Asymmetrical Capacitors for Propulsion

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Research with an EDGE SM

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The ISR Asymmetrical Capacitor Thruster; Experimental Results and Improved Designs

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The Team

AT ISR

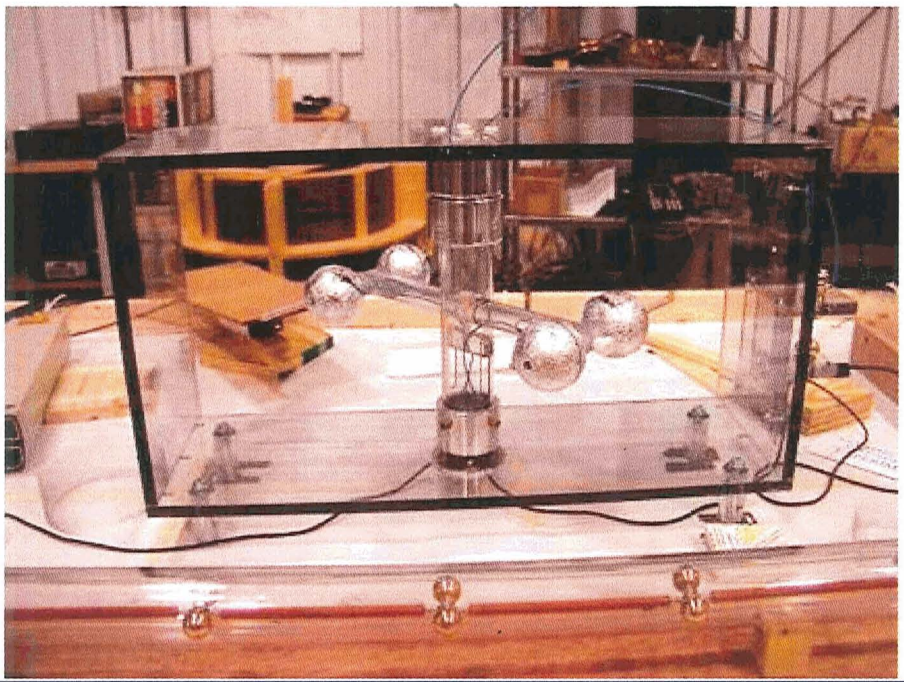
- Francis Canning
- Ed Winet
- Bob Ice
- Cory Melcher
- Phil Pesavento
- Alan Holmes
- Carey Butler

AT NASA Marshall

- John Cole
- Jonathan Campbell

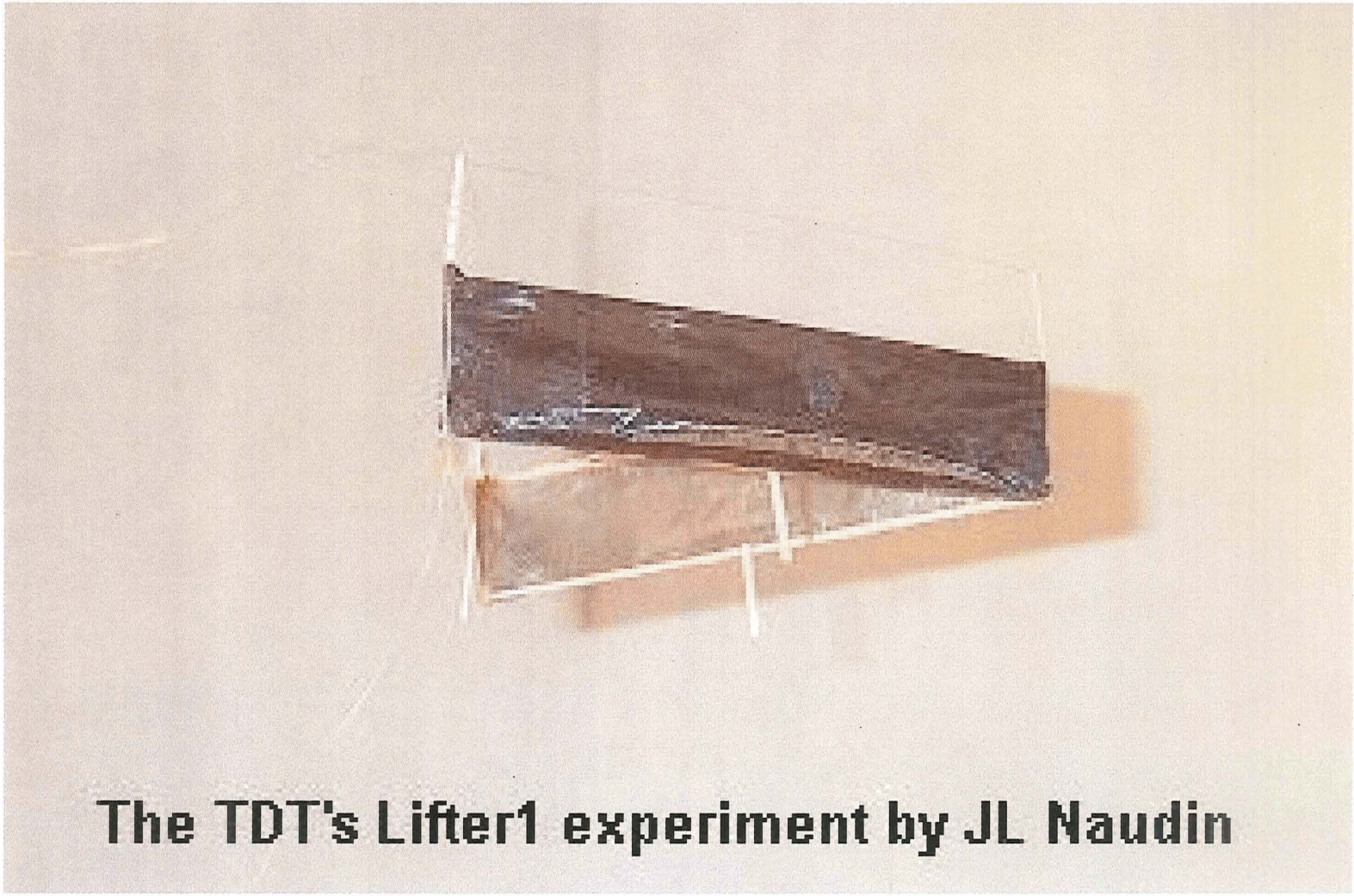
ACT Project Background

- Biefeld-Brown Effect – Thomas Townsend Brown 1922.
- NASA – Marshall Space Flight Center (J. Campbell).
- Lifters – Internet (J.L. Naudin, Tim Ventura, etc.).
- Still no peer review publications explaining the effect.
- Previous improvements have used intuition.



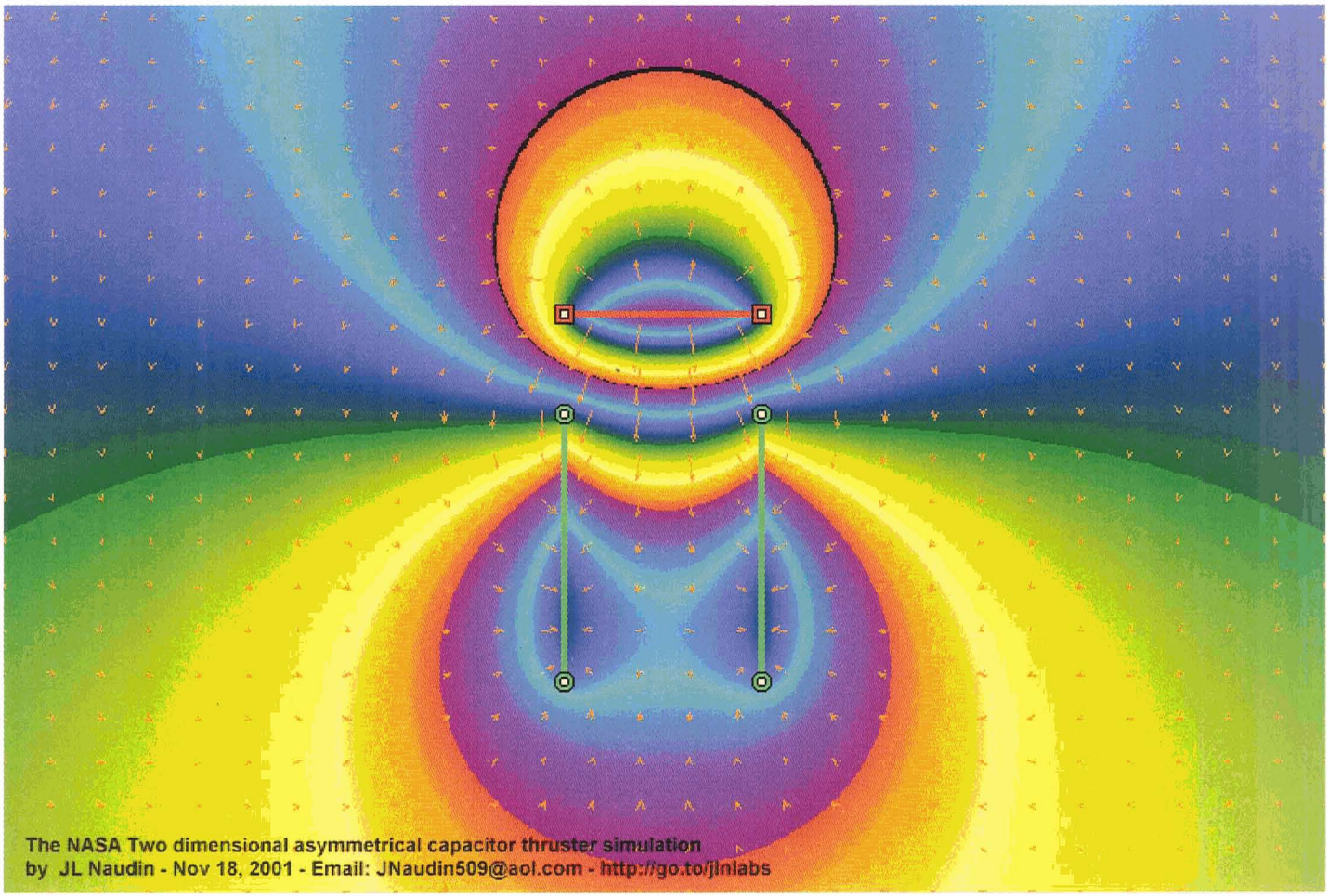
ISR

Lifters



The TDT's Lifter1 experiment by JL Naudin

New Science or Pseudo-Science



Project Goals

- Understand how to optimize the thrust.
- Understand how to use on other atmospheres.
- Understand how the force is produced.

