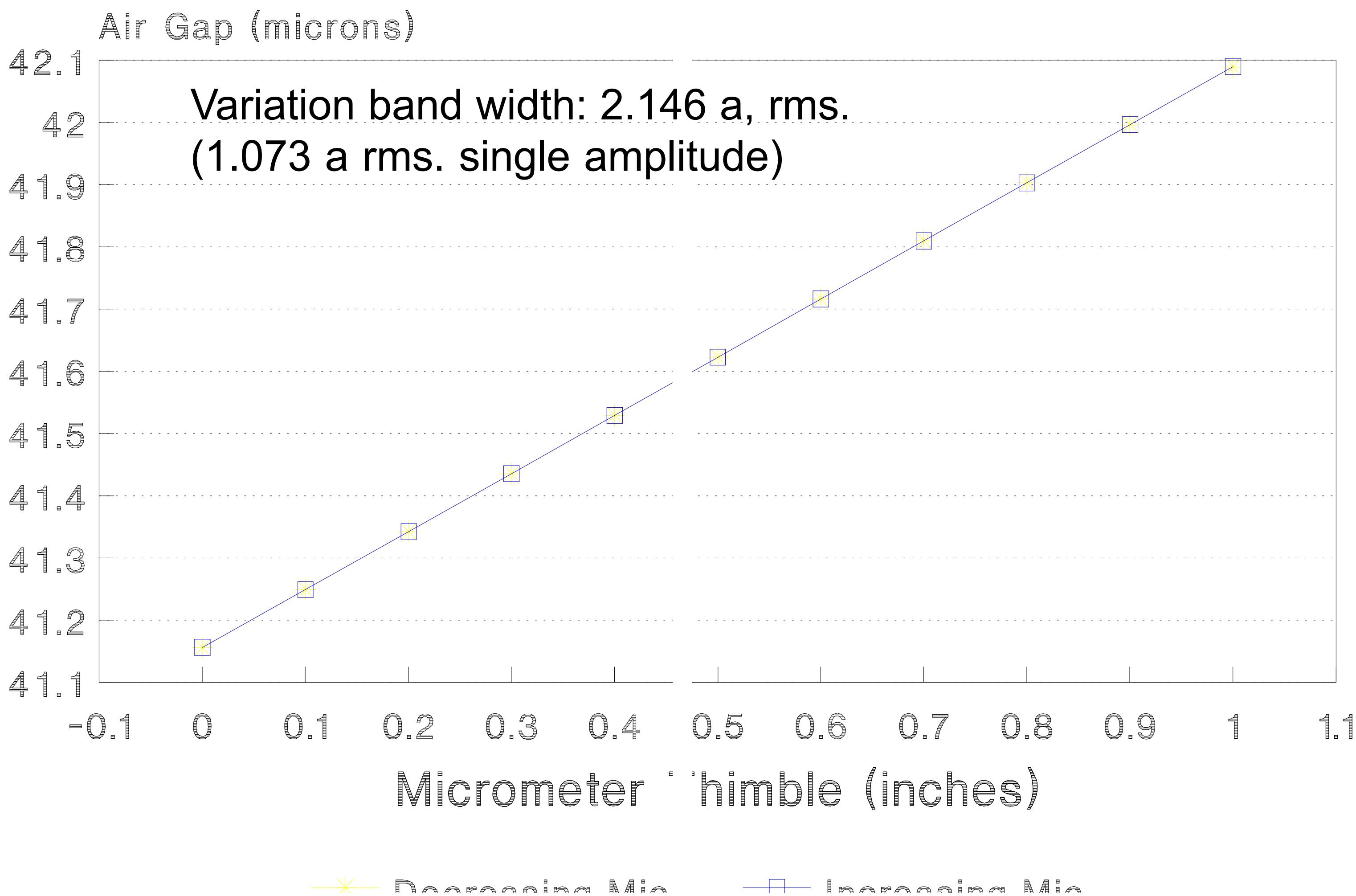
The Ångstrom^{tm} Transducer



