



# HECTOR-100<sup>tm</sup>

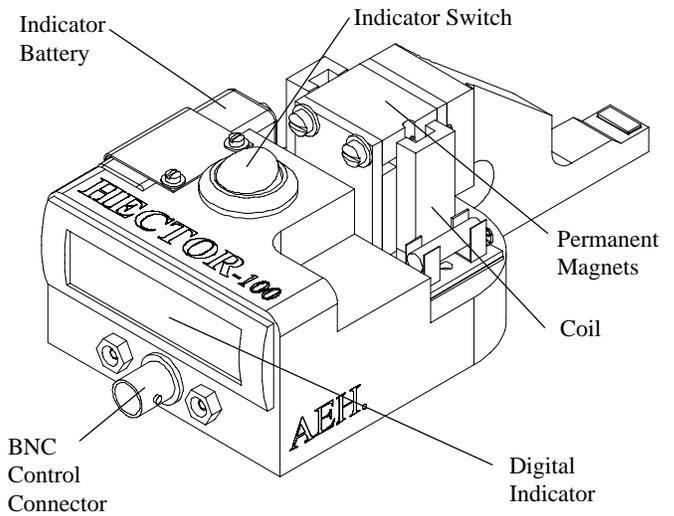
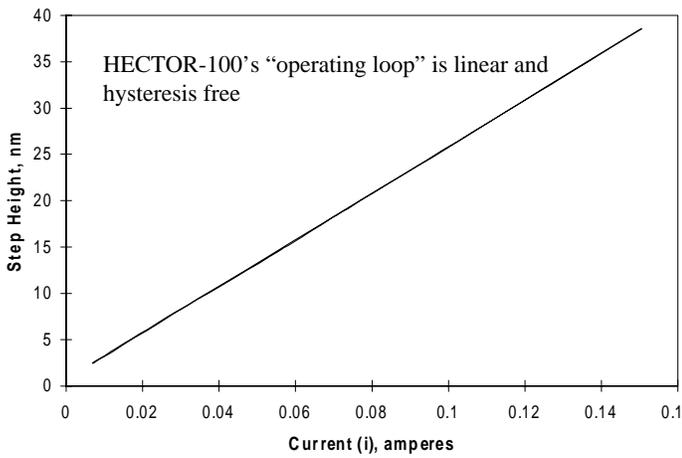
## Calibrated Displacement Actuator

### Nanometer Z-axis calibration for metrology instruments:

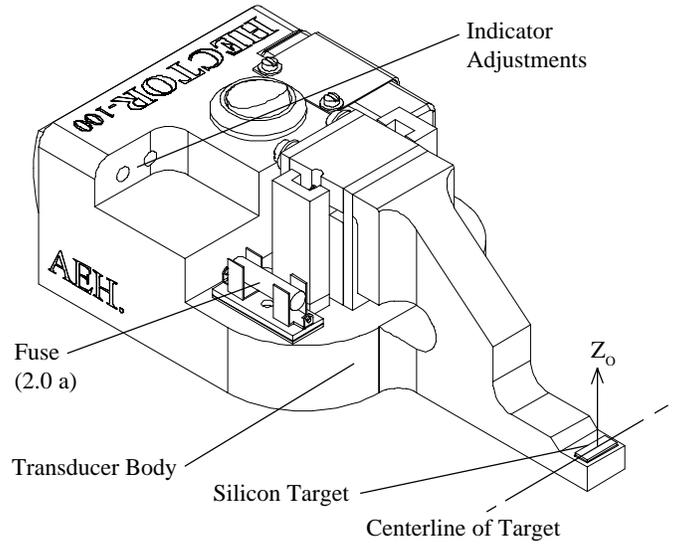
profilometers, interferometers and AFMs  
(contact and non-contact types)