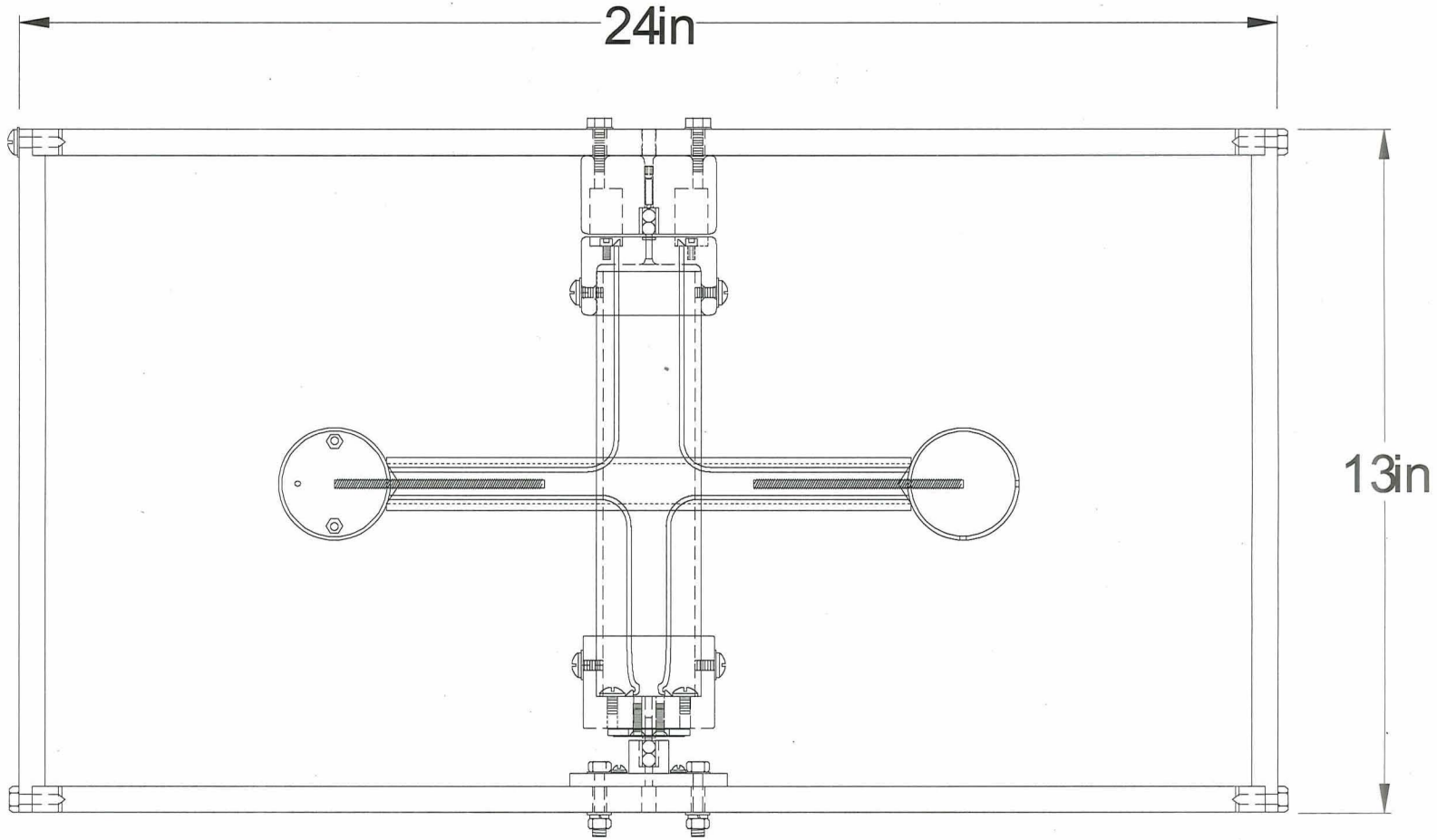
STRATEGY

- Develop several designs.
- Optimize these designs.
- Instrument for data acquisition.
- Develop computer models.
- Compare experiment and models.

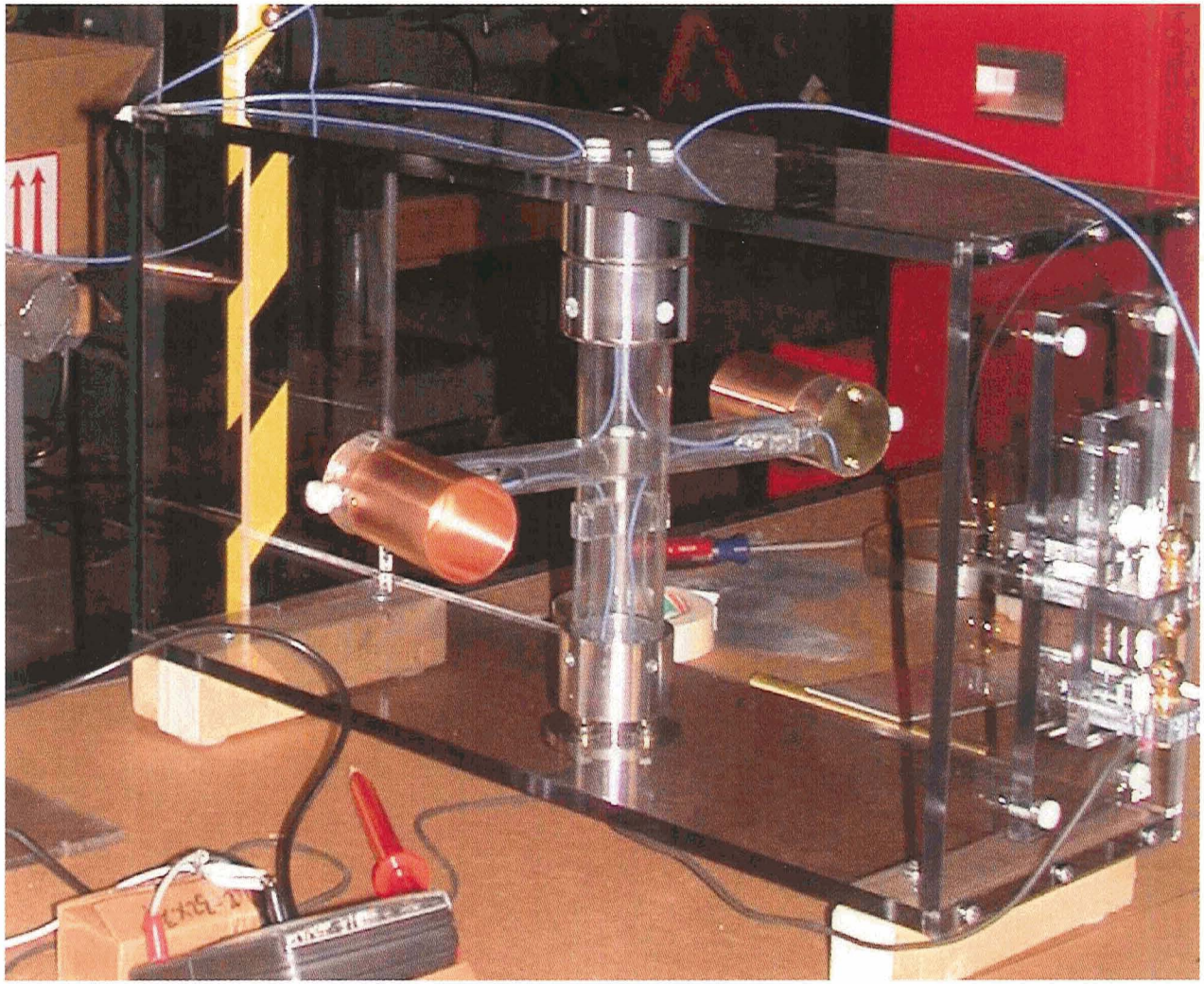
Outline

- Test apparatus
- Devices tested
- Circuits used
- Data collected
  - Time averaged
  - Time resolved
- Patterns Observed
- Force Calculation
- Electrostatic Modeling
- Understand it all

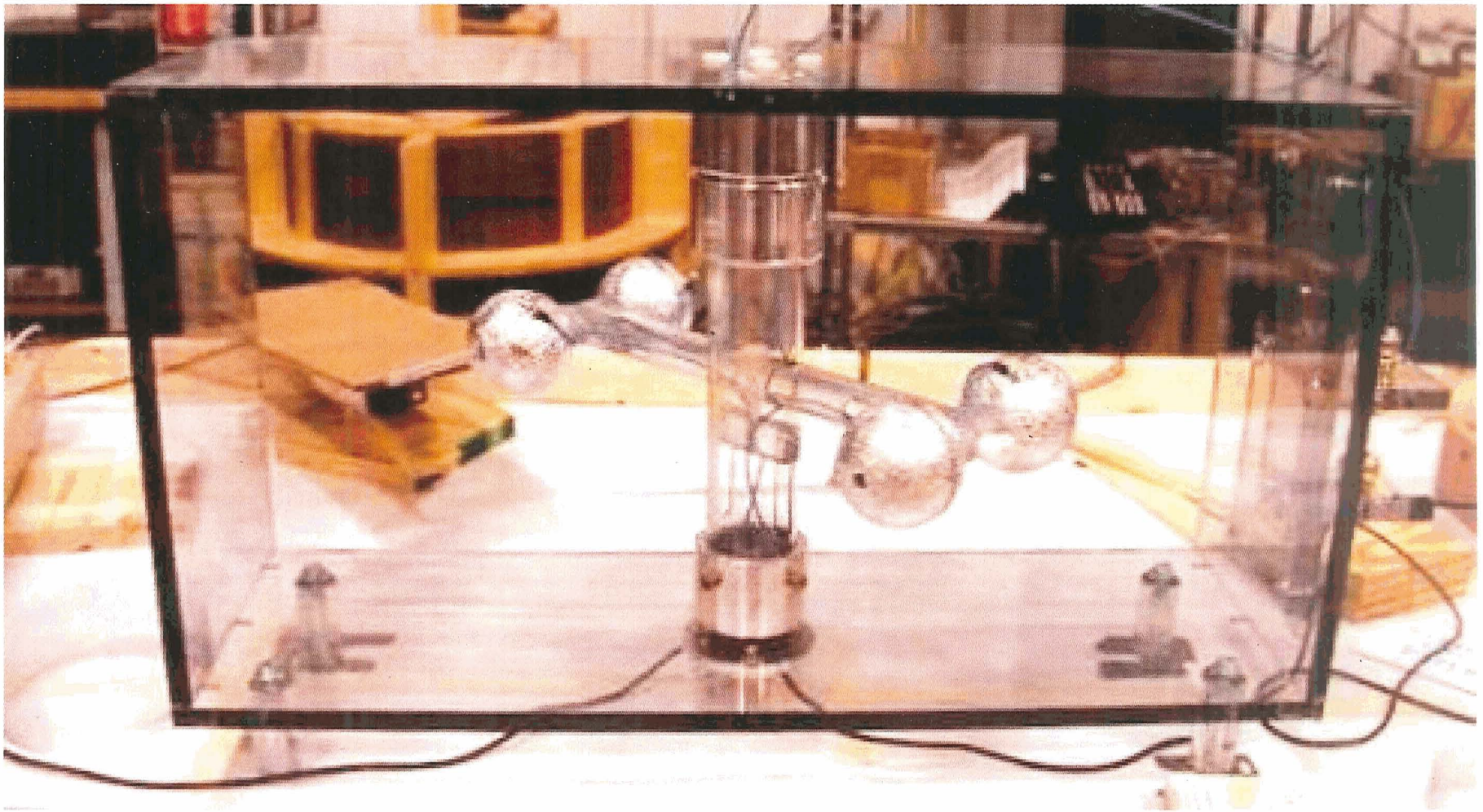
Test Apparatus: Design Features



The Test Apparatus



Many ACTs Were Tried

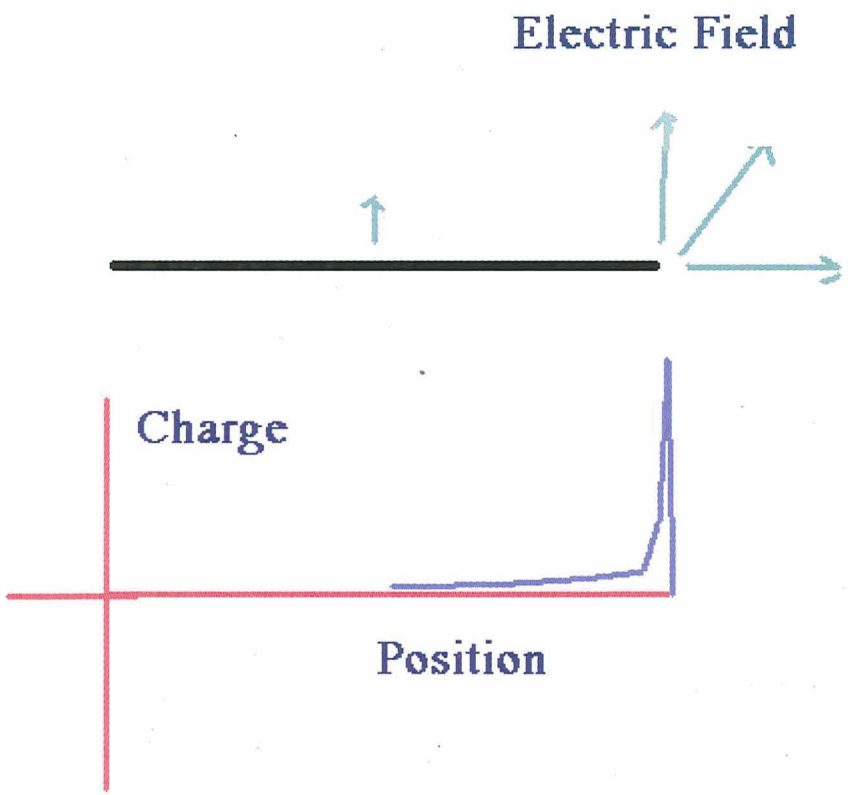


Asymmetry causes a force?