U. S. Patent No. 5,187,876

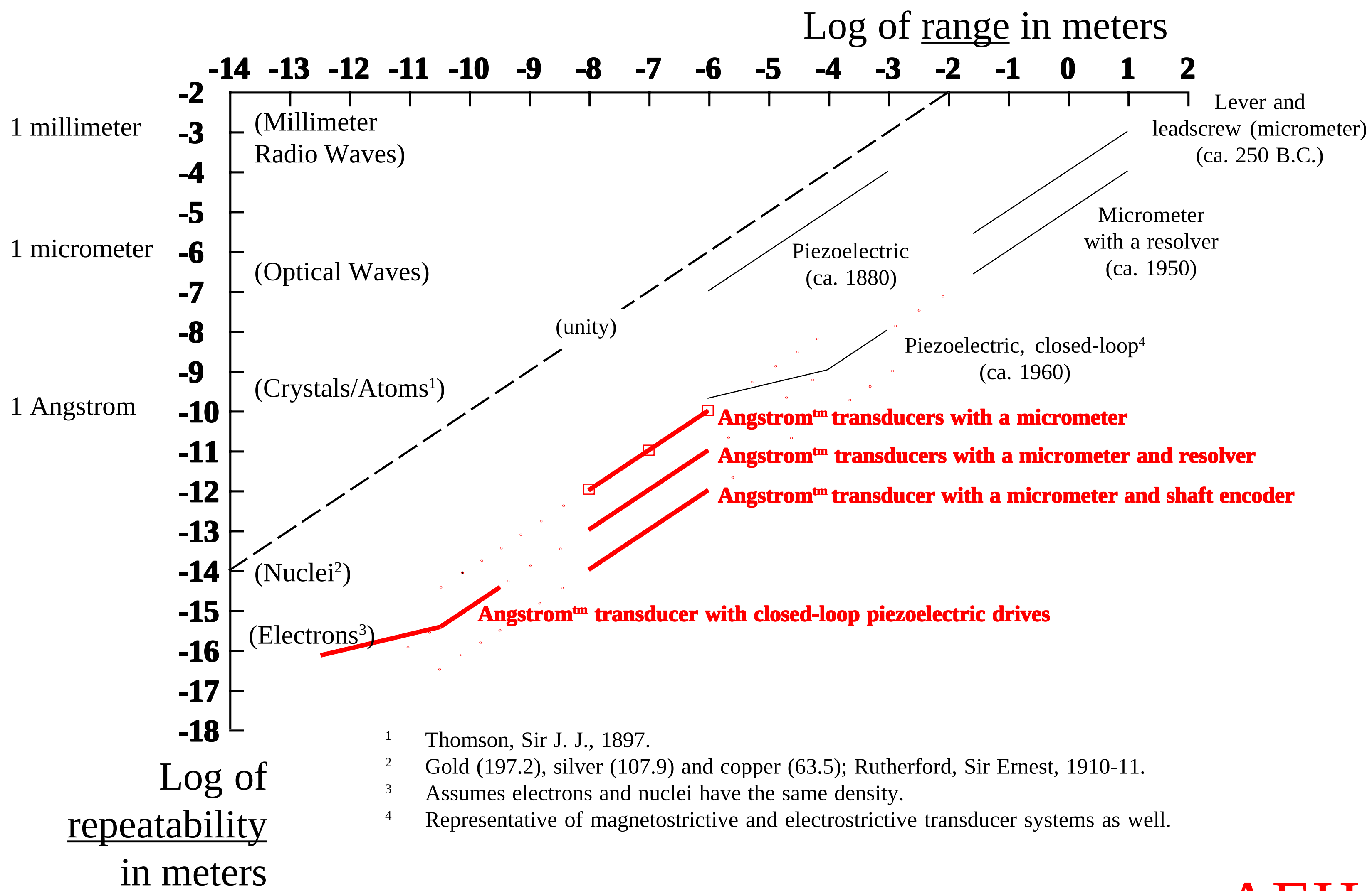
AEH.

MODEL 1000-1



AEH.