### Introduction

HECTOR-100 is an actuator that converts electrical current into very small physical displacements. The displacements occur at a superpolished silicon target which can carry contact instrument stili but is also reflective to visible light for operation with non-contact instruments. The physics of the actuator's transduction effect is mature and well understood, entirely linear and hysteresis-free (see figure below) and very stable over time and temperature. HECTOR-100 may be calibrated at conveniently large currents and displacements for accurate determination of the transduction effect. Its displacements may



be subdivided into very small fractions of the calibrated range, providing physical displacements from about 200 nanometers sizes to under 1/10 nanometer sizes as desired. HECTOR-100 may itself be calibrated in an optical interferometer which makes its artifacts traceable to the SI unit of length (the wave length of light). The artifacts may be accurate and repeatable to 1 part in 1,000 or better, depending upon the procedures employed.



### Description

HECTOR-100 is constructed on an aluminum transducer body that has been anodized black. The configuration of the HECTOR-100 calibrated displacement actuator is shown in the figures above. The permanent magnets are attached to the top of the elastic transducer and the coil is attached to the base of the elastic transducer. Current in the coil will produce strains in the structure of the elastic transducer which will move the silicon target up and down ( $Z_0$ ). The current should not exceed 2.0 amperes, the rating of the fuse in the actuator. The actuator provides three spherical feet in its bottom surface which kinematically support the actuator and also allow the elastic structure to deform freely under the influence of only the force from the current in the coil. A BNC electrical connector provides for connection to the controller or an external source of electric current.

### Calibration Stability

Of the common environmental factors only temperature and aging appear to have perceptible influences on the transduction effect. Atmospheric pressure, humidity and gravitational variation have no influences on HECTOR-100's transduction effect. The thermal influences are limited to effects on the magnetic field, B, and the stiffness, k. Aging influences the effectiveness ratio, E. R., as well as the magnetic field, B. Table II shows the magnitude, in parts per million, of the aging and thermal influences.

Table II. Environmental Influences on HECTOR-100's Transduction Effect

Transduction Quantity	Influence on Transduction Effect, ppm
Thermal influences:	
Magnetic Field, B	+300. per K°
Stiffness, k	-180. per K°
Aging influences:	
Eff. Ratio, E. R.	±0.00053 per year
Magnetic Field, B	-10. per year

Review of the data in Table II suggests that nanometer-sized artifacts generated in normal industrial environments ( $\pm 10$  C°) should be repeatable to 1.2 parts in one thousand (1.2:1,000). Furthermore, in carefully controlled laboratory conditions ( $\pm 1$  C°) HECTOR-100 should be repeatable to 1.2 parts in ten thousand (1.2:10,000) or even better.

The aging influences suggest that re-calibration of HECTOR-100 should not be necessary in less than ten years under normal full-time use and repeatability should be one part in ten thousand (1:10,000) over that period. However, the data for the aging effects on the magnetic field are incomplete so users of HECTOR-100 who require very high accuracy may wish to check the calibration of the transducer more frequently.

### The HECTOR-100 Z-axis Calibration System

The HECTOR-100 Z-axis calibration system consists of:

- 1) the HECTOR-100 calibrated displacement actuator,
- 2) the HECTOR-100 controller,
- 3) two spare batteries,
- 4) a thirty inch coaxial cable with BNC connectors and
- 5) a screwdriver for aligning the digital indicator.

These are stored in a custom hardwood instrument case for convenient storage and transportation.

HECTOR-100 is produced under  
U. S. Patent No. 5,187,876.

“HECTOR-100” is a trademarks of  
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### Specifications

Actuator Size	16.5 cm. long 7.7 cm. wide 5.3 cm. high
Silicon Target Size	4.0 mm. x 10.0 mm.
Mass	580 grams
Fuse:	2 amperes
Temperature	0 to 35 °C
Humidity	5 to 95% R. H.
Altitude	unlimited
Indicator Range	±199.99 nm.
Indicator Resolution	±0.01 nm.
Repeatability	<1:10,000
Stability	
Thermal	+120. ppm per K°
Temporal	-10. ppm per year



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