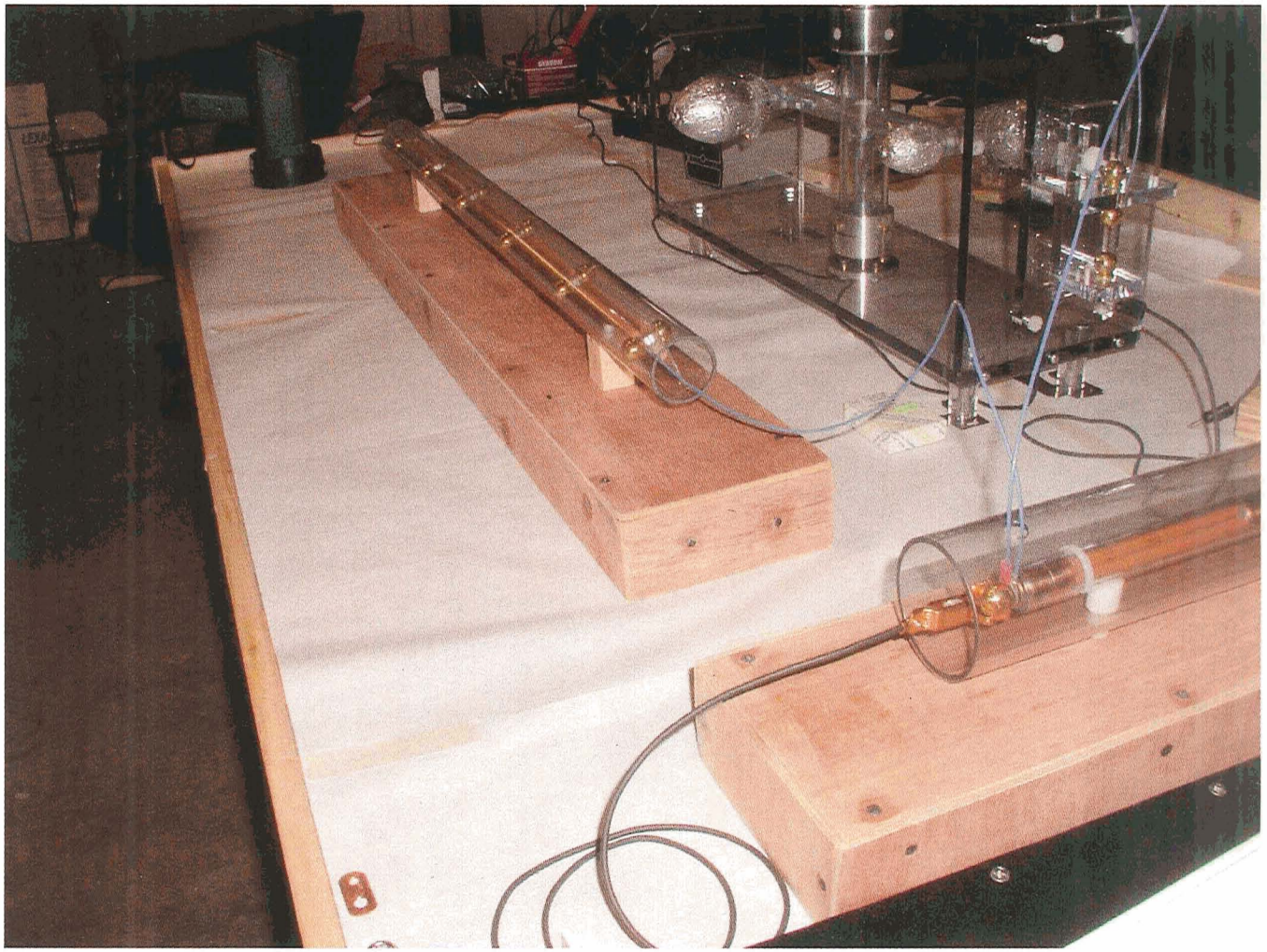
- Word on the street re direction is:
  - Sharp capacitor plate is forward side.
  - Polarity of excitation doesn't matter.

- Sharp edges cause high electric field:
  - Well known effect.
  - But, why does that matter.
    - Polarizing vacuum?
    - Current flow of ions?