Precision Positioning



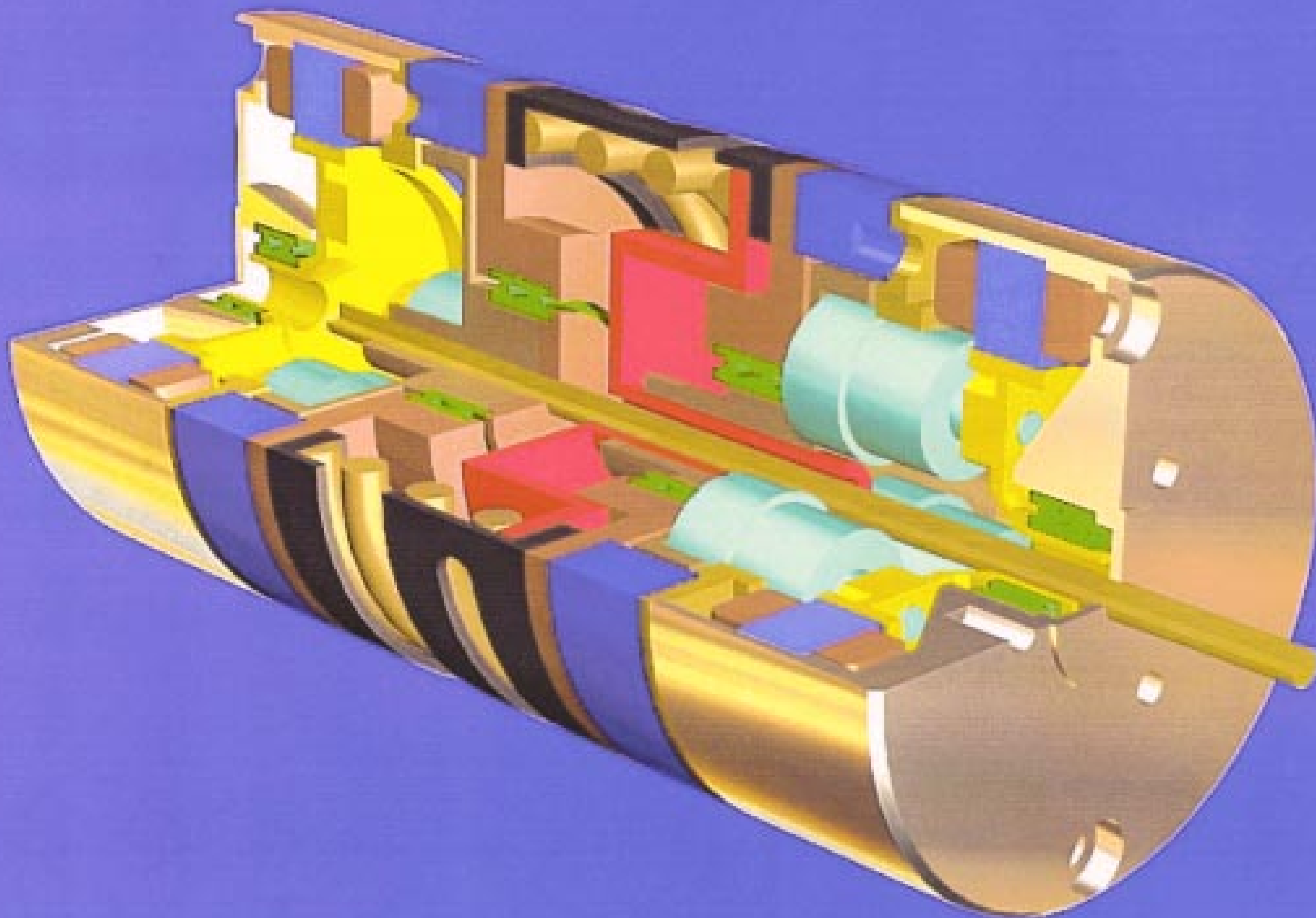
1. Thomson, Sir J. J., 1897.
2. Gold (197.2), silver (107.9) and copper (63.5); Rutherford, Sir Ernest, 1910-11.
3. Assumes electrons and nuclei have the same density.
4. Representative of magnetostrictive and electrostrictive transducer systems as well.

Engineered Solutions AEH.

Alson E. Hatheway Inc., Pasadena, California, 91101, (818) 795-0514

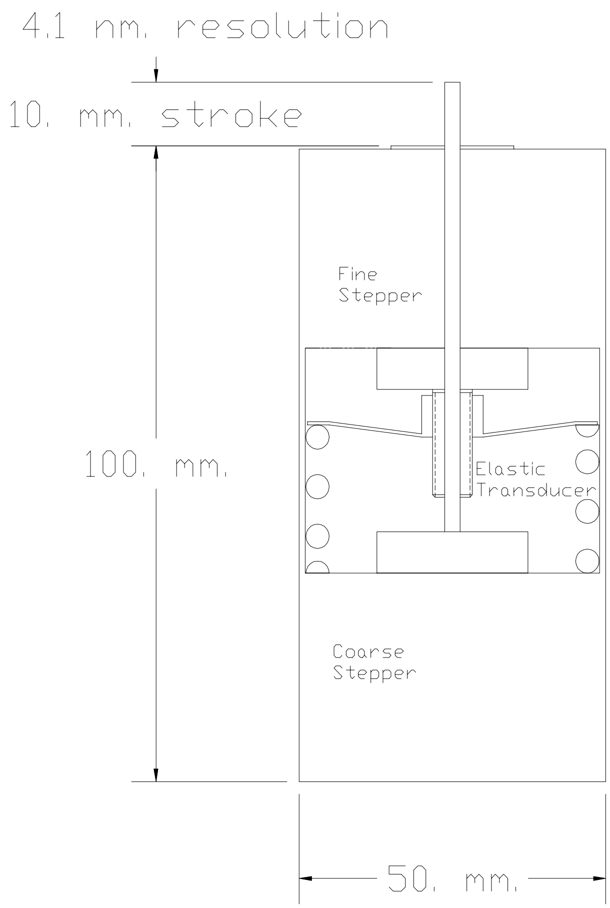
AEH.

NGST Ångstrom Type 2 Actuator



AEH.

This Ångstrom Actuator has Two Independent Stages



A two stage actuator:

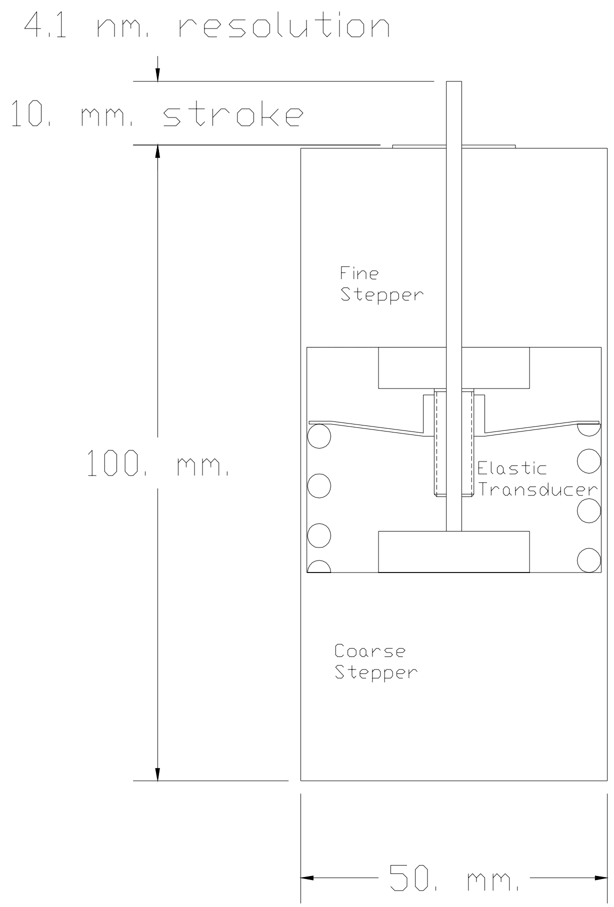
Coarse Stage (15,499 steps):
Range: 10.0 mm.
Resolution: .66 µm.

Fine Stage (15,499 steps):
Range: 62.7 µm.
Resolution: 4.1 nm.
(Using Ångstrom transducer)

The stages are mounted in series to "sum" their motions.

AEH.