Strong E Field, because…

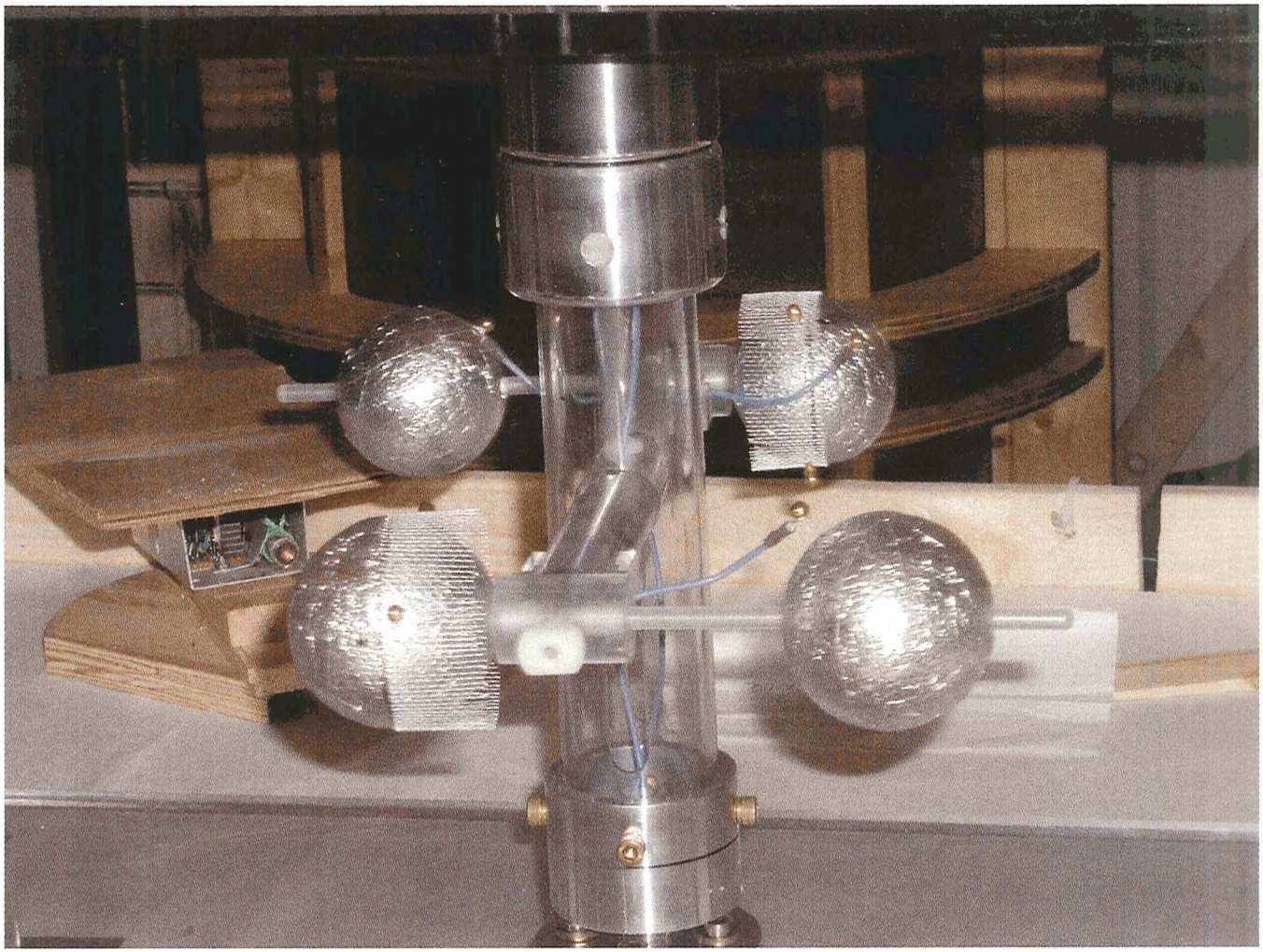


Resistors with NO Sharp Edges

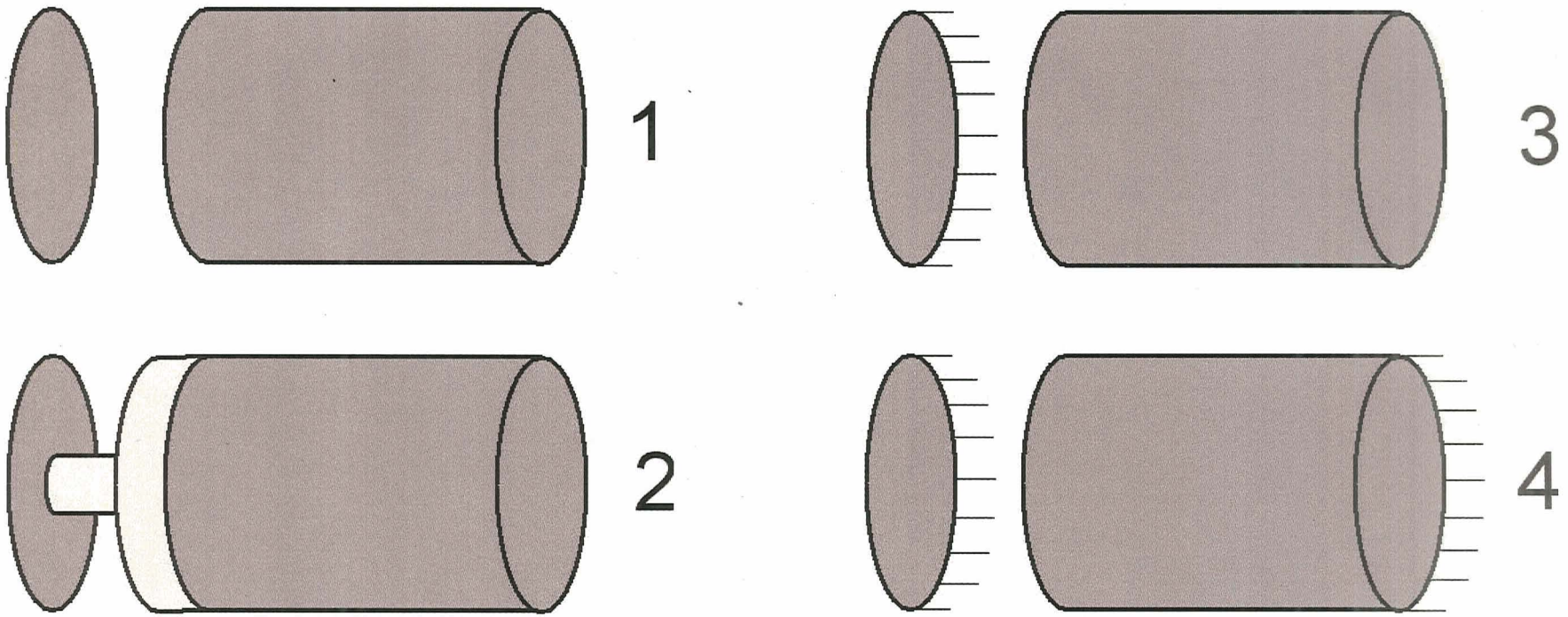


Wires on a Screen

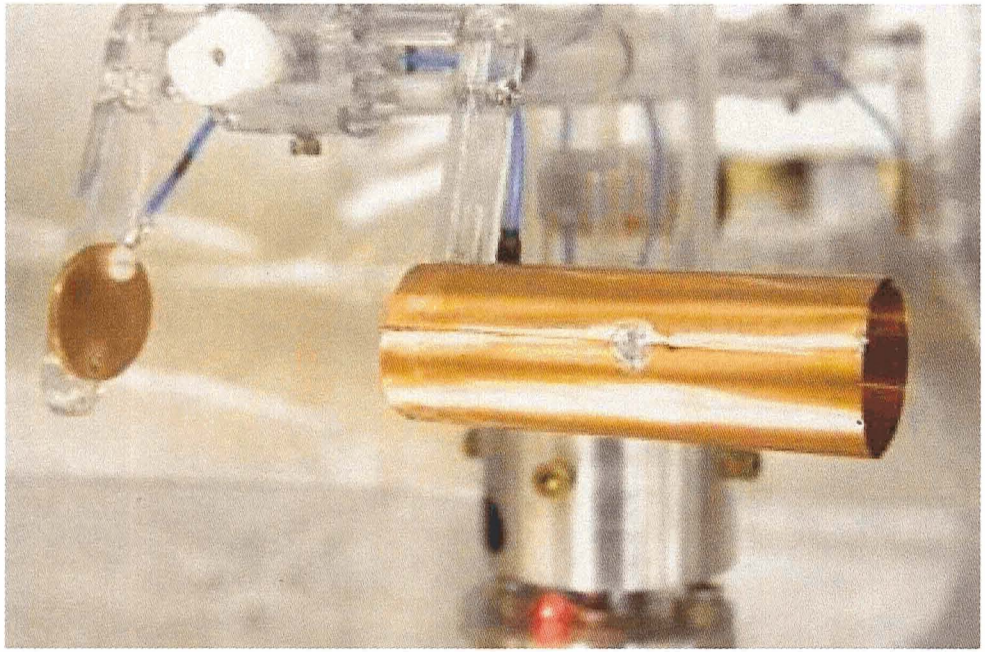
An Early Asymmetrical Capacitor

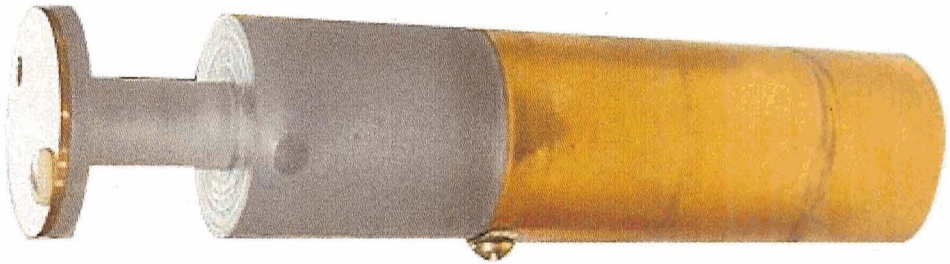


Four Devices Tested

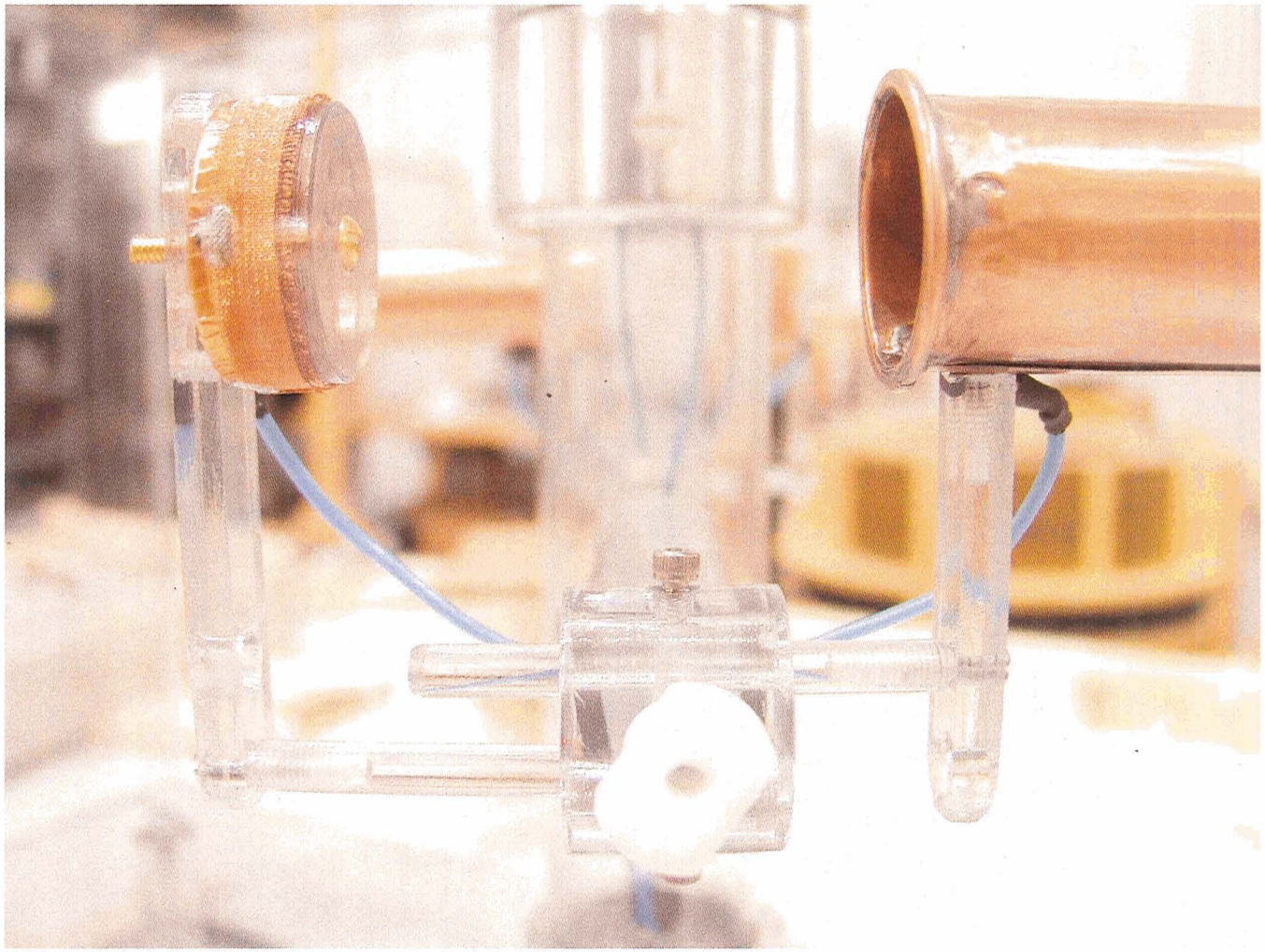


Devices 1 & 2

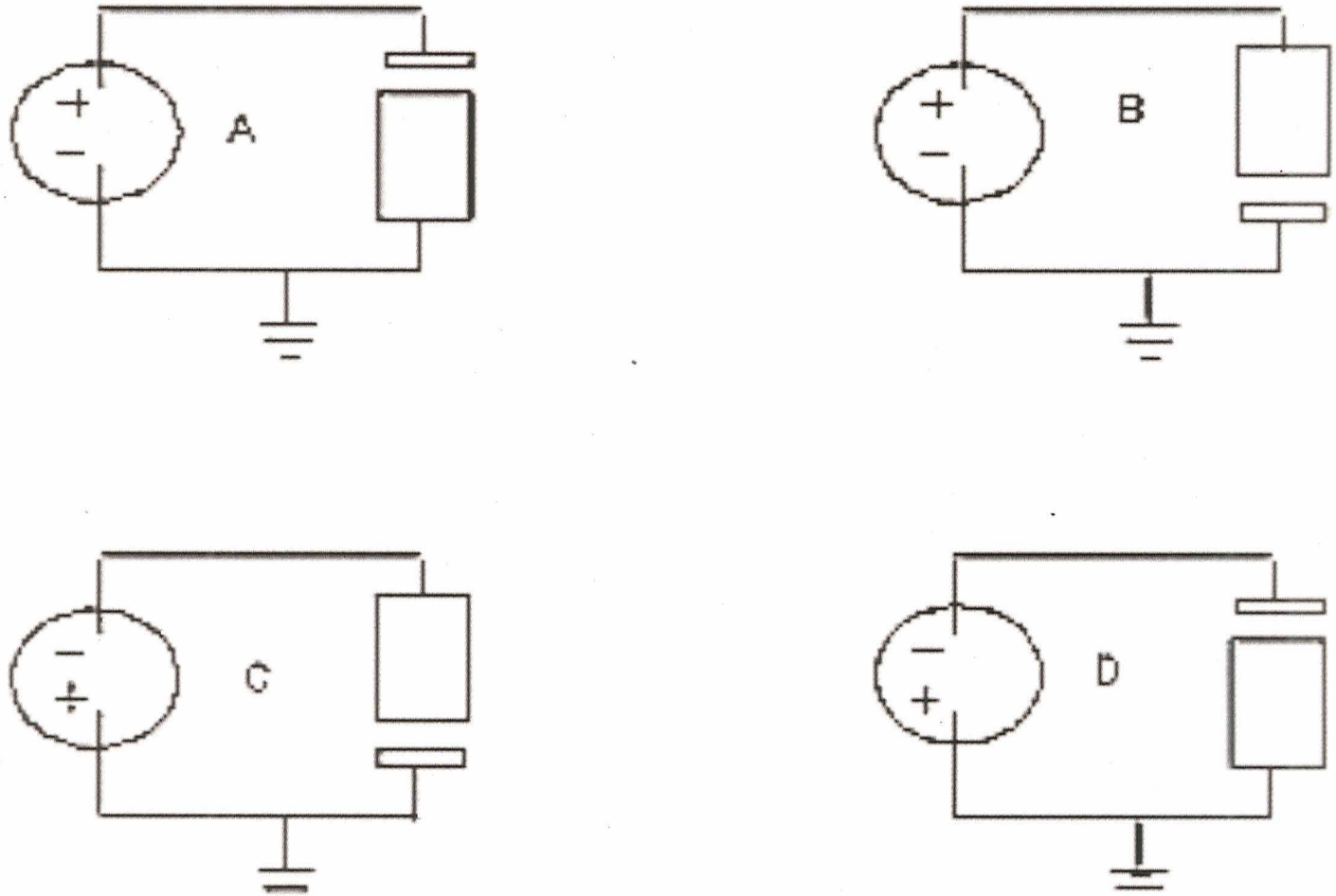