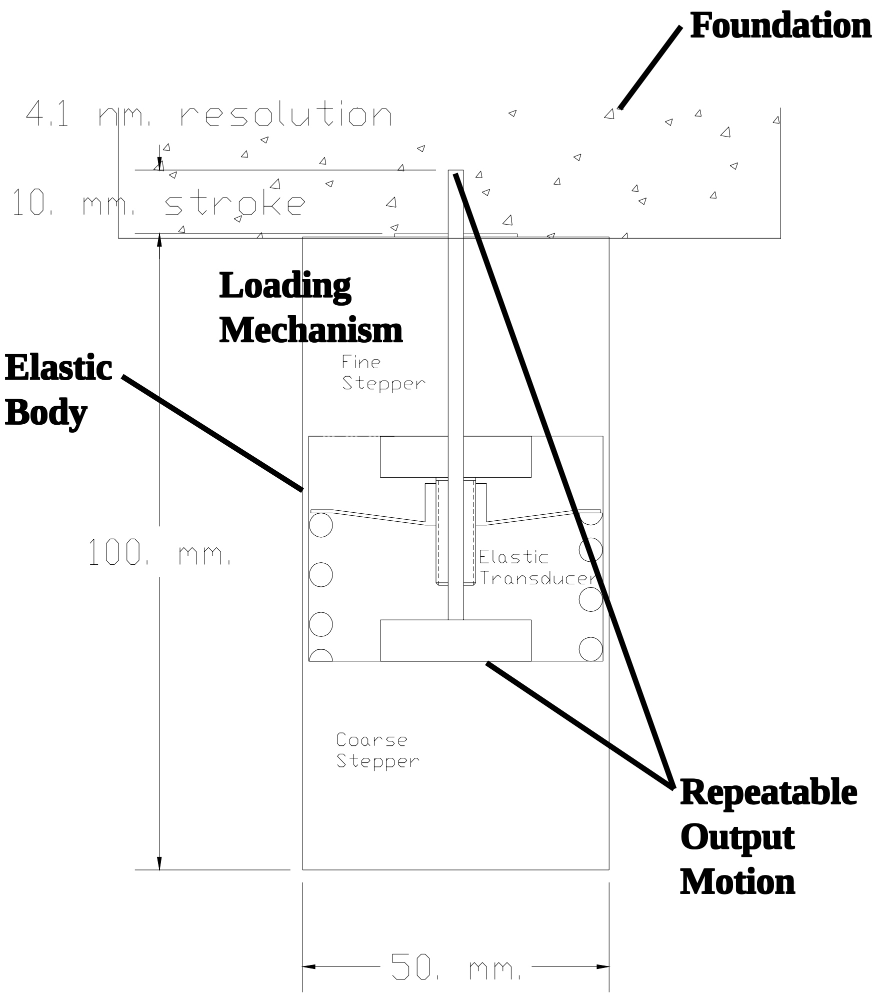
The Coarse Stage Is a Stepper Motor/Lead Screw Mechanism



Friction Torque:	**.030 Nm.**
Axial Load:	**20 N. max.**
Lead Screw:	**.125-40NS**
Stroke:	**10 mm.**
(Equ. turns: 15.8)	
Steps per Turn:	**984**
Resolution:	**.64 µm.**
Threads Engaged:	**6 min.**
Contact Area:	**24.6 x 10^{-6} m^2.**
Contact Pressure:	**.814 MPa. (119. psi.)**

AEH.

The Fine Stage is a Stepper Motor/Lead Screw Driving an Ångstrom Transducer



Stepper Motor/Lead Screw:

Friction Torque:	**.30 Nm.**
Axial Load:	**90 N max.**
Lead Screw:	**.250-40UNS**
Stroke:	**10 mm.**
(Equ. turns: 15.8)	
Steps per Turn:	**984**
Resolution:	**.64 μm.**
Threads Engaged:	**6 min.**
Contact Area:	**49.2 x 10^{-6} m^2**
Contact Pressure:	**2.03 MPa. (297. psi.)**

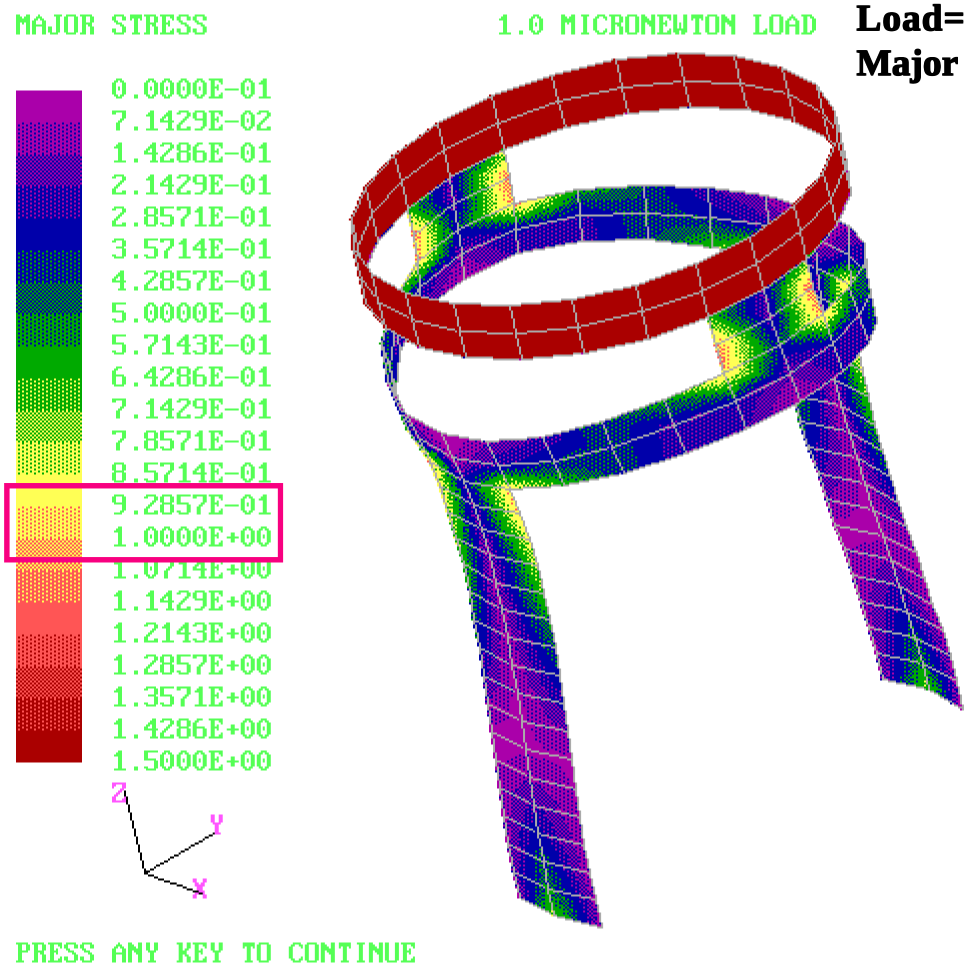
Ångstrom Transducer:

Coil Spring Stiffness	**8,900 N/m.**
Cylinder Stiffness	**1.42 x 10^6 N/m.**
Effectiveness Ratio:	**1:6.27 x 10^{-3}**
Output Stroke	**62.7 μm.**
Output Resolution	**4.1 nm.**

(U. S. Patent No. 5,187,876)

AEH.

The Fine Stage Controls Axial Stiffness, Lifecycles, Resolution, <u>Creep (OM)</u> and Axial Force Set-and-Hold



Load=1.0 μN.
Major Stress(σ)=~1.0 Pa.

For a load of 100 N., σ=~100 MPa. (14,600 psi.)

	416	310
Cr(%)	12-14	24-26
Ni(%)	-	19-22
S_{TU}(ksi)	75.	95.
S_{TY}(ksi)	40.	45.
S_{en}(ksi)	40.	

310 CRES exhibits <u>no creep</u> below 14,000 psi. at room temperature.

Creep, OM (nm./day)-0.0

(*Dimensional Instability*, Marschall and Maringer, Pergamon, 1977)