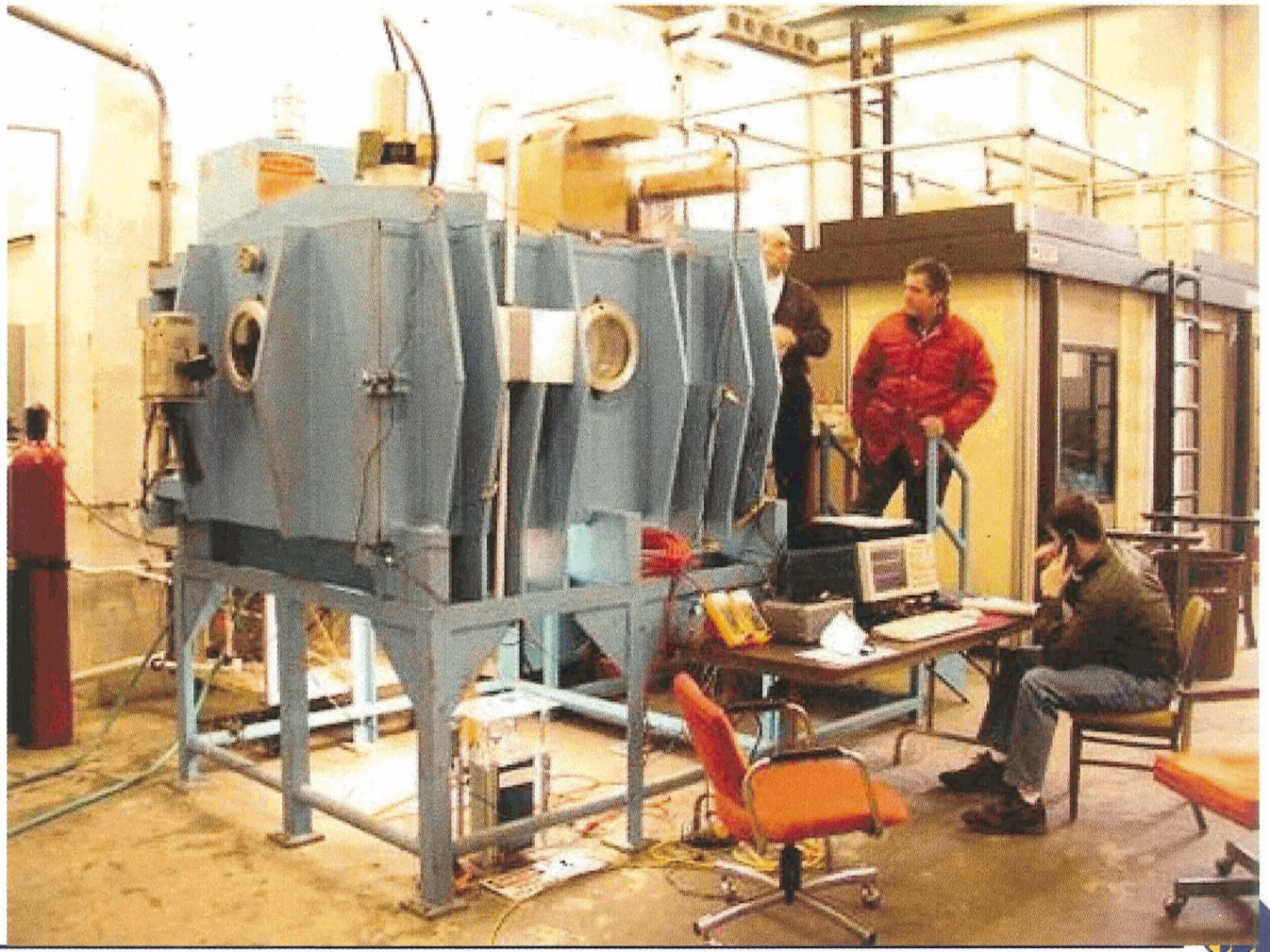
Device 3



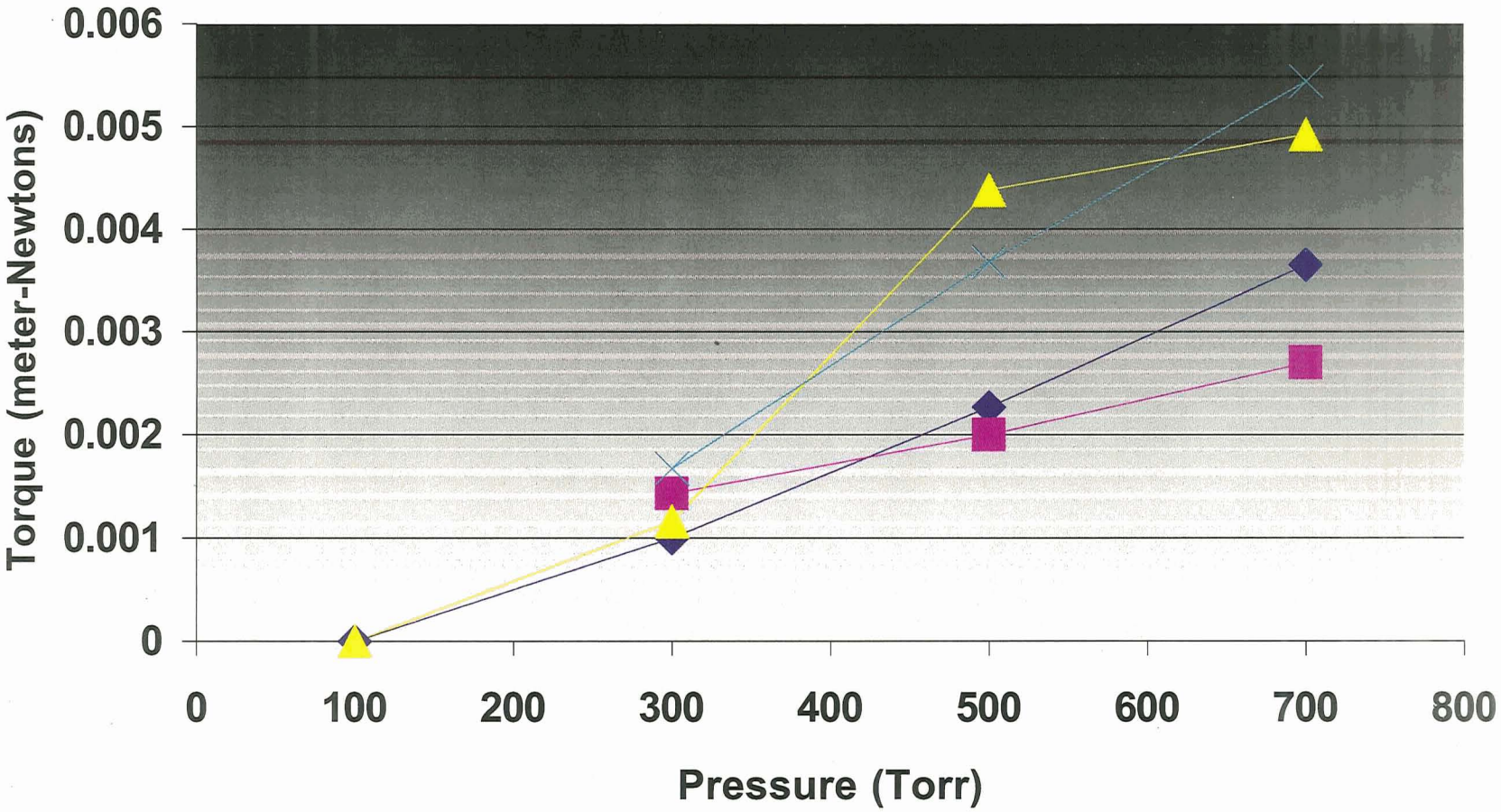
Four Circuits Tested



Vacuum Chamber



Force Vs Atmospheric Pressure

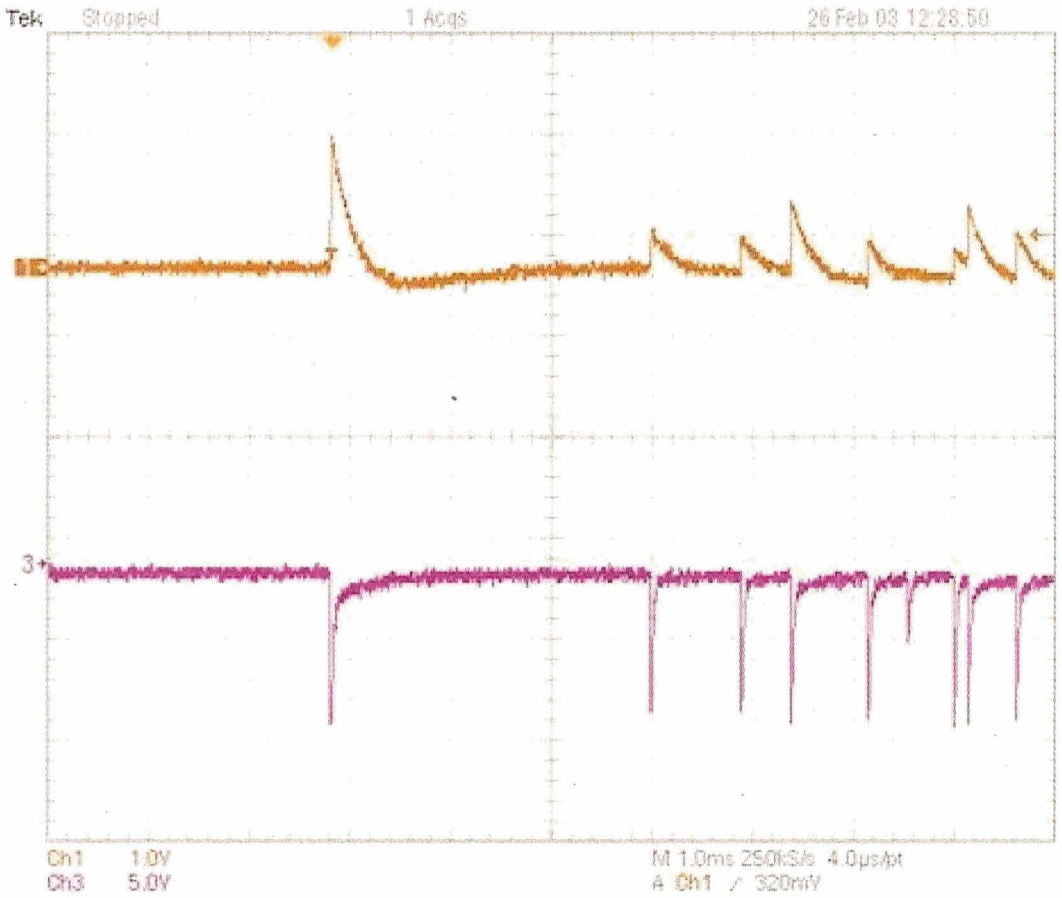


Data Collected

- Current into ACT.
- Current out of ACT.
- Voltage Applied.
- RPM.
- VLF Radiation.

- All time resolved on Oscilloscope / DAQ.
- Current into ACT measurement fluctuated.
- Also measured friction.