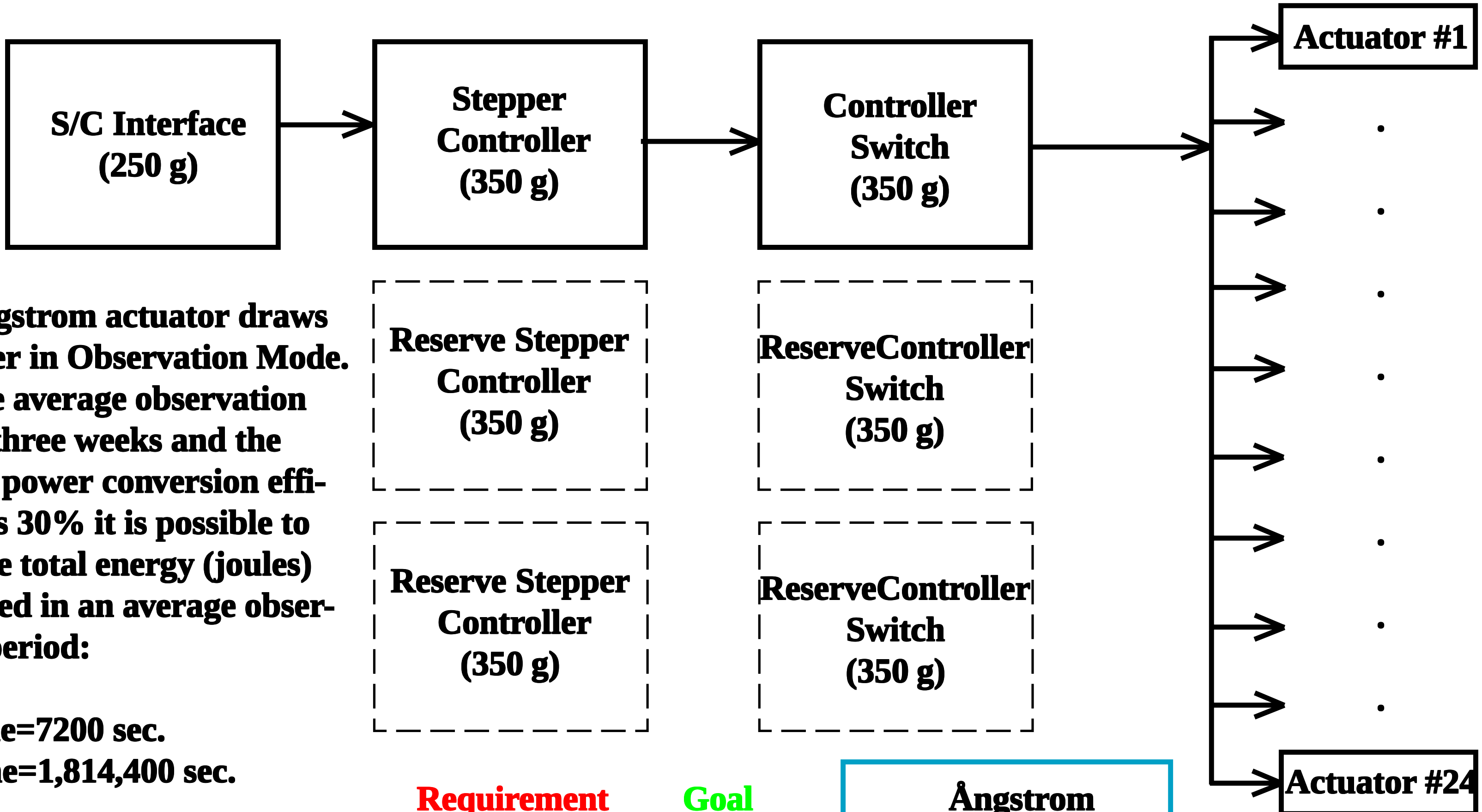
AEH.

The Ångstrom Actuator meets All NGST Requirements or Goals Except Mass

Property	NGST Requirement	NGST Goal	Ångstrom Performance
Resolution (nanometer)	≤20.	≤10.	4.1
Lifecycles	≥10,000	≥1,000,000	2,940,000
Stroke (mm.)	≥6.	≥10.	10.
Operating Temperature Range (°K)	20. to 60.	20. to 300.	20. to 300.
CM Heat Dissipation (milliwatts)	≤5.	≤0.5	4.2
OM Heat Dissipaton (milliwatts)	≤.05	≤0.0	0.0
Mass (grams)	≤40	≤20	180.
Outside Diameter, (cm.)	≤5	≤1	5.
Creep, OM (nm./day)	≤0.1	≤0.01	0.0
Thermal Stability, OM (nm./K°)	≤50	≤20	0.0 to ±49.5
Axial Force, set & hold, OM (N.)	≥0.5	≥1	±10.
Power Consumption, CM (watt)	≤1	≤0.1	.014
Power Consumption, OM (watt)			*0.0*
Axial Stiffness (N./micron)	≥1	≥1	1.19
Stowed Axial Length (cm.)	≤10	≤10	10.

AEH.