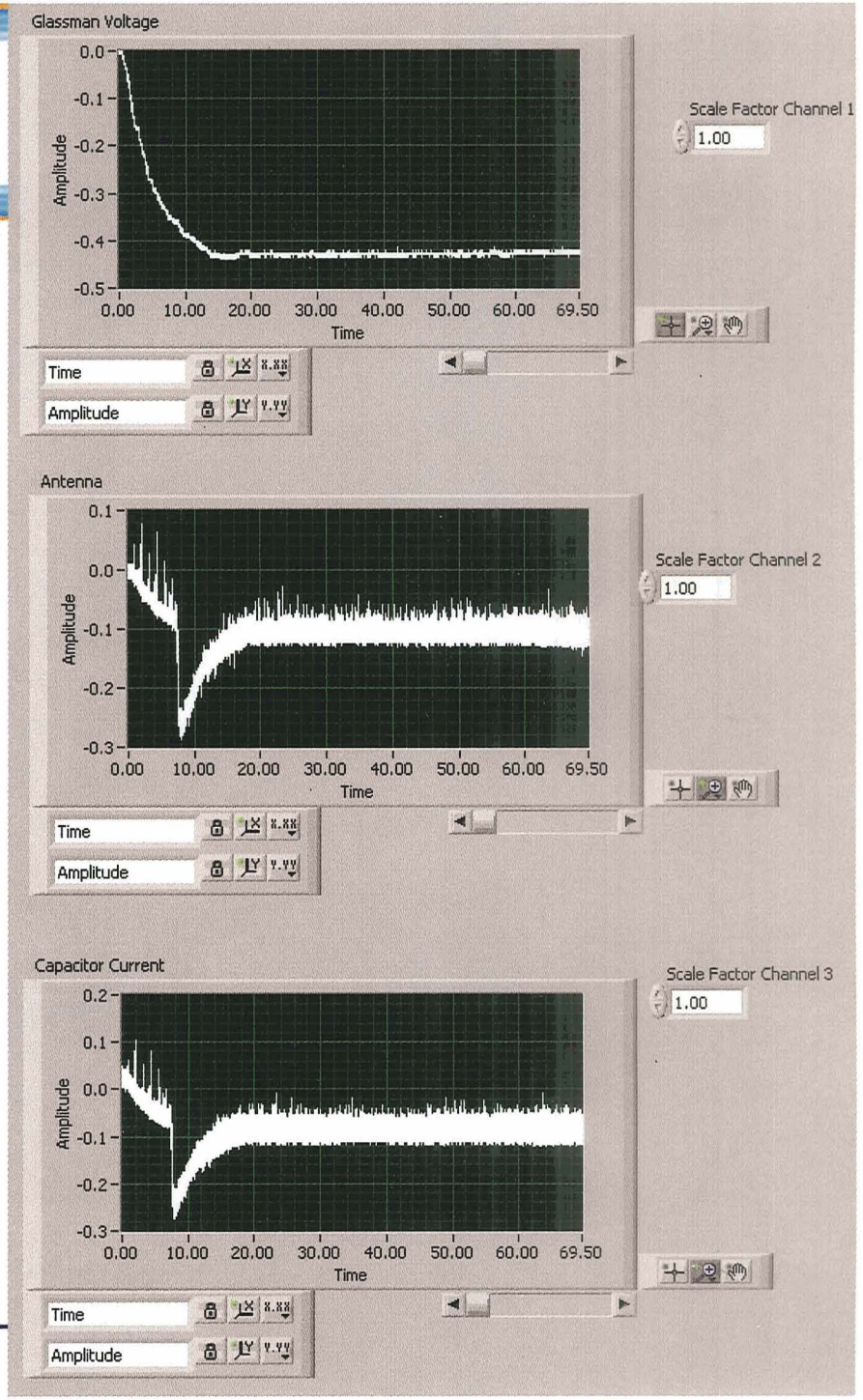
Current Vs Trichel Radiation



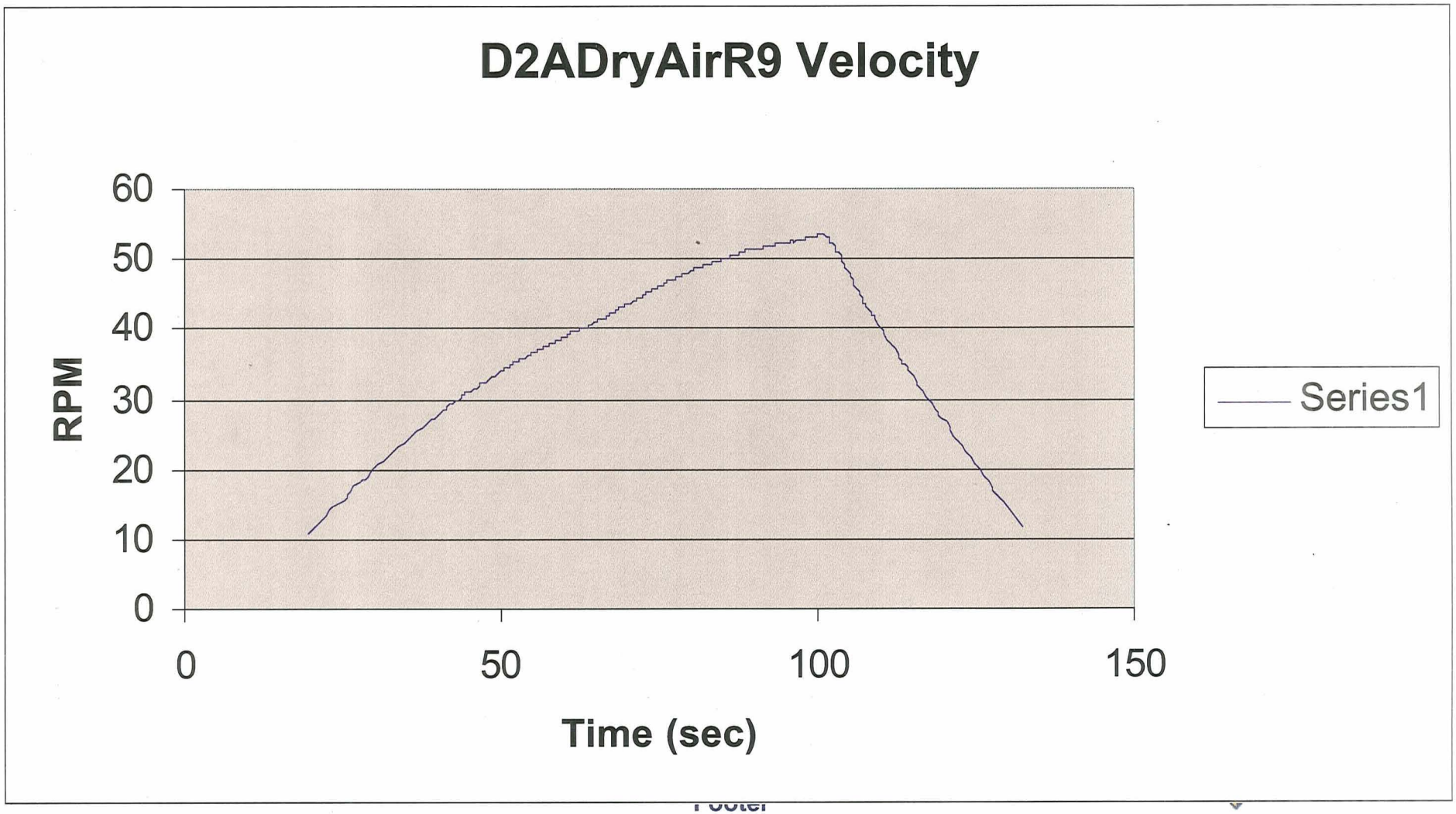
Top trace is radiation, bottom is current out of ACT

Data Acquisition System

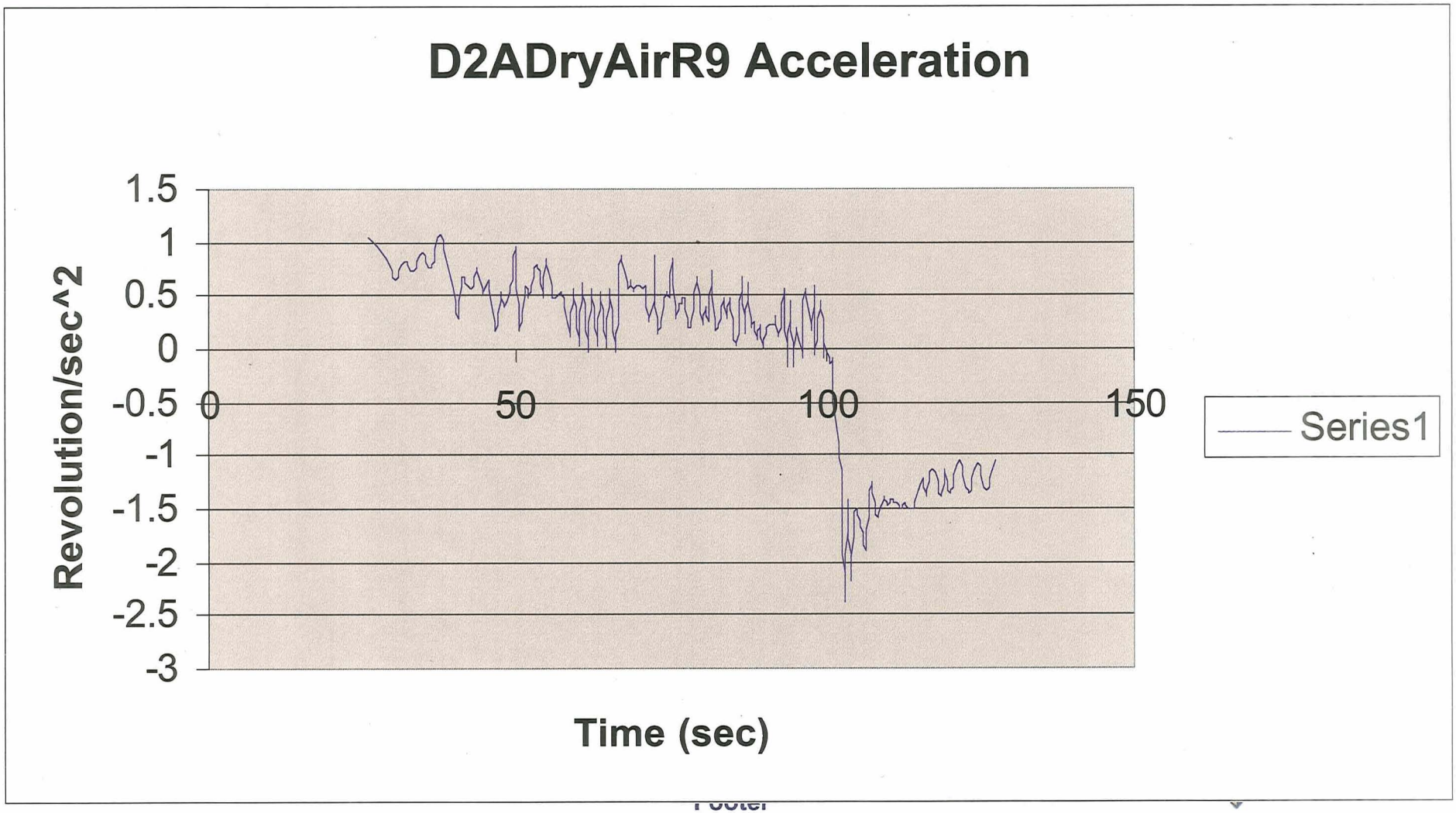
Time scale is
several orders of magnitude
longer than for oscilloscope



RPM Vs Time


D2ADryAirR9 Velocity
RPM
60
50
40
30
20
10
0
0
50
100
150
Time (sec)
Series1

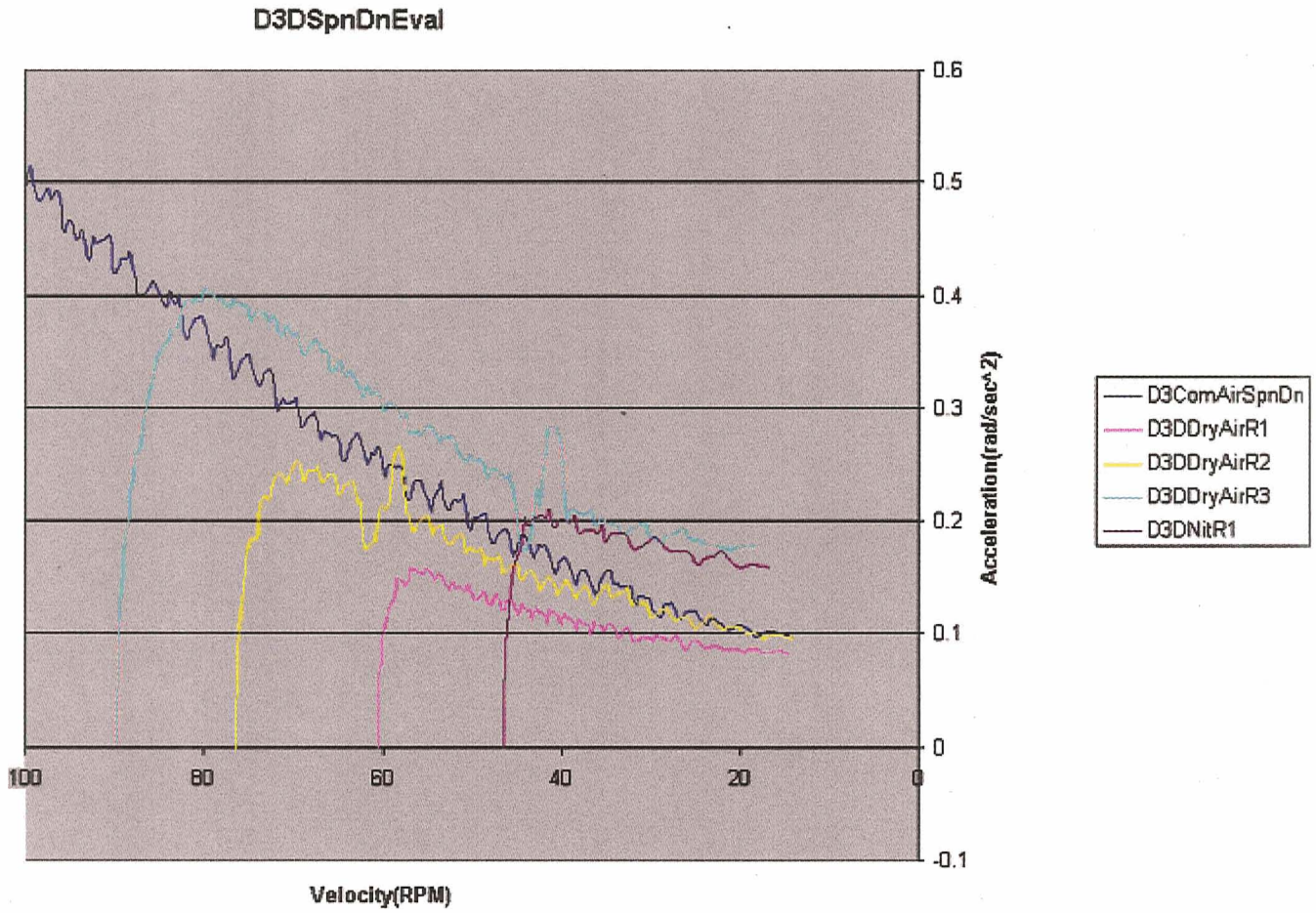
Raw Computed Acceleration



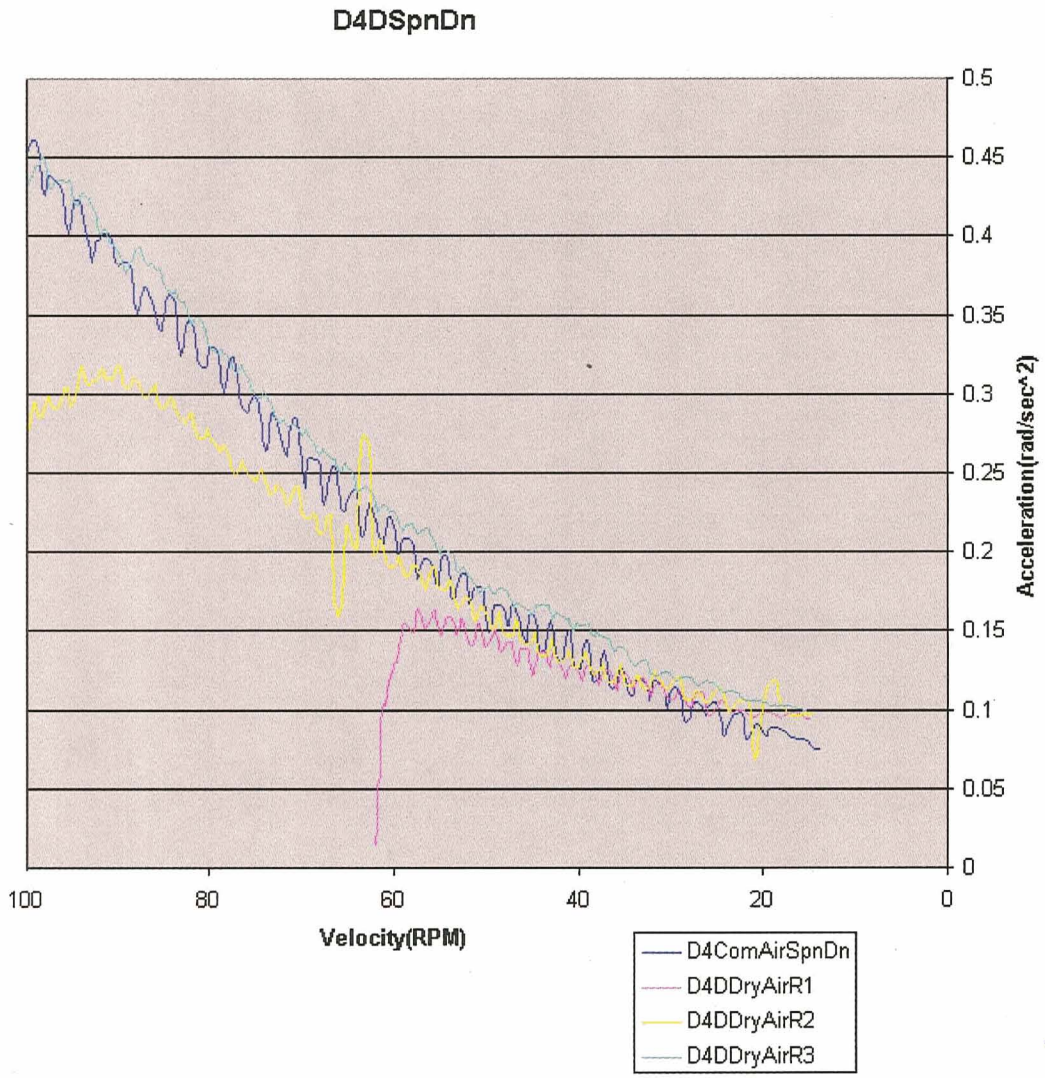
Smoothed Acceleration Data

- Smoothed Acceleration Data.
- Acceleration is a 2nd derivative of position.
- Puts noise into the result.
- Performed least squares fit of vel. vs time.
- Used five pairs of time and velocity.
- Took slope of fitted line as acceleration.
- Result still had some jitter- but much less.
- Plotted as Acceleration Vs Velocity.

Spin Down Device 3



Spin Down 4

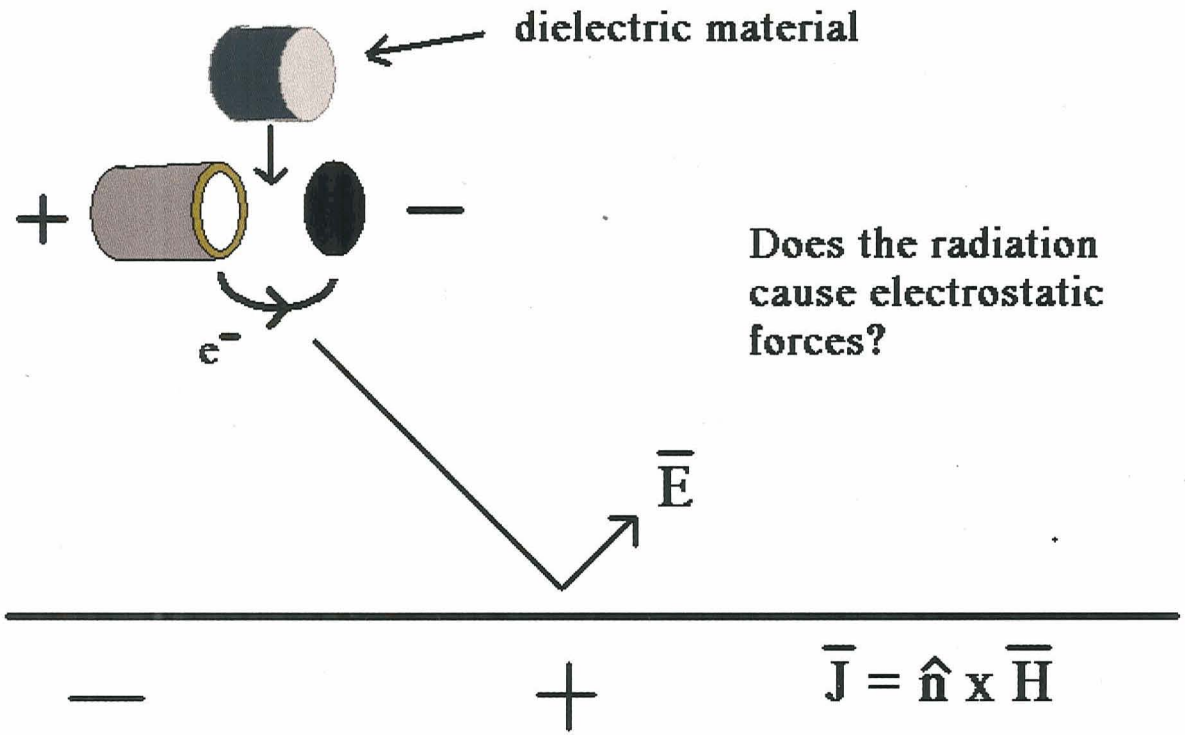

D4DSpnDn
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Acceleration(rad/sec^2)
100
80
60
40
20
0
Velocity(RPM)
D4ComAirSpnDn
D4DDryAirR1
D4DDryAirR2
D4DDryAirR3

Patterns Observed

- Devices 3 and 4 always rotated with the rough side first.
- Devices 1 and 2 always rotated so that the non grounded side was first.
- Changing polarity never changed the direction.
- Devices that moved weakly only moved with one polarity.

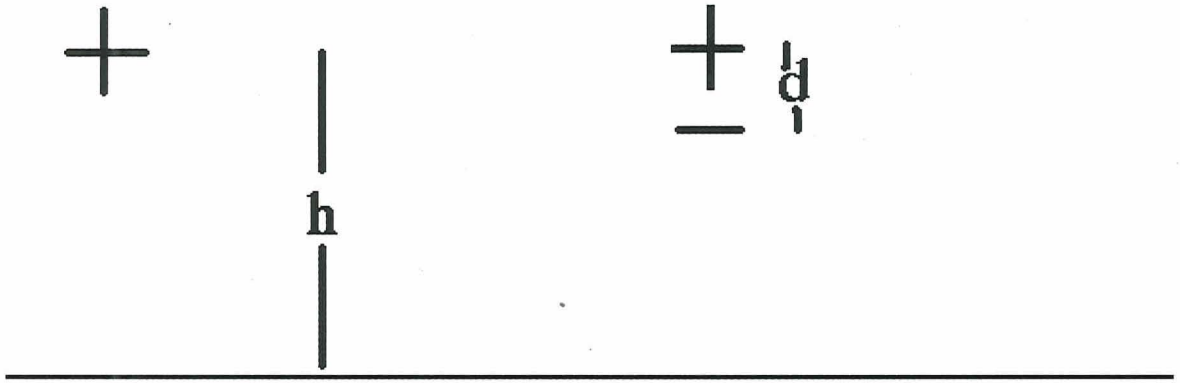
Induced Charges???

Accelerating Charges Radiate



Electrostatic Explanation???

Electrostatic Explanation



d/h = 0.01

0.05 lbs

About right

$0.05 \text{ lbs} * (d/h)^2$

$= 0.000005 \text{ lbs}$

Ablation???

- Particles may be ejected due to heating.
- Assume T=2,600 Kelvin.
- Assume KE = Thermal Energy & Copper mass.
- Implies 0.005Kg loss in six minutes.

- Doesn't seem reasonable for sustained op.
- May explain transients.

Ablation…back up with equations 1/2

$$\bar{v} = \left(\frac{8kT}{\pi m} \right)^{1/2}$$

$$\bar{v} = \left(\frac{8 \times \left(1.3807 \times 10^{-23}\ J/_{\circ}K\right) \times \left(2600^{\circ}K\right)}{\pi \left(1.0544 \times 10^{-25}\ kg\right)} \right)^{1/2} = 930\, m/s$$

Ablation…back up with equations 2/2

$$\frac{dm}{dt} = \frac{F}{\bar{v}}$$

$$\frac{dm}{dt} = 0.014\,N \Big/ 931.1\,m/s = 1.5\times10^{-5}\,kg/s$$

Polarizing the Vacuum???

- The energy to create an electron-positron pair = 1.0 MeV (from $2mc^2$).
- ACT has 100 keV, but over centimeters.
- Relevant comparison is work done on an atomic length scale (**or smaller**).
- Over one Angstrom, the available energy is less than 10^{-9} of an MeV.

THIS MECHANISM IS NOT PLAUSIBLE

Electrostatic with Ion Drift!!!

- Assume charged ions cross ACT.
- Assume 10^{10} collisions/sec with air.
- Assume loss of forward motion on collision.