The Ångstrom Actuator Permits Compact, Low Weight, <u>Low Power Electronics</u>



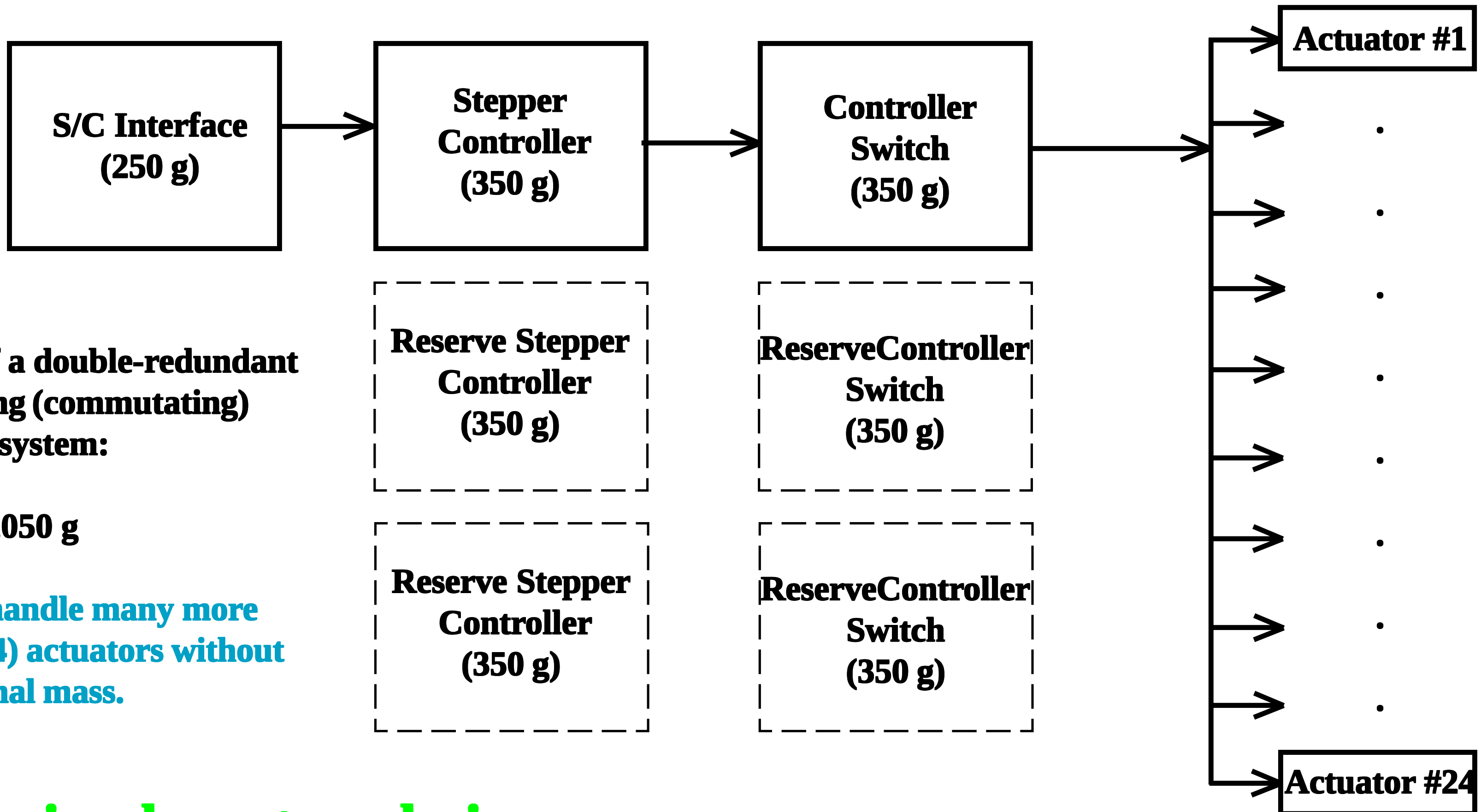
The Ångstrom actuator draws no power in Observation Mode. So if the average observation time is three weeks and the general power conversion efficiency is 30% it is possible to compare total energy (joules) consumed in an average observation period:

CM time=7200 sec.
OM time=1,814,400 sec.

	Requirement	Goal	Ångstrom
Power Consumption, CM (watt)	<1	<.1	.014
Power Consumption, OM (watt)	*<.1*	*<.01*	*0.0*
Observation Period Power (watt)	*<.1*	*<.01*	*.0000555*

AEH.

The Ångstrom Actuator Permits
<u>Compact, Low Weight</u>, Low Power Electronics



Mass of a double-redundant switching (commutating) control system:

2,050 g

Could handle many more (than 24) actuators without additional mass.

Very simple system design
Precludes multiple actuator failures

AEH.

High Performance
and Low Power

Ångstrom Transducers
Provide Enabling Technology
for NASA's Origins Mission

AEH.