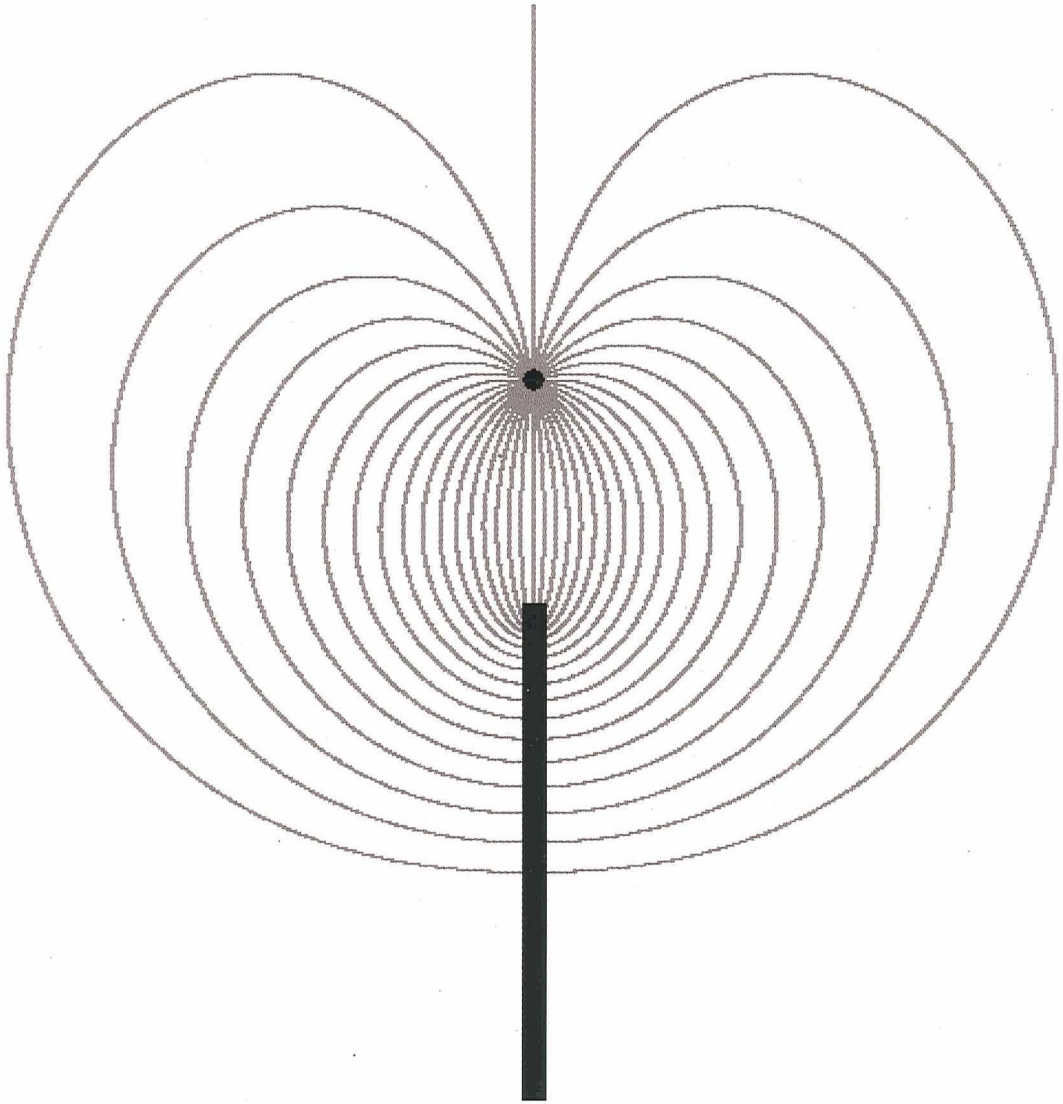
- $F = 2\ d\ (10/sec)\ m\ I\ /e$

- Note: Collisions cause momentum transfer.
- Note: The voltage causes an increased current, indirectly affecting F.

Electrostatic with…Backup

- $F = qE = qV/d = tIV/d$ (i)
- $d_0 = 0.5at_0^2 = 0.5\ a\ [10^{-10}\ sec]^2$
  - Where $a = F/m = [eV/d]/m$
- The total time to travel a distance d is
  - $t = 10^{-10}\ sec\ (d/d) = 2d(10^{10}\ /sec)/a$
    $= 2d^2\ 10^{10}\ sec\ m/(eV)$ (ii)
- Substituting (ii) into (i) gives:
  - $F=2\ d\ (10^{10}/sec)\ m\ I\ /e$
- F = 2(7cm)(4.7E-26 kg)(0.0035 Amps)x(10/sec)
  /(1.6E-19 Coulombs) = 1.44 Nt.

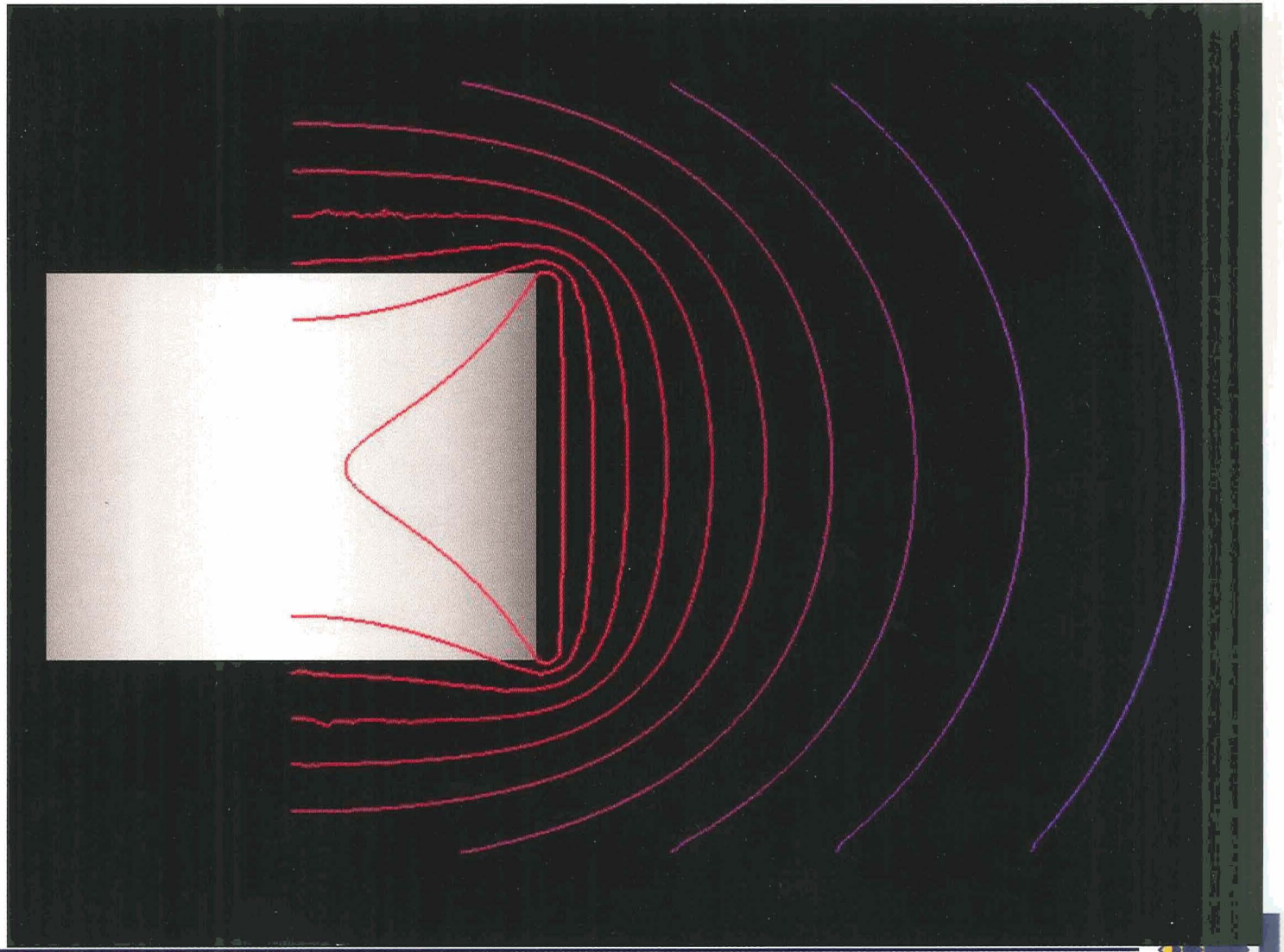
Ion Paths



Force and Speed Agree

- Force computed as above is slightly less than that measured.
- Device 4, Circuit A, was most efficient.
- Other Device/Circuit Combos significantly less efficient.
- Believe due to removing ambient ions.
- Found 1% power efficiency, and ratio of velocities was 100:1 also!

Voltage near a Cylinder



Patterns Observed....Repeated

- Devices 3 and 4 always rotated with the rough side first. (3&4 are most asymm.)
- Devices 1 and 2 always rotated so that the non grounded side was first. (least asymm.)
- Changing polarity never changed the direction.
- Changing polarity changed rotation rate.

Working Explanation re Efficiency

- Ions move in both directions.
  - Wrong way ions reduce force produced.
- Ionizing ambient air causes losses.

- Most efficient devices are the most asymmetric devices.
- Device 4 removes ambient ions, due to the rear wires. This improves efficiency.

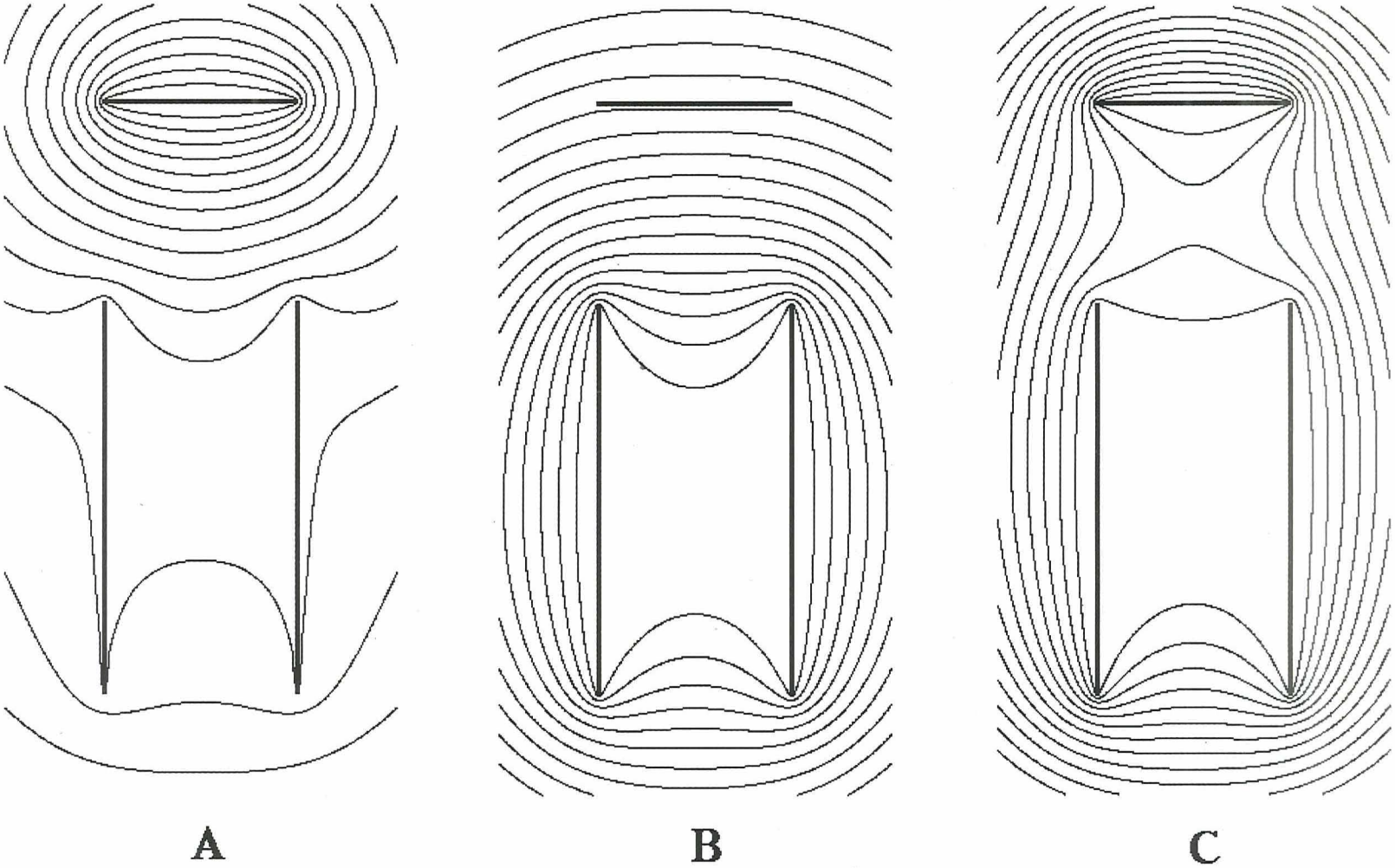
Working Explanation re Direction

- Ions are created at a rate depending on strength of E field.

- Sharp features cause larger E field.
- Grounding a side reduces its E field.

- CAN WE SHOW THIS BY NUMERICAL SIMULATION???

Electrostatic Modeling



A B C

Designing more efficient ACTs

- How to increase thrust?
  - Increase hang time for ions.
- Does it work in a vacuum?
  - No!
- How to improve efficiency?
  - Use it on a moving vehicle & decrease ion speed.
- Is there any new physics?
  - NO!

Summary

- The mechanism of operation for ACTs has been determined.
- Their efficiency is determined by the ratio of speeds of ions Vs the ACT.
- There is no new physics.
- They do not work in a vacuum.
- They can be optimized to work at various pressures and in various gasses.